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Evaluation of Insecticides for Control of Mango Mealybug (*Drosicha mangiferae*) in Bangladesh

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Abstract

Effectiveness of chemical insecticides namely Imidacloprid (0.4 g/L), Carbaryl (4 g/L), Thiamethoxam (0.4 g/L), Cypermethrin (1 ml/L), Carbosulfan (3 ml/L), Spinosad (0.4 ml/L), Dimethoate (2 ml/L) and Spirotetramate (2 ml/L) was evaluated to control 1st, 2nd, 3rd instar nymphs and adult females of mango mealybugs (*D. mangiferae*) at Entomology laboratory, Sher-e-Bangla Agricultural University. Imidacloprid, Carbaryl, Thiamethoxam, Cypermethrin, Carbosulfan, Spinosad, and Dimethoate gave 90% mortality of 1st instar nymph after 72 hr of spraying and dipping. At 2nd instar, Cypermethrin, Carbosulfan, Spinosad, and Dimethoate gave 91.67%, 88.33%, 85.00%, and 85.00% mortality respectively by spraying method after 72 hr of treatment. In the dipping method, the highest mortality (90%) was achieved with Cypermethrin which was statistically similar to Carbosulfan (88.33%), Spinosad (86.67%), and Dimethoate (85%). At this nymphal stage, the lowest (63.33%) mortality was observed under Spirotetramate. In the case of the 3rd instar, the highest (76.67%) and the lowest mortality (30.00%) was obtained with Cypermethrin and Spirotetramate respectively by spraying method. A similar trend was found in the dipping method. No mortality of adult females was found both in the spraying and dipping methods. Comparative susceptibility of 1st, 2nd, 3rd instars and adult females showed that the 1st instar nymph was more susceptible to all insecticides compared to 2nd, 3rd instar nymphs and adult females.

Subject Areas

Plant Science

Keywords

Mango Mealybug, Management, Insecticides

1. Introduction

Mango (*Mangifera indica* L.) is a member of the family Anacardiaceae. It is regarded and appreciated for its strong aroma, delicious taste, and high nutritive value [1] [2]. This tropical fruit mango is being grown in more than 100 countries [3]. Apart from that, it is also a valuable ornamental and shade tree with medicinal virtues [4]. Annually, about 1,165,804 metric tons of mangoes from an area of 44,366 hectares of mango orchards are harvested in Bangladesh [5]. Production of fruits is still far behind the country's present requirement. About 78 g of fruit is available per person in Bangladesh whereas 200 gm is the daily requirement [6]. Mango (*Mangifera indica* L.) is recognized as one of the choicest and well-accepted fruits all over the world due to its attractive color, marvelous flavor, delicious taste and high nutritive value. It is a nutritionally important fruit being a good source of vitamins A, B, C and minerals. It is also known as the "king of fruits" [7]. It is a rich source of carbohydrates, vitamins and minerals [8]. The mango tree is attacked by a number of insect pests [9]-[13] among them mango mealy (*Drosicha mangiferae* Green) is the most destructive pest. Mango mealybugs belong to family Monophlebidae (Hemiptera) is the most important pest of mango in Indo-Pakistan [2] [14] [15]. It is a polyphagous insect that feeds on many plant species [1]. The female lays eggs in the soils around the infested plant. Both nymph and adult females suck the cell sap from the plant as a result the affected inflorescence shriveled and ultimately dried [2]. They also secrete honeydew that causes the sooty mold to develop which affects the photosynthetic activity of the plant. Ants feed on honeydew and protect the mealybug from predators and parasitoids. Insecticides are considered to be the rapid method for the control of insect pests to overcome losses. Insecticides are always in ready form, and easily accessible and a wide range of insecticides are available in the market for the control of insect pests. Intensive, high agricultural production systems have traditionally used synthetic pesticides to eliminate pests as the main tool and sustain the lowest amount of economic damage to the crop. In advanced countries, three percent of the market value of crops is spent on insecticides [16]. The present research aimed to evaluate the efficacy of conventional insecticides against mango mealybug and determine the vulnerable stages of mealybug for efficient management.

