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Bio-efficacy of herbal extract against mango pest mealybug in nearby locality of Muzaffarpur, Bihar

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Abstract
The present study investigated the bio-efficacy of selected botanical extracts against the mango mealybug, *Drosicha mangiferae*, a major pest of mango, *Mangifera indica* L., in Muzaffarpur district, Bihar, India. Field surveys revealed that infestation peaked in February 2025, with the highest infestation intensity recorded on inflorescences, followed by leaves and stems. Laboratory bioassays were conducted using five botanical extracts—neem leaf, neem seed kernel, korobi, nishinda, and tobacco—against different nymphal instars of *D. mangiferae* using dipping and spraying methods. Neem seed kernel extract (HT5) generally produced the highest mortality across the first, second, and third instars in most observations. Neem leaf extract (HT1) was also among the more effective treatments, whereas tobacco leaf extract (HT4) showed moderate efficacy. Korobi (HT2) and nishinda (HT3) generally produced comparatively lower mortality. The effectiveness of dipping and spraying varied depending on the nymphal instar and observation interval, and no consistent superiority of either application method was observed. Overall, the findings indicate that neem seed kernel extract has potential as a botanical option for the management of mango mealybug. Its integration into integrated pest management strategies may help reduce dependence on synthetic insecticides, however, further field-based studies are required to validate its practical effectiveness. Future research should focus on optimizing extract concentrations and application methods and evaluating efficacy, environmental safety, and potential effects on non-target organisms under field conditions.

Keywords: Mango mealybug, *Drosicha Mangiferae*, botanical extracts, neem seed kernel extract, bio-efficacy, integrated pest management, nymphal mortality

Introduction

Mango (*Mangifera indica L.*) is one of the most preferred fruit crops of tropical and sub-tropical regions of the world. Its popularity is reflected in its recognition as the "King of Fruits" in tropical regions of the world. India is the major producer of mango and contributes about 40% of the total production (Thakor, 2019) [28]. Mango (Mangifera indica L.), belonging to the Anacardiaceae family, is native to the Indo-Burma region and has become widely cultivated across tropical and subtropical regions. India is home to the greatest diversity of mango varieties, with over 1,000 named cultivars (Kumar *et al*., 2023) [16]. Major mango-producing countries include India, China, Thailand, Mexico, Pakistan, the Philippines, Indonesia, Brazil, Nigeria, and Egypt. India leads global mango production with 2.5 million hectares under cultivation and an annual yield of 18 million tons. However, insect pests remain a significant constraint to realizing the full yield potential of mango varieties. Approximately 400 insect species are known to infest mango crops worldwide (Tandon & Verghese, 1985; Pena *et al*., 1998) [22]. The diversity and importance of mango insect pests have been documented by de Laroussilhe (1980), Tandon and Verghese (1985), and Veeresh (1989). Mango mealybug, considered as serious threat to mango production in Asia. The nymphs and adult females are sap-sucking pests that feed on inflorescences, tender leaves, shoots and also fruit peduncles. consequently, the infested inflorescences may dry up, badly affects the fruit set, and causing fruit drop. These bugs also excrete honeydew over the mango tree leaves, and results sooty mold fungus development which reducing the photosynthetic efficiency of the tree. It is a polyphagous pest and is found on over 60 other plant species. Chemical control of mealybugs with conventional insecticides is often difficult because adult mealybugs are protected by a waxy covering that can reduce insecticide contact and penetration; therefore, biological control using parasitoids, predators, and other biocontrol agents represents an important component of integrated mealybug management (Franco *et al*., 2009; Heidari, 1999; Joshi *et al*., 2010; Kosztarab, 1996; Orr & Suh, 1999; Panis, 1986; Prakash *et al*., 2011) [11, 15, 21, 23]. Chemical control of mealybugs is often difficult because their waxy coverings and protected feeding sites can reduce contact with insecticides, while overlapping generations may require repeated applications (Franco *et al*., 2009) [11]. Early reports documented *Phenacoccus solenopsis* as a damaging pest of cultivated cotton in Texas, United States (Fuchs *et al*., 1991) [12]. In addition, insecticide applications may adversely affect beneficial organisms and disrupt natural biological control, potentially contributing to increased pest problems.

In view of the economic importance of mango and the damage caused by mango mealybug, the present study was undertaken to investigate the occurrence and management of mango mealybug under laboratory and field conditions. Particular emphasis was given to evaluating the bio-efficacy of selected botanical extracts against different larval stages of the pest. The study aims to identify potentially effective, eco-friendly alternatives that could contribute to the development of sustainable management strategies. Further investigations involving additional botanical extracts,

different concentrations, and combinations of plant-based products may help identify more effective approaches for mango mealybug management.

