Project ID 613

## Competitive Research Grant

# Sub-Project Completion Report

## on

Distribution, severity, species diversity and damage assessment of papaya mealybug

**Project Duration**

**April 2017 to September 2018**

**Department of Entomology**
**Sher-e-Bangla Agricultural University**
**Dhaka-1207, Bangladesh**

**Submitted to**
**Project Implementation Unit-BARC, NATP 2**
**Bangladesh Agricultural Research Council**
**Farmgate, Dhaka-1215**

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**Citation**

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# Acronyms

NATP- National Agricultural Technology Program

BARC- Bangladesh Agricultural Research Council

CRG- Competitive Research Grant

SAU- Sher-e-Bangla Agricultural University

RCBD- Randomized Complete Block Design

cm- Centimetre

mm-Millimetre

g- Gram

Kg- Kilogram

ANOVA- Analysis of Variance

AEZ- Agro-Ecological Zone

SD- Standard deviation

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# Executive Summary

A survey was conducted in 10 districts such as Dhaka, Gazipur, Tangail, Narsingdi, Rajshahi, Bogura, Joypurhat, Natore, Pabna, and Kushtia to know the distribution and severity of papaya mealybug. Papaya mealybug was found in all locations under the selected districts. Percent plant infestation was highest (46.16 %) in Tangail district but lowest ( 32.31 %) in Rajshahi. Percent fruit infestation was highest (75.98 %) in Joypurhat and lowest in Rajshahi. In case of pest occurrence in papaya field 100% respondents expressed mealybug as a major pest of papaya. Maximum infestation was reported from fruit (36.31% farmers opinion) followed by flower (34.24% farmers opinion). Majority of the farmers (47.52%) sprayed imitaf 20SL/tido 20SL 3-4 times for controlling mealybug. Mealybug samples were collected from 10 selected districts and brought to the laboratory to study their morphology and biology to know the species diversity. Based on the biology and morphology it was found that all the collected individuals from different districts represented only one species *Paracoccus marginatus*. It was observed that the adult female laid an average of 122.8 eggs and female has three instar but male has four instar. At $1^{st}$ instar male and female could not be distinguished. The average duration, length and breadth of $1^{st}$ instar nymph was 4.8± .83 days, 0.41±0.3 mm, 0.25 ± .016 mm, respectively. The average duration of $2^{nd}$, $3^{rd}$ instar female nymph and adult female was 4.2±.83 days, 3.4±0.54 days and 10± 2 days, respectively. The average length of $2^{nd}$, $3^{rd}$ female nymph and adult female was 0.69± 0.03 mm, 1±0.14mm and 1.94±0.27 mm, respectively. The average duration of $2^{nd}$, $3^{rd}$ instar, pupa and adult male was 3.6± 0.54 days, 2.8 ± .83 days, 3.6 ±.54 days and 2.4 ±.54 days respectively. The average length of $2^{nd}$, $3^{rd}$ instar, pupa and adult male was 0.70± .06 mm, 0.85± .02 mm, 0.94 ± .04 mm and 0.98±.03 mm respectively. Damage of paya mealybug were assessed in field and found that mealybug infestation reduced plant height (52.25%), number of leaves $plant^{-1}$ (86.08%), petiole length (53.31%), number of flowers $plant^{-1}$ (86.23%), number of fruits $plant^{-1}$ (89.43%), individual fruit weight (88.01%) as well as total fruit weight $plant^{-1}$ (98%).

# CRG Sub-Project Completion Report (PCR)

## A. Sub-project Description

1. **Title of the CRG sub-project:** Distribution, severity, species diversity and damage assessment of papaya mealybug
2. **Implementing organization:** Department of Entomology, Sher-e-Bangla Agricultural Unbiversity, Dhaka-1207, Bangladesh
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):


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4. Sub-project budget (Tk): 1500000/-

   4.1 Total: 1500000/-

   4.2 Revised (if any): N/A

5. Duration of the sub-project:

   5.1 Start date (based on LoA signed): (based on LoA signed): May-2017

   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

   The papaya mealybug, *Paracoccus marginatus* is a Homopteran insect belonging to the family Pseudococcidae. It is polyphagous (Miller & Miller, 2002) in nature and sucks the sap from different parts of the plant. The leaves and all infested plant parts become crinkled, yellowish wither and dropped from the plants. The mealybug also injects a toxin as it feeds on leaves and fruit which results in chlorosis (yellowing), stunting, deform. The honeydew excreted by the bug is a good growing media of a fungus sooty mold which impairs photosynthetic efficiency of the

affected plants. Heavily attacked plants were killed (Walker *et al*., 2003; Hue *et al*., 2007). Mealybug also transmits viruses to the plant. It is a noxious insect pest attacking papaya and other agricultural plants of economic importance (Miller & Miller, 2002). It assumed the status of a major pest in India in 2009 when it caused severe damage to economically important crops and huge losses to farmers in Coimbatore, Erode, Tiruppur and Salem districts of Tamil Nadu (Tanwar *et al*., 2010). In 2009, it was reported from Bangladesh and Maldives and in 2010 in Cambodia, the Philippines and Thailand (Muniappan, 2011). Within a short period of time, the newly introduced papaya mealybug has now been spread many parts of Bangladesh and emerged as a major threat to papaya along with different crops (Karim *et al*., 2011). *P. marginatus* is newly invaded insect pest in Bangladesh and comprehensive research on papaya mealybug has not yet been undertaken in the country. A very few researches have been done in Bangladesh which was only on the management technique of papaya mealybug (Biswas *et al.,* 2015). So it is justifiable to do the basic research and explore its distribution, severity of attack and diversity of different species in Bangladesh. It was also desirable to undertake a preliminary assessment of damage prior to do the research on the management of this pest. Therefore, this study would provide a basis to design the efficient management techniques against this invasive pest.

7. Sub-project goal: know the distribution, severity of damage, species diversity and damage assessment of papaya mealybug.
8. Sub-project objective (s):
   - To know the distribution of papaya mealybug in Bangladesh
   - To determine the damage severity of papaya mealybug in major papaya growing districts of Bangladesh
   - To know the species diversity of papaya mealybug in Bangladesh
   - To assess the extent of loss caused by papaya mealybug.

9. Implementing location (s): Dhaka, Gazipur, Tangail, Narsingdi, Rajshahi, Bogura, Joypurhat, Natore, Pabna, and Kushtia.
10. Methodology in brief:

**Study area**

The present study was conducted in ten different districts of Bangladesh (Table 1). Dhaka, Gazipur, Tangail, Narsingdi, Rajshahi, Bogura, Joypurhat, Natore, Pabna, and Kushtia. The study area was taken with three upazilas of each district.

**Unit of analysis**

The unit of analysis of the study was the people who were engaged in papaya production (farmers).

**Population and sampling**

People who permanently reside in the selected upazila constituted the active population of the study. As all population of the study area could not possible to measure, head of the farm families of selected blocks of upazila (segmented by the Department of Agriculture Extension under the Ministry of Agriculture) of ten different districts were the population of the study. However, representative samples from the population were taken for collection of data following purposive sampling technique. One farmer (who operated farming activities of the family) from each farm family was considered as the respondent. Updated lists of all farm families of papaya producers of the selected blocks were prepared with the help of SAAO and local leader. Farm families who were engaged in papaya production and who provided the extension service to the papaya growers were considered as the study group. A purposive sampling procedure was followed to select ten districts from all over Bangladesh, and a random sampling method was used to select the upazila. Random sampling was also used to select the blocks of upazila as the study group. The total number of individuals sampled was estimated as many as 300 in the study area which is shown in Table 3. We collected data from 300 farmers (10 districts x 30 farmers).

**Study Group (SG) Sampling**

There are several methods for determining the sample size; here, we used Yamane's (1967) formula for study group:

$$\mathbf{n} = \frac{\boldsymbol{Z^2 P(1-P)N}}{\boldsymbol{Z^2 P(1-P)+N((e)^2}}$$

**Where,**

n = Sample size;

N, Population size = 17548;

e, The level of precision = 7%;

z = the value of the standard normal variable given the

z = 1.96 with a confidence level of 95 %) and

P, The proportion or degree of variability = 50%;

The sample size (n) is = 300

**Variables and their measurement techniques**

In a descriptive social research, selection and measurement of the variable is an important task. A variable is any characteristics which can assume varying or different values are successive individuals' cases (Ezekiel & Fox, 1959**)**. An organized research usually contains at least two identical elements i.e. independent and dependent variable. An independent variable is a factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is a factor, which appears, disappears or varies as the experimenter introduces, removes or varies the independent variables (Townsend, 1953). According to the relevance of the research area, the researcher selected some characteristics of the respondents as the independent variables (e.g. Insecticides usage, insecticides sources, harmful effects for chemical insecticides usages). On the other hand, insect pest management practices were dependent variable consisted of the dimensions i.e. chemical management practices. The following sections contain procedures of measurement of dependent and independent variables of the study along with the assessment of insect pest of papaya. The procedure followed in measuring the independent variables have been discussed in the subsequent sections.

**Insect pest occurrence in papaya orchard**

Insect pest occurrence in papaya field was assessed by providing score. Score one was provided for yes and score zero was provided for no answer. Data obtained in response to the interview schedule are presented in APPENDIX-I.

**Insect pest infestation status in papaya orchard**

Insect pest infestation status in papaya orchard was assessed by providing score. Score one was provided for minor answer and scores two was provided for major answer. Data obtained in response to the interview schedule are presented in APPENDIX-I.

**Data collection**

Data were collected personally through personal interview schedule from the sampled papaya growers of the selected blocks. A rapport was established with the rural people so that they feel easy to answer

the questions. A possible care was taken to establish rapport with the respondents so that they would not feel any indecision while taking the interview. Very good cooperation was obtained from the UAO, field extension workers and growers of the study area. No serious difficulty was faced during the collection of data. Questions were asked in different ways so that the respondents could easily understand the questions. Whenever a respondent faced difficulty in understanding any question, care was taken to explain the same clearly with a view to enabling him to answer it properly.

**Statistical analysis**

Data collected from the respondents were analyzed and interpreted in accordance with the objectives of the study. The analysis of data was performed using statistical treatment with SPSS (Statistical Package for Social Sciences) computer program, version 20. Statistical measures as a number, range, mean, standard deviation and pearson's product moment correlation (r) were used in describing the variables whenever applicable.