2. Materials and Methods

2.1. Selection of Insecticides

Eight insecticides namely, Imidacloprid, Carbaryl, Thiamethoxam, Cypermethrin, Carbosulfan, Spinosad, Dimethoate, and Spirotetramate were tested in vitro for their efficacy against mango mealybug. Common name, trade name, mode of action, and dose of the selected insecticides are shown in **Table 1**.

2.2. Collection of Insects

Mango mealybug nymphs of different instars and female adults were collected

from infested trees early in the morning in a jar with the help of an aspirator (for small ones) and brought to the laboratory as experimental materials. Fresh mango leaves were provided in the jars as a food source for the crawling nymphs.

Table 1. Insecticides with mode of action and doses used against mango mealybug.

Common name	Trade name	Mode of action	Doses used
Imidacloprid	Confidor 70 WG	A cetylcholine agonist (mimic)	0.4 gm/L
Cabaryl	Sevin 75 WP	Cholinesterase inhibitor	4 gm/L
Thiamethoxam	Actara 25 WG	Sodium channel modulator	0.4 gm/L
Cypermethrin	Ripcord 10 EC	Sodium channel modulator	1 ml/L
Carbosulfan	Marshal 25 EC	Cholinesterase inhibitor	3 ml/L
Spinosad	Tracer 2.5 SC	Sodium channel modulator	0.4 ml/L
Dimethoate	Dimegro 30 EC	Cholinesterase inhibitor	2 ml/L
Spirotetramate	Movento 150 OD	Lipid biosynthesis inhibitor (LBI)	2 ml/L

2.3. Bioassay of Selected Insecticides

To evaluate the efficacy of eight selected chemical insecticides against 1st, 2nd, and 3rd instar nymphs and adult females of mango mealybug, foliar spray, and leaf dipping bioassay methods were followed under laboratory conditions. Each insecticide solution was prepared by mixing with distilled water at their field-recommended doses (Table 1). The exact amount of each insecticide was taken in a 500 ml volumetric flask marked for each insecticide, and 200 ml distilled water was added to each flask. The flasks were shaken for five minutes for proper mixing of insecticides with water. After shaking, the volume was made up to the mark by adding more distilled water. Only 500 ml of distilled water was taken in a flask and marked for control.

2.4. Foliar Spray Method

Fresh mango leaves equal to the size of a Petri dish (12 cm × 2 cm) were sprayed with each insecticide solution with a hand sprayer and only water was sprayed for untreated control. After air drying, the treated leaves were placed in the Petri dishes containing moistened filter paper to avoid desiccation of the leaves. The insects of each developmental stage were released on treated leaves in each Petri dish with the help of a camel hair brush. In the case of 1st and 2nd instar nymph, 20 insects were released in each Petri dish, on the other hand, 10 insects were released in each Petri dish for 3rd instar nymph and adult female. Each Petri dish was placed in the laboratory at ambient temperature having a maximum of 29.07˚C ± 3.17˚C, a minimum of 25.07˚C ± 1.86˚C temperature, and 65.32% ± 7.11% relative humidity. Petri dishes were placed in the laboratory following a completely randomized design (CRD) with three replications. Data on mortality of the insects were recorded at 24, 48, and 72 hr of insecticide application. The moribund insects were considered dead.