Research Methodology

The study was conducted in selected mango orchards of Muzaffarpur district, Bihar, covering both urban (2–5 km around city center) and rural areas (20–25 km approximately from city centre). GPS coordinates were recorded, and a map of study sites was prepared. The approximate coordinates of the study region ranged from 26.07° to 26.15°N latitude and 85.35° to 85.50°E longitude. Laboratory experiments were conducted at Pusa Agricultural University, Samastipur, Bihar (November 2024–May 2025), using a Completely Randomized Design (CRD), while field trials followed a Randomized Complete Block Design (RCBD) with three replications.

Five botanical extracts (neem leaf, neem seed kernel, korobi, Nishinda, and tobacco) were prepared by blending 25 g of plant material with 400 mL of water. The mixture was filtered and the filtrate was subsequently diluted to a final volume of 500 mL.

Table 1: Botanical extracts, plant parts, and concentrations used against mango mealybug

Treatments	Phyto-Extracts	Scientific name	Plant parts used	Concentration (% w/v)
HT1	Neem	*Azadirachta indica*	Leaf	25g/500ml
HT2	Korobi	*Nerium oleander*	Leaf	25g/500ml
HT_3	Nishinda	*Vitex negundo*	Leaf	25g/500ml
HT_4	Tobacco	*Nicotiana tabacum*	Leaf	25g/500ml
HT_5	Neem Seed Kernel	*Azadirachta indica*	Seed kernel	25g/500ml
HT_6	Control	-	-	Water only

Note: HT-Herbal Treatment.

Mealybugs (*Drosicha mangiferae*) were collected and reared under laboratory conditions. Bioassays were conducted using two methods: (i) Foliar Spray, where treated mango leaves were exposed to insects, and (ii) Insect Dipping, where insects were dipped in the extracts. Mortality was recorded continuously for five days in particular time-interval at 24, 48, 72, 96, and 120 hours.

The experimental data were analyzed using Microsoft Excel. Analysis of variance (ANOVA) was performed to determine the significance of treatment effects, and treatment means were compared using the Least Significant Difference (LSD) test at the 5% level of significance."

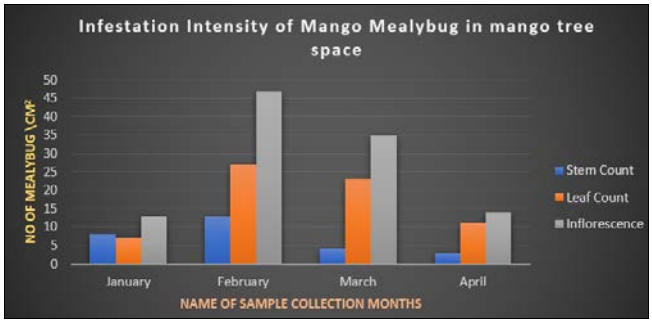
The percent mortality was calculated according to the following formula:

$$\%\text{Mortality} = \frac{\text{Number of dead nymphs}}{\text{Total number of nymphs}} \times 100$$

Results And Discussions

Infestation Intensity of Mango Mealybug (*Drosicha mangiferae*) on Mango Tree: Population dynamics of *Drosicha mangiferae* were monitored on the stem, leaves, and inflorescences of mango trees. Previous studies have also documented the occurrence and population of mango mealybug on different tree parts, including leaves, branches, trunks, and inflorescences (Gundappa *et al*., 2018; Kumar *et al*., 2009; Singh *et al*., 2011) [14, 26].

The highest infestation on the stem was recorded on February 2025, followed by a decline. Similar patterns were observed on the leaves and inflorescences. Overall, the leaf showed the highest mealybug population, while infestation intensity followed the order: inflorescence > leaf > stem (Figure 1). The observed seasonal fluctuation is consistent with previous studies reporting pronounced temporal variation in *D. mangiferae* populations on mango, with population peaks occurring during different stages of the mango growing season (Gundappa *et al*., 2018; Kumar *et al*., 2009; Singh *et al*., 2011) [14, 26].



1 Mortality percentage of 1st larval stage nymph of mango mealybug at different time- intervals after dipping in plant extracts

The data on the mortality percentage of 1st instar nymphs of mango mealybug at different post-treatment intervals are presented in Table 2. At 24 hours after treatment, the highest mortality (5.00 %) was observed in neem seed kernel extract, which was statistically almost similar to the mortality caused by neem leaf extract. After 48 hours, neem seed kernel extract again showed the highest mortality (10%), followed by neem leaf extract (6.67%). At 72 hours post-treatment, neem seed kernel extract resulted in the highest mortality (16.11%) of 1st instar nymphs, followed by neem leaf extract (11.67%). These findings are broadly consistent with earlier reports indicating the effectiveness of neem-based extracts under laboratory conditions (Webb *et al*., 1983[31]; Srivastava, 2008[27]; Satti *et al*., 2010). At 96 hours, neem seed kernel extract continued to show the highest mortality (12.22%), followed by neem leaf extract (10.56%).