## 11. Results and discussion

**Experiment 1. Distribution and damage severity of papaya mealybug**

The survey was conducted in 10 districts such as Dhaka, Gazipur, Tangail, Narsingdi, Rajshahi, Bogura, Joypurhat, Natore, Pabna, and Kushtia. Papaya mealybug was found in all locations under the selected districts (Table 1).

**Table 1. Table1: Selected surveyed districts of Bangladesh**

| Sl No. | Districts | Upazila | No. of orchard visited | Mealybug present or absent |
|---|---|---|---|---|
| 01 | Dhaka | Dhamrai<br>Savar<br>Keranigonj | 09 | + |
| 02 | Kushtia | Mirpur<br>Daluatpur<br>Veramara | 09 | + |
| 03 | Gazipur | Joydevpur<br>Tongi<br>Kaliakair | 09 | + |
| 04 | Pabna | Sadar<br>Atghoria<br>Ishwardi | 09 | + |
| 05 | Narsingdi | Polash<br>Sadar<br>Balavo | 09 | + |
| 06 | Tangail | Modhupur | | |

| | | | | |
|---|---|---|---|---|
| | | Shokhipur<br>Mirzapur | 09 | + |
| 07 | Joypurhat | Sadar<br>Kalai<br>Khetlal | 09 | + |
| 08 | Natore | Sadar<br>Lalpur<br>Bgatipara | 09 | + |
| 09 | Bogura | Sadar<br>Dhunat<br>Sherpur | 09 | + |
| 10 | Rajshahi | Tanor<br>Godagari<br>Bagha | 09 | + |

'+' indicate the presence of papaya mealybug

**Infestation intensity**

Percent plant infestation was highest (46.16 ± 0.46) in Tangail district followed by Joypurhat ( 45.29 % ) but lowest infestation was found ( 32.31 %) in Rajshahi. Similar trend of infestation was found in branch infestation. Regarding flower infestation highest 53.66 % infestation was found in Pabna and lowest 26.14 % was found in Rajshahi. Percent fruit infestation was highest 75.98 % in Joypurhat followed by Pabna ( 69.87 % ) and lowest was found in Rajshahi (Table 2)

**Table 2. Infestation intensity of papaya mealybug at farmer's field in ten papaya growing districts under study**

| Districts | Plant infestation by papaya mealybug(%) (Mean ± Sd) | Branch infestation per infested plant(%) (Mean ± Sd) | papaya flower infestation per infested plant(%) (Mean ± Sd) | papaya fruit infestation per infested plant(%) (Mean ± Sd) |
|---|---|---|---|---|
| Rajshahi | 32.31 ± 4.57 | 53.52 ± 6.09 | 26.14 ± 4.63 | 16.29 ± 9.37 |
| Natore | 44.35 ± 1.64 | 53.71 ± 3.21 | 48.88 ± 5.50 | 70.03 ± 7.73 |
| Bogura | 44.11 ± 1.19 | 50.37 ± 4.63 | 51.29 ± 1.50 | 64.97 ± 7.19 |
| Joypurhat | 45.29 ± 2.52 | 46.30 ± 1.70 | 50.16 ± 1.17 | 75.98 ± 1.48 |
| Pabna | 43.04 ± 1.27 | 63.15 ± 13.15 | 53.66 ± 2.69 | 69.87 ± 2.44 |
| Kushtia | 44.27 ± 1.45 | 62.41 ± 8.10 | 48.16 ± 0.94 | 61.99 ± 6.80 |
| Tangail | 46.16 ± 0.46 | 63.33 ± 8.94 | 45.71 ± 1.98 | 62.56 ± 6.15 |

| | | | | |
|---|---|---|---|---|
| Gazipur | 44.12 ±1.42 | 58.98 ± 2.52 | 48.24 ± 2.52 | 67.94 ± 1.61 |
| Dhaka | 44.63 ± 0.69 | 54.07 ± 4.49 | 49.73 ± 2.35 | 66.27 ± 2.49 |
| Narsingdi | 44.96 ± 1.31 | 55.74 ± 10.48 | 49.63 ± 2.50 | 65.39 ± 3.38 |

**Pest's infestation on papaya observed by farmers**

Information obtained from respondents by interview were measured, analyzed, tabulated and statistically treated according to the objectives of the study. This chapter has been discussed in five sections such as personal characteristics of the papaya growers, information about papaya cultivation, pests of papaya and information about mealybug.

**Pest's occurrence in papaya orchard**

According to the opinion expressed by the growers, papaya was infested by mealybug, whitefly, ant and mite in the orchard. Out of 300, all the papaya growers (100%) reported that papaya was infested in the field by mealybug. In case of multiple responses, 171 farmers (27.45%) reported whitefly, 25 farmers (4.01%) reported ant and 127 farmers (20.39%) reported mite as the pests of papaya in their field (Table 3).

**Table 3. Response of the papaya growers on incidence of insect pest on papaya**

| Name of pests | Farmer's interviwed (N = 300) | Response (%) |
|---|---|---|
| Mealybug | 300 | 48.15 |
| Whitefly | 171 | 27.45 |
| Ant | 25 | 4.01 |
| Mite | 127 | 20.39 |
| Multiple response | | 100.00 |

**Pest's infestation at different growing stages of papaya plant**

Four pests viz., mealybug, whitefly, ant and mites were reported by papaya growers of which whitefly, ant and mite infestations were reported from seedling stage, vegetative and fruiting stage of the papaya (Table 4) but whitefly infestation was reported from vegetative stage of the papaya. Highest

infestation of mealybug, whitefly and ant (>80.0%) was reported at fruiting stage but maximum mite infestation (50.45%) was reported from vegetative stage.

**Table 4.** Response of the papaya growers on pest infestation status at different stages of papaya

| Name of insect pests | Response on infestation at plant stages (%) | | |
|---|---|---|---|
| | Seedling stage | Vegetative stage | Fruiting stage |
| Mealybug | 4.01 | 15.87 | 80.12 |
| Whitefly | 0.0 | 7.24 | 92.76 |
| Ant | 5.25 | 14.10 | 80.65 |
| Mites | 34.87 | 50.45 | 14.68 |

**Farmers response on infested plant parts of papaya**

According to papaya growers leaf (17.83% farmers), stem (11.62% farmers), flower (34.24% farmers) and fruits (36.31% farmers) were infested by mealybug. Ant infestation was also reported from all plant parts (Table 5). But whitefly and mite infestation were reported from papaya leaves only.

**Table 5. Farmers' information on infested plant parts of papaya by different pests**

| Name of insect pests | Farmers response on pests infestation on plant parts (%) | | | |
|---|---|---|---|---|
| | Leaf | Stem | Flower | Fruits |
| Mealybug | 17.83 | 11.62 | 34.24 | 36.31 |
| Whitefly | 100.0 | - | - | - |
| Ant | 32.00 | 12.00 | 20.00 | 36.00 |
| Mite | 100.0 | - | - | - |

**Farmers' information on severity of infestation of different pests**

High severity of mealybug was reported by 43.83% growers and 47.83% reported medium severity of infestation on papaya. All farmers (100%) reported low severity of ant on papaya. High severity of whitefly and mite were also reported by 9.36% and 9.44% farmer's respectively (Table 6). Most of the farmers opined medium severity of whitefly (55.56%) and mite (59.06%) infestation on papaya.

**Table 6. Response of the papaya growers on severity of infestation of four pests of papaya**

| Name of insect pests | Response on status of four pests (%) | | |
|---|---|---|---|
| | Low | Medium | High |
| Mealybug | 8.70 | 47.83 | 43.83 |
| Whitefly | 35.08 | 55.56 | 9.36 |
| Ant | 100.0 | 0.0 | 0.0 |
| Mite | 31.50 | 59.06 | 9.44 |

**Farmers' information on status of insect pests of papaya**

In responding status of four pests of papaya, 100% farmers reported mealybug as the major damaging pest of papaya (Table 7). Whitefly and mites were also reported as major pests by 35.23% and 24.76% growers respectively.

**Table 7. Response of the papaya growers on status of different pests' infestation in papaya orchard**

| Name of insect pests | Response on status of four pests (%) | |
|---|---|---|
| | Major | Minor |
| Mealybug | 100.0 | 0.00 |
| Whitefly | 35.23 | 64.77 |
| Ant | 0.0 | 100.00 |
| Mite | 24.76 | 75.24 |

**Control measures of pests of papaya**

Out of 300 respondents, all expressed their opinions that they controlled different pests by application of chemical pesticides. None of the farmers used cultural or biological pest control methods.

**Insecticides uses against pests of papaya**

According to the opinion expressed by the papaya growers, they sprayed marshal 20EC (23.76%) and sumithion 20EC (18.36%) @ 2.0 ml/L water, imitaf 20SL/tido 20SL (47.52%) @ 0.50 ml/L water and caught 10EC (10.36%) @ 1.0 ml/L water 3-4 times for controlling papaya mealybug (Table 8). They also applied imitaf 20SL/tido 20SL (70.18%) 0.50 ml/L water and aktara 20WG (29.82%) 0.50 g/L water 1-2

times against whitefly. Sunmectin 1.8EC (30.00% farmers), acamite 1.8EC (18.03% farmers) and vertimec (51.97% farmers) @ 2.0 ml/L were used 2-3 times against mite pest of papaya. Majority of the papaya growers used imitaf 20SL/ tido 20SL (Imidacloprid) for controlling mealybug and whitefly infesting papaya (Table 8)

**Table 8. Response of the papaya growers on insecticide use in papaya orchard**

| Name of pests | Insecticides and their doses used against pests of papaya | | | Used frequency |
|---|---|---|---|---|
| | **Insecticides** | **Response(%)** | **Dose** | |
| Mealybug | Marshal 20EC | 23.76 | 2.0 ml/L | 3-4 |
| | Sumithion 50EC | 18.36 | 2.0 ml/L | |
| | Imitaf 20SL / Tido 20SL | 47.52 | 0.50 ml/L | |
| | Caught 10EC | 10.36 | 1.0 ml/L | |
| Whitefly | Imitaf 20SL/ Tido 20SL | 70.18 | 0.5 ml/L | 1-2 |
| | Aktara 20WG | 29.82 | 0.5 g/L | |
| Ant | No inseciticide | 100.0 | - | - |
| Mite | Sunmectin 1.8EC | 30.00 | 2.0 ml/L | 2-3 |
| | Acamite 1.8EC | 18.03 | 2.0 ml/L | |
| | Vertimec 1.8EC | 51.97 | 2.0 ml/L | |

**Farmers information on mealybug infestation on papaya**

Out of 300 respondents, all expressed their opinions that that their papaya plant infested by mealybug. The details about mealybug infestation and control measures are discussed herein.

