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Management of Mango Mealybug (*Drosicha Mangiferae*) in Jackfruit Trees Through Physical Barrier and Chemical Practices

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Abstract

Mango mealybug (*Drosicha mangiferae)* is a cryptic, destructive and polyphagous pest in South Asia and its adjacent countries. It was a wide host range, and Jackfruit, *Artocarpus heterophyllus* is a most vulnerable host for this pest. Various mechanical barriers and chemical insecticide with mechanical blockade were tested and validated for managing *D. mangiferae* in Jackfruit orchard. Among physical barriers, double girdle alkathene bands with grease were found to be highly effective followed by the single alkathene band with grease, to restrict the upward movement of nymphs towards the plant canopy. Amid various chemical treatments with mechanical blockade, the combined application of single alkathene band with grease and spinosad suppressed the mealybug population by 87.41 per cent of 1st instar numphs followed by application of single alkathene band with grease and antario (81.21%). But the effectiveness of chemical pesticides comparatively decreases with the nymphal stages since 2nd and 3rd instar nymphs develop waxy coating which protect them from penetration of pesticide. The physical modules based upon alkathene band are recommended for the eco-friendly management of *D. mangiferae* on jackfruit plant and this technique has the potential to be adopted by resource-poor farmers in Bangladesh.

Keywords: Chemical treatments, Jackfruit, Mango mealybug, Physical barriers

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Introduction

Mealybugs belong to the insect group that is commonly known as scale insects; they have soft segmented oval bodies, but without an outer shell. The name mealybug is descriptive of an insect's body, which is covered by a white sticky powder resembling cornmeal. Their common name is derived from the mealy wax secretion that usually covers their bodies (Kosztarab and Kozar 1988). Mealybugs are not only phloem feeders and suck the cell sap from all parts of the plants but also, they transmit some plant diseases. Mealybugs take large quantities of plant fluids and therefore excrete liquid waste called honey that encourages the growth of a black fungus called sooty mould(Mani and Shivaraju, 2016a).

The waxy secretion is the most common conspicuous symptomatic trait of the mealybug family. Wax is produced by the epidermal wax glands and transported to the body surface via ducts, pores, and secretory setae of various types (Foldi 1983; Gullan and Kostarab 1997). In some cases, the wax also serves to cover the honeydew droplets and to protect the mealybugs from contamination by their own honeydew and defensive exudates (Gullan and Kosztarab 1997). Adult mealybugs and the nymphal instars are covered with waxy coating. Also, the eggs of mealybugs, protected by the waxy filamentous secretions of the ovisac, are almost impossible to reach with insecticides (Mani and Shivaraju, 2016b).

Mango mealybug (*Drosichamangiferae*) adversely damages the inflorescence, tender leaves, tender twigs, roots and fruits along with secretion of honeydew where sooty mold develops and significantly reduces the fruit yield and quality. (Bhagat 2004, Ibrahim *et al*. 2021). Mealybugs develop several defense mechanisms including waxy coating on the body surface of adult and the nymphal instars, show a tendency to aggregate and settle in protected and perforated place of host plants (Lo and Walker 2011; Gupta *et al*. 2021; Subramanian *et al*. 2021) which makes them hard as well as unresponsive to be controlled by chemical insecticides (Mani and Shivaraju, 2016b). This cryptic behavior of mealybug may provide a spatial refuge from natural enemies and harsh environmental conditions (Gutierrez *et al.* 2008a). Hence, these pests are considered as "hard to kill insects".

Fruit production is the most promising industry in Bangladesh according to the report of the United Nations Food and Agricultural Organizations (FAO). Regardless of rice domination in cropping sector, fruit production in the country is currently booming at a fast rate and is the second largest producer of jackfruit in the world. In the year 2021-22 jackfruit production was 10.49 hundred thousand metric tons with an average yield per fruit bearing tree was 116.74 kg (BBS, 2022). Bangladesh exports jackfruit in many countries including the EU market. From last decades, one of the prominent hindrances of jackfruit production faced by farmers in the country is the high incidence of insect pests and diseases. Among the insect pests attacking jackfruit, mango mealybug has been considered as a secondary pest which is now considered as a primary pest.