The lowest mortality (3.30%) was observed in tobacco leaf extract. Neem seed kernel extract maintained its effectiveness through 120 hours post-treatment. After 5 days, neem leaf extract recorded 8.33% mortality, which was statistically similar to that of tobacco leaf extract. Overall, neem seed kernel extract showed the highest mortality of first-instar mango mealybug nymphs across the different observation intervals. This trend agrees with

previous evidence that neem-derived formulations can suppress mealybug populations through multiple modes of action, including toxic, antifeedant, and growth-regulating effects (Srivastava, 2008; Ukwela, 2006) [27, 29].

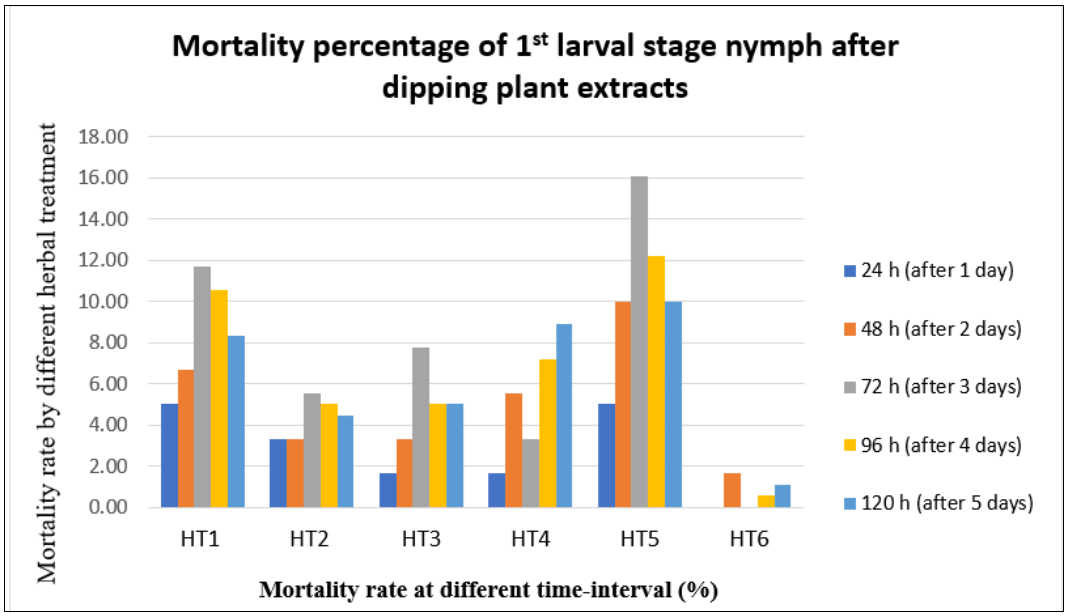
Table 2: Percentage mortality First instar nymphs of Mango Mealybug Following Dipping in different Plant Extracts at Different Time Intervals

Herbal Treatments sample	Mortality of mealybug at different time-interval (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	5.00	6.67	11.67	10.56	8.33
HT2	3.33	3.33	5.56	5.00	4.44
HT_3	1.67	3.33	7.78	5.00	5.00
HT_4	1.67	5.56	3.33	7.22	8.33
HT_5	5.00	10.00	16.11	12.22	10.00
HT_6	0.00	1.67	0.00	0.56	1.11
LSD $_{(0.05)}$	1.77899323	1.6772509	1.02710222	2.09656362	1.72887065
CV (%)	84.8528137	60.9406096	74.5131256	63.5561558	54.3641403

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment HT_3= Nishinda leaf Treatment HT_4=Tobacco leaf Treatment HT_5 =Neem seed kernel Treatment, HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



2 Mortality of 1st instar nymphs of mango mealybug at different intervals after spraying by plant extracts

The mortality percentage of first-instar nymphs of mango mealybug at different post-treatment intervals is presented in Table 3. The results showed significant variation among the treatments.

Neem seed kernel extract was found to be the most effective, resulting in maximum mortality (5.33%) at 24 hours, followed by neem leaf extract (3.66%). After treatments of 48 hours, neem seed kernel extract again shown the highest mortality (11.87%), which has been followed by neem leaves treatments (8.78%) and tobacco leaves treatments (6.77%). At 72 hours post-treatment, neem seed kernel extract remained the most effective botanical treatment, resulting in (14.33%) mortality, followed by neem leaves (11.75%).