**Growth stages of plant infesting mealybug**

According to farmers' information, mealybug infestation occurred from seedling stage to mature plants. Majority of farmers (65.27%) opined that mealybug infestation occurred at fruiting stage of papaya followed by 24.78% reported at vegetative stage of plant infestation and 9.96% reported seedling infestation of papaya (Table 9).

**Table 9. Response of the papaya growers on different growing stage of plant infested by mealybug in papaya orchard**

| Growing stage of plant | Farmers interviewed [N=300] | Response (%) |
|---|---|---|
| Seedling | 45 | 9.96 |
| Growing plant | 112 | 24.78 |
| Fruiting stage | 295 | 65.27 |
| Multiple response | | 100.00 |

**Mealybug infested parts of papaya plant**

Papaya growers opined that all parts of papaya plants viz. leaf, stem, flower and fruits were infested by mealybug. Majority of the farmers (36.31%) reported fruit infestation followed by flower, leaf and stem infestation as reported by 34.24%, 17.83% and 11.62% farmers respectively (Table 10).

**Table 10. Farmers' information on infested parts of papaya plant by mealybug**

| Infested part of papaya | Farmers interviwed [N=300] | Response (%) |
|---|---|---|
| Leaf | 112 | 17.83 |
| Stem | 73 | 11.62 |
| Flower | 215 | 34.24 |
| Fruit | 228 | 36.31 |
| Multiple response | | 100 |

**Severity of mealybug infestation**

Papaya growers reported low to high level of mealybug infestation on papaya. Majority of the farmers (47.83%) reported medium level of mealybug infestation followed by 43.83% farmer's who reported high severity of mealybug infestation. Few farmers (8.70%) reported low severity of mealybug infestation (Table 11).

**Table 11. Farmers' information on severity of mealybug infestation on papaya**

| Severity of mealybug infestation | Farmers interviewed [N=300] | Response (%) |
|---|---|---|
| Low | 30 | 8.70 |
| Medium | 165 | 47.83 |
| High | 150 | 43.48 |
| Multiple response | | 100 |

**Time of mealybug infestation**

According to farmers information, mealybug infestation occurred throughout the year. However majority of them (63.72%) reported that mealybug in festation occurred at summer season followed by winter season as reported by 30.28% farmers. Few farmers (5.99%) reported mealybug infestation during rainy season (Table 12) .

**Table 12. Farmers' information on time of mealybug infestation on papaya**

| Season of mealybug infestation | Farmers interviewed [N=300] | Response (%) |
|---|---|---|
| Summer | 202 | 63.72 |
| Rainy | 19 | 5.99 |
| Winter | 96 | 30.28 |
| Multiple response | | 100.00 |

**Control methods for mealybug**

Farmers used cultural (clean cultivation), mechanical (hand collection and destruction) and chemical control for papaya mealybug. However majority of the farmers (96.42%) used chemical insecticides for controlling mealybug. Few farmers used cultural (1.95%) and mechanical (1.63%) methods for mealybug control (Figure 1).

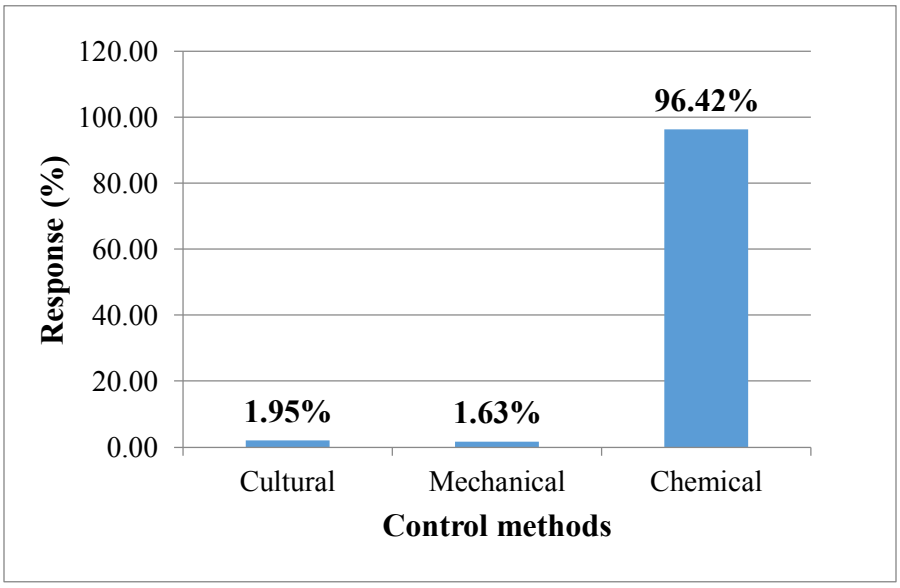



**Figure 1.** Farmers' response on control methods against papaya mealybug.

**Insecticides spray frequency for controlling mealybug**

Farmers sprayed chemical insecticides 3-4 times for controlling papaya mealybug. Majority of the farmers (58.92%) sprayed insecticides 3 times but 41.08% of them sprayed insecticides 4 times (Figure 2).

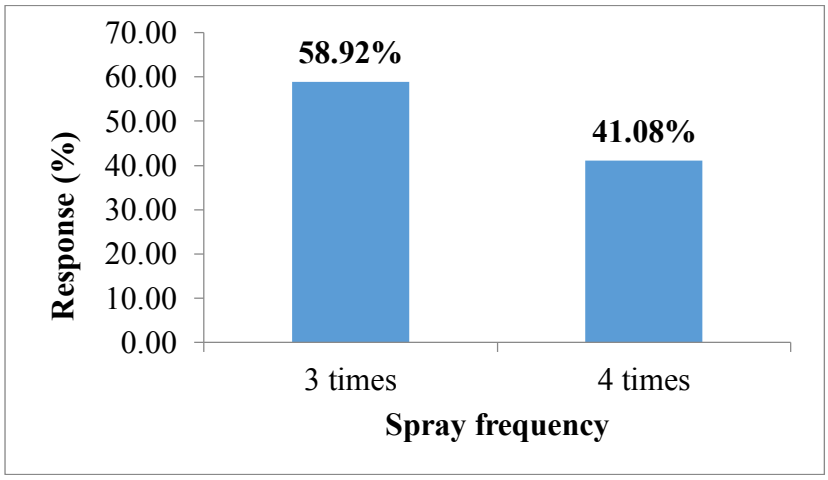



**Figure 2.** Farmers' response on frequency of insecticides spray for controlling papaya mealybug.

**Effectiveness of insecticides for controlling mealybug**

In responding on the effectiveness of insecticides against papaya mealybug, 93.33% farmers reported that papaya mealybug was controlled after insecticides spray. Only 6.67 % farmers opined that papaya mealybug was not controlled by insecticides spray (Figure 3).

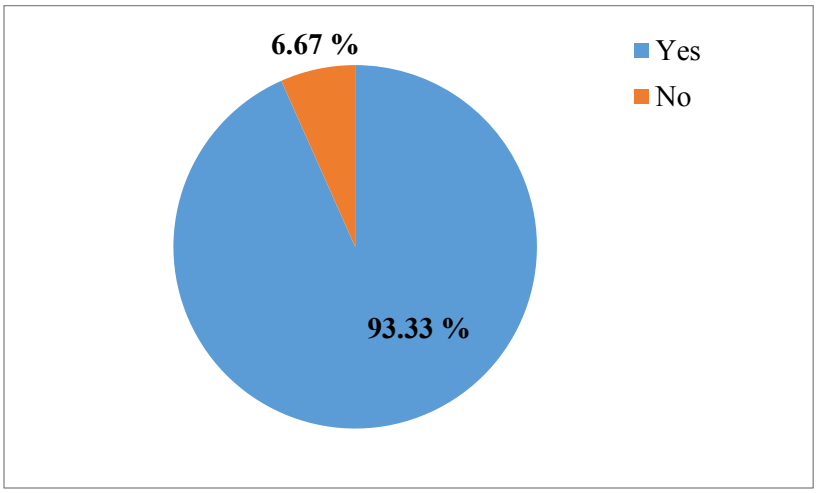



**Figure 3.** Farmers' response on effectiveness of insecticides against papaya mealybug.

**Harmful effect of insecticides**

Out of 300 papaya growers, 97.67% (292) opined that insecticides had harmful effect and only 2.33% (8) farmers were not conscious about side effect of insecticides (Figure 4). In responding on the hazardous effect of insecticides, 96.93% farmers informed that insecticides caused health hazard on human and 3.07% papaya growers reported harmful effect of insecticides on environment (Figure 5).

