



Eco-friendly Management of Mealybugs (Pseudococcidae) Infestation in Guava (*Psidium guajava* L.) using Herbal Pesticides Derived from *Bidens pilosa*

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Abstract

Guava (*Psidium guajava* L.) is a nutritionally and economically significant fruit crop globally, but its productivity is severely hampered by sap-sucking pests like mealybugs (Pseudococcidae). Over-reliance on synthetic pesticides has led to resistance, residue accumulation, and environmental degradation. This necessitates the exploration of effective, biodegradable, and eco-friendly alternatives. This study aimed to evaluate the efficacy of herbal pesticides derived from the common weed *Bidens pilosa* (Blackjack) found in North-east region especially in Manipur against mealybug infestation in guava plants. Aqueous and ethanolic extracts of *B. pilosa* (whole plant) were prepared at concentrations of 5%, 10%, and 15% (w/v). Laboratory bioassays and field trials were conducted. In the lab, direct contact and residual toxicity against adult mealybugs were assessed. In the field, a randomized complete block design (RCBD) was used with three replications per treatment. Mealybug population density, plant damage index, and fruit yield were recorded pre- and post-application at 1, 3, 7, and 14 days. The 15% ethanolic extract of *B. pilosa* demonstrated the highest efficacy, causing 92.4% mortality in laboratory bioassays within 72 hours. In field trials, the same treatment resulted in a significant reduction ($p < 0.05$) in mealybug population (88.7%) and a marked decrease in plant damage score. This was comparable to the synthetic pesticide control (Imidacloprid) and significantly superior to the untreated control. The aqueous extract also showed significant activity, though lower than the ethanolic extract. No phytotoxic effects were observed on the guava plants. The findings conclusively demonstrate that *Bidens pilosa* extracts, particularly the 15% ethanolic formulation, are a potent, eco-friendly, and sustainable alternative for the integrated management of mealybugs in guava orchards. This approach offers a way to utilize a common weed for crop protection, reducing dependency on synthetic chemicals.

Keywords: *Bidens pilosa*, Guava, Mealybugs, Herbal Pesticide, Botanicals, Integrated Pest Management (IPM), Eco-friendly, Blackjack.

1. Introduction

Guava (*Psidium guajava* L.), often termed the "apple of the tropics," is a highly valued fruit crop due to its rich nutritional profile, containing high levels of Vitamin C, dietary fiber, and antioxidants. Despite its hardiness, guava is susceptible to attack by a plethora of insect pests,

among which mealybugs (Hemiptera: Pseudococcidae) are particularly devastating [1]. These polyphagous pests suck sap from tender shoots, leaves, and fruits, leading to stunted growth, leaf curling, sooty mold growth on honeydew, and fruit deformation, ultimately causing significant quantitative and qualitative yield losses [2].



Fig.1- Showing a Guava Twig infested with Mealybugs

The conventional management strategy for mealybugs has heavily relied on the application of systemic insecticides like neonicotinoids and organophosphates. However, the cryptic nature of mealybugs, their waxy coating, and their tendency to inhabit concealed plant parts often render chemical control inefficient [3]. More critically, the indiscriminate use of these synthetic pesticides has resulted in well-documented adverse consequences, including the development of insecticide resistance, elimination of natural enemies, harmful residues on fruits, and environmental pollution [4].

In this context, Integrated Pest Management (IPM) emphasizes the use of biorational pesticides, including plant-derived botanicals. These are generally biodegradable, target-specific, have multiple modes of action, and are safer for non-target organisms and the ecosystem [5]. *Bidens pilosa* L., commonly known as Blackjack or Spanish Needle, is a widespread annual weed belonging to the Asteraceae family. Traditionally, it has been used in folk medicine for its anti-inflammatory, antimicrobial, and antidiabetic properties [6].

Crucially, phytochemical studies have revealed that *B. pilosa* is rich in bioactive compounds, particularly polyynes (e.g., phenylheptatriyne) and flavonoids, which have demonstrated significant insecticidal, antifeedant, and repellent activities against various arthropod pests [7, 8].