2.5. Insect Dip Method

For the insect dip bioassay method, insects were counted and kept in a sieve and dipped into an insecticide solution for 10 seconds. After air drying, the treated insects were placed in the Petri dishes having moist filter paper at the bottom on which mango leaves were placed as food for the nymph. Petri dishes were placed on the laboratory desk under the same conditions as already mentioned. Only insects were dipped in water for untreated control. Mortality data were taken at 24, 48, and 72 hr after dipping, and moribund insects were considered dead. Mortality of the insect was computed following a standard formula [17] as shown below

$$\%\ \text{corrected mortality} = \frac{\text{Treatment mortality} - \text{Control mortality}}{100 - \text{Control mortality}} \times 100$$

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

3. Results

3.1. Toxic Action of Insecticides against 1st Instar Nymph of *D. mangiferae*

Spray method: In the spray method, 90% mortality of 1st instar was achieved with Imidacloprid, Cypermethrin, Carbosulfan, Spinosad and Dimethoate under laboratory conditions at 24 hr after treatment. However, their efficacy was not significantly different. Cabaryl caused 85% mortality but its efficacy was statistically similar to the former five insecticides. Thiamethoxam and Spirotetramate showed 65% and 58.33% mortality at 24 hr after treatment and their efficacy was statistically similar. A similar trend was found in the case of mortality recorded after 48 hr of treatment. At 72 hr after treatment, significantly the lowest mortality of 68.33% was obtained with Sprirotetramate but the other seven insecticides gave 90.00% mortality (Table 2).

Table 2. Effectiveness of insecticides against 1st instar nymph of mango mealybug on excised mango leaf tested following spraying and dipping methods.

Treatments	% Mortality after different intervals of data collection after spraying			% Mortality after different intervals of data collection after dipping		
	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr
Imidacloprid	90.00a	90.00a	90.00a	90.00a	90.00a	90.00a
Cabaryl	85.00a	85.00a	90.00a	85.00a	90.00a	90.00a
Thiamethoxam	65.00b	65.00b	85.00a	65.00b	80.00b	85.00a
Cypermethrin	90.00a	90.00a	90.00a	90.00a	90.00a	90.00a
Carbosulfan	90.00a	90.00a	90.00a	90.00a	90.00a	90.00a
Spinosad	90.00a	90.00a	90.00a	90.00a	90.00a	90.00a
Dimethoate	90.00a	90.00a	90.00a	90.00a	90.00a	90.00a
Spirotetramate	58.33b	63.33b	68.33b	55.00c	55.00c	70.00b
LSD (P = 0.05)	**10.75**	**14.46**	**14.78**	**9.179**	**7.495**	**11.85**

Values with the same column with a common letter(s) do not differ significantly (P =

0.05).

Dipping method: In the dipping method, significantly the highest mortality of 90.00% was achieved with Cypermethrin at 24, 48, and 72 hr after treatment. Significantly lowest mortality of 55.00%, 55.00%, and 70.00% were recorded from leaves treated with Sprirotetramateat 24, 48, and 72 hr after treatment, respectively. Thiamethoxam gave 65.00%, 80.00%, and 85.00%, Cabarylcaused 85.00%, 90.00%, and 90.00% mortality at 24, 48, and 72 hr after treatment, respectively (Table 2).

3.2. Toxic Action of Insecticides against 2nd Instar Nymph of *D. mangiferae*

Spray method: After 24 hr of treatment, significantly the highest and lowest mortality of 83.33% and 40.00% was obtained with Cypermethrin and Spirotetramate spray, respectively. Other six insecticides caused 53.33% - 61.67% mortality but their efficacy was not significantly different. After 48 hr of spray, significantly the highest mortality of 90.00% was achieved with Cypermethrin. The lowest mortality of 53.33% was recorded from Thiamethoxam and Spirotetramate, which was statistically similar to Imidacloprid. The insecticides Carbosulfan, Spinosad and Dimethoate caused 76.67%, 76.67% and 75% mortality. Their efficacy was not significantly different (Table 3). After 72 hr of spray, Cabaryl, Cypermethrin, Carbosulfan, Spinosad, and Dimethoate gave higher mortality and their efficacy was statistically similar but significantly higher compared to the other three insecticides. The lowest mortality was observed under Sprirotetramate, (56.67%) which was statistically similar to Thiamethoxam (60%) and significantly lower compared to Imidacloprid (Table 3).

Table 3. Effectiveness of insecticides against 2nd instar nymph of mango mealybug on excised mango leaf tested following spraying and dipping methods.