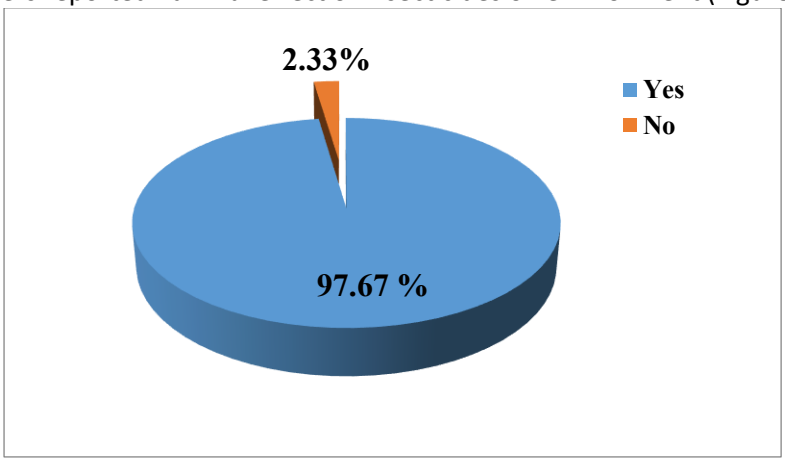



**Figure 4.** Farmers' response on harmful effect of insecticides.

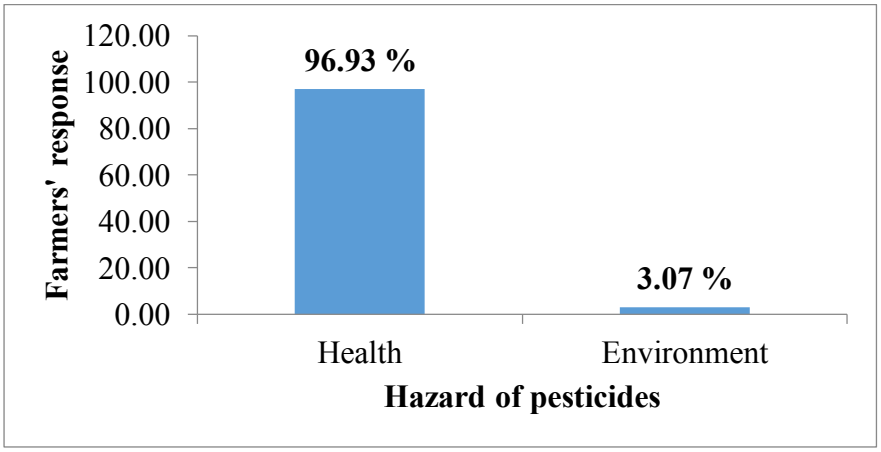



**Figure 5.** Farmers' response on hazards of insecticides on human health and environment.

**Experiment 2. Species diversity of papaya mealybug in laboratory**

**Materials and method**

Biology studies of papaya mealybug was carried out in Entomology laboratory, Sher-e-Bangla Agricultural University. The individual leaves of host plants with petioles were removed and kept in Petri

dish lined with moist cotton cannot withstand for about one month even if the base of the petiole is covered with a water soaked cotton swab to prevent desiccation of leaf. Hence, the whole plant with intact root system was used in the study.

**Duration of instars of male and female papya mealybug**

Each leaf was inoculated with eggs of papaya mealybug (1 egg sack leaf$^{-1}$) using a camel hair brush. All Petri dishes were observed daily for egg hatch. The interval between each moulting was checked by examining exuviae on the leaves using a hand lens (10 X magnification) and the exuviae were removed after each moulting. Morphological determination of all the instars was done under a stereo microscope in the laboratory. The number of days to egg hatch, emergence of first instars, duration of second instar males and females, duration of third instar males and females and duration of fourth instar males (pupa) were recorded.

**Data collection**

The adult female mealybugs were individually transferred to new leaf (leaves of plant lined with moistened cotton) for monitoring the reproductive period (oviposition and incubation). Adult longevity of five male and female mealybugs was observed daily until they died. Five egg sacs were taken and eggs were counted under stereo microscope.

## 11. Results and discussion

Results based on the specimens of papaya infesting mealybug collected from different locations in Bangladesh, their morphometric analysis of different stages and biology study indicate that only *Paracoccus marginatus* Williams and Granara de Willink was found to attack papaya plants. No other species of mealybug was found in 10 surveyed districts of Bangladesh. The detail morphometric characteristics of different stages of papaya mealybug and its biology have been described in below.

**Biology of Papaya Mealybug**

**Egg sac**

The papaya mealybug (*Paracoccus marginatus)* laid eggs in an egg sac. Each female lays one egg sac (Table 13) after laying the eggs female was died. Egg sac was made of whitish cottony layer (Plate 1).

**Egg**

Adult female lays 97-150 eggs per sac (Table 14). Eggs were yellowish color and oval shape (Plate 2). The length of egg was 0.35±0.01mm and the breadth was 0.14±0.008mm (Table 15). The average incubation

period of the eggs was 4-7 days. The oviposition period of a female was 5-8 days (Table 14). Chellappan, *et. al.* (2006) reported that the length of egg was 0.34±0.01mm and the breadth was 0.15±0.01mm which is also confirmed by the present study. They also reported that incubation period was 8.5±0.85 days and oviposition period 7.8±0.63 days is also close to the present study. Females usually lay 150-600 eggs in an ovisac. The results of the present study are lying between the ranges of these findings. Egg laying usually occurs over the period of 3-4 days, which is lower than the present study. Egg hatch in about ten days which is lower than the present study. However, this variation might be due to the environmental condition (Jithu, *et. al*., 2016). The adult female of *P. marginatus* laid about 150 to 200 eggs inside the ovisacs which are close to the present study (Al-Hilal *et. al.,*2012). Suganthy *et al.* (2011) reported that the period of egg was 6.33±0.58 days and this finding is lying between the present studies. Females usually lay 100 to 600 eggs. Eggs are greenish yellow and are laid in an ovisac and these findings are similar to the present study but they also reported that egg laying usually continues over a period of one to two weeks and eggs hatch in about 10 days, these results are somewhat different to the present study. This variation might be occurred due to environmental condition or host species (Tanwar *et al.,* 2010).

**Plate 1. Egg sac (30X)**

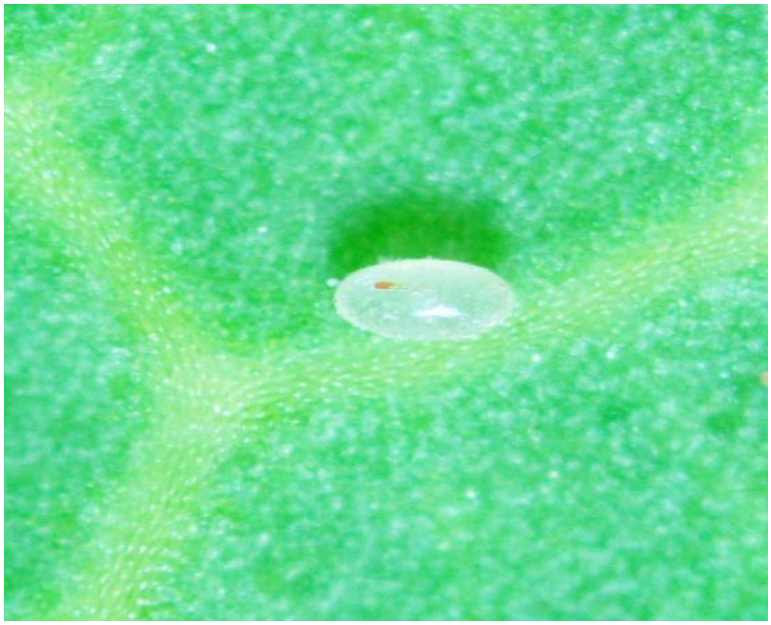


**Plate 2.** Egg (90X)

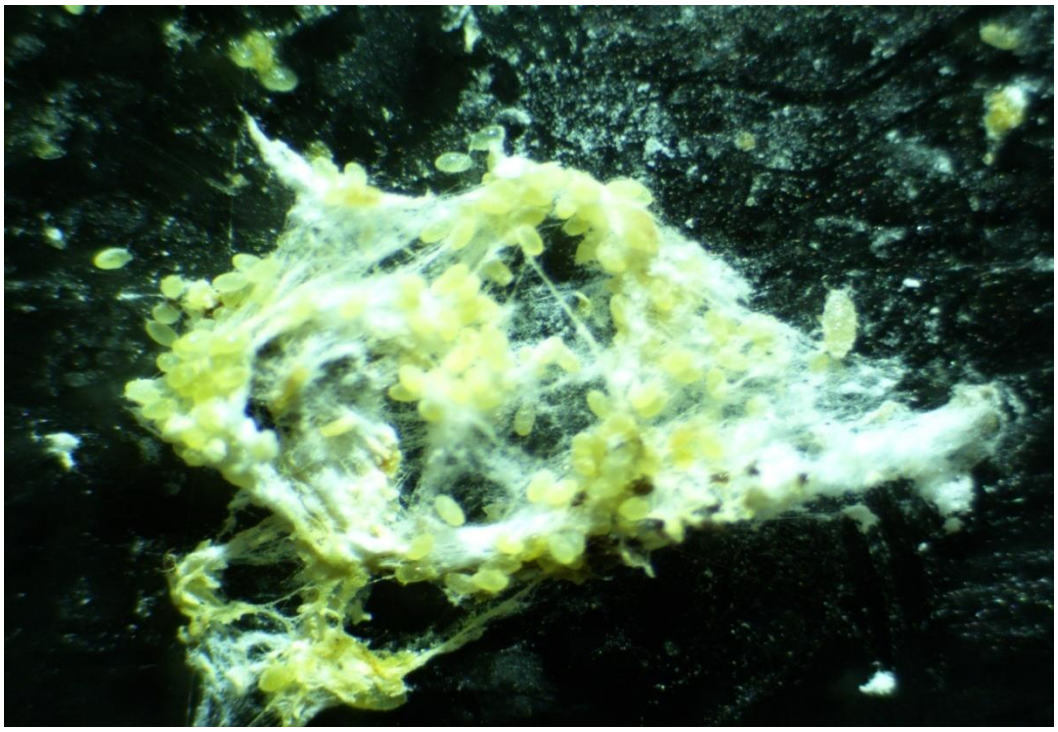


**Plate 3.** A mass of eggs (30X)

**Plate 4.** A mass of 1st Instar Nymph (30X)

**Table 13.** Number of eggs sac$^{-1}$, egg sac female$^{-1}$

| Observations | Egg number | Mean± SD | Egg sac female$^{-1}$ |
|---|---|---|---|
| 1 | 97.00 | | 1.0 |
| 2 | 120.0 | | 1.0 |
| 3 | 118.0 | 123±19.52 | 1.0 |
| 4 | 130.0 | | 1.0 |
| 5 | 150.0 | | 1.0 |

**Nymph**

Females have three instars whereas males have four instars (Table 2). Al-Hilal *et al.* (2012) observed that in case of *P. marginatus,* generally four and three nymphal instars took place in case of male and female mealybug, respectively, this finding is same as present result.