Traditionally, mealybugs were simply managed through pruning of trees, destruction of Mango trees and the exploitation of insecticides (Karar et al. 2009). Nevertheless, with the beginning of time, these insects have developed structural, morphological and behavioral adaptations to the existing control measures, and are gradually turning resistant to the pesticides (Prabhaker et al. 2012; Subramanian et al. 2021).

Keeping the above facts and situation, this study had been proposed to understand the impact of creating a pre-infestation physical barriers and application of chemical insecticides in various nymphal stages to develop an effective management practice for mango mealybug.

Materials And Methods

Research location

To development of an effective management practices for mango mealybug,the experiment was conducted in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka campus 23°46′13.68″N, 90°22′39.42″Ein established jackfruit orchard fromNovember, 2022to June 2023.

Experimental design

Two types of treatments were selected for management of *Drosicha mangiferae.*In mechanical practices, different types of barriers with or without grease and in chemical practices, physical barrier with three different groups of insecticides and bio pesticides was evaluated with an untreated control. The experiment was conducted in a randomized complete block design (RCBD) with three replications. Treatments of two categories are described below:

Treatments related to physical barrier:

Four treatments related to physical barriers namely T1 = Single Alkathene band, T2 = Double girdle Alkathene band, T3 = Single Alkathene band + Grease, T4 = Double girdle Alkathene band+ Grease were tested and compared with untreated control (T8).

For each Treatment, three jackfruit plants were tied round with a band of polythene which is 25 cm wide and 50-100 cm above the ground and its lower edge was plastered over with mud which made it sufficiently slippery to prevent the passage of *Drosicha* species nymphs. In case of T2 and T4 treatment, the second band was knotted20 cm above the first band, which made subsequent obstacle as it stopped the few nymphs that managed to cross the first band. In the event of, T3 and T4 treatment, to made more difficulties for upward and downward movement 4 cm grease was applied on the middle portion of the band and spread evenly with light fingers. Repeated application of grease was done in every 15 days due to a layer of dust above the grease that reduced the capacity of nymph’s sticky.

Fig. 1. Single and double layer alkathene band with and without grease

Treatments related to physical obstacle with chemical application:

Three chemicals were applied with physical barricade to develop a management practices, namely T5 = Single alkathene band with grease + Imidacloprid, T6 = Single alkathene band with grease + Spinosad, T7 = Single alkathene band with grease + Antario were evaluated with an untreated control (T8) to observe the effectiveness of those treatments.

Aimed at randomly selected jackfruit plants, a physical barricade was prepared like treatment T1 and chemical pesticides were thoroughly sprayed the different parts of plants with hand knapsack sprayer using 2-3 L of spray solution per tree from 1.5 to 2 meter height. In preparation for Imidacloprid solution, 0.25 ml/L water spray solution was prepared according their recommended doses. Actual volume of insecticide was taken in a sprayer and thoroughly mixed with water, as soon as the spray solution was applied to the respective jackfruit plant. For the purpose of Spinosad solution, 0.40 ml/L water spray solution was prepared rendering their mentioned doses. In order to facilitate Antario solution, according their suggested doses 2 gm/L water used to make desired volume of spray solution. First chemical spreading at the crawler stages after hatching of eggs. Subsequently 2nd and 3rd sprays of pesticides were applied at 2nd and 3rdinstars of *Drosicha mangiferae* at the last week of February and third week of March. Data were recorded on different parameters after each spraying at 24 hours, 48 hours and 72 hours.

Place of observation

The selected jackfruit tree was inspected from the 1st week of December and data was recorded early in the morning. Though all parts of the plants were inspected keenly, data was recorded on inflorescence, leaves, tender fruits and fruitstalks etc. infestation because mealybugs settled on soft parts of plants.

Fig. 2. Concentration of nymphs underneath the band

Fig. 3. Nymphs aggregated on tender plant parts

Data collection and analysis

Subject to mechanical practices, after emergence of each instar insect population that remained in inflorescence, leaves, fruits and fruit stalks were counted visually and recorded in every three, five and seven days. But in case of chemical treatment with mechanical blockade data was recorded before and after application of pesticides with an interval of 24 hours, 48 hours and 72 hours from inflorescence, leaves, tender fruits and fruit stalks.

Averages of insect observation were considered by using the following formula:

$$\text{Mean number of insect population} = \frac{N_1+N_2+N_3\ldots\ldots\ldots\ldots N_{10}}{\text{Total number of observations}}$$

Percent insect population reduction over untreated control was calculated using a formula given by Dutta*et. al*. (2014).

$$\% \text{ Reduction} = \frac{\text{Average population recorded in control- Average population recorded in treatment}}{\text{Average population recorded in control}} \times 100$$

Results and Discussion

Effects of physical barriers on the1st instars nymphs

Data on the effectiveness of various physical barrier used to stop the movement as well as chemical treatment with physical blockade for the management of mealybug revealed a significant reduction among different treatments. Among four treatments regarding physical barrier T4 (Double girdle alkathene band with grease) showed more effective results, which inhibit upward movement of 1st instars nymph by 49.04% in inflorescence, 48.89% in leaf, 50.30% in fruit and 49.19 % in fruitstalk. It was also observed that, by using different types of physical barrier 33.32% to 50.30% nymph reduction occur in inflorescence, leaf, fruit and fruitstalk. In case of chemical treatment with physical barrier,the maximum reduction of 1st instar mango mealybug observed in T6 (Single alkathene band + Spinosad) treatment, where 1.7 nymphs/2.5cm^{2}were recorded, it occurred 86.03% population reduction in inflorescence found over control. In leaf, fruit and fruitstalk population reduction over control also occurred86% in T6 treatment (Single alkathene band with grease + Spinosad). Treatment T5 (Single alkathene band with grease + Imidacloprid) and T7(Single alkathene band with grease + Antario) also showed good amount of 1st instar population reduction in all parts of Jackfruit plant compared to 2nd and 3rd instar nymphs. First instar nymph of mealybug susceptible to chemical because waxy layer remains undeveloped during crawler stage. The data regarding the incidence of 1st instar mango mealybug in different treatments are given in Table I.

Table 1. Average number of 1st instar nymphs per 2.5 cm^2 area in different plant parts

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Single band (T1)	8.100 b	5.900 b	3.600 b	6.733 b
Single band with Grease (T2)	7.500 bc	5.566 bc	3.366 b	6.033 bc
Double band (T3)	6.833 bc	5.066 bc	3.133 b	5.667 bc
Double band withGrease (T4)	6.200 c	4.600 c	2.733 b	5.200 c
Single band with Grease + Imidacloprid (T5)	2.900 d	1.933 d	1.233 c	2.267 d
Single band with Grease + Spinosad (T6)	1.700 d	1.133 d	0.766 c	1.400 d
Single band with Grease + Antario (T7)	2.467 d	1.833 d	1.033 c	2.033 d

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Untreated Control (T8)	12.167 a	9.00 a	5.500 a	10.233 a
Standard Error (SE)	0.6678	0.5988	0.4115	0.5298
Significance	***	***	***	***
CV (%)	13.67	16.75	18.87	13.12

Means followed by different letter are significantly different at 5% level by LSD.

*** Significant at P≤0.001, ** Significant at P≤0.01, * Significant at P≤0.05, NS = Non significant

Effects of physical barriers and chemicals on the 2nd instars nymphs

Similar to 1st instar nymph, all treatment regarding physical barrier (T1-T4) reduced significantly the number of 2nd instar nymphs over control. The 2nd instar nymphs suck the cell sap from different plant parts especially in inflorescence, leaf, fruit and fruitstalk but the reduction range of population was more or less similar. Among the different physical barriers used, population reduction range over control was recorded in a range of 33.19 to 49.68%, in leaf, fruit and fruits talk. Though their efficacy was significantly similar each other but significantly higher over control. Significantly the highest reduction of 2nd instar nymphs (56.90%) was recorded in T6 (Single alkathene band with grease +Spinosad) in inflorescence and lowest reduction (33.42%) was recorded in T1 (Single alkathene band) in case of leaf. Combination of physical barricade with chemical pesticide showed better result than use of physical barrier. The data regarding the incidence of 2nd instar mango mealybug in different treatments are given in Table 2.

Table 2. Average number of 2nd instar nymph per 2.5 cm^2 area in different plant parts

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Single band (T1)	11.500 b	8.167 b	6.733 b	9.267 b
Single band with Grease (T2)	10.500 bc	7.567 bc	6.367 bc	8.767 bc
Double band (T3)	9.833 bcd	6.933 bcd	5.800 bcd	8.000 bcd
Double band and Grease (T4)	8.900 cde	6.233 cde	5.200 cd	7.533 cde
Single band with Grease + Imidacloprid (T5)	8.567 cde	5.933 de	5.033 cd	6.933 de
Single band with Grease + Spinosad (T6)	7.500 e	5.333 e	4.600 d	6.200 e

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Single band with Grease + Antario (T7)	8.133 de	5.833 de	5.000 d	6.700 de
Untreated Control (T8)	17.400 a	12.267 a	10.333 a	14.233 a
Standard Error (SE)	0.9499	0.5012	0.6325	0.6358
Significance	***	***	***	***
CV (%)	11.30	11.92	12.63	9.21

Means followed by different letter are significantly different at 5% level by LSD.

*** Significant at P≤0.001, ** Significant at P≤0.01, * Significant at P≤0.05, NS = Non significant

Effects of physical barriers and chemicals on the 3rdinstars nymphs

At 3rd instar nymphal stage, the highest mean population (25.30 insects/2.5 cm^2) was recorded in inflorescence in control plant. Among four treatments related to physical barrier, population reduction over control was recorded in a range of 31-51% in inflorescence, leaf, fruit and fruit stalks. Population of 3rd instar nymph were low in fruit compare to other parts of jackfruit plant because they are sedentary in nature and suck the cell sap from tender area. Due to a physical blockade, the insects concentrate near the band and application of chemical insecticide eradicate a considerable number of populations. There were comparative susceptibility of 1st, 2nd and 3rd instar nymphs to three insecticides after 24, 48 and 72 hours of spray. It was observed that 3rd instar nymphs were more resistant to all insecticides compared to 1st and 2nd instar nymphs. In case of mealybug, 3rd instar nymphs are completely covered with a white waxy layer which prevent its body to absorb insecticide. The data regarding the incidence of 3rd instar mango mealybug in different treatments are given in Table 3.

Table 3. Average number of 3rd instar nymphs per 2.5 cm^2 area in different plant parts

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Single band (T1)	16.533 c	12.633 c	9.300 cd	14.667cde
Single band with Grease (T2)	15.500 cd	12.100 c	8.900 cd	13.900de
Double band (T3)	14.600 cd	11.500 cd	8.167 d	12.800e
Double band with Grease (T4)	12.533 d	10.033 d	6.867 d	10.500e
Single band with Grease + Imidacloprid (T5)	19.933 b	15.633 b	11.367bc	17.267bcd
Single band with Grease + Spinosad (T6)	21.233 b	16.667 b	12.167ab	18.833abc
Single band with Grease + Antario (T7)	21.833 b	16.967 b	12.567ab	19.433ab
Untreated Control (T8)	25.300 a	19.867 a	14.500 a	22.233 a

Treatment	Inflorescence	Leaf	Fruit	Fruit stalk
Standard Error (SE)	1.0458	0.5961	1.2568	2.0506
Significance	***	***	***	***
CV (%)	9.81	7.16	14.69	15.50

Means followed by different letter are significantly different at 5% level by LSD.

*** Significant at P≤0.001, ** Significant at P≤0.01, * Significant at P≤0.05, NS = Non significant

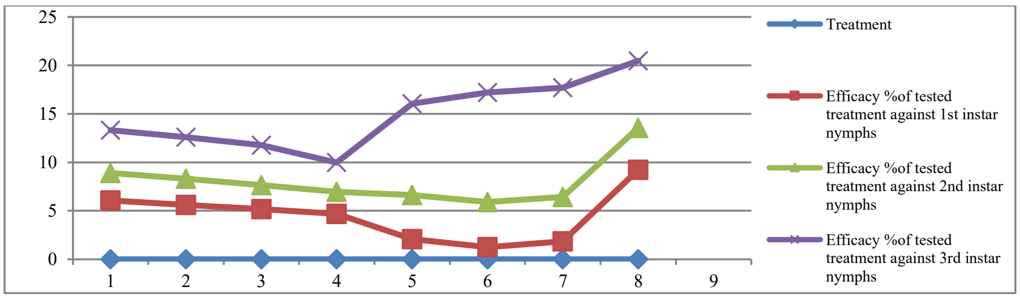

Fig. 4. Comparison of efficacy % of tested treatments based on number of nymphs per 2.5 cm^2 area of plants among 1st, 2nd and 3rd Instar.

Treatment T6 (Single alkathene band with grease +Spinosad) showed higher efficacy to suppress 1stinstar nymph followed by treatment T5 (Single alkathene band with grease+ Imidacloprid), On the other hand, for the management of 2nd instar nymphs, Treatment T6 (Single alkathene band with grease+Spinosad), T5 (Single alkathene band with grease+Imidacloprid) and T4 (Double girdle alkathene band with grease) showed statistically non-significant difference but in case of 3rd instar nymph T4 (Double girdle alkathene band with grease)showed better result than all physical barrier and chemical treatments with physical blockade. It is supposed that this efficacy % was varied due to temperature and wax development on the body surface of adult and nymphal instars of mealybugs. Though crawler stage is not covered with wax, and hence, this is perhaps one of the most susceptible stages of mealybug to chemicals.

The above-mentioned findings agree with the findings of Gul *et al.* (1997) who worked on and reported *D. stebbingi* that combination of banding of tree trunks, eggs destruction by soil working and application of insecticides was the most effectual control approach. Tandon and verghese (1985) suggested that removal of weeds, exposure of eggs during summer, conservation of natural enemies, application of alkathene bands and spray with garlic oil or neem seed extract 4% on tree trunk below band significantly reduced the population of *Rastococcus iceryoides* and *Drosicha* spp. Mango mealybug is difficult to control by using only chemical insecticide and in most cases, it has been proven in efficient (Khan and Ahsan 2008).

Ishaq *et al.* (2004) studied on integrated management approach of mango mealybug and reported that water-based insecticides are not appropriate to control such type of pest. It is recorded that for management by using physical barrier such as sticky bands along with burning and burying treatments significantly reduced the infestation incidence of mango mealybug (0.00-15.79%). Similar results also reported by Bajwa and Gul (2000) their results showed *Paulownia* spp attacked by mango mealybug and they effectively managed through banding of trees, destruction of eggs and application of insecticide together.

Karar *et al.* (2007) tested nine different types of tree bands to check the upward movement of mealybugs (*Drosicha mangiferae*) and found Haider's band (Plastic sheet having a layer of 3.8 cm of grease in middle portion) is most effective to prevent movement of insects from reaching tree canopies.Some findings showed that above 80% reduction over control in mango mealy bug can be achieved through integrating mechanical and cultural methods of control.

Slippery band of alkathene was most effective of all in blocking the ascending nymphs, as an average of 2.79 nymphs per sample area were able to cross it every alternate day as compared with 407.3 nymphs on untreated trees (Mani *et al*. 2016b). A 30 cm wide polythene bandtied round the tree 50-100 cm above the ground andwith its lower edge plastered over with mud and sufficiently slippery to prevent the passage of *Drosicha stebbingi* nymph and much cheaper than the conventional sticky band (Bindra and Sohi1974).

Conclusion

Management of mealybugs was achieved by banding the jackfruit tree before hatching of first instar nymphs and application of chemical insecticide prior to waxy secretion by epidermal wax glands. The findings of this research can be concluded in such manner that mealybugs are most susceptible to chemicals when they are in the crawler stage though this period is available only for a few daysand 86% insects can be killed by using spinosad at crawler stage. But in later, high volume wet sprays are required in order to penetrate the waxy coating that protects mealybug. Similarly, physical barriers play a vital role to inhibit the upward movement of crawler and downward migration of gravid female mealybugs. Moreover, pest suppression through physical barriers showed a significant reduction in all related treatments as compared to control. Further research on various integrated management aspects as well as chemical control through biopesticide and mechanical barrier will facilitate the researchers to devise worthy management options of mango mealybugs.

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