Treatments	% Mortality after different intervals of data collection after the spray			% Mortality after different intervals of data collection after dipping		
	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr
Imidacloprid	55.00b	63.33cd	70.00b	60.00b	68.33b	73.33c
Cabaryl	58.33b	71.67bc	85.00a	61.67b	70.00ab	80.00b
Thiamethoxam	53.33b	53.33d	60.00c	53.33c	56.67c	58.33d
Cypermethrin	83.33a	90.00a	91.67a	73.33a	76.67a	90.00a
Carbosulfan	61.67b	76.67b	88.33a	70.00a	71.67ab	88.33a
Spinosad	61.67b	76.67b	85.00a	68.33a	68.33b	86.67a
Dimethoate	58.33b	75.00b	85.00a	61.67b	68.33b	85.00ab
Spirotetramate	40.00c	53.33d	56.67c	53.33c	53.33c	63.33d
LSD (P = 0.05)	**8.36**	**10.45**	**7.066**	**6.120**	**6.370**	**5.859**

Values with the same column with a common letter(s) do not differ significantly (P = 0.05).

Dipping method: In the leaf dipping method, the trends in the efficacy of the

tested insecticides were more or less similar to the trends recorded in the spraying method (Table 3). At 24 hr of treatment, the highest mortality of 2nd instar nymph was obtained with Cypermethrin followed by Carbosulfan and Spinosad and gave respectively 73.33%, 70% and 68.33% mortality, which were statistically similar but significantly higher compared to all other insecticides. Significantly lowest mortality of 53.33% was obtained with Thiamethoxam and Spirotetramate. The efficacy of Imidacloprid (60.00%), Cabaryl, and Dimethoate (61.67%) was not significantly different. At 48 hrs of spray, the highest mortality of 2nd instar nymphs was achieved with Cypermethrin, which was statistically similar to Cabaryl, and Carbosulfan showing 76.67%, 71.67%, and 70.00% mortality, respectively. The lowest mortality was observed under Spirotetramate which was statistically similar to only Thiamethoxam (Table 3). After 72 hr of treatment, the mortality of 2nd instar nymph was 90.00%, 88.33%, 86.67%, and 85% with Cypermethrin, Carbosulfan, Spinosad, and Dimethoate, respectively. Their efficacy was statistically similar but significantly higher compared to other insecticides tested. The least effective insecticide was Thiamethoxam giving 58.33% mortality, which was statistically similar to Spirotetramate showing 63.33% mortality of the 2nd instar nymph of mango mealybug.

3.3. Toxic Action of Insecticides against 3rd Instar Nymph of *D. mangiferae*

Spray method: At 24 hr of data collection after spray, the maximum mortality of 60.00% was obtained with Cypermethrin, which was statistically identical to Carbosulfan and Carbaryl but significantly higher compared to other insecticides. Second highest mortality of 43.33% was obtained with Carbosulfan and Carbaryl which were statistically similar to Dimethoate (40%), Imidacloprid, Spinosad (26.67%), and Spirotetramate (23.33%). Their efficacy was not significantly different. Thiamethoxam was the least effective insecticide causing only 13.33% mortality of 3rd instar nymph of mango mealybug. At 48 hr after of spray, the mortality of 3rd instar nymph was maximam (70.00%) under Cypermethrin followed by Cabaryl (58.33%), Carbosulfan (56.67%), and Dimethoate (53.33%). Their efficacy was statistically similar. The least effective insecticide was Spirotetramate and Thiamethoxam which showed 26.67% mortality of mango mealybug at 3rd instar nymphs. At 72 hr of data collection, the significantly highest mortality of 76.67% was obtained with Cypermethrin. The second highest mortality of 65.00% was obtained with Carbaryl followed by Carbosulfan (60%) and Dimethoate (56.67%). The lowest mortality of 30.00% was observed when the leaves were sprayed with Spirotetramate (Table 4).