**First instar nymph**

At this stage male and female could not be distinguished. First instar nymph were very active. The length of the nymph was 0.41±.08 mm and the breadth was 0.25±.016 mm (Table 15). The average duration of 1st instar nymph was 4-6 days (Table 14). The first instar nymph is yellowish color (Plate 4). Miller and Miller (2002), reported that in 1st instar gender could not be determined and nymph is yellow color which is similar to the present findings. They also reported that the length and breadth of nymph was 0.4 mm and 0.2 mm which is close to the present findings. 1st instar nymph was 4.6±0.52 days this result is in accordance with the present result (Chellappan *et al.,* 2006). Seni and Sahoo (2014) studied the biology of *P. marginatus* on sprouted potato throughout the year revealed that the duration of 1st instar nymphs ranged from 3-17 days and the present study finding is also lying between the ranges of this findings. The sexes of which could not be distinguished and this finding is same as the present result. The length of 1st instar nymph was 0.42± 0.074 mm and 0.024±0.27 mm in width. This instar appears yellowish in color which is similar to the present findings (Al- *et al.,* 2012). Suganthy *et. al.* (2011) reported that the period of 1st instar nymph was 4.00±1.00 days and this finding is lying between the present studies.

**Second instar nymph**

The 1st instar nymph was moulted to 2nd instar nymph and casted their exuvae. The 2nd instar female was yellowish color (Plate 5) and male was pink color (Plate 7). Female length was 0.69±0.03mm and breadth was 0.44±0.02 mm and the male was 0.70±.065 mm long and 0.38±0.04 mm wide (Table 15). Average duration of 2nd instar female nymph was 3-5 days and the 2nd instar male nymph was 3-4 days (Table 14). Miller and Miller (2002) reported that the 2nd instar female was yellowish color and male was pink color which is similar to the present study. They also reported that 2nd instar female length and breadth was 0.7 mm and 0.04 mm which is close to the present study. But the 2nd instar male nymph 0.4 mm long and 0.02 mm wide which is somewhat different to the present result. Chellappan *et. al.* (2006) confirmed the present result according to them 2nd instar male nymph is 0.75±0.02 mm long and 0.44±0.02 mm wide. They also observed that 2nd instar female nymph lasts for 4.2±0.63 days and 2ndinstar male nymph average duration was 4.3±0.67 days. Al-Hilal *et. al.* (2012) observed the length of 2nd instar female nymph was 0.6±0.054 mm and 0.089±0.4 mm in width. Body color appeared yellow in field conditions. Length of 2nd instar male nymph was 0.62±0.044 mm and 0.09±0.3 mm in width. Body looks like yellow in color during field observation. The length of 2nd instar male and female is close to the present result but the width shows different result and this might be due to the environmental

condition or host species. The period of 2nd instar nymph was 3.67±0.58 days and this finding is lying between the present studies (Suganthy *et. al.,* 2011).

**Plate 5.** 1st instar nymph (30X)

**Plate 6.** 2nd Instar nymph female (30X)

**Plate 7.** 2nd Instar nymph male (30X)

**Plate 8.** 3rd Instar nymph female (30X)

**Plate 9.** 3rd Instar nymph male (30X)

**Plate 10.** Pupa (30X)

**Plate 11.** Adult female (60X)

**Third instar nymph**

The 2nd instar female moulted after 3-4 days and male was moulted after 2-4 days into 3rd instar nymph (Table 14). The 3rd instar male was pink color (Plate 9) and the female was yellowish color (Plate 8). Female length was 1± 0.14 mm and breadth was 0.72±0.05 mm and male 2nd instar nymph was 0.85± 0.02 mm long and 0.41±.02 mm wide (Table 15). Miller and Miller (2002) reported that the 3rd instar female was yellowish color and male was pink color which is confirmed the present study. They also reported that 3rd instar female length and breadth was 1.1 mm and 0.7 mm and male was 0.9 mm and 0.4mm which is similar to the present result. Studies made by Chellappan, *et al.* (2006) reported that 3rd instar female and male average duration were 5.1±0.32 days and 2.6±0.52 days which confirmed the present study. Al-Hilal *et al.* (2012) observed the length of third instar nymph was 0.89±0.11mm and it was 0.12±0.51 mm in width

**Table 14**. Duration of different life stages of *Paracoccus marginatus*

| Life stage | Life duration (days) | | Mean±SD | Observations number (n) |
|---|---|---|---|---|
| | Minimum | Maximum | | |
| 1st instar gender is not identified | 4.00 | 6.0 | 4.80±0.83 | 5 |
| 2ndinstar female | 3.00 | 5.00 | 4.20±0.83 | 5 |
| 3rdinstar female | 3.00 | 4.00 | 3.40±0.54 | 5 |
| Adult female | 8.00 | 13.0 | 10.0±2.00 | 5 |
| 2ndinstar male | 3.00 | 4.00 | 3.60±0.54 | 5 |
| 3rdinstar male | 2.00 | 4.00 | 2.80±0.83 | 5 |
| Pupa | 3.00 | 4.00 | 3.60±0.54 | 5 |
| Adult male | 2.00 | 3.00 | 2.40±0.54 | 5 |
| Total lifespan (male) | 14.00 | 21.00 | 17.2±2.86 | 5 |
| Total lifespan of (female) | 18.00 | 28.00 | 22.4±3.70 | 5 |
| Oviposition | 5.00 | 8.00 | 6.00±1.22 | 5 |
| Incubation period | 4.00 | 7.00 | 5.80±1.09 | 5 |

Body appears yellow in color during field observation. Length of third instar male nymph was 1.05±0.23 mm and 0.156±0.59 mm in width. Body looks like yellow in color during field observation. This result is somewhat different from the present result and this might be due to variation in environmental condition or host species. The period of third instar nymph was 5.00±1.00 days and this finding is higher than the present study. This variation might be due to the environmental condition or host species (Suganthy *et al*., 2011).

**Table 15**. Measurement of different life stages of *Paracoccus marginatus*

| Stage | Length (mm) | | | Breadth (mm) | | |
|---|---|---|---|---|---|---|
| | **Min.** | **Max.** | **Av.±SD** | **Min.** | **Max.** | **Av.±SD** |
| Egg | 0.31 | 0.39 | 0.35±.03 | 0.13 | 0.18 | 0.14±.01 |
| 1st instar gender is not identified | 0.30 | 0.50 | 0.41±.08 | 0.21 | 0.30 | 0.25±.03 |
| 2ndinstar female | 0.58 | 0.78 | 0.69±.03 | 0.37 | 0.49 | 0.44±.02 |
| 3rdinstar female | 0.7 | 1.50 | 1± 0.14 | 0.67 | 0.80 | 0.72±.05 |
| Adult female | 1.60 | 2.30 | 1.94±.27 | 1.25 | 1.55 | 1.38±.05 |
| 2ndinstar male | 0.50 | 0.85 | 0.7±.06 | 0.28 | 0.40 | 0.38±.04 |
| 3rdinstar male | 0.80 | 0.90 | 0.85±.02 | 0.30 | 0.46 | 0.41±.02 |
| Pupa | 0.90 | 1.0 | 0.94±.04 | 0.20 | 0.30 | 0.26±.03 |
| Adult male | 0.90 | 1,10 | 0.98±.03 | 0.20 | 0.30 | 0.26±.01 |

**Pupa**

The 4th instar male is the pupal stage. The duration of this stage is 3-4days (Table 14). The length of pupa was 0.94 ±.04 mm and breadth was 0.26±.03 mm (Table 15). Pupal stage was occurred in a cocoon. The cocoon was made of whitish cotton like thread. The color of pupa was pink. The pupa was pink color and length and breadth of pupa was 1.0 mm and .03 mm which is in accordance with the present result (Miller and Miller, 2002). Average duration of pupa was 4.2±0.63 days which were almost similar to that determined by (Chellappan *et al.* 2006). Al-Hilal *et al.* (2012) observed that the length of fourth instar nymph was 0.98±0.075 mm and 0.02±0.49 mm in width. Body color appeared pink but occasionally yellowish. Only width is different from the present result but length and color shows similar result as present study.

**Adult female**

Body is yellowish color, dusted with mealy wax not thick enough to hide body color, without discrete bare areas on dorsum, with many short waxy filaments around body margin. Body was 1.94±0.27 mm long and 1.38±0.0 mm wide (Table 14). The antennal segment of this adult female was 8. The average duration of adult female was 8-13 days. The adult female was yellow color and 2.2 mm long and 1.4 mm wide which are close to the present findings (Miller and Miller, 2002). Chellappan *et. al.* (2006) studied that the average duration of adult female was 17.6 ± 0.84 days which is somewhat different to the present result. The length of adult female was 2.08±0.354 mm and it was 1± 0.063 mm in width. Body is yellow in color during field observation. The length of this finding is close to the present finding but the width is less than the present finding (Al-Hilal *et al.,* 2012). Suganthy *et. al.* (2011) reported adult longevity of females was 20.33±1.53 days which is higher than the present finding. This variation might be due to variation in environmental condition or host species.

**Plate 12.** Adult Male (90X)

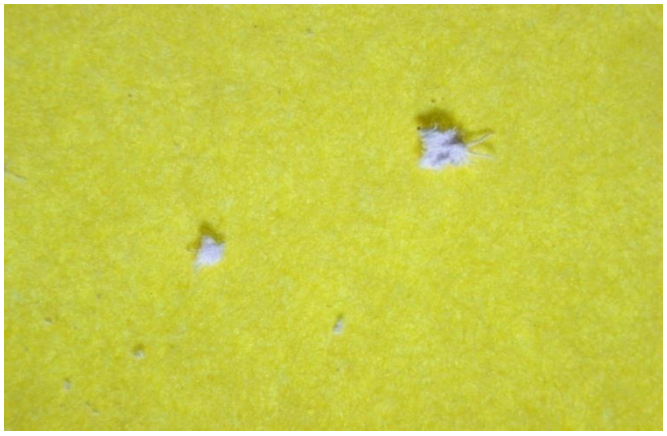


**Plate 13.** Casted exuviae (60X)

**Adult male**

Adult male was winged (Plate 12). Antenna was 10 segmented. The length of the adult male was 0.98 ±0.03 mm and the breadth 0.26±.01 mm. The wings are white color. The longevity of adult male was 2-3 days (Table 14).