At 96 hours after treatment, neem seed kernel extract recorded the highest mortality (16.67%), followed by neem leaf extract (11.67%). At 120 hours after treatment, neem seed kernel extract again recorded the highest mortality (10.00%), followed by neem leaf extract (8.67%). The comparatively greater efficacy of neem seed kernel extract observed in the present study is consistent with previous reports demonstrating the insecticidal potential of neem-derived products against mango mealybug and other mealybug species (Srivastava, 2008; Banu *et al.*, 2010; Madasamy *et al.*, 2023) [27, 8, 18].

Table 3: Mortality percentage of 1st instar nymph of mango mealybug at different time- intervals after spraying with plant extracts:

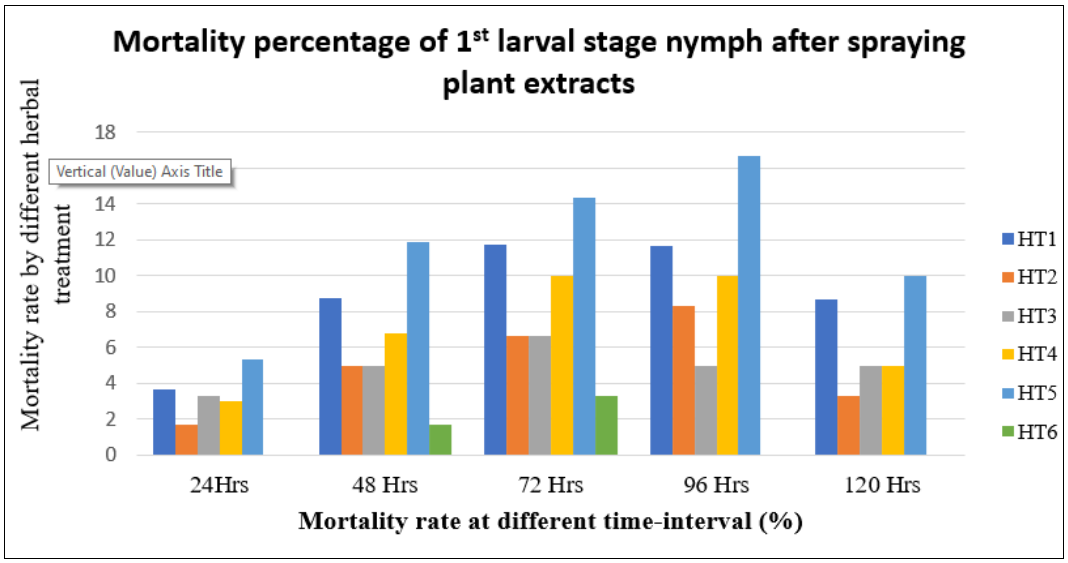
Herbal Treatments sample	Mortality of mango mealybug at different time-intervals (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	3.66	8.78	11.75	11.67	8.67
HT_2	1.67	5.00	6.67	8.33	3.33
HT_3	3.33	5.00	6.67	5.00	5.00
HT_4	3.00	6.77	10.00	10.00	5.00

HT_5	5.33	11.87	14.33	16.67	10.00
HT_6	0.00	1.67	0.00	0.00	0.00
LSD $_{(0.05)}$	1.77899323	1.82774179	4.0653877	3.93350202	1.96675101
CV (%)	79.1783106	55.0019098	69.1869118	71.3018526	70.2516983

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment, HT_3= Nishinda leaf Treatment, HT_4=Tobacco leaf Treatment, HT_5 =Neem seed kernel Treatment, HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



3 Percentage of mortality second Larval stage Nymphs of Mango Mealybug Following Dipping in Various Plant Extracts at Different Time Intervals

The mortality percentage of second-instar nymphs of mango mealybug at different post-treatment intervals is presented in Table 4. At 24 hours of treatment, neem seed kernel extract was the most effective in causing insect mortality (8.99%), followed by neem leaves (6.66%) and tobacco leaves (5%). Nishinda leaf extract resulted in relatively low mortality at 24 hours (1.87%). After 48 hours, mortality increased to (26%) with neem seed kernel extract, followed by neem leaves (14.33%) and tobacco leaves (11.80%). These findings support earlier studies Satti *et al.* (2010), who reported that neem seed extract is highly effective under laboratory conditions. The greater efficacy of neem seed kernel extract observed in the present study is consistent with previous reports demonstrating the insecticidal activity of neem-based products against mealybugs such as neem seed kernel extract has been reported to suppress *Drosicha mangiferae* nymphs, while laboratory studies on other mealybug species have demonstrated substantial mortality following treatment with neem seed extracts (Badshah *et al*., 2015; Srivastava, 2008) [7, 27]. At 72 hours, neem seed kernel extract continued to show the highest effectiveness against 2nd instar mango mealybug with 19.30% mortality, followed by neem leaves (12.60%) and tobacco leaves (10.0%). Previous laboratory studies have also reported similar results for increasing mortality of mealybugs over time following treatment with neem-based products, indicating a time-dependent insecticidal effect (Badshah *et al*., 2015; Kumar *et al*., 2013) [17].