Dipping method: After 24 hr of data collection following dipping, insecticide Cypermethrin gave significantly the highest mortality (58.33%) of 3rd instar nymphs. The second highest mortality of 50.00% was recorded from leaves dipped in Carbosulfan followed by Carbaryl (43.33%), and Dimethoate (40%). Spirotetramate and Thiamethoxam were found as the least effective chemicals against mango mealybug showing 26.67% mortality followed by Dimethoate at

24 hr of data collection.

Table 4. Effectiveness of insecticides against 3rd instar nymph of mango mealybug on excised mango leaf tested following spraying and dipping methods.

Treatments	% Mortality after different intervals of data collection after spraying			% Mortality after different intervals of data collection after dipping		
	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr
Imidacloprid	26.67bc	33.33c	40.00d	30.00e	35.00c	36.67c
Cabaryl	43.33ab	58.33ab	65.00b	43.33c	66.67a	71.67a
Thiamethoxam	13.33d	26.67c	33.33de	26.67e	33.33c	33.33c
Cypermethrin	60.00a	70.00a	76.67a	58.33a	68.33a	76.67a
Carbosulfan	43.33ab	56.67ab	60.00bc	50.00b	53.33b	56.67b
Spinosad	26.67bc	40.00bc	51.67c	36.67d	46.67b	56.67b
Dimethoate	40.00b	53.33ab	56.67bc	40.00cd	46.67b	53.33 b
Spirotetramate	23.33bc	26.67c	30.00e	26.67e	30.00c	33.33c
LSD (P = 0.05)	**18.36**	**18.86**	**9.348**	**5.859**	**10.15**	**9.993**

Values with the same column with a common letter(s) do not differ significantly (P = 0.05).

At 48 and 72 hr of data collection, the mortality 3rd instar nymph under Cabaryl and Cypermethrin was statistically similar and significantly higher compared to other insecticides. Spirotetramate was found as the least effective against 3rd instar nymph and statistically similar with Thiamethoxam after 72 hr of treatment. Their efficacy was also statistically similar but significantly lower compared to other insecticides (Table 4).

In this study, Cypermethrin resulted in the highest mortality after 24, 48, and 72 hr of treatment at all nymphal stages of mango mealybug.

3.4. Efficacy of Insecticides against Adult Females under Laboratory Condition

Under laboratory conditions, treatment of excised mango leaves with eight insecticides namely Imidacloprid, Cabaryl, Thiamethoxam, Cypermethrin, Carbosulfan, Spinosad, Dimethoate, and Spirotetramate following spraying and dipping methods completely failed to kill adult mango mealybug showing 0.00% mortality (Table 5). The findings indicate that the application of insecticides against mango mealybug was not effective at its adult stage.

Table 5. The efficacy of insecticides against adult female mango mealybug was recorded after 24, 48, and 72 hr of treatment by spraying and dipping methods.

Insecticide	% Mortality at different intervals of data collection after spraying			% Mortality at different intervals of data collection after dipping		
	24 hr	48 hr	72 hr	24 hr	48 hr	72 hr

Imidacloprid	0.00	0.00	0.00	0.00	0.00	0.00
Continued						
Cabaryl	0.00	0.00	0.00	0.00	0.00	0.00
Thiamethoxam	0.00	0.00	0.00	0.00	0.00	0.00
Cypermethrin	0.00	0.00	0.00	0.00	0.00	0.00
Carbosulfan	0.00	0.00	0.00	0.00	0.00	0.00
Spinosad	0.00	0.00	0.00	0.00	0.00	0.00
Dimethoate	0.00	0.00	0.00	0.00	0.00	0.00
Spirotetramate	0.00	0.00	0.00	0.00	0.00	0.00

3.5. Comparative Susceptibility of Different Stages of Mango Mealybug to Insecticides under Laboratory Condition

Three figures were drawn using the data presented in Tables 2-5 recorded during the present experiment (Figures 1-3). The comparative susceptibility of 1st, 2nd, and 3rd instar nymphs and adult females to eight insecticides after 24 hr, 48 hr, and 72 hr of spray is shown in Figures 1-3. It was evident from the Figure that the 1st instar nymph was more susceptible to all insecticides compared to 2nd, and 3rd instar nymphs and adult females. Similar trends of susceptibility of different stages of mango mealybug were also observed at 48 and 72 hrs of treatment (Figure 2 and Figure 3).