Miller and Miller (2002) reported that the adult male was winged and length and breadth of male was 1.0 mm and 0.03 mm which is close to the present findings. Chellappan *et. al.* (2006) observed that the average duration of adult male was 2.7±0.48 days which are in accordance with the present result. The length of adult male was 1.5 mm and 0.5 mm in width. Body color appeared pink, but occasionally yellowish, these findings different from the present findings. This variation might be due to differential environmental conditions or host species (Al-Hilal *et al.,* 2012). Suganthy, *et. al.* (2011) reported adult longevity of males was 1.67±1.15 days and this finding is close to the present study.

**Experiment 3. Damage assessment of papaya mealybug**

**Materials and method**

The experiment was conducted at Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from June, 2017 to August, 2018. The papaya variety used in the experiment was "Red lady". This is a high yielding variety. The seeds were collected from krishibid nursery khamarbari, Dhaka.

**Treatments of the experiment**

The experiment contained two treatments and 10 replications.

$T_1$= Papaya plant covered with fine net and imidacloprid Admire 200SL @ 1ml/L of water sprayed at 7 days interval.

$T_2$ = Artificially infested by papaya mealybug (100 nymph of papaya mealybug were released plant$^{-1}$).

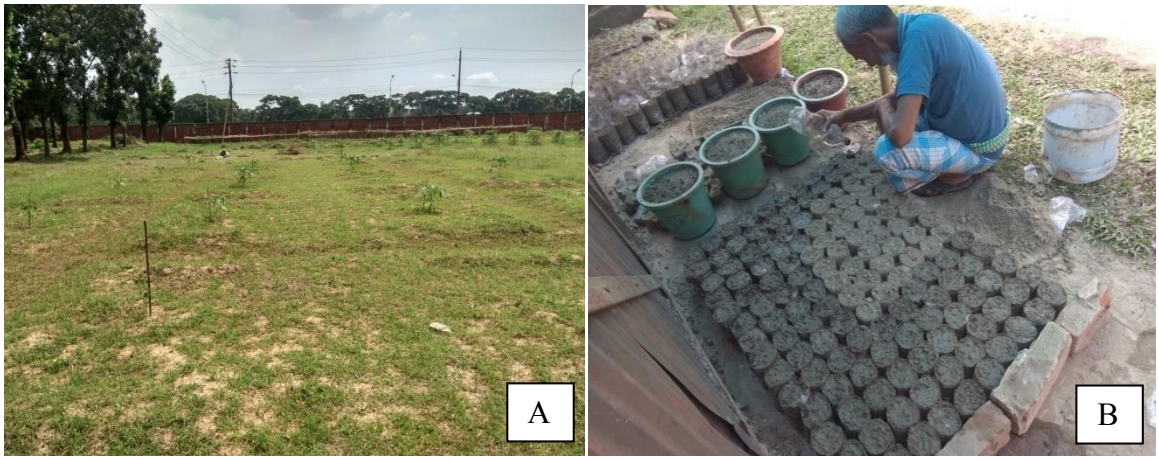



**Plate 14. Experimental field (A), Seed sowing (B)**

**Plate 15. Preparation of land for transoplant (A), transplanting of plant (B)**

**Plate 16. Infested plant (A), Healthy plant (B) after transplant**

**Plate 17. Experimental field after netting (A), Individual plant after netting (B)**

**Plate 18. Individual netted plant during spraying by insecticide (A & B)**

**Design and layout of the experiment**

The experiment was laid out in a Randomized Complete Block Design (RCBD) having two treatments with ten replications. An area of 25 m x 15 m was divided into two equal blocks. Each block was consisted of 10 plots where two treatments were allotted randomly. There were 20 unit plots in the experiment. The size of each plot was 1.8 m x 2 m. The distance between two blocks and two plots were kept 1 m and 0.5 m respectively.

**Data collection**

Plant height, number of leaves plant,$^{-1}$ petiole length, number of flowers,$^{-1}$ number of fruits cluster,$^{-1}$ fruit weight and yield of fruit were manually counted at three stages early mid and reproductive stage of the insects.

**Data analysis**

Percent damage due to infestation of mealybug was calculated by following formula:

$$\text{Percent damage} = \frac{T_1 - T_2}{T_1} \times 100$$

Here,

$T_1$= Papaya plants covered with fine net and imidacloprid Admire 200SL @ 1ml/L of water sprayed at 15 days interval

$T_2$ = Artificially infested by papaya mealybug (100 nymphs of papaya mealybug were released plant$^{-1}$)

**Statistical analysis**

The recorded data on various parameters were statistically analyzed using SPSS statistical package program. The mean for all the treatments was calculated and analysis of variance (ANOVA) for all the characters were performed by paired t test.

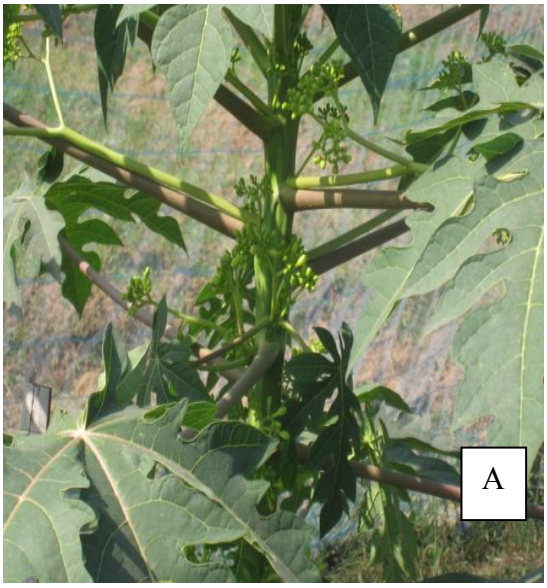
**Results and discussion**

**Plant height**

The result indicated that papaya plant height increased progressively with the advancement of time and growth stages. At early stage, average plant height was 49.6 cm in $T_1$ and 23.80 cm in $T_2$. At middle stage, $T_1$ showed 83.6 cm per plant and $T_2$ showed 48.20 cm per plant. At later stage, average height of $T_1$ per plant was 114.70 cm and average height of $T_2$ per plant was 75.30 cm. The result indicated that $T_1$ showed the higher plant height and $T_2$ became stunted. This result indicate that at early, mid and late stage plant height was reduced by 52.01%, 42.6%, 52.25% respectively due to infestation of papaya mealybug (Figure.10).

**Table 17.** Average plant height, leaf number and petiole length at three plant growth stages

| Treatments | Plant growth stages | Plant height in cm (Mean±SD) | Number of leaf ( Mean±SD) | Petiole length in cm (Mean±SD) | Number of observations (n) |
|---|---|---|---|---|---|
| $T_1$ | Early | 49.60±4.05 | 10.50±1.58 | 16.65±2.43 | 10 |
| | Mid | 83.60±4.97 | 21.00±3.91 | 35.85±5.18 | 10 |
| | Late | 114.70±11.64 | 23.10±6.36 | 55.61±9.28 | 10 |
| $T_2$ | Early | 23.80±2.34 | 3.20±1.47 | 7.52±1.29 | 10 |
| | Mid | 48.20±2.69 | 2.80±1.22 | 15.17±2.21 | 10 |
| | Late | 75.30±7.49 | 3.10±1.44 | 25.96±5.42 | 10 |



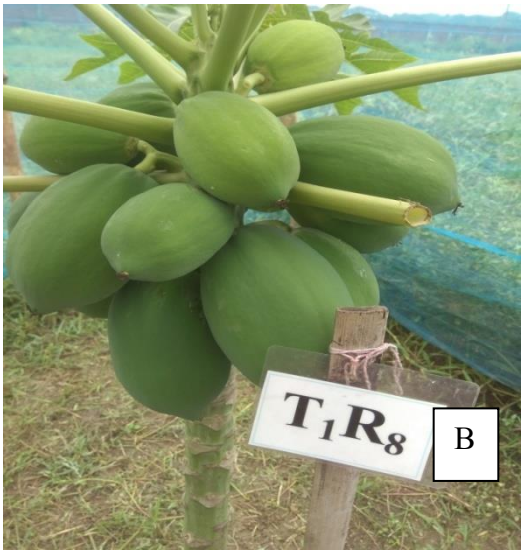




**Plate** 19**.** Managed papaya plant (A & B)

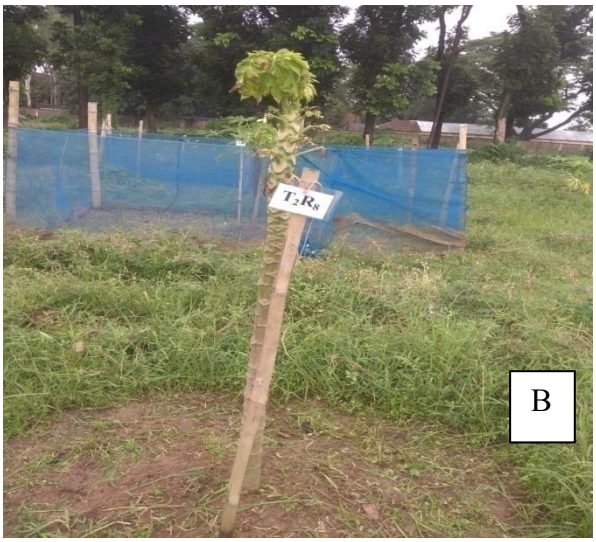




**Plate 20.** Infested papaya plant (A & B)

**Leaf number**

At early stage in case of $T_1$ plant leaf number was 10.5 and in case of $T_2$ plant which was infested with mealybug showed lower number of leaf that is 3.2. In mid stage $T_1$ plant leaf number increased to 21 rapidly but $T_2$ plant showed very poor number of leaf that was 2.8. In late stage $T_1$ plant also showed leaf number increasing that was 23 on the other hand leaf number of $T_2$ plant was 3.1 which was very lower than that of $T_1$ plant. This result

indicated that at early, mid and late stage leaf number was reduced by 69.5%, 86.6%, 86.08% respectively due to infestation of papaya mealybug (Table 16)

**Petiole length**

At early stage, average petiole length of $T_1$ was 16.65 cm and the average petiole length of $T_2$ was 7.52 cm. At mid stage, petiole length in $T_1$ was 35.85 cm and 15.17 cm in $T_2$. At later stage, average petiole length of $T_1$ was 55.61 cm and average petiole length of $T_2$ was 25.96 cm. The result indicated that $T_1$ showed longer petiole length than $T_2$. This result indicated that at early, mid and late stage petiole length was reduced by 54.83%, 57.68%, 53.31% respectively due to infestation of papaya mealybug (Table 16).