Among the botanical treatments, korobi leaf extract recorded the lowest mortality at 96 hours (10.00%), whereas nishinda leaf extract recorded the lowest mortality at 120 hours (2.33%). At 96 hours, the highest mortality was again recorded with neem seed kernel extract (23.33%), followed by neem leaf extract (21.67%) and tobacco leaf extract (16.67%). At 120 hours, neem seed kernel extract maintained the highest mortality (11.00%), followed by neem leaf extract (6.00%). Overall, neem seed kernel extract was and most effective treatment against second-instar nymphs of mango mealybug throughout the observation period. This finding is broadly consistent with earlier studies reporting the effectiveness of neem seed kernel extract against mealybugs (Badshah *et al*., 2015; Kumar *et al*., 2013; Srivastava, 2008) [7, 17, 27].

Table 4: Percentage of mortality second instar Nymphs of Mango Mealybug Following Dipping in Various Plant Extracts at Different Time Intervals

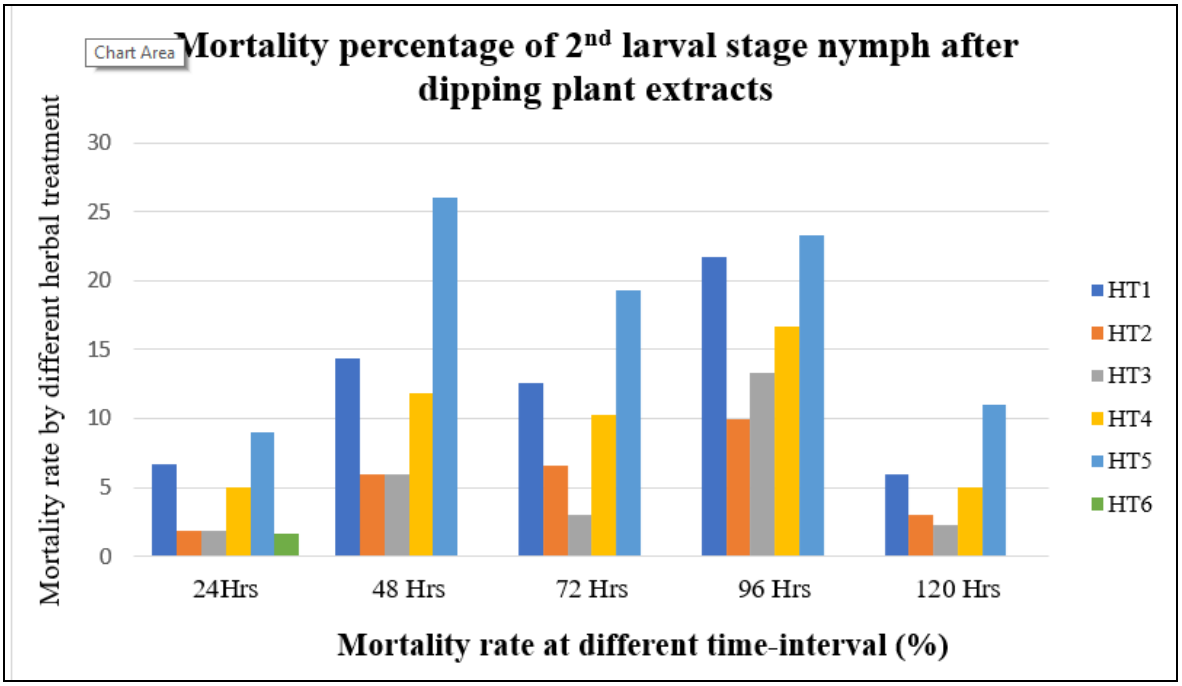
Herbal Treatments sample	Mortality of mango mealybug at different time-intervals (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	6.66	14.33	12.60	21.67	6.00
HT_2	1.89	6.00	6.55	10.00	3.00
HT_3	1.87	6.00	3.00	13.33	2.33
HT_4	5.00	11.80	10.25	16.67	5.00
HT_5	8.99	26.00	19.30	23.33	11.00

HT_6	1.67	0.00	0.00	0.00	0.00
LSD $_{(0.05)}$	2.09656362	2.09656362	2.44499233	4.59334076	2.05420444
CV (%)	78.5162075	80.581141	79.512669	62.154807	85.1517676

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment, HT_3= Nishinda leaf Treatment, HT_4=Tobacco leaf Treatment, HT_5 =Neem seed kernel Treatment , HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



4 Percentage of mortality second Larval stage nymph of mango mealybug at different time- intervals after spraying by plant extracts

The mortality of second-instar nymphs of mango mealybug at different time intervals after spraying with plant extracts is presented in Table 5. At 24 hours after treatment, neem seed kernel extract showed the highest mortality (3.78%), followed by neem leaf and korobi leaf extracts (2.67% each).

At 48 hours after treatment, neem seed kernel extract recorded the highest mortality (23.33%), followed by neem leaf extract (19.30%) and tobacco leaf extract (16.60%). At 72 hours, tobacco leaf extract resulted in the highest mortality (18.35%), followed by neem seed kernel extract (16.60%).

At 96 hours, neem seed kernel extract again recorded the highest mortality (15.00%), followed by neem leaf extract (13.33%) and nishinda leaf extract (12.67%).

At 120 hours after treatment, neem seed kernel extract recorded the highest mortality (13.30%), followed by neem leaf extract (11.67%) and tobacco leaf extract (10.00%). Overall, neem seed kernel extract showed comparatively high mortality across most observation intervals, indicating its potential effectiveness against second-instar nymphs of mango mealybug. This observation is consistent with previous studies reporting the insecticidal activity of neem-derived products against mealybugs and the effectiveness of neem seed extracts against immature stages of these pests (Badshah *et al*., 2015; Kumar *et al*., 2013; Srivastava, 2008) [7, 17, 27].

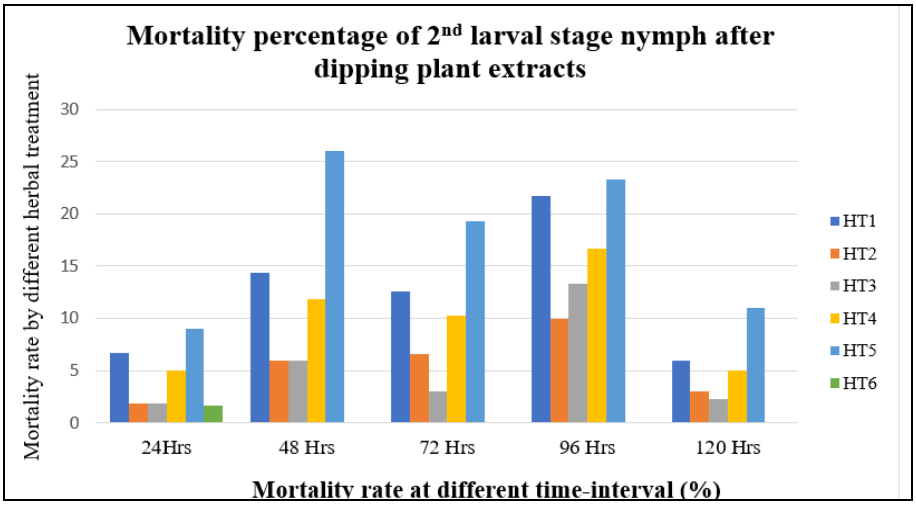
Table 5: Mortality percentage of 2nd larval stage nymph of mango mealybug at different time- intervals after spraying by plant extracts:

Herbal Treatments sample	Mortality of mealybug at different time-interval (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	2.67	19.30	11.67	13.33	11.67
HT_2	2.67	8.33	5.00	8.33	6.67
HT_3	1.67	15.00	11.60	12.67	3.00
HT_4	1.67	16.60	18.35	10.00	10.0
HT_5	3.78	23.33	16.60	15.00	13.3
HT_6	0.00	0.00	0.00	0.00	1.67
LSD $_{(0.05)}$	2.17881283	4.17210893	4.17210893	4.31708873	2.13808376
CV (%)	99.7383433	62.4722787	69.3553735	61.8846268	61.7313284

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment, HT_3= Nishinda leaf Treatment, HT_4=Tobacco leaf Treatment , HT_5 =Neem seed kernel Treatment, HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



5 Percentage of mortality third Larval stage Nymphs of Mango Mealybug Following Dipping in Various Plant Extracts at Different Time Intervals

At 24 hours after treatment, neem seed kernel extract recorded the highest mortality among third-instar nymphs of mango mealybug (9.00%), followed by tobacco leaf extract (6.77%) and nishinda leaf extract (5.00%). Korobi leaf extract showed no mortality at 24 hours. At 48 hours, neem seed kernel extract again recorded the highest mortality (10.00%), followed by neem leaf extract (8.50%). At 72 hours, tobacco leaf extract showed the highest mortality (6.67%), whereas neem leaf and neem seed kernel extracts each recorded 5.00% mortality. At 96 and 120 hours, neem seed kernel extract again showed comparatively higher mortality, recording 10.00% and 8.33%, respectively as presented in table 6. Overall, neem seed kernel extract was among the most effective treatments against third-instar nymphs during the observation period.

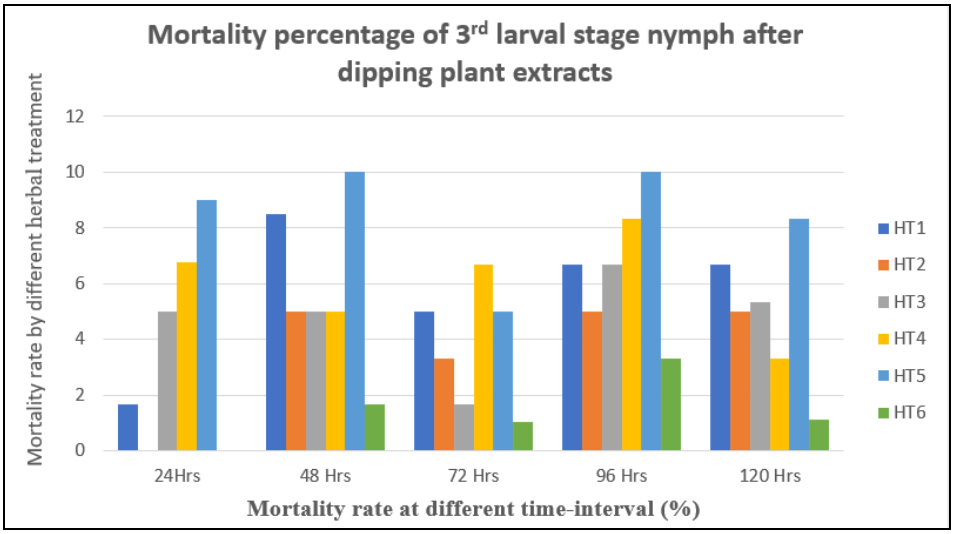
Table 6: Percentage of mortality at third instar Nymphs of Mango Mealybug Following Dipping in Various Plant Extracts at Different Time Intervals

Herbal Treatments sample	Mortality of mealybug at different time-interval (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	1.67	8.50	5.00	6.67	6.67
HT_2	0.00	5.00	3.33	5.00	5.00
HT_3	5.00	5.00	1.67	6.67	5.33
HT_4	6.77	5.00	6.67	8.33	3.33
HT_5	9.00	10.00	5.00	10.0	8.33
HT_6	0.00	1.67	1.04	3.33	1.12
LSD $_{(0.05)}$	1.51185353	1.45254189	2.09656362	4.35762566	3.13784911
CV (%)	99.4987437	51.1570798	68.6860978	61.2372436	68.5994341

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment, HT_3= Nishinda leaf Treatment, HT_4=Tobacco leaf Treatment , HT_5 =Neem seed kernel Treatment, HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



6 Percentage of mortality at third Larval stage nymph of mango mealybug at different time- intervals after spraying by plant extracts

At 24 hours after treatment, neem seed kernel extract recorded the highest mortality (5.00%), followed by tobacco leaf extract (4.00%) and neem leaf extract (3.65%). At 48 hours, mortality was highest with neem seed kernel extract (12.45%), followed by neem leaf extract (8.50%) and tobacco leaf extract (6.67%). At 72 hours, neem seed kernel extract continued to record the highest mortality (10.00%), followed by neem leaf and tobacco leaf extracts (8.33% each).

At 96 hours, neem seed kernel extract again showed the highest mortality (8.33%), followed by tobacco leaf extract (6.67%). At 120 hours, neem seed kernel extract recorded the highest mortality (11.67%), followed by neem leaf extract (10.00%) and tobacco leaf extract (8.33%). Overall, neem seed kernel extract was the most effective treatment against third-instar nymphs of mango mealybug under the spraying method. This finding is consistent with previous studies demonstrating the insecticidal activity of neem-based products against mealybugs, including *Drosicha mangiferae* (Badshah *et al*., 2015; Kumar *et al*., 2013; Srivastava, 2008) [7, 17, 27].

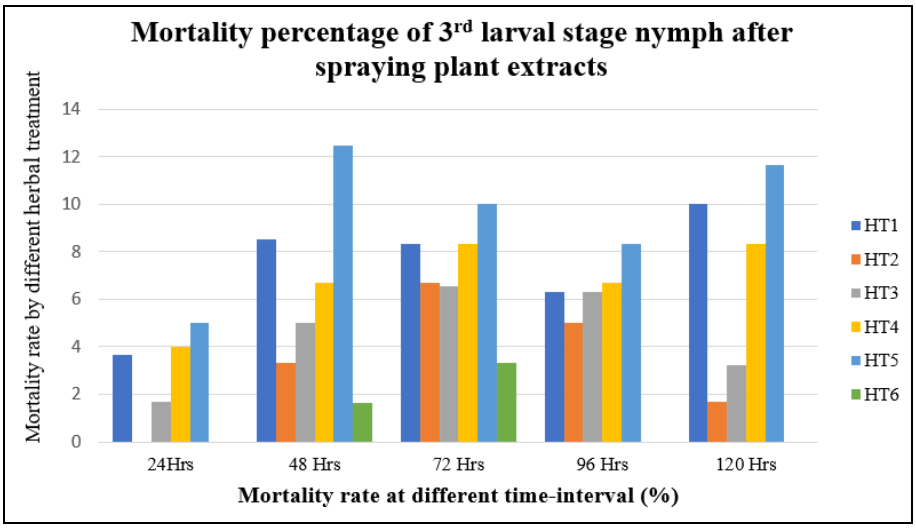
Table 7: Mortality percentage of 3rd larval stage nymph of mango mealybug at different time- intervals after spraying by plant extracts

Herbal Treatments sample	Mortality of mealybug at different time-interval (%)				
	24 h (after 1 day)	48 h (after 2 days)	72 h (after 3 days)	96 h (after 4 days)	120 h (after 5 days)
HT_1	3.65	8.50	8.33	6.33	10.0
HT_2	0.00	3.33	6.67	5.00	1.67
HT_3	1.67	5.00	6.57	6.33	3.23
HT_4	4.00	6.67	8.33	6.67	8.33
HT_5	5.00	12.45	10.0	8.33	11.67
HT_6	0.00	1.66	3.33	0.00	0.00
LSD $_{(0.05)}$	0.93761176	2.01095318	2.51587635	1.39070298	1.02710222
CV (%)	89.2964513	64.0561579	40.3603676	53.8118239	78.5523277

Note: HT=Herbal Treatment

HT_1=Neem leaf Treatment, HT_2= Korobi leaf Treatment, HT_3= Nishinda leaf Treatment HT_4=Tobacco leaf Treatment, HT_5 =Neem seed kernel Treatment, HT_6= Control

LSD $_{(0.05)}$ = Least significance Difference; CV% = Coefficient of Variation



Conclusion

The study on the infestation intensity and management of mango mealybug (*Drosicha mangiferae*) revealed important findings regarding population dynamics and the efficacy of various botanical extracts against different nymphal instars. The infestation peaked in February 2025, with the highest mealybug population observed on mango leaves, although the overall infestation intensity followed the order: inflorescence > leaf > stem.

In laboratory bioassays, neem seed kernel extract (HT5) generally demonstrated the highest mortality across the first, second, and third instars of mango mealybug under both dipping and spraying methods. However, mortality varied across different observation intervals rather than showing a consistent increase over time. Neem leaf extract (HT1) was generally among the more effective treatments, while tobacco leaf extract (HT4) showed moderate efficacy. Korobi (HT2) and Nishinda (HT3) leaf extracts generally showed comparatively lower effectiveness across the different observation intervals and nymphal instars.

Among the application methods, the relative effectiveness of spraying and dipping varied depending on the nymphal instar and observation interval. In several observations, spraying produced mortality comparable to or higher than that observed with dipping; however, no consistent superiority of either application method was observed across all instars and observation intervals.

Overall, the findings suggest that neem seed kernel extract has potential as an effective botanical option for the management of mango mealybug. Its use may contribute to reducing dependence on synthetic insecticides, particularly as part of an integrated pest management (IPM) approach.

However, further field-based studies are required before making strong recommendations regarding its practical application.

Further field trials across different agro-climatic conditions are recommended to validate the laboratory findings. Future research should focus on optimizing extract concentration and application methods, evaluating environmental safety and effects on non-target organisms, and comparing the efficacy of neem seed kernel extract with commercially available bio-pesticides. Such studies may support the development of more sustainable and effective management strategies for mango mealybug.

Fig 1: Nishinda plant

Fig 2: Korobi plant

Fig 3: Neem Leaf

Fig 4: Neem Seeds Kernel

Fig 5: Tobacco Plant

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