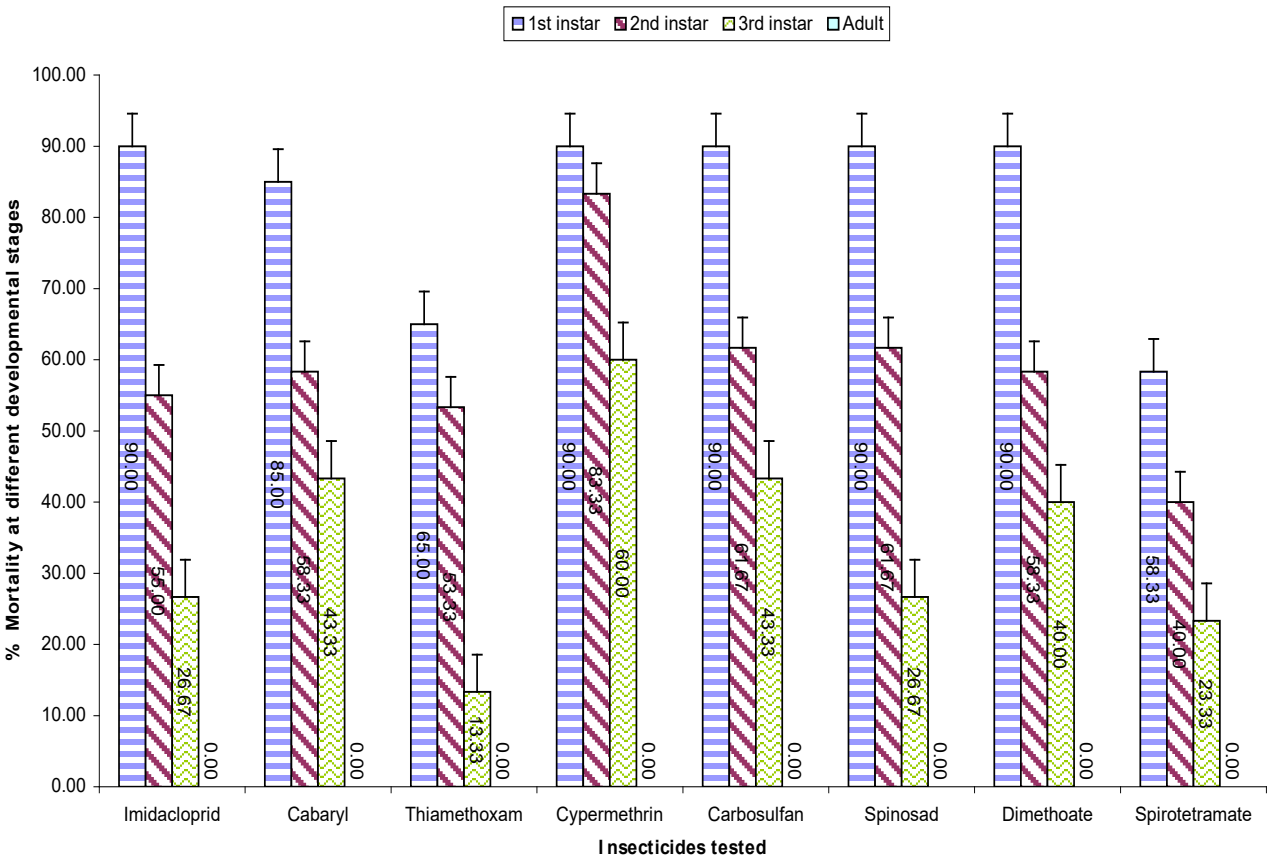

Figure 1. Effect of treatment of excised mango leaf by spray with insecticides on mortality of mango mealybug at different developmental stages after 24 hrs.

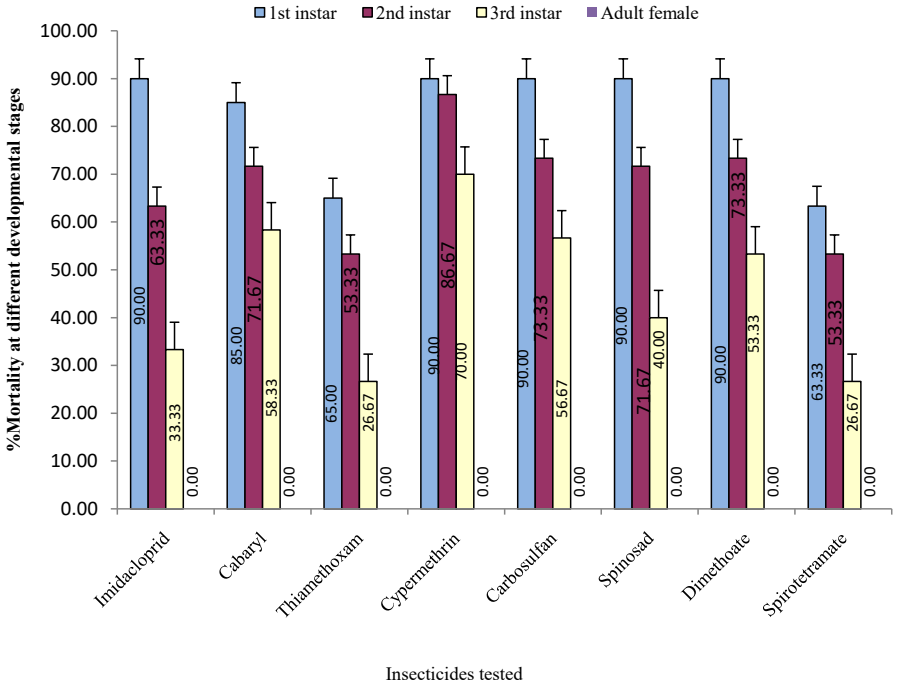

Figure 2. Effect of treatment of excised mango leaf by spray with insecticides on mortality of mango mealybug at different developmental stages recorded after 48 hr.