**Flowers number**

No of flowers in $T_1$ was 13.80 but $T_2$ showed very lower number of flowers. Average flowers number for $T_2$ was 1.90. This result indicated that in reproductive stage flowers number was reduced by 86.23% due to infestation of papaya mealybug (Table 16).

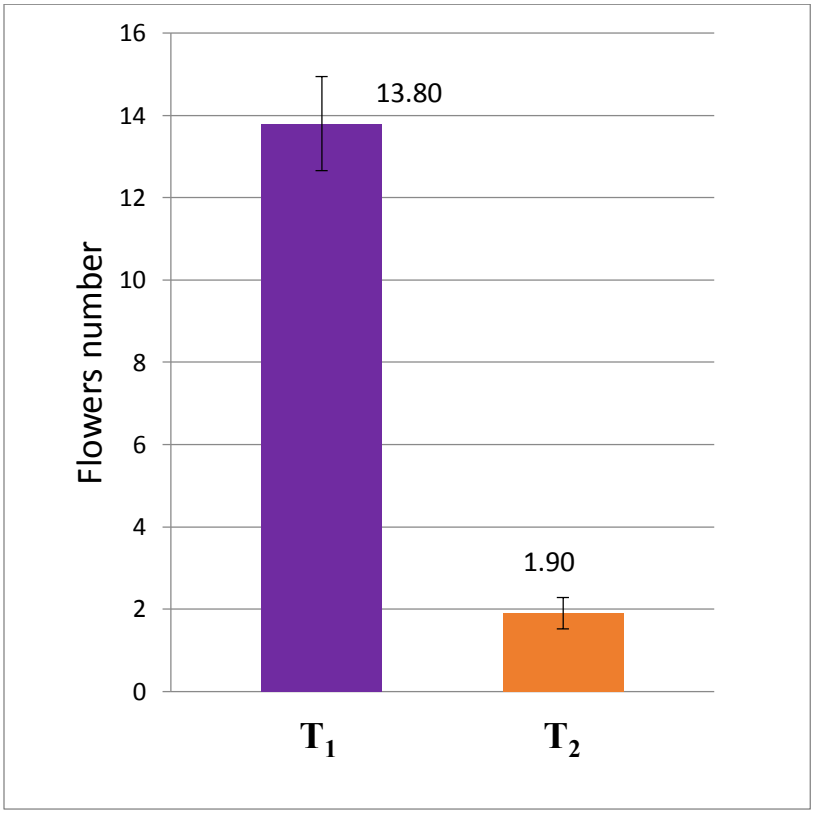



**Figure 6.** Average numbers of flowers per plant**.**

**Fruit number**

In case of $T_1$ average number of fruits per plant recorded was 12.30. On the other hand, the average number of fruits in $T_2$ recorded was 1.30. This result indicated that in reproductive stage fruit number was reduced by 89.43% due to infestation of papaya mealybug (Figure. 10)

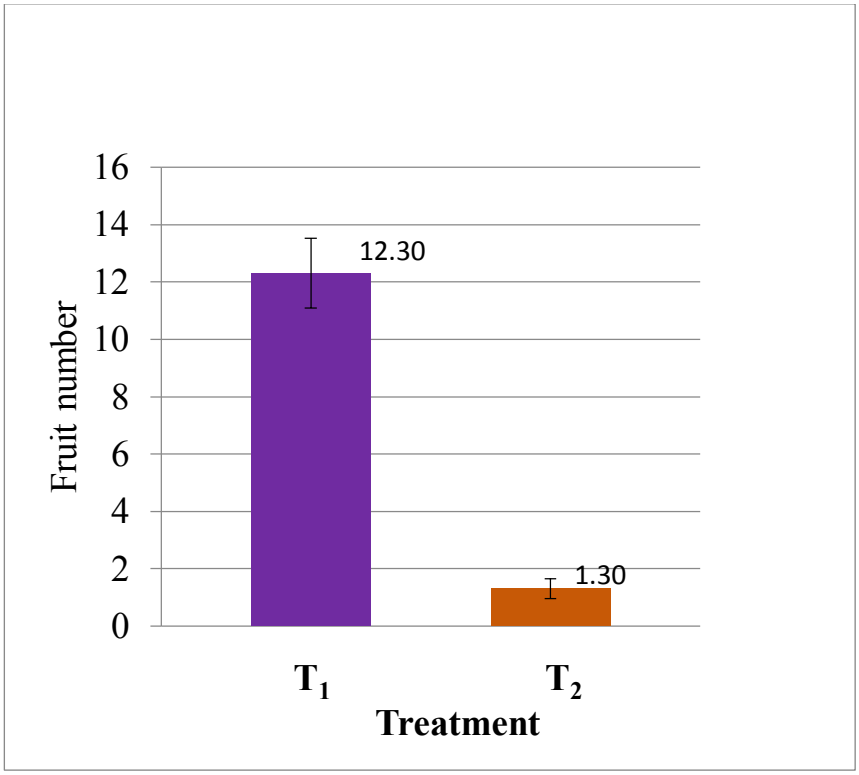



**Figure 7.** Average numbers of fruits per plant.

**Average fruit weight**

Average weight of fruit in $T_1$ was 559.7 g on the contrary average weight fruit was 67.1 g in $T_2$. This result indicated that fruit weight was reduced by 89.43% due to infestation of papaya mealybug (Figure.08)

**Total fruit yield plant$^{-1}$**

Total fruit yield per plant in $T_1$ was 6.88 kg on the contrary total fruit yield 0.087 kg in $T_2$. This result indicated that total fruit yield per plant was reduced by 98% due to infestation of papaya mealybug (Figure. 08)

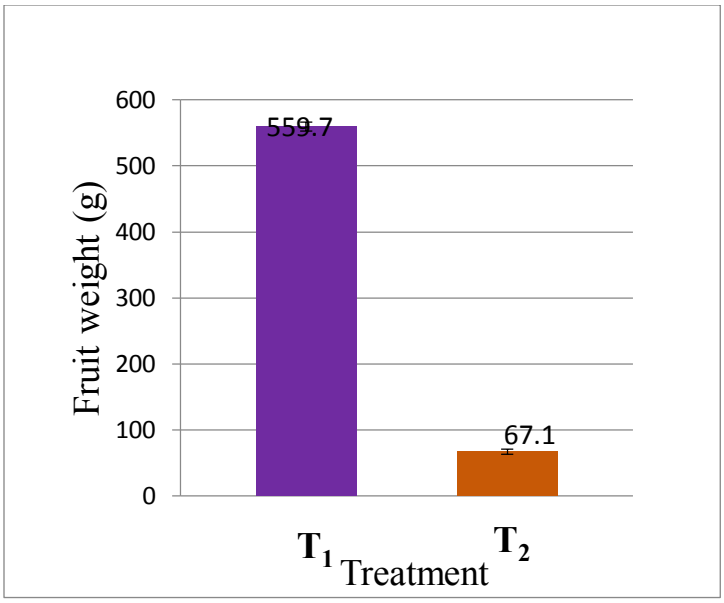



**Figure 8.** Average weight of individual fruit plant$^{-1}$.

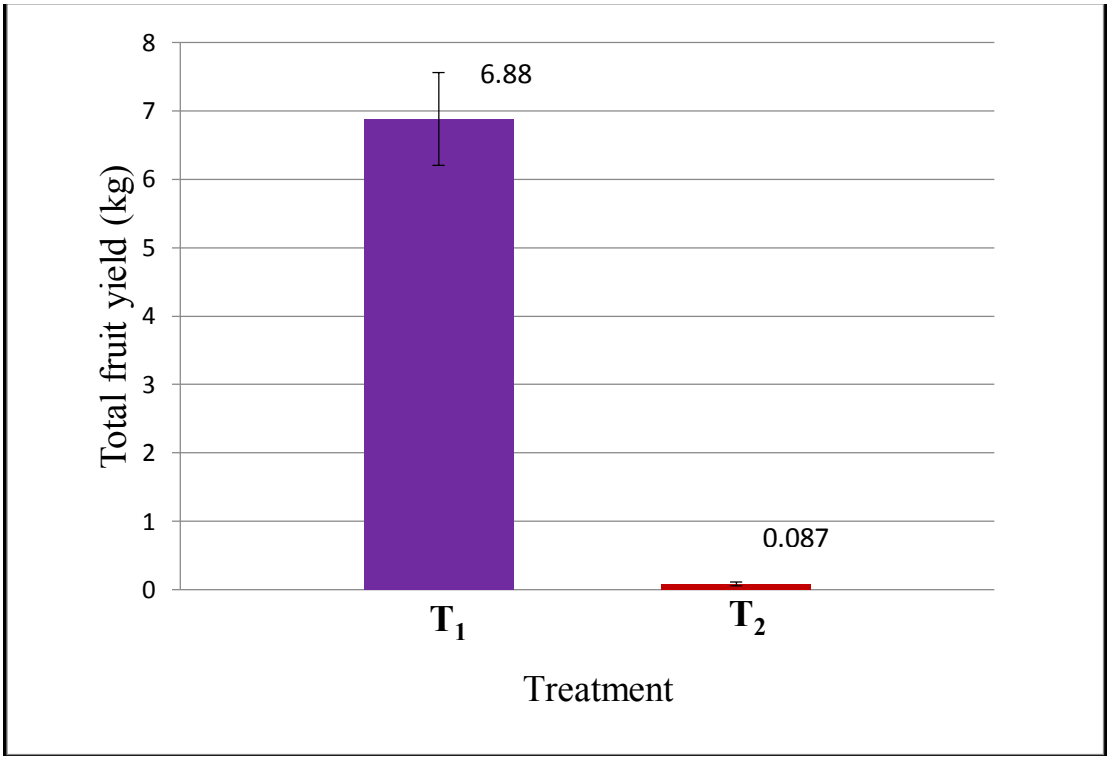



**Figure 9.** Total fruit yield plant$^{-1}$.

**Percent reduction of flowers, fruits, weight fruit$^{-1}$, fruit yield plant$^{-1}$ due to mealybug infestation**

Due to infestation of mealybug, number flowers, number of fruits, weight of individual fruit, fruit yield were reduced by 86.23%, 89.43%, 88.01% and 98% respectively per plant.