This study hypothesizes that extracts derived from *Bidens pilosa* can effectively suppress mealybug populations on guava plants without causing phytotoxicity. The objective was to systematically evaluate the efficacy of different concentrations of aqueous and ethanolic extracts of *B. pilosa* against mealybugs under both laboratory and field conditions.

2. Materials and Methods

2.1. Collection and Preparation of Plant Material

The whole plant of *Bidens pilosa* (including leaves, stems, and roots) was collected from non-cultivated, pesticide-free areas during its flowering stage. The plant was authenticated by a botanist (Voucher Specimen No: BP-AGR-101). The collected material was thoroughly washed with tap water, shade-dried at room temperature ($25\pm 2^{\circ}\text{C}$) for two weeks, and pulverized into a fine powder using a mechanical grinder.

2.2. Extraction

Aqueous Extract: 100g of powdered plant material was soaked in 1000 mL of distilled water (1:10 ratio) for 48 hours with occasional stirring. The mixture was filtered first through muslin cloth and then through Whatman No. 1 filter paper. The filtrate was considered a 10% stock solution (w/v), from which 5% and 15% concentrations were prepared by dilution.

Ethanolic Extract: 100g of powder was subjected to Soxhlet extraction using 95% ethanol as the solvent for 6 hours. The extract was concentrated using a rotary evaporator at 40°C . The resultant gummy residue was re-dissolved in distilled water with 0.1% Tween-80 as an emulsifier to create 5%, 10%, and 15% concentrations (w/v).

2.3. Insect Rearing and Experimental Site

A laboratory culture of mealybugs (*Planococcus citri*) was maintained on pumpkin fruits in controlled conditions ($25\pm 1^{\circ}\text{C}$, $65\pm 5\%$ RH, 16:8 L:D) for bioassays. Field trials were conducted in a naturally infested guava orchard that had not received any pesticide application for the preceding three months.

2.4. Bioassay Studies

2.4.1. Direct Contact Toxicity: A leaf-dip bioassay was performed. Guava leaf discs were dipped in respective test solutions for 30 seconds, air-dried, and placed in Petri dishes. Ten adult mealybugs were released onto each disc. Mortality was recorded at 24, 48, and 72 hours post-treatment. Control setups used distilled water and water with 0.1% Tween-80.

2.4.2. Residual Toxicity: Treated leaves were aged for 0, 24, and 48 hours under lab conditions before introducing insects to assess the persistence of the extracts.

2.5. Field Evaluation

A Randomized Complete Block Design (RCBD) with seven treatments and three replications was employed. Each plot contained three guava trees. The treatments were:

- T1: Aqueous Extract (5%)
- T2: Aqueous Extract (10%)
- T3: Aqueous Extract (15%)
- T4: Ethanolic Extract (5%)
- T5: Ethanolic Extract (10%)
- T6: Ethanolic Extract (15%)
- T7: Synthetic Check (0.05% Imidacloprid)
- T8: Untreated Control (Water with 0.1% Tween-80)

Sprays were applied to runoff using a knapsack sprayer during the evening. Data on the number of mealybugs per 10 cm terminal shoot and a plant damage index (0-5 scale) were recorded pre-spray and at 1, 3, 7, and 14 days after spraying (DAS). Fruit yield per tree was recorded at harvest.

2.6. Phytotoxicity Assessment

Treated plants were monitored daily for 7 days for any symptoms of phytotoxicity, such as leaf chlorosis, necrosis, or epinasty.

2.7. Statistical Analysis

Mortality data from bioassays were corrected using Abbott's formula. Data were subjected to Analysis of Variance (ANOVA), and treatment means were separated using Tukey's HSD test at a 5% significance level ($p < 0.05$) using SPSS software (v.26.0).

3. Results

3.1. Laboratory Bioassay

Both extracts exhibited concentration- and time-dependent mortality. The 15% ethanolic extract was the most effective, causing 92.4% mortality at 72 hours, significantly higher ($p < 0.05$) than all other botanical treatments (Table 1). The aqueous extracts were less potent but still caused significant mortality (65.8% for 15% aqueous at 72 hours). The residual effect of the ethanolic extract was also more persistent, showing significant mortality even after 48 hours of aging.

Table 1: Percent Mortality of Mealybugs in Laboratory Bioassay (72 Hrs)

Treatment Concentration Mortality (%) $\pm$ SE

Aqueous Extract 5%	45.2 $\pm$ 2.1d
Aqueous Extract 10%	58.7 $\pm$ 1.8c
Aqueous Extract 15%	65.8 $\pm$ 2.4c
Ethanolic Extract 5%	68.3 $\pm$ 1.9c
Ethanolic Extract 10%	83.6 $\pm$ 1.5b
Ethanolic Extract 15%	92.4 $\pm$ 1.1a
Control (Water) -	4.5 $\pm$ 0.9e

Means within a column followed by the same letter are not significantly different ($p > 0.05$).

3.2. Field Trial

The field results corroborated the laboratory findings. All extract treatments significantly reduced the mealybug population compared to the untreated control (Table 2). The 15% ethanolic extract (T6) resulted in the highest population reduction (88.7%), which was statistically on par with the synthetic check, Imidacloprid (T7), which achieved 94.2% reduction. The plant damage index was also lowest in T6 and T7. Consequently, the highest fruit yield was recorded in trees treated with T6 and T7.

Table 2: Field Efficacy of *B. pilosa* Extracts against Mealybugs on Guava (14 DAS)

Treatment Mean No. of Mealybugs/Shoot % Reduction Over Control Damage Index (0-5) Yield (kg/tree)

T1: Aq. 5%	18.5 $\pm$ 1.2c	55.1	2.5	21.3c
T2: Aq. 10%	12.3 $\pm$ 0.9d	70.2	2.0	24.1b
T3: Aq. 15%	9.8 $\pm$ 0.8de	76.2	1.8	25.8b
T4: Eth. 5%	11.2 $\pm$ 1.0d	72.8	1.8	25.2b
T5: Eth. 10%	6.5 $\pm$ 0.7e	84.2	1.3	27.9a
T6: Eth. 15%	4.1 $\pm$ 0.5f	88.7	1.0	29.5a
T7: Imidacloprid	2.1 $\pm$ 0.3f	94.2	0.8	30.1a
T8: Control	41.2 $\pm$ 2.5a	-	4.0	16.4d

Means within a column followed by the same letter are not significantly different ($p > 0.05$).

3.3. Phytotoxicity

No visible symptoms of phytotoxicity were observed on any of the guava plants treated with the *B. pilosa* extracts throughout the observation period.

4. Discussion

The results of this study provide compelling evidence for the insecticidal potential of *Bidens pilosa* against guava mealybugs. The superior performance of the ethanolic extract over the aqueous extract can be attributed to the higher efficiency of ethanol in extracting non-polar bioactive compounds. The primary insecticidal constituents of *B. pilosa* are polyacetylenes and flavonoids, which are more soluble in organic solvents [7, 8].

The high mortality caused by the 15% ethanolic extract is likely due to a combination of modes of action. Polyynes like phenylheptatriyne are known to act as neurotoxins and metabolic disruptors in insects [9]. Furthermore, flavonoids can exhibit antifeedant and growth-regulating properties, disrupting the normal development and feeding behavior of sap-sucking insects [5]. The significant reduction in the field population and the concomitant increase in fruit yield confirm that the extract not only kills the pest but also allows the plant to recover and produce economically.

The lack of phytotoxicity is a critical finding, underscoring the safety of this botanical for use on guava crops. This makes it an ideal candidate for inclusion in IPM programs, where it can be rotated with other biorationals or combined with the release of natural enemies like *Cryptolaemus montrouzieri*, without causing harm to the ecosystem.

5. Conclusion

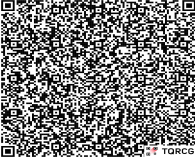
This research successfully validates the traditional wisdom of using *Bidens pilosa* for pest control and provides a scientific basis for its application. The 15% ethanolic extract of *B. pilosa* was identified as a highly effective, eco-friendly, and phytotoxic-free alternative to synthetic pesticides for managing mealybug infestations in guava. By transforming a common agricultural weed into a

valuable resource for crop protection, this approach promotes agricultural sustainability, reduces production costs, and minimizes environmental footprint. Future studies should focus on the large-scale production, standardization, and formulation of this extract for commercial use.

6. References

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