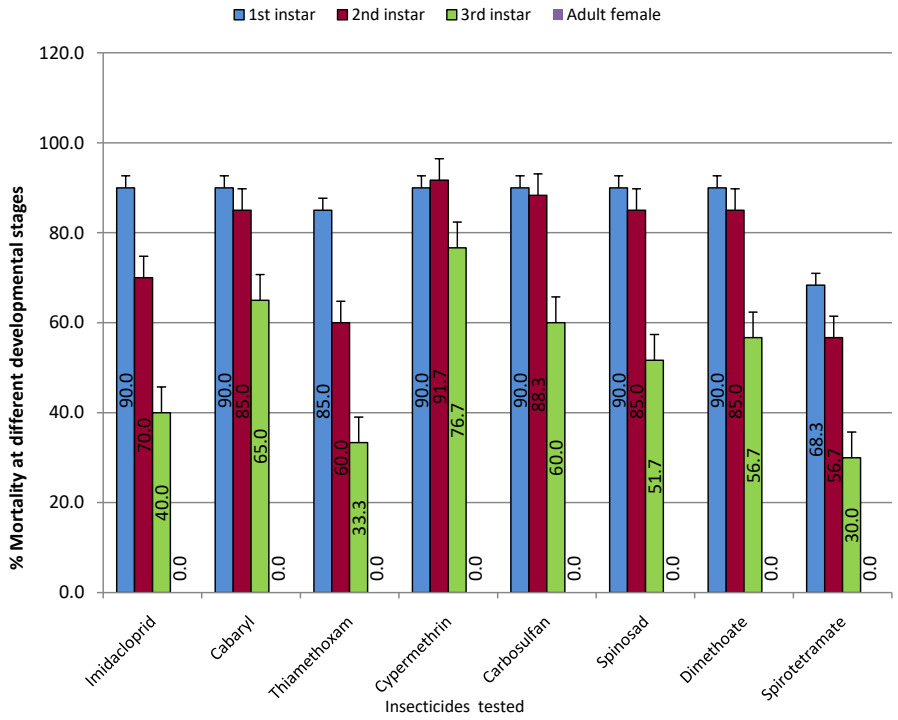

Figure 3. Effect of treatment of excised mango leaf by spray with insecticides on mortality of mango mealybug at different developmental stages recorded after 72 hr.

4. Discussion

Damage caused by insects is the major reason for crop failure. Chemical control is important for insect pest management. Identifying an effective insecticide is an important factor for insect control. Farmers are familiar with the rapid action of these insecticides. Many researchers evaluated the toxicity of different insecticides against mango mealybug [1] [2] [18] [19]. In the present study, bioassays were carried out to evaluate the effective insecticides against mango mealybug in all stages of life cycle at the laboratory. The present results revealed that all the insecticides showed 90% mortality at 1st instar nymph of mango mealybug in both spraying and dipping methods. In the case of 2nd instar nymph 91.67% mortality was found in Cypermethrin which was statistically similar to Carbosulfan, Spinosad and Dimethoate in spraying method. A similar trend was observed in dipping method. In the case of 3rd instar nymph highest (76.67%) mortality was found in Cypermethrin in both spraying and dipping methods and a similar trend was found in dipping method. All insecticides showed no mortality of adult females both in spraying and dipping methods. In comparative susceptibility of 1st, 2nd, 3rd instar and adults, the results showed that the 1st instar nymph was more susceptible to all insecticides compared to 2nd, 3rd instar nymphs and adult females. The results of the present investigation, contradict the findings of [7], who obtained the lowest mortality of the pest by spraying Ripcord (Cypermethrin) and Imidacloprid. [20] also reported that mango mealybug is difficult to control using insecticides suspended in water. The findings are in agreement with the findings of [21]-[23] who reported that Cypermethrin is the best chemical to combat the mango mealybug. The second effective insecticide may be Carbaryl. This result supported the findings of [7] who observed 91% mortality at 1st instar nymph, 81% mortality at 2nd and 3rd instar nymph after 168 hr of spray with Mospilan and also observed that in the case of 2nd and 3rd instar, the mortality with Confidor and Ripcord was 64% and 43%, respectively. The results are slightly contradictory to the findings obtained by [8], who found that Profenofos resulted in the highest mortality of 93.3% and 86.67% at 1st and 2nd instar nymph, respectively and Trizophos caused 100% mortality at the adult stage in case of foliar application.

5. Conclusion

The present results revealed that all the insecticides showed 90% mortality at 1st instar nymph of mango mealybug in both spraying and dipping methods. In the case of 2nd instar nymph 91.67% mortality was found in Cypermethrin which was statistically similar to Carbosulfan, Spinosad, and Dimethoate in the spraying method. A similar trend was observed in the dipping method. In the case of 3rd instar nymph highest (76.67%) mortality was found in Cypermethrin in both spraying and dipping methods and a Similar trend was found in dipping method. All insecticides showed no mortality of adult females both in spraying and

dipping methods. In comparative susceptibility of 1st, 2nd, 3rd instars and adult females, the results showed that the 1st instar nymph was more susceptible to all insecticides compared to 2nd, 3rd instar nymphs and adult females.

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Authors' Contributions

This work was carried out in collaboration among all authors. Author NA conducted the research work. Author MZA designed and edited the manuscript. Author MAL designed and supervised the study, managed the literature searches, and edited the manuscript. Author MAR managed the literature search. Author MRUM and IHM managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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