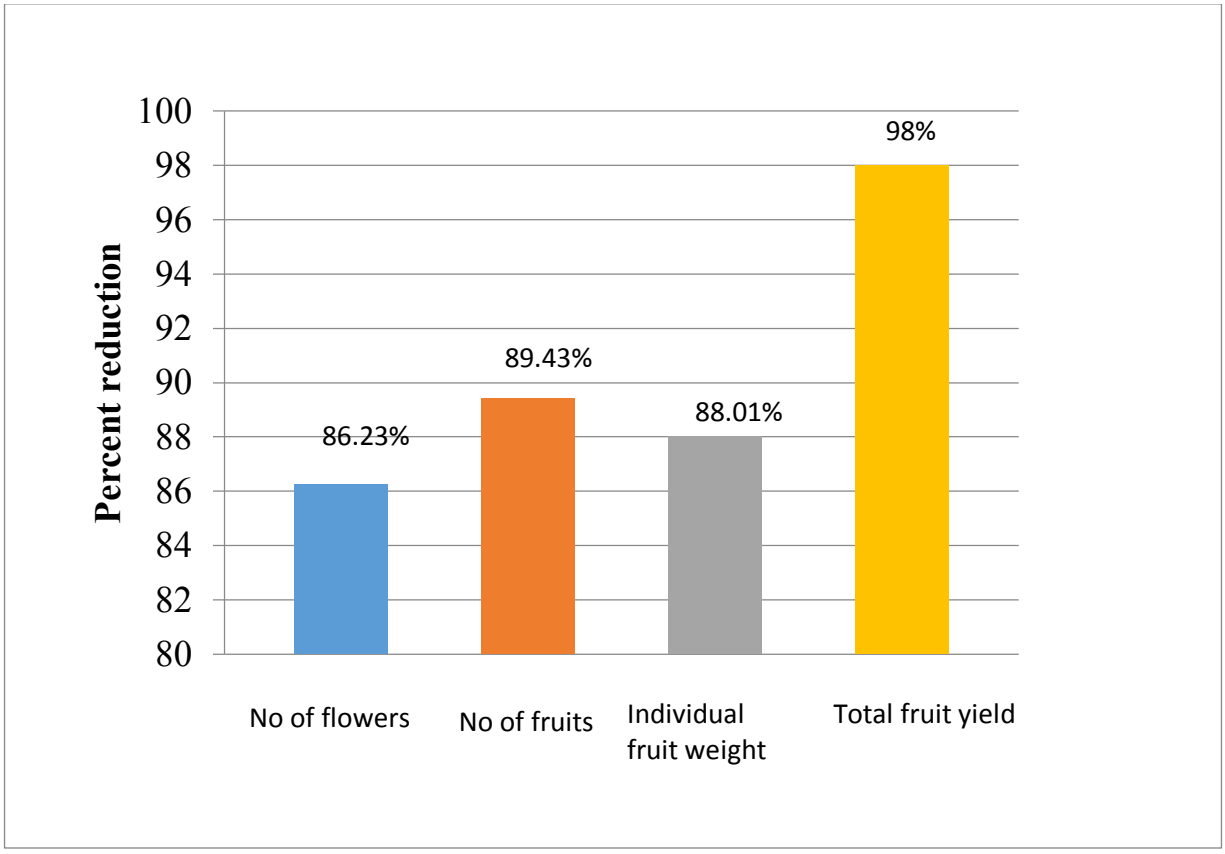



**Figure. 10** Percent reduction of flowers, fruits, weight fruit$^{-1}$, fruit yield plant$^{-1}$ due to mealybug

**Research highlight/findings**

- Papaya mealybug was found in all surveyed districts (Dhaka, Gazipur, Tangail, Narshindi, Rajshahi, Bogura, Joypurhat, Natore, Pabna, and Kustia).
- Percent infestation of plant, branch, flower and fruit was found as 32.31 to 46.16, 46.30 to 63.33, 26.16 to 53.66 and 16.29 to 75.98 respectively. Highest infestation found in Joypurhat district and lowest infestation was found in Rajshahi district.
- *Paracoccus marginatus* was the only species which was found from 10 selected districts.
- Papaya mealybug reduced 98% yield plant.$^{-1}$

**B. Implementation Position**

**1. Procurement:**

| Description of equipment and capital items | PP Target | | Achievement | | Remarks |
|---|---|---|---|---|---|
| | Phy (#) | Fin (Tk) | Phy (#) | Fin (Tk) | |
| (a) Office equipment | | | | | N/A |
| (b) Lab &field equipment | Apparatus | 205500 | Bought | 205500 | |
| (c) Other capital items | • Laptop computer<br>• Printer<br>• Digital camera<br>• Stereo microscope | 50000/-<br><br>15000/-<br>25000/-<br>300000/- | Bought | 50000/-<br><br>15000/-<br>25000/-<br>300000/- | |

**2. Establishment/renovation facilities:**

| Description of facilities | Newly established | | Upgraded/refurbished | | Remarks |
|---|---|---|---|---|---|
| | PP Target | Achievement | PP Target | Achievement | |
| | | | | | N/A |
| | | | | | N/A |
| | | | | | N/A |
| | | | | | N/A |

**3. Training/study tour/ seminar/workshop/conference organized:**

| Description | Number of participant | | | Duration (Days/weeks/ months) | Remarks |
|---|---|---|---|---|---|
| | Male | Female | Total | | |
| (a) Training | | | | | N/A |
| (b) Workshop | | | | | N/A |

**C. Financial and physical progress**

**Fig in Tk**

| Items of expenditure/activities | Total approved budget | Fund received | Actual expenditure | Balance/ unspent | Physical progress (%) | Reasons for deviation |
|---|---|---|---|---|---|---|
| A. Contractual staff salary | 407180/- | 407180/- | 407180/- | 0 | | |
| B. Field research/lab expenses and supplies | 461275/- | 461275/- | 460802/- | 473/- | | |
| C. Operating expenses | 115000/- | 103205/- | 103205/- | 0 | | |
| D. Vehicle hire and fuel, oil & maintenance | 50000/- | 50000/- | 50000/- | 0 | | |
| E. Training/workshop/seminar etc. | | | | | | |
| F. Publications and printing | 74920/- | 15000/- | 14920/- | 80/- | | |
| G. Miscellaneous | 1825/- | 1688/- | 1600/- | 88/- | | |
| H. Capital expenses | 389800/- | 389800/- | 389800/- | 0 | | |

**D. Achievement of Sub-project by objectives: (Tangible form)**

| Specific objectives of the sub-project | Major technical activities performed in respect of the set objectives | Output(i.e. product obtained, visible, measurable) | Outcome(short term effect of the research) |
|---|---|---|---|
| To know the distribution of papaya mealybug in 10 selected districts. | • Survey of the selected districts<br>• Mealybug species collection | Mealybug species were collected from 10 districts. Pest management to be taken in mealybug infested areas. | Timely and properly management action against mealybug infestation of the selected districts would be possible. |
| To determine the damage severity of papaya mealybug in major papaya growing districts of Bangladesh | • Stems, leaves, inflorescence and fruits of papaya observed visually and number of insects were counted in infested twigs, branches, stems, leaves, inflorescences and fruits | Percent infestation of plant, branch, flower and fruit was found 32.31 to 46.16, 46.30 to 63.33, 26.16 to 53.66 and 16.29 to 75.98 respectively. | Integrated management of the mealybug pest could be possible based on the plant stages attacked by the pest. |
| To know the species diversity of papaya mealybug in Bangladesh. | • Mealybug species were studied under microscope to observe morphological characters for identification | *Paracoccus marginatus* was the only species which was found from 10 selected districts | Pest management action can be taken only for one species *Paracoccus marginatus*. The information can be used by the researcher, scientists, academician, extension personnel and the stakeholder of the country. |
| To assess the extent of loss caused by papaya mealybug | • Damage assessment was done by comparing the production of infested plant with uninfested plant in field. | Papaya mealybug reduced 98% yield plant.$^{-1}$ | The results clearly indicate the papaya mealybug is a devastating pest of the papaya plant and thus appropriate management technique need to be developed to save papaya crop in Bangladesh. |

**E. Materials Development/Publication made under the Sub-project:**

| Publication | Number of publication | | Remarks (e.g. paper title, name of journal, conference name, etc.) |
|---|---|---|---|
| | Under preparation | Completed and published | |
| Technology bulletin/ booklet/leaflet/flyer etc. | | | |
| Journal publication | | | |
| Information development | | | |
| Other publications, if any | | **MS thesis**<br>1. Infestation intensity of papaya mealybug (*Paracoccus marginatus*) in farmer's field and its management<br>2. Biology and damage assessment of papaya mealybug, *paracoccus marginatus* | |

**F. Technology/Knowledge generation/Policy Support (as applied)**

**Generation of new knowledge that help in developing more technology in future**

- Papaya mealybug is exists 10 selected districts.
- Highest infestation was found in Joypurhat district and lowest was found in Rajshahi district.
- Mealybug species *Paracoccus marginatus* is only the species found in 10 selected districts.
- Papaya mealybug reduced 98% yield.

**G. Information regarding Desk and Field Monitoring**

| Name with position | Organization |
|---|---|
| 1.Dr. Md. Aziz Zilani Chowdhury, Member Director (Crop) | BARC, Farmgate, Dhaka |
| 2.Mr. Md. Rafique Ahsan Chowdhury, Scientific officer, Crop Zoning Project | BARC, Farmgate, Dhaka |

**H. Lesson learned**

The results suggest that papaya mealybug is a big threat to papaya cultivation and thus effective environmentally safe low cost management technique(s) for the pest are to be developed.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal