HOST DIVERSITY AND DAMAGE ASSESSMENT OF MEALYBUG IN BANGLADESH

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MASTER 0F SCIENCE

IN

ENTOMOLOGY

DEPARTMENT OF ENTOMOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207, BANGLADESH

JUNE, 2017

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Reg. No. 11-04260

A thesis

Submitted to the Department of Entomology,
Sher-e-Bangla Agricultural University, Dhaka-1207
in partial fulfillment of the requirements
for the degree of

MASTER 0F SCIENCE

IN

ENTOMOLOGY

SEMESTER: JANUARY-JUNE, 2017

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CERTIFICATE

This is to certify that the thesis entitled, "**HOST DIVERSITY AND DAMAGE ASSESSMENT OF MEALYBUG IN BANGLADESH**" submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in ENTOMOLOGY** embodies the result of a piece of bona fide research work carried out by **G. M. APEL MAHMUD**, Registration No. **11-04260** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: June, 2017
Place: SAU, Dhaka, Bangladesh

Professor Dr. Md. Razzab Ali
Supervisor

Dedicated To

My Beloved Parents

Acknowledgement

All praises to the Almighty and kind full trust on to “Omnipotent Creator” for His never-ending blessing, the author deems it a great pleasure to express his profound thankfulness to his respected parents, who endured much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor, Dr. Md. Razzab Ali, Professor, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period, gratuitous labor in conducting and successfully completing the research work, and in the preparation of the manuscript.

The author also grateful to his respected Co-Supervisor, Dr. TahminaAkter, Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for her scholastic guidance, helpful comments and constant inspiration, inestimable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses his sincere gratitude towards the sincerity of the Chairman, Dr. Mst. NurMohalAkhterBanu, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for her valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Entomology, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

Date: June, 2017 The Author

Place: SAU, Dhaka.

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ABSTRACT

The study was conducted in 30 upazilla of 10 selected major crop growing districts of Bangladesh during the period from January to May 2017 to find out the present status and diversity of mealybug pest, their risks and management options. The data were collected through interview of 300 crop growing farmers considering 10 farmers from each upazilla and 100 farmers participated in focus group discussion (FGD). The data were analyzed using computer program SPSS 20.0 version. The field study that was conducted among 300 farmers, majority(82%) was male farmers, while only 18% farmers were female. Among them 106 farmers (35.21%) were field crop farmers, whereas 26.16% farmers (78) were vegetable growers, whereas 20.72% farmers (62) were fruit growers and the lowest proportion 17.9% farmers (54) were flower growers. About 95% of them (286) responded about mealybug infestation in their crop field.Most (56.8%) of the farmers reported cotton as a major field crop host of mealybug. Most (46.11%) of the farmers (138) reported that the durba grass was infested in the field by mealybug. Among different vegetables, 51.03% farmers (153) reported mealybug incidence occurred in papaya.In terms of fruit plants, jackfruit, mango and guava were infested severely as reported by 96.2%, 95.5% and 93.3% farmers, respectively.In case of forest tree, most (51.57%) of the farmers (155) reported that the sisso tree was infested by mealybug.In case of flower plant, 47.9% of the farmers reported that the china rose was mostly infested flower plant in the field by mealybug.All of the 300 farmers took action for controlling mealybug.About 97.08% of the farmers (291) sprayed insecticides on their plants to control mealybug, removing weeds, hand picking, soap water, IPM also used as control option. Maximum 88.92% farmers (267) used fighter as an effective insecticide, several insecticides like malathion, ethrin, imidachloprid, darsban, sumithion, native, mipsin, ripcord, cypermethrin and aktarawere also used for controlling of mealybug.

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ABBREVIATIONS AND ACRONYMS

AEO	=	Agricultural Extension Officer
Ann.	=	Annual
BADC	=	Bangladesh Agriculture Development Corporation
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BCSIR	=	Bangladesh Council of Scientific and Industrial Research
Biol.	=	Biology
Ca	=	Calcium
DAE	=	Department of Agricultural Extension
e.g.	=	exempli gratia (L), for example
Entomol.	=	Entomology
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
FGD	=	Focus Group Discussion
i.e.	=	id est (L), that is
K	=	Potassium
M.S.	=	Master of Science
Na	=	Sodium
Rev.	=	Review
SAAO	=	Sub Assistant Agricultural Officer
Sci.	=	Science
UAO	=	Upazilla Agricultural Officer
var.	=	Variety
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Mealybugs are the insects in the family Pseudococcidae, found in moist, warm climates. They are considered as pests as they feed on plant juices of greenhouse plants, house plants and subtropical trees and also act as a vector for several plant diseases. Mealybugs are cottony in appearance, small oval, soft-bodied sucking insects. Adult mealybugs are found on leaves, stems and roots and are covered with white mealy wax, which makes them difficult to eradicate. They form colonies on stems and leaves developing into dense, waxy, white masses. They suck a large amount of sap from leaves and stems with the help of piercing/sucking mouth parts, depriving plants of essential nutrients. The excess sap is excreted as honeydew which attracts ants and develops sooty mould inhibiting the plant's ability to manufacture food (Miller, 1991).

About 5000 species of mealybugs have been reported from 246 families of plants throughout the world. Among these, 56 species have been reported from 15 genera of family Malvaceae, including cotton and many other plants of economic importance (Ben-Dov, 1994).

Pseudococcus is a genus of unarmoured scale insects in the family Pseudococcidae, the mealybugs. There are more than 150 species of *Pseudococcus*. *Pseudococcus maritimus*, the grape mealybug, is a scale insect species in the genus *Pseudococcus* infesting grapevines. It is also a vector of little cherry disease (Mekuria *et al.*, 2013).

In the current decade, the trend of increased build up of various mealybug species in crop plants and in the wild is observed mainly due to certain abiotic changes in climate and environment. During the last few years mealybugs, which were considered to be minor pests in many crops have acquired the status of major pests

especially in cotton, vegetables and fruits. Recently in India the cotton crop in Punjab, Rajasthan, Maharashtra and Gujarat is being seriously infested with mealybug. During 2005, the sudden appearance of the pest in cotton in Multan, Sanghar, Mirpurkhas and Tando Allahyar of Pakistan destroyed the entire crop within a few days (Muhammad, 2007).

In Brazil, mealybug are small phoem-sucking insects, the nymphs and adults females of which feed by sucking sap from the trunk, roots, leaves, rachis and fruits of grapevines, causing direct and indirect damage, depending on the species and the site used for feedling (Golino *et al.,* 2002)

The most serious pests are mealybugs that feed on citrus; other species damage sugarcane, grapes, pineapple (Jahn *et al.*, 2003), coffee trees, cassava, ferns, cacti, gardenias, papaya, mulberry, sunflower and orchids. Mealybugs only tend to be serious pests in the presence of ants because the ants protect them from predators and parasitoids (Johnson *et al.,* 2001). Mealybugs also infest some species of carnivorous plant such as Sarracenia (pitcher plants); in such cases it is difficult to eradicate them without repeated applications of insecticide such as diazinon. Small infestations may not inflict significant damage. In larger amounts though, they can induce leaf drop. In Bangladesh, there are different types of crops are cultivated. A large number of crops are affected by different types of mealybugs. The major mealybug affected districts are Norshingdi, Manikgonj, Gazipur, Comilla, Chapainwabgonj, Chittagong, Bogra, Jessore, Jhenidah, Dhaka.

But, there is no comprehensive list of insect pests risk of mealybug in different crops along with the status and damage intensity in Bangladesh. Therefore, the incidence, distribution and infestation severity are need to be investigated. In this context, the risk analysis of mealybug in Bangladesh is indispensable. Thus, the study on risk

analysis of mealybug in Bangladesh was conducted aiming to identify incidence of mealybug in different crops grown areas and evaluate their risk as well as to identify risk management options.

Objectives

Considering the above facts and points, the present research program has been designed with the following objectives:

1. Listing of major and minor hosts of mealybug in Bangladesh;
2. To conduct risk analysis of different mealybug species in Bangladesh and
3. To identify the control measures for the management of mealybug in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

2.1 Mealubug

Mealybugs belonging to the family Pseudococcidae under Homoptera order of class Insecta are cottony in appearance, small oval, soft-bodied sucking insects. Adult mealybugs are found on leaves, stems and roots and are covered with white mealy wax, which makes them difficult to eradicate. They form colonies on stems and leaves developing into dense, waxy, white masses. They suck a large amount of sap from leaves and stems with the help of piercing sucking mouth parts, depriving plants of essential nutrients.

Taxonomic position

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Homoptera

Suborder: Sternorrhyncha

Superfamily: Coccoidea

Family: Pseudococcidae/Monophlebidae (Heymons, 1915)

2.2 Geographical distribution

Mealybugs occur in all parts of the world. Mostly occur naturally only in warmer parts, and get introduced into greenhouses and other buildings in cooler countries. It is unlikely that they live in the Arctic or Antarctic, except perhaps in buildings. The solenopsis mealybug (*Phenacoccus solenopsis*) was originally described in New Mexico in 1897. First discovered in cotton crops in Texas in 1990, it caused widespread damage. Two years later it was present in Central America, the Caribbean and Ecuador. Significant damage and crop losses occurred in India and Pakistan in 2004, and by 2008 the mealybug had spread to China. Solenopsis was first detected in

Australia during the 2009-10 season on cotton in the Emerald and the Burdekin regions (Anonymous, 2013).

Solenopsis mealybug is widely distributed throughout the cotton and horticultural production regions of Queensland at low densities, and outbreaks could occur when local conditions are suitable. It is present on cotton in the Burdekin, Emerald and the South Burnett, and at low densities on one cotton farm on the Darling Downs. It has also been identified on ornamental plants in Brisbane and Bundaberg. Todate there have been no sightings in NSW (Vennila *et al.*, 2009).

Australia has a number of native mealybug species including the long-tailed mealybug (*Pseudococcus longispinus*), the citrophilus mealybug (*Pseudococcus calceolariae*) and the golden mealybug (*Nipaecoccus aurilanatus*). These species do not attack cotton (Anonymous, 2013).

The passionvine mealybug, *Planococcus minor* (Maskell), is also known by the common names pacific mealybug and guava mealybug. *P. minor* is one of 35 species belonging to this genus, which is native to the Old World (Cox, 1989). The genus also includes many well-known pests of economic plants such as *Planococcus citri* (Risso) and *Planococcus ficus* (Signoret) (Williams & Watson, 1988; Cox, 1989). The passionvine mealybug was originally described by Cox (1981) as *P. pacificus* from material collected from the South Pacific region. Later, Cox (1989) placed the lectotype, *Pseudococcus calceolariae* var. *minor* Maskell, previously regarded as a synonym of *P. citri* as *P. minor*, and *P. pacificus* was synonymized with it. *Planococcus minor* is widely distributed throughout the Oriental, Austro-Oriental, Australian, Polynesian, Nearctic, Afrotropical, Malagasian, and Neotropical regions (Williams & Willink, 1992). The identification of many species in the genus *Planococcu*s using morphological characters has been challenging (Cox & Wetton,

1988). Two such examples are *P. citri* and *P. minor*, which have been taxonomically confused and routinely misidentified due to similarity in appearance, host plant range, and geographic distribution (Williams, 1985). Several authors highlighted inaccuracies in past literature, where the species of *Planococcus* commonly occurring in the Austro-oriental, Polynesian regions, and the Neotropics, was *P. minor* and not *P. citri*, despite most published records listing the latter (Cox & Freeston, 1985).

These early misidentifications emphasize the significance of the morphological scoring matrix developed by Cox (1983). This author first determined that *P. minor* could be distinguished from *P. citri* by differences in the number and size of key morphological characters on the body such as ventral tubular ducts, multilocular disc pores, and the ratio of length of hind tibia + tarsus to length of trochanter + femur. Because these characters vary appreciably under different environmental conditions, she developed a matrix of six diagnostic characters, and these characters were scored using a point system to identify adult females based on their total numbers, presence or absence, and width on the body. Specimens having a total score of 0 to 35 from both sides of the body were determined to be *P. minor*, while those having a total score of 35 to 120 were determined to be *P. citri*. This system is still relied upon by mealybug taxonomists to separate these two species. Molecular diagnostic techniques have been useful for distinguishing mealybugs in the genus *Planococcus*, and a rapid and more dependable method to identify such cryptic species accurately has important ecological and diagnostic implications (Demontis *et al*., 2007).

A survey and seasonal abundance of mealybugs and their associated parasitoid and predators species were conducted on guava trees in Giza Governorate, Egypt for two years, (January 2014 to December 2014). Fifteen plants were randomly chosen and five leaves/plant were collected biweekly, one from the four cardinal directions and

the middle of the inspected trees. Four mealybug, 6 predatory, 8 primary parasitoid species (6 parasitoids on mealybugs and two on coccinellids) and one hyperparasitoid were recorded (Adly *et al., 2016*). The most dominant insect species were; the mealybug *Ferrisia virgate* (Ckll.), the predator *Scymnus syriacus* (Mars.), the parasitoid that attacked coccicinellids *Homolotylus vicinus* Silvestri, the primary parasitoid of mealybugs, *Gyranusoidea indica*, *Leptomastrix dactylopii* and the hyperparasitoid, *Chartocerus subaeneus* (Foerester). *F. vignata* is the first record on guava trees in Egypt and the primary parasitoid *Aenasius sp*. was recorded for the first time in the Egyptian fauna (Adly *et al.,* 2016)

2.3 Morphology

The external diagnostic characters include 18 pairs of short, stout wax filaments along margins, of which the anal and two preceding pairs are slightly longer than the rest but less than 20% of body length. Dorsum covered with fine mealy wax with a slightly darker, longitudinal, median stripe from first thoracic to mid-abdominal segments. Body colour beneath wax is usually yellow to peach pink. Antenna 8 segmented. Authoritative identification requires microscopic study of slide-mounted females; Sirisena *et al.* (2013) provided a method for preparation of slide mounts of adult females.

Body of slide-mounted adult female oval, 1.6-3.2 mm long, 1.2-2.0 mm wide (Cox, 1989). Body margin with 18 pairs of cerarii, each cerarius with two conical setae except for the pre-ocular pair which may have one or three setae each. Legs elongate; hind trochanter + femur 220-350 µm long; hind tibia + tarsus 260-420 µm long. Ratio of hind tibia + tarsus to hind trochanter + femur 1.1-1.3; translucent pores present on hind coxae and tibiae. Circulus quadrate, width 120-200 µm. Cisanal setae shorter than anal ring setae. Anal lobes moderately developed; anal lobe cerarii each situated

on a small, moderately sclerotized area; venter of each anal lobe with sclerotized anal lobe bar bearing apical seta and bar seta.

Mealybug is a bisexual insect with multiple generations annually. Like other mealybugs, this species is distinguished by the morphology of the adult female. Adult females are covered with a powdery, waxy secretion with six pairs of transverse, dark bands that are located across the pro- to meta-thoracic segments. A series of waxy filaments extend from around the margin of the body with the pair of terminal filaments longest. The ovisac is composed of fluffy, loose-textured wax strands (Kosztarab, 1996). Adult females range from 2 to 5 mm long and 2 to 4 mm wide. Slide-mounted females are distinguished ventrally by the presence of nine-segmented antennae, five-segmented legs with translucent pores on meta-femur and meta-tibia, each claw with a minute tooth, two sizes of oral collar tubular ducts, absence of quinquelocular pores, a large circulus, and a series of multilocular pores concentrated around the vulva and submarginal areas of abdominal segments (Kosztarab, 1996). On the dorsum, 18 pairs of cerarii, each with two spinose setae, are located around the marginal area, with evenly distributed trilocular pores, and minute circular pores. Also, oral rim ducts, oral collar tubular ducts, and multilocular pores are absent on the dorsum. Upon hatching, female development consists of first (crawler), second, and third instars and the adult, whereas males undergo first, second, prepupa, pupa and adult stages of development. The mealybugs damage the plant by extracting sap, which stresses the plant, resulting in leaves becoming chlorotic and shedding over time, as well as fruit bodies being aborted. Flowers or fruit not shed often take on an abnormal shape, reducing yield. Infested leaves of sunflowers were reported to become curled, crinkled and acquiring a rosette pattern with the plant appearing bushy and stunted (Jagadish *et al.*, 2009). In addition, the high numbers of developing

mealybugs produce large amounts of honeydew that fall onto the lower leaves producing a substrate for the development of sooty mold, which inhibits photosynthesis within the plant. The honeydew attracts ants that collect the material rich in carbohydrate, sugars, amino acids and minerals to feed to their brood. The foraging ants enter into a mutualistic association with the mealybugs by collecting the honeydew and keeping the area clean of the excess waste product, while protecting the mealybugs from potential natural enemies. The production of honeydew and its occurrence on the lint can also interfere with the processing of the cotton by making the ginning process more difficult.

Plate 1. Mealybug adult female

Plate 2. Mealybug adult male

Plate 3. Mealybug adult females in cluster

Plate 4. Mealybug eggs enclosed inside the egg sac

Plate 5. Mealybug eggs

Plate 6. Adult female mealybugs and crawlers

2.4 Biology

Mealybugs are sexually dimorphic: females appear as nymphs, exhibiting reduced morphology, and lack wings, although unlike many female scale insects, they often retain legs and can move. Males are smaller, gnat-like and have wings. Since mealybugs (as well as all other Hemiptera) are hemimetabolous insects, they do not undergo complete metamorphosis in the true sense of the word. However, male mealybugs do exhibit a radical change during their life cycle, changing from wingless, ovoid nymphs to wasp-like flying adults. Mealybug females feed on plant sap, normally in roots or other crevices, and in a few cases the bottoms of stored fruit. They attach themselves to the plant and secrete a powdery wax layer (hence the name mealybug) used for protection while they suck the plant juices. In Asia, mango mealybug is considered a major menace for the mango crop. The males on the other hand are short-lived as they do not feed at all as adults and only live to fertilize the females. Male citrus mealybugs fly to the females and resemble fluffy gnats. Despite the threat posed by this pest, there is still a lack of detailed life history data on *P. minor*. Furthermore, because of the taxonomic difficulty of separating this species from *P. citri*, there is uncertainty regarding the identity of some of the mealybugs used in earlier studies since the two species often occur together. Developmental Biology The few studies undertaken on the life history of *P. minor* were conducted at either a single temperature (Martinez & Suris, 1998) or fluctuating temperature regimes on different readily available host plants (Maity *et al.,* 1998; Biswas & Ghosh, 2000). Eggs 19 took as little as 2-5 days to hatch at 26° development time for males was longer than for females (Maity *et al.,* 1998), and the time to complete a single generation ranged from 31-50 days (Biswas & Ghosh, 2000). These differences in methodologies therefore complicate efforts in estimating key life history

parameters of *P. minor* and the employment of these data in predicting its potential spread and distribution.

2.5 Reproductive Biology

Some species of mealybug lay their eggs in the same waxy layer used for protection in quantities of 50–100; other species are born directly from the female. Most mealybug species reproduce sexually (Gullan & Kosztarab, 1997), but studies to determine if reproduction is achieved asexually through parthenogenesis have never been undertaken for *P. minor*. However, both sexes occur in populations where males can mate multiple times and have been reported to be less numerous than females (Maity *et al.,* 1998). The preoviposition and oviposition periods of gravid females ranged from 6-11 and 8-14 days (Maity *et al.,* 1998), and 6-8 and 8-9 days (Biswas & Ghosh 2000). Findings from the few studies conducted showed that fecundity varied depending on the host plant. Biswas & Ghosh (2000) reported 66-159 eggs on *Ixora signaporensis*, soybean (*Glycine max*), and *Acalypha wilkesiana*. However, Maity *et al*. (1998) reported as many as 266-426 eggs on taro (*Colocasia esculenta*), sprouted potato (*Solanum tuberosum*), and pumpkin (*Cucurbita moschata*). In warm climates, these mealybugs stay active and reproduce throughout the year (Ben-Dov, 1994). Sahoo *et al.* (1999) reported as many as 10 generations occurring per year in India.

2.6 Influence of weather factors on the growth and development of mealybug

An insect's rate of development is affected by the temperature it is exposed to (Campbell *et al.,* 1974), and its development occurs within a definite range of temperature (Wagner *et al.,* 1984). The amount of heat required over time for an insect to complete some aspect of development is a thermal constant (Campbell *et al.,* 1974). The developmental thresholds are the temperatures below or above which no development occurs, and the upper and lower thresholds along with the thermal

constant are useful indicators of potential distribution and abundance of an insect (Huffaker *et al.,* 1999). Mathematical models that describe developmental rates as a function of temperature are therefore important in predicting the seasonal occurrence of insects (Wagner *et al.,* 1984). Two such models are the thermal summation model (Campbell *et al.,* 1974) and Logan 6 model (Logan *et al.,* 1976), which are widely used to explain the relationship between developmental time and temperature. Data such as thermal constants and temperature thresholds derived from these mathematical models can be used by simulation models such as CLIMEX and NAPPFAST to help predict potential spread and distribution of *P. minor* in the continental U.S.

2.7 Injury symptoms

Mealybugs have piercing-sucking mouthparts which they insert into the plant vascular tissue, and they can remain in place through several molts (Arnett, 1993), sucking up plant sap (Daane, 2003). Feeding activity of *P. minor* causes reduced yield, lower plant or fruit quality, stunted growth, discoloration, and leaf loss (Venette & Davis, 2004). In some cases, some species often reach high densities (Ben-Dov, 1994), killing perennial plants (Walton *et al.,* 2004). Plant death may also be caused by viral diseases because *P. minor* is known to be a vector of important viruses (Williams, 1985; Cox, 1989). One such example known to occur in Trinidad is Cacao (Trinidad) virus and its various isolates (Kirkpatrick, 1950). In such cases, these mealybugs may be economic pests even at low densities (Franco *et al.,* 2009).

Similar to other pseudococcids, *P. minor* excretes copious amounts of honeydew onto the plant. Up to 90% of the ingested plant sap may be excreted in this way by mealybugs (Mittler & Douglas, 2003). Sooty mold grows on the honeydew and builds up on the leaves, shoots, fruits, and other plant parts (Mani, 1989). This mold can

cover so much of the plant that it interferes with the plant's normal photosynthetic activity (Williams & Willink, 1992). Honeydew and sooty mold cause cosmetic defects to plants and/or their fruits, which become soiled even from small mealybug populations, and they directly affect the sale of such produce (Millar *et al.,* 2002).

2.8 Economic importance and host range

Venette & Davis (2004) have compiled a list of more than 250 wild and cultivated host plants in nearly 80 families that are reportedly attacked by *P. minor*. Franco *et al.* (2009) noted that most of the economically important mealybug species are associated with long lists of hosts, yet under low pressure of natural enemies they spread in new areas and are observed on relatively large numbers of host plants. This polyphagous pest has also become established in some temperate areas in greenhouses where it can be a serious horticultural pest (Williams & Watson, 1988). Additionally, plant host susceptibility to *P. minor* can vary widely (Venette & Davis, 2004), and infestation levels can fluctuate spatially, even on plants in close proximity (Miller & Kosztarab, 1979). With this potentially wide host plant range, it is reasonable to anticipate that *P. minor* will find and utilize additional new hosts as it spreads throughout the geographic limits of its distribution in new habitats (USDA, APHIS, 2002). Therefore, any local survey needs to also take into account those local susceptible plant species, which may prove to be hosts (USDA, APHIS, 2002). Although some species of *Planococcus* have a wide host plant range, a few such as *P. minor* show distinct preferences, commonly occurring on cocoa (*Theobroma cacao*) throughout its geographic range (Cox, 1989).

Since multiple species from the genus *Planococcus* may occur on the same host plant, it becomes difficult to estimate the economic impact of *P. minor* alone (Venette & Davis, 2004). Although widely distributed, this mealybug is not reported as an

economic pest in many countries. Additionally, some earlier host records in certain regions might be erroneous because of misidentification as *P. citri* (Cox, 1989). For example, Szent-Ivany (1956) reported it as *P. citri* from Papua New Guinea where it seriously damaged coffee (*Coffea* spp.). Szent-Ivany & Stevens (1966) again reported it as *P. citri* where it comprised more than 90% of a mixed population with another pseudococcid and two different soft scales on coffee, and caused 70-75% reduction in crop yield. In India, this mealybug was reported as part of a *Planococcus* spp. complex or singly attacking custard apple (*Annona reticulata*) (Shukla &Tandon, 1984); grape (*Vitis* spp.) (Batra *et al.,* 1987; Tandon & Verghese, 1987); ber (*Ziziphus* sp.), guava (*Psidium guajava*), and mangoes (*Mangifera indica*) (Tandon & Verghese, 1987); and coffee (Reddy *et al.,* 1997). In Taiwan, it was listed as a major pest of important crops, including banana (*Musa* spp.), *Citrus* spp., mango, celery (*Apium* spp.), melon (*Benincasa* sp.), pumpkin (*Cucurbita* spp.), soybean (*Glycine max*), betel nut (*Areca catechu*), star fruit (*Averrhoa carambola*), guava, and passionvine (*Passiflora* spp.) (Ho *et al.,* 2007).

2.9 Host preferance

The movement of invasive mealybugs (Hemiptera: Pseudococcidae) which are major pests of a wide range of agricultural, horticultural and ornamental plants worldwide has been documented by Muniappan (2011). As envisaged in the paper after the invasion of papaya mealybug, and *Phenacoccus madeirensis* (Madeira mealybug), the Jack Beardsley mealybug was recorded in India (Mani *et al.*, 2012). Certain of attributes of the Pseudococcidae, viz., wide host range, short generation time, cosmopolitan nature, ability to transmit some important plant viruses, etc., have contributed to their enormous damage potential (Meyer *et al.*, 2008). In this regard, *Pseudococcus jackbeardsleyi* Gimpel and Miller (Hemiptera: Pseudococcidae),

known as the Jack Beardsley mealybug, a polyphagous species of neotropical origin commonly occurring in Caribbean and Central and South America, that is known to attack 93 plant species including several vegetable and fruit and ornamental crop species (CAB Intl., 2001) has entered India infesting several of crop plants. The invasive mealybug is greyish in colour; thin filaments around the body, caudal pair about one half of the length of the body, and ovisac covering hind part of the body (Williams, 2004). The presence of ovisac differentiates it from *Pseudococcus longispinus* (Targioni Tozzetti). Morphological details of the *P. jackbeardsleyi* occurring in India are given by Mani *et al.* (2012).

Survey for invasive insects in southern parts of India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu, and Karnataka. It was found associated with papaya mealybug on papaya at Ravindranath Tagore Nagar in Bangalore. Other plants in the area like *Cordyline terminalis* (Agavaceae), an ornamental plant native to Southeast Asia, Australia, New Zealand was found to harbour *P. jackbeardsleyi*. The nymphs were found scattered on the leaves singly, similarly it was found on flowers of custard apple (*Anonna squamosa*), Purple martin (*Streptocarpus sp.*) Jasmine (*Jasminum multiform*) in pure form. Along with papaya mealybug, *Paracoccus marginatus*, it was found in papaya, tapioca, chrysanthemum and Indian spinach (*Basella alba*). It is associated with *P. solenopsis* on parthenium and chrysanthemum. In some crops it was associated with aphids and spiraling whiteflies as in case of basil, chrysanthemum and jasmine. The Jack Beardsley mealybug is distributed throughout the Neotropical region and a few countries in southern Asia (Williams and Watson, 1988).

Jack Beardsley mealybug is a polyphagous species known to attack 93 plant species including several vegetable and fruit and ornamental crop species (CAB Intl., 2001).

United States quarantine department recorded on a wide diversity of hosts from annuals such as peppers, eggplant, and tomatoes to many tropical fruit trees, and tropical shrubs, and ornamentals. It has been recorded on more than 35 host plant families at quarantine interceptions at US ports. Importation consignments of fresh potatoes from Mexico were found to contain *P. jackbeardsleyi* (USDA APHIS, 2003). As many as 22 plant species have been reported as hosts of *P. jackbeardsleyi* in Asian countries (Williams, 2004) including banana, *Aglaonema*, *Dieffenbachia*, tomato, potato, pepper, *Hibiscus*, *Anthurium*, orchids, floral ginger, *Annona*, *Dracaena*, and ivy gourd. It was originally identified as the banana mealybug in Hawaii (Beardsley, 1986).

Ever since the first report of this invasive mealybug, the host range is expanding day by day in India. Several of the host plants of *P. jackbeardsleyi* are economically important. As in case of the other invasive species observed viz., *P. solenopsis* and *P. marginatus*, in the beginning the establishment was on weeds and ornamental crops was fast and co-existence with several other sucking pests was observed. This invasive mealybug is a very slow establishing species and is expanding slowly. Some of the local natural enemies like *Cryptolaemus montrouzieri*, *Spalgis epius* and some species of gnats are keeping the spread under check. Miller *et al.* (2002) worked on the incidence and developmental stage of *P. marginatus* in different host plants in U.S.A. The genus *Paracoccus* includes some 79 species of varied distribution from the "Austro-Oriental, Ethiopian ,Madagasian, Nearctic, Neotropical, Newzealand , Pacific, Palaearetic and oriental regions" (Ben-Dov, 1994).Although most assigned species have not been recognized as major economic pest, there are two notable exception. *P.marginatus* is a polyphagous insect, it has recorded on about 55 host

plants in more than 25 genera. Economically important host plants of this severe pest are shown in Table 1.

Table 1. Host plants and references of *Paracoccus marginatus*.

Acacia sp.	Miller *et al.* (1999)
Acalypha sp.	Miller *et al.(*1999)
Acalypha wilkesiana Muell.-Arg.	Williams and Willink (1992)
Ambrosia cumanensis auct.non Kunth	Williams and Willink (1992)
Annona.squamosa L.	Miller *et al.* (1999)
Bauhinia sp.	Williams and Willink (1992)
Carica papaya L.	Miller *et al.* (1999)
Carica sp.	Williams and Willink (1992)
Cestrum nocturnum L.	Miller *et al.* (1999)
Citrux x paradisi Macfad.(pro sp.)	Williams and Willink (1992)
Clerodendrum panicuatum L.	Miller *et al.* (1999)
Coccoloba sp.	Miller *et al.* (1999)
Fistulosa sp.	Miller *et al.* (1999)
Guazuma ulmifolia Lam.	Miller *et al.* (1999)
Hamelia patens jacq.	Williams and Willink (1992)
Hamelia sp.	Williams and Willink (1992)
Hibiscus sp.	Miller *et al.* (1999)
Hibiscus rosa-sinensis L.	Williams and Willink (1992)
Ipomoea carnea jacq.	Miller *et al.* (1999)
Ipomoea sp.	Miller *et al.* (1999)
Jatropha integerrima jacq.	Miller *et al.* (1999)
Jatropha sp.	Williams and Willink (1992)
Malvaviscus penduliflorus DC.	Miller *et al.* (1999)
Manihot chlorosticta Standl.& Goldman	Williams and Willink (1992), Miller *et al.* (1999)
Manihot esculenta Crantz	Williams and Willink (1992), Miller *et al.* (1999)
Mimosa pigra L.	Williams and Willink (1992)
Parthenium hysterophorus L.	Williams and Willink (1992), Miller *et al*. (1999)
Persea americana P. Mill.	Miller *et al.* (1999)
Plumeria rubra L.	Williams and Willink (1992)
Plumeria sp.	Miller *et al.* (1999)
Rhaphiolepis umbellate (Thunb.) Makino	Williams and Willink (1992)
Sida sp.	Williams and Willink (1992), Miller *et al.* (1999)
Solanum melongena L.	Miller *et al.* (1999)
Uniola paniculata L.	Miller *et al.* (1999)
Zea mays L.	Miller *et al.* (1999)

Indra *et al.* (2008) reported that *P. marginatus* is a polyphagous pest and it has been recorded on about 55 host plants in more than 25 genera. Economically important host plants of this mealybug include papaya, *hibiscus*, pomegranate, avocado, citrus, cotton, tomato, eggplant, peppers, beans, peas, sweet potato, mango, cherry etc. In Sri Lanka *P. marginatus* has been reported in about 30 families of host plants. However, papaya (*Carica papaya* L.) had been recorded as the most preferred host plant while Manioc (*M. utilissima*) and temple trees (*Plumeria acuminata*) as the next preferred ones.

In Bangladesh there are many host plants of *P. marginatus*. At present a considerable number of host plants of papaya mealybug have been encountered attacking different vegetable, fruit and ornamental categories belonging to different families of Plant kingdom. The name of these host plants are listed below (Table 2):

Table 2: List of recorded hosts of papaya mealybug, *P. marginatus* in Bangladesh (Plant Names of Bangladesh ; Native and Scientific by Huq, 1986)

Native names	**English names**	**Scientific names**
Am	Mango	*Mangifera indica* L.
Anaras	Pineapple	*Ananas sativus* schult.
Arhar, Arhar-Dal	Pigeon pea	*Cajanus cajan* (L.) Millsp.
Babla	Blackthorn	*Acacia nilotica* (L.)
Begun	Brinjal	*Solanum melongena* wall. (Solana.)
Bhutta	Maize	*Zea mays* L. (Gramineae)
Dalim	Pomegranate	*Punica granatum* L. (Punicaceae)
Belati-gab	Mabolo	*Disopyros philippensis* (Desr.)
Desi-gab	Mabalar ebony	*Disopyros peregrina* (Gaertn.)
Dhanchi (Din)	Knotgrass	*Pologonum fagopyrum* L.
Dheras	Okra	*Abelmoschus esculentus* (L.) Moen
Hital	Mangrove date	*Phoenix paludosa* Roxb. (Palmae)
Ipil-ipil	Lead tree	*Leucaena latisiliqua* (L.) Gills (Legum.)
Jaba	China rose	*Hibiscus rosa-sinensis* L. (Malvaceae)
Kanthal	Jackfruit	*Artocarpus heterophyllus* Lamk.
Karpas, Karpastula	Karpas	*Gossypium harbaceum* L. (Malvaceae)
Lebu	Olive	*Citrus aurantifolia* (Christ.)
Pepe	Papaya	*Carica papaya* L. (Caricaceae)
Peyara	Guava	*Psidium guajava* (L.) Bat. (Myrtaceae)
Seuli	Night jasmine	*Nyctanthes arbortristis* L. (Oleaceae)

Native names	English names	Scientific names
Shimul	Cotton tree	*Bombax ceiba* L. (Bombacaceae)
Sisu	Indian rosewood	*Dalbergia sissoo* Roxb. (Leguminosae)
Til	Sesame	*Sesamum indicum* L. (Pedaliaceae)
Tomato	Tomato	*Lycopersicon lycopersicum* (L.) Karst.
Tulshi	Hoary basil	*Ocimum americanum* L. (Labiatae)
Misti alu	Sweet potato	*Ipomoea batatas* Lamk. (Convolvu.)

2.10 Control options

A number of tactics have been employed to control mealybug pests, including cultural practices that involve cutting and burning of infested plant parts, chemical control, biological control, and the use of sex pheromones (Barrett, 2000). For practical and economic reasons, insecticide use and biological control have been the most widely implemented for mealybug management.

2.10.1 Monitoring and detection

Within the genus *Planococcus*, sex pheromones have been identified and synthesized for *P. citri* (Bierl-Leonhardt *et al.,* 1981) and *P. ficus* (Hinkens *et al.,* 2001) and successfully used in monitoring programs (Ortu *et al.,* 2006). In addition to monitoring purposes, these pheromones have other potential uses, such as for mating disruption and attract-and-kill technologies (Walton *et al.,* 2006) and complement other tactics used in IPM programs.

Recently, the sex pheromone of *P. minor* was identified and synthesized (Ho *et al.,* 2007; Millar, 2008). Small doses of the pheromone were found to be very attractive to *P. minor* males in lab bioassays (Ho *et al.,* 2007). Millar (2008) suggested that sex pheromone-baited traps would therefore provide a sensitive and effective method of detecting small populations of this pest. Although positive finds on a trap do not pinpoint the exact location of an infestation, they aid in defining the area where detailed field surveys need to be undertaken (Daane, 2003). Such a monitoring system

should have an immediate impact as a detection tool in threatened or high-risk areas for introduction of *P. minor*.

2.10.2 Chemical control

Despite its frequent use, chemical control is often ineffective (Krishnamoorthy & Mani, 1989) because mealybugs are located primarily in protected sites on plants such as cracks and crevices, and under bark where insecticide penetration may be difficult (Geiger & Daane, 2001). They also have a protective wax covering and form dense colonies (Arnett, 1993) and their eggs are laid in a protective ovisac (Mani, 1989). Insecticides can also negatively impact natural enemy populations (Walton *et al.,* 2004); therefore, applications should be timed carefully to minimize disruption of these beneficial insects (Walton & Pringle, 1999). Systemic insecticides that reach all parts of the plant are currently the most effective (Daane *et al.,* 2004), and control of mealybugs has improved with the introduction of many new systemic products. Some examples include neonicotinoids such as acetamiprid, clothianidin, dinotefuran, imidacloprid, thiamethoxam, along with several insect growth regulators (IGR) that are used to control scale insects and mealybugs (Buss & Turner, 2006). Imidacloprid and an IGR (buprofezin) have provided promising results for suppression of *P. ficus* in Californian vineyards and are alternatives to in-season use of organophosphates (Daane *et al.,* 2006).

2.10.3 Biological control

Mealybugs are amenable candidates for biological control (Mani, 1988), and this option is deemed the best form of long-term control because it reduces the considerable costs associated with chemical control (Sagarra & Peterkin, 1999). Also, unlike chemical control, biological control is relatively safe for human healthn and the environment (Flint & Dreistadt, 1998). Classical biological control would most likely

be a major part of the overall control strategy against this mealybug pest. This approach involves the importation and establishment of non-native natural enemy populations for suppression of non-native or native organisms (Van-Driesche & Bellows, 1996). The steps involved in classical biological control are outlined by Van-Driesche & Bellows (1996). There have been many such programs against invasive mealybugs in recent times, including the mango mealybug, *Rastrococcus invadens* Williams in West Africa (Bokonon-Ganta *et al.,* 2002), the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) in the Caribbean and California (Roltsch *et al.,* 2006), the cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero in Africa (Neuenschwander, 2001), and the papaya mealybug, *Paracoccus marginatus* (Muniappan *et al.,* 2006). The principal mealybug natural enemies are predators and parasitoids, and the key species associated with *Planococcus* spp. are discussed below.

2.10.4 Predators

As many as 47 predators in diverse insect orders and families are known to feed on mealybugs. These include Coleoptera (coccinellids), Diptera (cecidomyiids), Neuroptera (chrysopids and hemerobiids), Lepidoptera (lycanids), and Hemiptera (Mani, 1989). Of these, coccinellid ladybird beetles are very important species. One of the most important is *Cryptolaemus montrouzieri* Mulsant, a generalist feeder, which has been utilized extensively against many mealybugs and scale insects. Successful control of *P. citri* was obtained through periodic releases of *C. montrouzieri* in citrus in California (Smith & Armitage, 1931), and it has been reported to be effective in several crops infested with *Planococcus* spp. in India (Mani & Krishnamoorthy, 2007). Much earlier, another member of the genus, *Cryptolaemus affinis* crotch was also reported to be effective against *P. minor* in Papua New Guinea

(Szent-Ivany & Stevens, 1966). The biology of another coccinellid, *Brumoides suturalis* (Fabricius) has also been investigated in some detail as a potential control agent for a number of mealybug pests including *P. minor* (Chandrababu *et al.,* 1999).

2.10.5 Parasitoids

Parasitoids utilized for biological control belong to the orders Hymenoptera and to a lesser extent, Diptera (Van-Driesche & Bellows, 1996). Important hymenopteran parasitoids of *Planococcus* spp. belong to the family Encyrtidae and include the solitary endoparasitoids, *Leptomastix dactylopii* Howard, *Leptomastidea abnormis* (Girault), *Anagyrus pseudococci* (Girault), and *Coccidoxenoides perminutus* Girault (*Pauridia peregrine),* Timberlake (*Coccidoxenoides peregrinus)* (Bartlett, 1978; Noyes & Hayat, 1994). Other reported genera that have been reared from *Planococcus* spp. include *Aenasuis*, *Gyranusoidea* and *Pseudaphycus* (USDA, APHIS, 2002), and *Pativana* (Boucek & Bhuiya, 1990). However, two of the most widely used of these encyrtid wasps in biological control programs against *P. citri* in particular have been *L. dactylopii* and *C. perminutus* (Noyes & Hayat, 1994), but there is sparse information available on the use of these two bio-control agents against *P. minor*.

Leptomastix dactylopii is thought to be of Afrotropical origin and has been used extensively in many countries to control *P. citri* (Noyes & Hayat, 1994). In the US, this primary parasitoid was used successfully in control programs in California (Clausen, 1956), Florida (Watson & Thompson, 1940), and Texas (Meyerdirk *et al.,* 1998). More recently, Krishnamoorthy & Singh (1987) reported that *L. dactylopii* was introduced from the West Indies and released in citrus in India where complete control of *P. citri* was achieved in several months. It was also released to control *Planococcus* spp. in coffee and achieved levels of field parasitism as high as 85%

(Reddy *et al.,* 1997). In Australia, *L. dactylopii* was the principal control agent used successfully against *P. citri* on citrus and custard apple (Smith *et al.,* 1988).

Coccidoxenoides perminutus originated from Asia and has been used against *P. citri* since 1951 (Noyes & Hayat, 1994) in parts of Africa, North and South America, Asia, and Europe (Bartlett 1978). There has been some success with this primary parasitoid, such as in Texas (Meyerdirk *et al.,* 1978), Bermuda and Italy (Cock, 1985), but releases were usually made together with other species (Ceballo & Walter, 2004). More recently, *C. perminutus* was reported in India by Krishnamoorthy & Mani (1989), where it caused up to 30% parasitism of *P. citri* in citrus orchards. Several years later, it was the dominant species recovered and was most likely responsible for *P. citri* decline in citrus (Mani, 1994). However, it achieved low levels of field parasitism in Australia (Davies *et al.,* 2004), mainly due to the prevailing climate in the area (Ceballo & Walter, 2005).

Both parasitoids have also been evaluated in combination with other species. Meyerdirk *et al.* (1978) reported that a parasitoid complex consisting of *L. dactylopii*, *C. perminutus*, and *Anagyrus* sp. offered seasonal control of *P. citri* on citrus in Texas. They reported that 21% of *P. citri* was parasitized by *L. dactylopii* in mid August, 49% was parasitized by *C. perminutus* in late August, which had replaced *L. dactylopii* as the dominant species, while only 4% was parasitized by by the only recovered species, *Anagyrus* sp. in mid September. In greenhouse citrus, Summy *et al.* (1986) demonstrated that inoculative releases of *L. dactylopii*, *C. perminutus*, *L. abn*ormis, *A. pseudococci*, and *Chrysoplatycerus splendens* Howard rapidly suppressed populations of *P. citri*. *P. citri* cohorts exposed to searching parasitoids for 8 weeks had 90% decline in populations, while cohort populations protected from parasitoids increased by 828%.

Although these two parasitoids were introduced throughout the Neotropics for use against *Planococcus* spp. (Noyes & Hayat, 1994), there are no records of intentional introduction of either species in Trinidad. *L. dactylopii* was recorded from mealybugs identified at that time as *P. citri* (Kirkpatrick, 1953). *L. dactylopii* was also shipped from Trinidad to other areas for biological control of *P. citri* (Cock, 1985).

Rosen & Debach (1977) reported that certain wasps in the superfamily Chalcidoidea, which includes the encyrtids, can discriminate cryptic species of *Planococcus*. Because there is no available biological information for these parasitoids with *P. minor*, it is important to investigate to what degree they will attack this species. Although the degree of host specificity of these primary parasitoids is not known with any certainty, they are able to develop in a number of different hosts (Noyes & Hayat, 1994). For instance, *L. dactylopii* has been recorded from more than 20 mealybug hosts across many genera, but development was most successful in *P. citri* (Noyes & Hayat, 1994). *C. perminutus* on the other hand, has been recorded from less than 10 hosts (Noyes & Hayat, 1994), and its most successful development appears to be restricted to *P. citri* and to *P. ficus* (Gol'berg, 1982).

The biology of *L. dactylopii* was described by various authors (Tingle & Copland, 1989). A female laid up to 10 eggs per day in *P. citri* (Kirkpatrick, 1953), with oviposition taking place in 3rd instar and adult female mealybugs (de Jong & van Alphen, 1989). Fecundity was greatest at 30°C (Tingle & Copland, 1989), and development was completed in as little as two weeks at 27°C (de Jong & van Alphen, 1989). More female parasitoids were reared from large hosts of *P. citri*, while predominantly males were reared from smaller hosts (de Jong & van Alphen, 1989). Similarly, several authors have described the biology of *C. perminutus* (Gol'berg, 1982; Ceballo & Walter, 2004). Ceballo & Walter (2004) reported that the mode of

reproduction was almost entirely thelytokous, where females are produced from unfertilized eggs. However, Flanders (1965) had earlier produced males by exposing a female population to temperatures as high as 35°C throughout the embryonic and larval stages of the parasitoid's development. Females oviposited into the first three instars of *P. citri*; however, their productivity relied mainly on second instar hosts and they had an average fecundity of 239 eggs (Ceballo & Walter, 2004). Relative humidity had a strong effect on the parasitoid's survival, with females surviving best at 21.5°C and 92% RH (Gol'berg, 1982). Krishnamoorthy & Mani (1989) reported that *C. perminutus* took 23-27 days to complete its development at 28°C.

Although there are multiple parasitoids that are effective biocontrol agents against *Planococcus* spp., these parasitoids may vary with regard to suitability of mealybug species as hosts. Furthermore, some parasitoids may be ineffective for some species due to a lack of preference to oviposit in a particular host species (Van-Driesche *et al.,* 1987) or an inability to escape encapsulation by the host (Blumberg *et al.,* 1995). Encapsulation is a defense mechanism of mealybugs against their internal parasitoids (Blumberg, 1997), and its frequency varies depending on the host species, its age, and conditions under which the host and parasitoid are reared (Blumberg, 1997). Little information is available on the degree of suitability of *L. dactylopii* and its various hosts, except for *P. citri*, in which its eggs are seldom encapsulated (Blumberg & Van-Driesche, 2001). Conversely, Ceballo & Walter (2004) reported that eggs deposited into adult hosts of *P. citri* by *C. perminutus* were most likely encapsulated and destroyed. These findings on host immune response are especially significant given the many similarities between *P. citri* and *P. minor*.

CHAPTER III

MATERIALS AND METHOD

3.1. Study area

The survey was conducted in some selected major mealybug affected districts of Bangladesh namely Dhaka, Gazipur, Narsingdi, Manikgonj, Jessore, Bogra, Comilla, Chapainwabgonj, Chittagong and Jhenaidah. In the survey program, at least 10 mealybug affected farmers were interviewed from each upazilla of the selected districts. Thus a total of 300 farmers were interviewed for data collection.

3.2. Study design

The survey study was conducted in the 10 major districts of Bangladesh where mealybug became a serious problem. A total of 30 upazilas were selected under 10 sampled districts considering 3 upazila for each district and 10 famers were interviewed at each upazila through pre-tested questionnaire. Thus, a total of 300 affected farmers were interviewed from 10 sampled districts.

Ten (10) focus group discussions (FGD) were also conducted in ten districts with the participation of at least 10 farmers for each FGD. The FGD conducted using pre-designed FGD guidelines. Thus, a total of 100 farmers was covered from sampled ten districts.

3.3. Study indicators

The researcher considered the following variables/indicators to be considered:

Demographic : Name, Age, Sex

Social : Education, Profession

Study related indicators:

Types of farmer, farm size, variety of crops cultivated,

Occurrence and severity of mealybug on different agricultural crops,

Potential risk and economic damage caused by this pest,

Status of the pest on different crops,

Effective measures practiced by the farmers in controlling mealybug and

Suggestions for improving management options for controlling mealybug in Bangladesh.

3.4. Development of questionnaire/instruments for data collection

According to the sample design, 400 respondents were covered under the study, of which 300 respondents were participated for face-to face interview and the selection of respondents were made on a stratified sampling technique for sampled districts and simple random sampling technique within the sampled districts. There were two types questionnaire were prepared for two types of data collection such as (a) Respondent's survey, (b) Focus Group Discussion (FGD) and these are given below (Appendix I & II):

3.5. Respondents survey

The respondent's survey was conducted in the 10 selected districts of Bangladesh. The face to face interview was conducted among 300 respondents and they filled up a set of pre-designed questionnaire (**Appendix-1)** encompassing issues about the above mentioned study indicators.

3.6. Focus Group Discussion (FGD)

The people who are associated with the problem of mealybug in the selected districts were participated in the FGD. The FGD was conducted at a venue, which was convenient for the participants and was allowed them to speak freely. The FGD was conducted to collect the information using pre-designed FGD guidelines (**Appendix-2)** encompassing issues about the above mentioned study indicators.

3.7. Respondents distribution in the sampled upazilla and districts

The sampled 300 flowers farmers and 100 mealybug infested crop farmers for focus group discussion (FGD) were selected from 30 upazilla under 10 major mealybug

infested districts of Bangladesh. The distribution of sampled respondents has been presented in the following table:

Sl. No.	District	Upazila	Remarks
1.	Norshingdi	Sadar Shibpur Raipura	10 farmers for each upazila, 3 upazila for each district A total of 300 farmers will be interviewed 100 mealybug infested farmers for focus group discussion from 10 districts
2.	Manikgonj	Singair Saturia Sadar	
3.	Gazipur	Kaligonj Kapasia Kaliakoir	
4.	Comilla	Chandina Daudkandi Burichong	
5.	Chapainwabgonj	Gomastapur Nachol Sadar	
6.	Chittagong	Potia Shitakunda Mirershorai,	
7.	Bogra	Sadar Shibgonj Shajhanpur	
8.	Jessore	Bagarpara Chougacha Keshobpur	
9.	Jhenidah	Kaligonj Courtchandpur Shoilokupa	
10.	Dhaka	Savar Dhamrai Keranigonj	
Total	**10**	**30**	**400**

3.8. Data collection

3.8.1. Respondents' survey

Direct personal interview approach was adopted for collection of primary data. The researcher personally contacted with the farmers in the respective upazila under 10 sampled districts. When found the target respondents and the researcher started interview by explaining the objectives of the study to the respondents. After getting

respondents, the researcher filled up each question of the questionnaire one by one and obtain desired information.

3.8.2. Focus group discussion

The researcher identified 10 participants from among all the respondents based on their potentials for providing more specific and accurate feedback not only in identifying the hosts, but also in identifying the species of mealybug and rating them as quarantine and non-quarantine in a focus group discussion through group discussions and sharing their experiences.

The field level data and focus group discussion data collections were conducted for a period from January 2017 to May 2017. After the completion of data collection, all filled up questionnaires were preserved according to the category of respondents for processing and data analysis.

3.9. Data analysis

Data on different parameters were analyzed through computer software SPSS version 20. As soon as data collected from the field, the filled up questionnaires were coded and data entry were completed using SPSS and MS Access computer packages as well as analyzed for tabulation of the primary data into data tables.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted in the 30 upazilas of 10 selected major crop growing districts of Bangladesh during the period from January to May, 2017 to find out the current status and damage intensity of mealybug, their risks and management options. The data were collected through interview of 300 farmers using a pre-designed questionnaire considering 10 farmers from each upazila and 50 field level officers of DAE considering one UAO, one AEO and one SAAO of DAE. The results obtained from the studies have been presented below sequentially in various forms and thus interpreted and discussed as to extract the findings systematically in the line of the objective of the study.

4.1. Farmers' knowledge on mealybug infestation, their risks and management

The results of the farmers' knowledge on mealybug infestation and their risks have been discussed under the following sub-headings:

4.1.1. Gender of the farmers

The field survey was conducted among 300 farmers in 10 major crop growing districts. Out of 300, 82% of the farmers were male (245), while only 18% farmers participated in the study were female (55) (Figure 1).

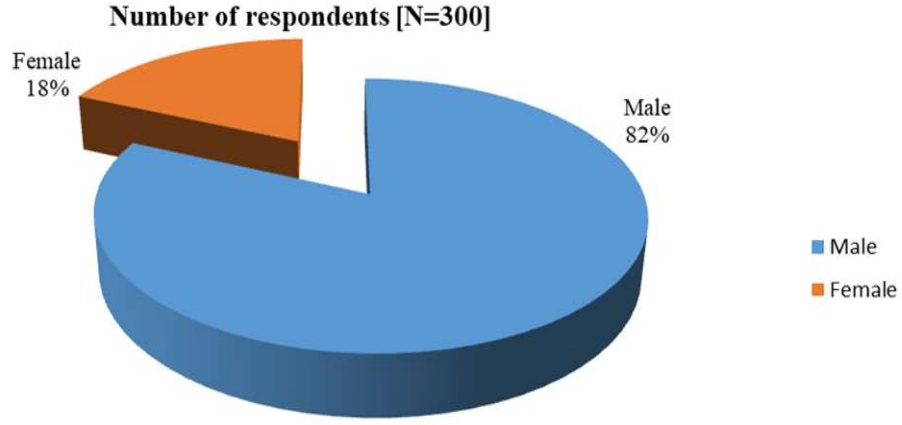

Figure 1. Gender of the farmers participated in the survey

4.1.2. Categories of farmers

Out of 300 crop growers participated in the field study, maximum 35.21% of them (106) were field crop farmers, whereas 26.16% farmers (78) were vegetable growers, whereas 20.72% farmers (62) were fruit growers and the lowest proportion of 17.9% farmers (54) were flower cultivars (Table 3).

Table 3. Categories of the farmers participated in the survey

Farmer's categories	Number of respondents [N=300]	% response
Field crop farmers	106	35.21
Vegetable growers	78	26.16
Fruit growers	62	20.72
Flower cultivars	54	17.9
Total	300	100

4.1.3 Education level of the farmers

In the survey, out of 300 farmers, 54 farmers (18%) were illiterate. 108 farmers (36%) had primary education, 72 farmers (24%) studied up to class eight, 35 farmers (11.67%) passed SSC, 20 farmers (6.67%) passed HSC, only 6 farmers (2%) have had bachelor degree and 5 farmers (1.67%) of them had masters or higher degree (Table 4).

Table 4. Education level of the farmers participated in the survey

Education level	Number of respondents [N=300]	% response
Not literate	54	18
Upto primary	108	36
Upto Class eight	72	24
SSC	35	11.67
HSC	20	6.67
Bachelor degree	6	2
Masters or higher degree	5	1.67
Total	300	100

4.1.4 Age of the farmers

Out of 300 farmers, highest number of respondents i.e., 96 farmers (31.93%) were in the range of 41-50 years old, followed by 78 farmers (26.16%) were of 51-60 years old. Least number of respondents i.e., 6 farmers (1.85%) were of below the age of 20 years (Table 5).

Table 5. Age of the farmers of the survey

Age range	Number of respondents [N=300]	% response
< 20 years	6	1.85
20-30 years	13	4.36
31-40 years	50	16.61
41-50 years	96	31.93
51-60 years	78	26.16
> 60 years	57	19.08
Total	300	100

4.1.5 Farmers response

Out of 300 farmers participated in the field study, 95% of them (286) responded about mealybug and only 5% farmers (14) didn't know about it (Figure 2).

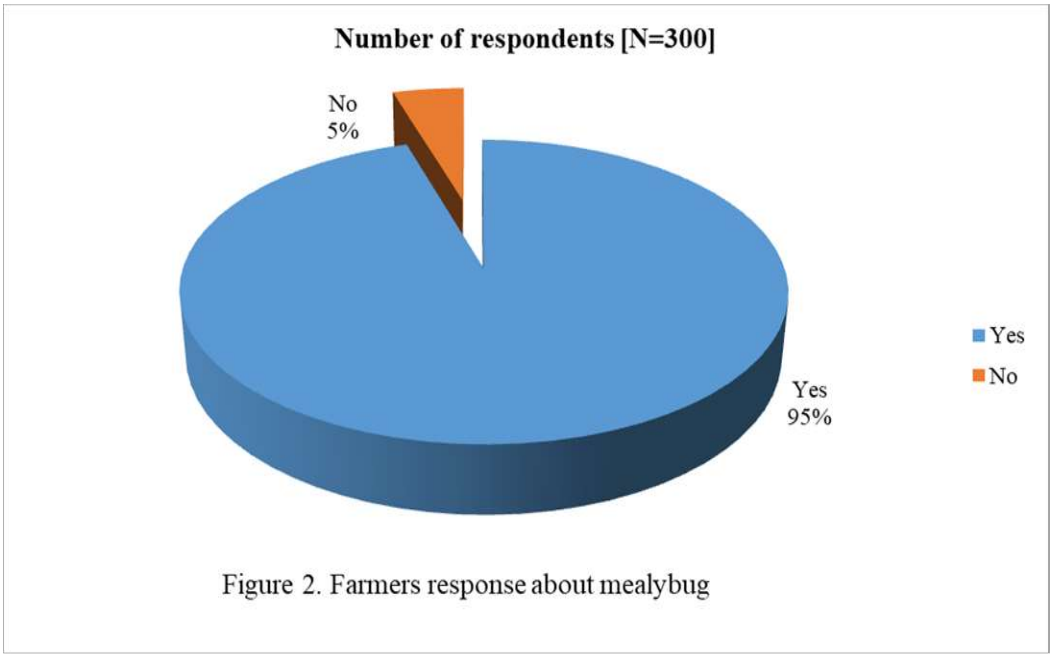

Figure 2. Farmers response about mealybug

4.1.6 Percent of response on mealybug incidence on different field crops and weeds

In field crops

According to the opinion expressed by the farmers, out of 300 farmers, highest 160 farmers (53.41%) responded to mealybug infestation in cotton, followed by 148 farmers (49.36%) in tobacco, followed by 147 farmers (48.87%) in groundnut. Whereas, lowest number of (59) farmers (19.56%) reported infestation of mealybug in jute, followed by 80 farmers found mealybug in lentil (26.77) (Table 6).

In weeds

According to the opinion expressed by the flowers growing farmers, bermuda grass is mostly infested by mealybug. Out of 300 farmers, 46.11% of them (138) reported that the bermuda grass was infested in the field by mealybug, which was followed by infestation on dodder as reported by 31.49% farmers (94), this was followed by kantabagun as reported by 78 farmers (26.15%), followed by parthenium as reported by 60 farmers (19.84%) (Table 6).

Table.6 Percent of response on mealybug incidence on different field crops and weeds

Sl. No.	Name of crops	% response on mealybug incidence					
		Yes		No		No idea	
		Number	% response	Number	% response	Number	% response
Field crops							
1	Cotton	160	53.41	88	29.44	51	17.15
2	Jute	59	19.56	75	24.95	166	55.49
3	Sugarcane	114	37.87	94	31.48	92	30.66
4	Wheat	119	39.69	124	41.3	57	19.02
5	Sesame	96	31.89	145	48.33	59	19.79
6	Tobacco	148	49.36	93	31.08	59	19.56
7	Chickpea	130	43.46	115	38.41	54	18.13
8	Garden pea	97	32.33	160	53.25	43	14.43
9	Lentil	80	26.77	135	44.93	85	28.3
10	Mungbean	144	47.89	80	26.77	76	25.34
11	Mustard	110	36.82	106	35.31	84	27.87

Sl. No.	Name of crops	% response on mealybug incidence					
		Yes		No		No idea	
		Number	% response	Number	% response	Number	% response
12	Groundnut	147	48.87	86	28.74	67	22.39
13	Maize	141	47.07	94	31.48	64	21.46
14	Rice	93	31.13	147	49.7	59	19.8
Weeds							
15	Dodder	94	31.49	119	39.59	87	28.92
16	Bermuda grass	138	46.11	82	27.39	79	26.49
17	Parthanium	60	19.84	150	49.85	91	30.31
18	Sticky nightshade	78	26.15	143	47.7	78	26.15
Multiple response							

4.1.7 Infestation severity of mealybug on different field crops and weeds

In Field crpos

According to the opinion expressed by the farmers, 56.8% of them reported cotton as a major host of mealybug, which was followed by jute (47.9%). Whereas, groundnut was infested a little by mealybug as reported by few farmers (11.8%), followed by the response on garden pea (13.2%), and by sugarcane (13.3%) (Table 7).

In Weeds

According to the opinion expressed by the farmers, dodder grass was a major host as reported by (22.7%) farmers, which is followed by kantabagun by 17.4%, by bermuda grass 16.2%, and by parthenium 11.9% farmers (Table 7).

Table 7. Infestation severity of mealybug on different field crops and weeds

Sl. No.	Name of crops	% response on host status	
		Major	Minor
Field Crops			
1	Cotton	56.8	43.2
2	Jute	47.9	52.1
3	Sugarcane	13.3	86.7
4	Wheat	29.1	70.9
5	Sesame	34.5	65.5
6	Tobacco	46.6	53.4
7	Chickpea	26.7	73.3

Sl. No.	Name of crops	% response on host status	
		Major	Minor
8	Garden pea	13.2	86.8
9	Lentil	16.8	83.2
10	Mungbean	21.4	78.6
11	Mustard	8.9	91.1
12	Groundnut	11.8	88.2
13	Maize	26.3	73.7
14	Rice	7.6	92.4
Weeds			
15	Dodder	22.7	77.3
16	Bermuda grass	16.2	83.8
17	Parthanium	11.9	88.1
18	Sticky nightshade	17.4	82.6
Multiple response			

4.1.8 Vulnerable stages of different field crops and weed by mealybug in field condition

In field crops

According to the opinion expressed by the farmers, at seedling stage, 20.6% of them found infestation on cotton by mealybug, followed by jute by 18.6% farmers. In vegetative stage, 83.3% farmers found infestation on rice mealybug, which is followed by 29.8% farmers observed mealybug on maize. In fruiting stage, groundnut was infested by mealybug as reported by 81.2% farmers, followed by sesame as obtained by 77.8% of the respondents. Only 2.17% farmers found infestation on rice at its fruiting stage in the field (Table 8.)

In weeds

According to the opinion expressed by the farmers, in seedling stage, dodder was mostly (16.9%) infested by mealybug, followed by bermudagrass (13.4%). In vegetative stage, Kantabagun was mostly (87.8%) infested by mealybug, followed by bermuda grass (19.7%). In fruiting stage, parthanium was mostly (76%) infested, which was followed by dodder (67.9%), which was also followed by bermuda grass

(66.9%). Kantabagun was least (3.5%) infested by mealybug in field condition (Table 8).

Table 8. Vulnerable stages of different field crops and weed by mealybug in field condition

Sl. No.	Name of crops	% response on vulnerable stage of host		
		Seedling	Vegetative	Fruiting
Field crops				
1	Cotton	20.6	25.8	53.6
2	Jute	18.6	21.2	60.2
3	Sugarcane	11.5	22.6	65.9
4	Wheat	15.2	12.7	72.1
5	Sesame	10.3	11.9	77.8
6	Tobacco	14.4	16.7	68.9
7	Chickpea	13.8	12.4	73.8
8	Garden pea	10.5	12.9	76.6
9	Lentil	13.6	26.1	60.3
10	Mungbean	14.1	11.8	74.1
11	Mustard	10.3	12.8	76.9
12	Groundnut	8.1	10.7	81.2
13	Maize	8.2	29.8	62
14	Rice	14.6	83.3	2.1
Weeds				
15	Dodder	16.9	15.2	67.9
16	Bermuda grass	13.4	19.7	66.9
17	Parthanium	9.7	14.3	76
18	Sticky nightshade	3.5	87.8	8.7
Multiple response				

4.1.9 Vulnerable parts of different crops and weeds to mealybug pests in field condition

In field crops

According to the opinion expressed by the farmers, in terms of leaf, tobacco was mostly infested (32.4%) by mealybug. Chickpea was least (14.7%) infested by mealybug as reported by farmers. In terms of stem, tobacco was the most (45.7%) vulnerable crop, which was followed by maize (34.8%). Lentil was the least (13.7%) infested crop, which was followed by groundnut (14.3%) (Table 9).

In terms of inflorescence, Cotton was the most (25.3%) vulnerable crop, which was followed by sugarcane (25.1%). Wheat was the least (10.6%) infested crop

In terms of flower, rice was the most (29.1%) vulnerable crop. Tobacco was the least (5.6%) infested crop, which was followed by cotton (7.9%).

In terms of fruit, Lentil was the most (24.5%) vulnerable crop, which was followed by sesame (23.5%). Tobacco was the least infested crop as reported by farmers 4.7%.

In terms of root, groundnut was the most (25.6%) vulnerable crop, which was followed by wheat (11.7%). Tobacco root was not infested by mealybug at all in the field condition (Table 9).

In weeds

According to the opinion expressed by the farmers, dodder stem was the most (43.8%) vulnerable stage, which was followed by kantabagun (41.9%) leaf stage. Whereas, dodder root was least (2.3%) infested by mealybug, which was followed by kantabagun (2.8%) in both inflorescence and fruit stage in field condition (Table 9).

Table 9. Vulnerable parts of different crops and weeds to mealybug pests in field condition

Sl. No.	Name of crops	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
Field crops							
1	Cotton	20.1	19.6	25.3	16.4	12.9	5.7
2	Jute	15.6	19.9	21.2	14.1	17.8	11.4
3	Sugarcane	20.2	18.1	25.1	11.9	15.3	9.4
4	Wheat	30.5	19.6	10.6	16.7	10.9	11.7
5	Sesame	15.7	18.9	17.4	18.8	23.5	5.7
6	Tobacco	32.4	45.7	11.6	5.6	4.7	0
7	Chickpea	14.7	18.6	16.5	25.5	18.9	5.8
8	Garden pea	19.1	17.4	17.3	19.8	16.6	9.8
9	Lentil	25.1	13.7	22.9	7.9	24.5	5.9
10	Mungbean	16.9	21.3	14.9	25.1	19.5	2.3
11	Mustard	24.7	25.4	21.6	10.9	11.5	5.9
12	Groundnut	16.6	14.3	11.4	9.5	22.6	25.6

Sl. No.	Name of crops	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
13	Maize	26.1	34.8	11.9	10.9	11.4	4.9
14	Rice	26.7	20.4	10.9	29.1	5.1	7.8
Weeds							
15	Dodder	29.4	43.8	2.9	17.5	4.1	2.3
16	Bermuda grass	38.4	28.1	5.6	15.9	8.6	3.4
17	Parthanium	12.8	30.9	9.5	26.8	15.9	4.1
18	Sticky nightshade	41.9	31.5	2.8	12.5	2.8	8.5
Multiple response							

4.1.10 Severity of infestation in field condition

In field crops

According to the opinion expressed by the farmers, cotton showed the highest (62.2%) percentage of infestation, which was followed by sugarcane (27.2%) by mealybug in field condition. Whereas, 94.1% farmers reported that rice showed low severity of infestation, which was followed by 93.7% in maize (Table 10).

In weeds

According to the opinion by the farmers, 3% farmers reported that dodder showed highest severity of infestation, which was followed by bermuda grass (2%), parthanium (1.4%), and kantabagun (1.2%). Whereas, 96.2% farmers reported that kantabagun showed lowest severity of infestation, which was followed by dodder (95.5%) (Table 10).

Table 10. Severity of different crops and weeds to mealybug pests in field condition

Sl. No.	Name of crops	% response on severity of infestation		
		High	Medium	Low
Field crops				
1	Cotton	62.2	33.7	4.1
2	Jute	3.5	44.6	51.9
3	Sugarcane	27.2	33.4	39.4
4	Wheat	4.1	24	71.9
5	Sesame	15	30	55
6	Tobacco	11.9	38.5	49.6

Sl. No.	Name of crops	% response on severity of infestation		
		High	Medium	Low
7	Chickpea	6.9	44.5	48.6
8	Garden pea	2.8	54.2	43
9	Lentil	4.1	10.6	85.3
10	Mungbean	9.4	29.2	61.4
11	Mustard	2.9	8.7	88.4
12	Groundnut	5.7	15.8	78.5
13	Maize	1.4	4.9	93.7
14	Rice	1.6	4.3	94.1
Weeds				
15	Dodder	3	1.5	95.5
16	Bermuda grass	2	4.7	93.3
17	Parthanium	1.4	5.8	92.8
18	Sticky nightshade	1.2	2.6	96.2
Multiple response				

4.1.11 Extent of damage of different field crops and weeds

In field crops

According to the opinion expressed by the farmers, highest entire crop damage found in cotton (21.2%), which was followed by sugercane (19.8%). Whereas, least entire crop damage found in rice (1.6%), which was followed by groundnut (10.7%). Highest partial damage found in groundnut (81.2%), which was followed by mustard (78.9%). Whereas, rice showed lowest (2.2%) partial damage. After all, rice showed lowest extent of damage by mealybug in field condition (Table 11).

In weeds

According to the opinion expressed by the farmers, highest (19.7%) amount of entire crop damage was observed in bermuda grass, which was followed by parthenium (14.3%), which was followed by dodder (11.3%) and which was also followed by kantabagun (8.7%). Highest amount of partial damage found in kantabagun (87.8%), which was followed by dodder (76.3%) (Table 11).

Table 11. Idea about amount of damage by mealybug in different field crops and weeds

Sl. No.	Name of crops	% response on extent of damage		
		Entire crops	Partial damage	Not so much damage
Field crops				
01.	Cotton	21.2	60.2	18.6
02.	Jute	15.8	63.6	20.6
03.	Sugarcane	19.8	72.0	8.2
04.	Whea	15.7	72.1	12.2
05.	Sesame	11.9	77.8	10.3
06.	Tobacco	16.7	68.9	14.4
07.	Chickpea	14.4	73.8	11.8
08.	Garden pea	12.9	76.6	10.5
09.	Lentil	12.1	74.7	13.2
10.	Mungbean	11.8	74.1	14.1
11.	Mustard	11.8	78.9	9.3
12.	Groundnut	10.7	81.2	8.1
13.	Maize	11.8	77.8	10.4
14.	Rice	1.6	2.2	96.2
Weeds				
15.	Dodder	11.3	67.9	12.4
16.	Bermuda grass	19.7	66.9	13.4
17.	Parthanium	14.3	76.0	9.7
18.	Sticky nightshade	8.7	87.8	3.5
Multiple response				

4.1.12 Pick period of damage in field condition

In field crops

According to the opinion expressed by the farmers, in summer, highest (47.4%) damage was observed in tobacco, which was followed by cotton (33.7%). Whereas, lowest (17.5%) damage was observed in jute in summer, which was followed by groundnut (18.4%). In winter, highest (34.8%) damage was observed in sugarcane, which was followed by chickpea (31.2%). Lowest (12.6%) damage was observed in cotton, which was followed by tobacco (18.6%). In rainy season, highest (31.9%) damage was observed in cotton, which was followed by rice (27.1%). Whereas, lowest (18.5%) damage was found in sugarcane, which was followed by chickpea

(19.4%). Jute showed highest (41.3%) damage whole the year round, which was followed by garden pea (36.6%) (Table 12).

In weeds

According to the opinion expressed by the farmers dodder responded highest (28.4%) damage in the rainy season, bermuda grass (30.2%) in all year round, 28.1% farmers stated summer as pick period of damage for kantabagun (Table 12).

Table 12. Pick period of infestation of mealybug in different crops and weeds

Sl. No.	Name of crops	% response on the pick period of damage			
		Summer	Winter	Rainy season	Whole year
Field crops					
01.	Cotton	33.7	12.6	31.9	21.8
02.	Jute	17.5	21.5	19.7	41.3
03.	Sugarcane	26.5	34.8	18.5	20.2
04.	Wheat	28.9	26.7	23.8	20.6
05.	Sesame	33.1	29.4	20.1	17.4
06.	Tobacco	47.4	18.6	23.7	10.3
07.	Chickpea	28.1	31.2	19.4	21.3
08.	Garden pea	22.3	19.7	21.4	36.6
09.	Lentil	25.3	28.1	20.2	26.4
10.	Mungbean	22.3	19.2	24.2	34.3
11.	Mustard	23.1	24.5	24.7	27.7
12.	Groundnut	18.4	26.4	22.7	32.5
13.	Maize	28.4	29.6	23.2	18.8
14.	Rice	21.5	23.4	27.1	28
Weeds					
15.	Dodder	22.5	23.4	28.4	25.7
16.	Bermuda grass	26.1	19.9	23.8	30.2
17.	Parthanium	22.2	17.8	26.8	33.2
18.	Sticky nightshade	28.1	26.3	22.1	23.5
Multiple response					

4.1.13 Incidence of mealybug on different vegetable crops

According to the opinion expressed by the farmers, out of 300 farmers, maximum 51.03% of them (153) reported that mealybug incidence occurred papaya, whereas 48.34% farmers (145) reported Brinjal. On the other hand, only 21.18% farmers (64)

reported onion as least affected vegetable, which was followed by 22.07% farmers (66) response on amaranth (Table 13).

Table 13. Incidence of mealybug on different vegetable crops

Sl. No.	Name of vegetables	Response on mealybug incidence					
		Yes		No		No idea	
		Number	% response	Number	% response	Number	% response
Vegetable crops							
1	Chilli	75	25.10	140	46.54	85	28.36
2	Onion	64	21.18	80	26.56	157	52.26
3	Sweet gourd	120	39.87	90	30.05	90	30.08
4	Ridge gourd	124	41.41	124	41.30	52	17.30
5	Bottle gourd	101	33.54	150	49.97	49	16.49
6	Bitter gourd	132	43.90	111	36.95	57	19.15
7	Pointed gourd	125	41.66	105	35.15	70	23.20
8	Tomato	86	28.74	155	51.57	59	19.69
9	Brinjal	145	48.34	85	28.38	70	23.28
10	Potato	134	44.57	75	24.93	91	30.49
11	Sweet potato	143	47.70	93	31.00	64	21.30
12	Papaya	153	51.03	80	26.64	67	22.33
13	Carrot	137	45.75	90	29.85	73	24.39
14	Radish	104	34.80	114	38.16	81	27.03
15	Okra	134	44.57	78	26.16	88	29.26
16	Amaranth	66	22.07	145	48.25	89	29.69
Multiple response							

4.1.14 Infestation severity of different vegetable crops by mealybug in field condition

After completion of the survey, out of 300 farmers, most of farmers (55.6%) reported papaya as a major mealybug infested vegetable, which was followed by brinjal as reported by 53.6% farmers. Whereas, 82.1% farmers reported chilli as a minor one, which was followed by bottle gourd as reported by 81.4% farmers (Table 14).

Table 14. Infestation severity of different vegetable crops by mealybug in field condition

Sl. No.	Name of vegetables	% response on pest status	
		Major	Minor
1	Chilli	17.9	82.1
2	Onion	19.3	80.7
3	Sweet gourd	19.6	80.4
4	Ridge gourd	27.4	72.6
5	Bottle gourd	18.6	81.4
6	Bitter gourd	19.3	80.7
7	Pointed gourd	28.9	71.1
8	Tomato	19.6	80.4
9	Brinjal	53.6	46.4
10	Potato	22.9	77.1
11	Sweet potato	29.1	70.9
12	Papaya	55.6	44.4
13	Carrot	29.6	70.4
14	Radish	22.7	77.3
15	Okra	39.6	60.4
16	Amaranth	19.6	80.4
Multiple response			

4.1.15 Vulnerable stage of different vegetable crops by mealybug in field condition

After completion of the survey, out of 300 farmers, most of farmers (75.7%) reported fruiting stage of papaya as most devastating stage, which was followed by fruiting stage of amaranth as reported by 72.9% farmers. 26.2% farmers reported seedling stage as vulnerable stage for brinjal, carrot seedling stage was reported least vulnerable stage as 9.5% farmers. Most vulnerable vegetative stage found on tamato as reported by 62.3% farmers, whereas, papaya vegetative stage was least vulnerable stage as reported by 11.7% farmers (Table 15).

Table 15. Vulnerable stage of different vegetable crops by mealybug in field condition

Sl. No.	Name of vegetables	% response on vulnerable stage		
		Seedling	Vegetative	Fruiting
1	Chilli	16.2	32.2	51.6
2	Onion	20.2	29.1	50.7
3	Sweet gourd	21.7	27.2	51.1
4	Ridge gourd	15.2	12.7	72.1

Sl. No.	Name of vegetables	% response on vulnerable stage		
		Seedling	Vegetative	Fruiting
5	Bottle gourd	11.6	18.6	69.8
6	Bitter gourd	15.9	28.1	56
7	Pointed gourd	18.4	32.5	49.1
8	Tomato	20.8	62.3	16.9
9	Brinjal	26.2	26.7	47.1
10	Potato	14.9	18.9	66.2
11	Sweet potato	18.3	22.1	59.6
12	Papaya	12.6	11.7	75.7
13	Carrot	9.5	41.4	49.1
14	Radish	17.1	16.4	66.5
15	Okra	19.2	25.7	55.1
16	Amaranth	11.9	15.2	72.9
Multiple response				

4.1.16 Vulnerable parts of different vegetables to mealybug in field condition

According to the opinion expressed by the farmers, in terms of leaf, tomato was mostly infested (43.8%) by mealybug, followed by carrot (34.8%). Whereas, chilli was least (13.7%) infested by mealybug, followed by papaya (14.3%). In terms of stem, okra was the most (38.4%) vulnerable crop, followed by ridge gourd (30.5%). Amaranth was the least (12.8%) infested crop, followed by pointed gourd (14.7%). In terms of inflorescence, chilli was the most (24.5%) vulnerable crop, which was followed by bottle gourd (23.5%). Whereas, tomato was the least (2.9%) infested crop, followed by potato (5.1%). In terms of flower, brinjal was the most (25.3%) vulnerable crop, followed by sweet gourd (25.1%). Whereas, tomato was the least (4.1%) infested crop, followed by okra (8.6%). In terms of fruit, potato was the most (29.1%) vulnerable crop, followed by amaranth (26.8%). Whereas, chilli was the least (7.9%) infested crop, followed by papaya (9.5%). In terms of root, papaya was the most (25.6%) vulnerable crop, which was followed by ridge gourd (11.7%). Whereas, bitter gourd and tomato root was infested least (2.3%) by mealybug at all in the field condition (Table 16).

Table 16. Vulnerable parts of different vegetables to mealybug pests in field condition

Sl. No.	Name of vegetables	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
1	Chilli	13.7	25.1	24.5	22.9	7.9	5.9
2	Onion	19.9	15.6	17.8	21.2	14.1	11.4
3	Sweet gourd	18.1	20.2	15.3	25.1	11.9	9.4
4	Ridge gourd	19.6	30.5	10.9	10.6	16.7	11.7
5	Bottle gourd	18.9	15.7	23.5	17.4	18.8	5.7
6	Bitter gourd	21.3	16.9	19.5	14.9	25.1	2.3
7	Pointed gourd	18.6	14.7	18.9	16.5	25.5	5.8
8	Tomato	43.8	29.4	2.9	4.1	17.5	2.3
9	Brinjal	19.6	20.1	12.9	25.3	16.4	5.7
10	Potato	20.4	26.7	5.1	10.9	29.1	7.8
11	Sweet potato	25.4	24.7	11.5	21.6	10.9	5.9
12	Papaya	14.3	16.6	22.6	11.4	9.5	25.6
13	Carrot	34.8	26.1	11.4	11.9	10.9	4.9
14	Radish	17.4	19.1	16.6	17.3	19.8	9.8
15	Okra	28.1	38.4	5.6	8.6	15.9	3.4
16	Amaranth	30.9	12.8	9.5	15.9	26.8	4.1
Multiple response							

4.1.17 Severity of different vegetables to mealybug pests in field condition

According to the opinion expressed by the farmers, payaya showed the highest (95.5%) percentage of infestation, which is followed by okra (93.3%) by mealybug in field condition. Whereas, 93.7% farmers reported that carrot showed lowest severity of infestation, which was followed by 88.4% in sweet gourd (Table 17).

Table 17. Severity of different vegetables to mealybug pests in field condition

Sl. No.	Name of vegetables	% response on severity of infestation		
		High	Medium	Low
1	Chilli	33.7	62.2	4.1
2	Onion	51.9	44.6	3.5
3	Sweet gourd	39.4	27.2	33.4
4	Ridge gourd	24	4.1	71.9
5	Bottle gourd	30	15	55
6	Bitter gourd	38.5	11.9	49.6
7	Pointed gourd	44.5	6.9	48.6
8	Tomato	54.2	2.8	43
9	Brinjal	10.6	4.1	85.3
10	Potato	29.2	9.4	61.4
11	Sweet potato	8.7	2.9	88.4
12	Papaya	95.5	1.5	3
13	Carrot	4.9	1.4	93.7
14	Radish	15.8	5.7	78.5
15	Okra	93.3	4.7	2
16	Amaranth	92.8	5.8	1.4
Multiple response				

4.1.18 Extent of damage of different field crops and weeds

According to the opinion expressed by the farmers, highest entire crop damage found in brinjal (20.6%), which was followed by onion (18.6%). Whereas, least entire crop damage found in papaya (8.1%), which was followed by carrot (8.2%). Highest partial damage found in papaya (81.2%), which was followed by sweet potato (78.9%). Whereas, onion showed lowest (60.2%) partial damage, which was followed by brinjal (63.6%). Least damage found in onion reported by 21.2% farmers (Table 18).

Table 18. Idea about amount of damage by mealybug in different vegetables

Sl. No.	Name of vegetables	% response on extent of damage		
		Entire crops	Partial damage	Not so much damage
1	Chilli	13.2	74.7	12.1
2	Onion	18.6	60.2	21.2
3	Sweet gourd	10.4	77.8	11.8
4	Ridge gourd	12.2	72.1	15.7
5	Bottle gourd	10.3	77.8	11.9
6	Bitter gourd	14.4	68.9	16.7
7	Pointed gourd	11.8	73.8	14.4
8	Tomato	10.5	76.6	12.9
9	Brinjal	20.6	63.6	15.8
10	Potato	14.1	74.1	11.8
11	Sweet potato	9.3	78.9	11.8
12	Papaya	8.1	81.2	10.7
13	Carrot	8.2	72	19.8
14	Radish	12.4	76.3	11.3
15	Okra	13.4	66.9	19.7
16	Amaranth	9.7	76	14.3

4.1.19 Pick period of infestation of mealybug in different vegetables

According to the opinion expressed by the farmers, in summer, highest (47.4%) damage was observed in papaya, which was followed by ridge gourd (34.5%). Whereas, lowest (19.1%) damage was observed in pointed gourd in summer, which was followed by bitter gourd (19.5%). In winter, highest (33.1%) damage was observed in brinjal, which was followed by bitter gourd (31.5%). Lowest (18.6%) damage was observed in papaya, which was followed by tomato (19.1%). In rainy season, highest (34.2%) damage was observed in potato, which was followed by bottle gourd (29.1%). Whereas, lowest (17.7%) damage was found in bitter gourd, which was followed by tomato (20.2%). Tomato (33.8%) showed highest damage whole the year round, which was followed by bitter gourd (31.3%). Whereas, lowest (10.3%) damage was found in papaya, which was followed by bottle gourd (17.4%).

Table 19. Pick period of infestation of mealybug in different vegetables

Sl. No.	Name of vegetables	% response on pick period of damage			
		Summer	Winter	Rainy season	Whole year
1	Chilli	23.5	21.4	27.1	28
2	Onion	32.4	26.7	20.4	20.5
3	Sweet gourd	20.8	23.6	26.9	28.7
4	Ridge gourd	34.5	26.8	20.5	18.2
5	Bottle gourd	33.1	20.4	29.1	17.4
6	Bitter gourd	19.5	31.5	17.7	31.3
7	Pointed gourd	19.1	31.3	28.4	21.2
8	Tomato	26.9	19.1	20.2	33.8
9	Brinjal	20.3	33.1	26.4	20.2
10	Potato	20.3	21.2	34.2	24.3
11	Sweet potato	27.1	20.7	28.5	23.7
12	Papaya	47.4	18.6	23.7	10.3
13	Carrot	28.4	29.2	23.6	18.8
14	Radish	19.8	29.4	23.4	27.4
15	Okra	28.7	25.4	22.4	23.5
16	Amaranth	28.3	19.7	21.4	30.6

4.1.20 Incidence of mealybugon different fruit and woody plants

In fruit plants

According to the opinion expressed by the farmers, out of 300 farmers, highest 155 farmers (51.57%) responded to mealybug incidence in mango, followed by 150 farmers (49.97%) in jackfruit, followed by 145 farmers (48.25%) in pomegranate. Whereas, lowest 75 farmers (24.9%) reported incidence of mealybug in orange, followed by 78 farmers (26.11%) in date palm (Table 20).

In woody plants

According to the opinion expressed by the farmers, sisso plant was severely infested by mealybug. Out of 300 farmers, most (51.57%) of the farmers (155) reported that the sisso plant was infested in the field by mealybug, which was followed by neem infestation as reported by 35.15% farmers (105), which is followed by acasia as

reported by 92 farmers (30.82%), followed by rain tree as reported by 91 farmers (30.34%) (Table 20).

Table 20. Incidence of mealybugon different fruit and woody plants

Sl. No.	Name of plants	Response on pest incidence					
		Yes		No		No idea	
		Number	% response	Number	% response	Number	% response
Fruit plants							
1	Jujube	115	38.18	104	34.79	81	27.03
2	Mango	155	51.57	86	28.74	59	19.69
3	Jackfruit	150	49.97	101	33.54	49	16.49
4	Guava	90	29.85	137	45.74	73	24.41
5	Citrus	85	28.38	145	48.34	70	23.28
6	Orange	75	24.9	134	44.59	92	30.51
7	Pineapple	93	31.02	143	47.69	64	21.3
8	Date palm	78	26.11	134	44.61	88	29.28
9	Coconut	105	35.15	125	41.66	70	23.2
10	Betel nut	96	31.98	139	46.31	65	21.7
11	Pomegranate	145	48.25	66	22.07	89	29.69
12	Banana	80	26.64	153	51.03	67	22.33
13	Olive	90	30.05	120	39.87	90	30.08
14	Litchi	85	28.21	59	19.52	157	52.26
15	Tamarind	124	41.3	124	41.41	52	17.3
16	Almond	140	46.54	75	25.1	85	28.36
17	Grape	111	36.95	132	43.9	57	19.15
18	Palm	124	41.3	124	41.41	52	17.3
19	Strawberry	85	28.21	59	19.56	157	52.23
Woody plants							
20	Rain tree	91	30.34	137	45.59	72	24.07
21	Neem	105	35.15	125	41.66	70	23.2
22	Sisso	155	51.57	86	28.74	59	19.69
23	Acasia	92	30.82	145	48.36	62	20.82
Multiple response							

4.1.21 Infestation severity of different fruit and woody plants by mealybug

In Fruit plants

According to the opinion expressed by the farmers, most (82.6%) of the farmers reported that the mango was severely infested in the field by mealybug, which was

followed by both jackfruit and guava infestation (70.4%).Whereas, coconut is minorly infested by mealybug reported by 82.1% farmers, which was followed by orange as reported by 81.4% farmers (Table 21).

In Woody plants

According to the opinion expressed by the farmers, acasia tree a minor infested crop as reported by 82.1% farmers, which was followed by rain tree as reported by 81.4% farmers, which was also followed by sisso (77.1%) and which was followed by neem (70.9%) (Table 21).

Table 21. Infestation severity of different fruit and woody plants by mealybug in field condition

Sl. No.	Name of plants	% response on pest status	
		Major	Minor
Fruit plants			
1	Jujube	53.6	46.4
2	Mango	82.6	17.4
3	Jackfruit	70.4	29.6
4	Guava	70.4	29.6
5	Citrus	55.6	44.4
6	Orange	18.6	81.4
7	Pineapple	28.9	71.1
8	Date palm	39.6	60.4
9	Coconut	17.9	82.1
10	Betel nut	22.9	77.1
11	Pomegranate	29.1	70.9
12	Banana	60.7	39.3
13	Olive	29.6	70.4
14	Litchi	32.7	67.3
15	Tamarind	39.6	60.4
16	Almond	29.6	70.4
17	Grape	51.7	48.3
18	Palm	39.6	60.4
19	Strawberry	62.6	37.4
Woody plants			
20	Rain tree	18.6	81.4
21	Neem	29.1	70.9
22	Sisso	22.9	77.1
23	Acasia	17.9	82.1
Multiple response			

4.1.22 Vulnerable stages of different fruit and woody plants by mealybug in field condition

In fruit plants

According to the opinion expressed by the farmers, in seedling stage, guava was mostly (26.2%) infested by mealybug, followed by jackfruit (21.7%) infestation. In vegetative stage, both mango and jujube were mostly (62.3%) infested by mealybug, which is followed by pomegranate (60.9%). In fruiting stage, banana was mostly (75.7%) infested by mealybug, whereas olive was least infested (9.5%) in seedling stage by mealybug in field condition (Table 22).

In woody plants

According to the opinion expressed by the farmers, in seedling stage, neem was mostly (18.3%) infested by mealybug, followed by acasia (15.9%). In vegetative stage, acasia was mostly (28.1%) infested by mealybug, followed by neen (22.1%). In fruiting stage, rain tree was mostly (75.7%) infested, which was followed by sisso (66.2%), which was also followed by neem (59.6%). Rain tree was least (11.7%) infested in vegetative stage by mealybug in field condition (Table 22).

Table 22. Vulnerable stages of different fruit and woody plants by mealybug in field condition

Sl. No.	Name of plants	% response on vulnerable stage		
		Seedling	Vegetative	Fruiting
Fruit plants				
1	Jujube	20.8	62.3	16.9
2	Mango	20.8	62.3	16.9
3	Jackfruit	21.7	27.2	51.1
4	Guava	26.2	26.7	47.1
5	Citrus	11.6	18.6	69.8
6	Orange	15.2	12.7	72.1
7	Pineapple	18.4	32.5	49.1
8	Date palm	20.2	29.1	50.7
9	Coconut	15.9	28.1	56
10	Betel nut	14.9	18.9	66.2
11	Pomegranate	17.2	60.9	21.9
12	Banana	12.6	11.7	75.7
13	Olive	9.5	41.4	49.1

Sl. No.	Name of plants	% response on vulnerable stage		
		Seedling	Vegetative	Fruiting
14	Litchi	17.1	16.4	66.5
15	Tamarind	19.2	25.7	55.1
16	Almond	11.9	15.2	72.9
17	Grape	18.3	22.1	59.6
18	Palm	16.2	32.2	51.6
19	Strawberry	11.9	15.2	72.9
Woody plants				
20	Rain tree	12.6	11.7	75.7
21	Neem	18.3	22.1	59.6
22	Sisso	14.9	18.9	66.2
23	Acasia	15.9	28.1	56
Multiple response				

4.1.23 Vulnerable parts of different fruits and woody plants to mealybug pests

In fruit plants

According to the opinion expressed by the farmers, in terms of leaf, guava was mostly infested (43.8%) by mealybug, followed by olive (34.8%).Whereas, both coconut and jackfruit were least (13.7%) infested by mealybug. In terms of stem, mango was the most (41.9%) vulnerable crop, which was followed by tamarind (38.4%). Almond was the least (12.8%) infested crop, followed by pineapple (14.7%). In terms of inflorescence, both coconut and jackfruit were the most (24.5%) vulnerable crops, which was followed by citrus (23.5%). Whereas, mango was the least (2.8%) infested crop, followed by guava (2.9%). In terms of flower, jujube was the most (25.3%) vulnerable crop, which was followed by both palm and watermelon (25.1%). Whereas, mango was the least (2.8%) infested crop, which was followed by guava (4.1%). In terms of fruit, orange was the most (29.1%) vulnerable crop, which was followed by almond (26.8%). Whereas, both coconut and jackfruit were the least (7.9%) infested crops, which was followed by banana (9.5%). In terms of root, banana was the most (25.6%) vulnerable crop, which was followed by lichi (11.7%). Guava, tamarind, almond, and olive were the least infested fruit plant as reported respectively by 2.3%, 3.4%, 4.1% and 4.9% farmers (Table 23).

In woody plants

According to the opinion expressed by the farmers, rain tree fruit and stem were the most vulnerable part as reported by 29.1% and 26.7% farmers, which was followed by neem fruit (25.5%). On the other hand rain tree inflorescence, neem root and acasia root were the least infested by mealybug on the field condition as reported respectively by 5.1% 5.8% and 5.7% (Table 23).

Table 23. Vulnerable parts of different fruits and woody plants to mealybug pests in field condition

Sl. No.	Name of plants	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
Fruit plants							
1	Jujube	19.6	20.1	12.9	25.3	16.4	5.7
2	Mango	31.5	41.9	2.8	2.8	12.5	8.5
3	Jackfruit	13.7	25.1	24.5	22.9	7.9	5.9
4	Guava	43.8	29.4	2.9	4.1	17.5	2.3
5	Citrus	18.9	15.7	23.5	17.4	18.8	5.7
6	Orange	20.4	26.7	5.1	10.9	29.1	7.8
7	Pineapple	18.6	14.7	18.9	16.5	25.5	5.8
8	Date palm	17.4	19.1	16.6	17.3	19.8	9.8
9	Coconut	13.7	25.1	24.5	22.9	7.9	5.9
10	Betel nut	21.3	16.9	19.5	14.9	25.1	2.3
11	Pomegranate	25.4	24.7	11.5	21.6	10.9	5.9
12	Banana	14.3	16.6	22.6	11.4	9.5	25.6
13	Olive	34.8	26.1	11.4	11.9	10.9	4.9
14	Litchi	19.6	30.5	10.9	10.6	16.7	11.7
15	Tamarind	28.1	38.4	5.6	8.6	15.9	3.4
16	Almond	30.9	12.8	9.5	15.9	26.8	4.1
17	Grape	19.9	15.6	17.8	21.2	14.1	11.4
18	Palm	18.1	20.2	15.3	25.1	11.9	9.4
19	Strawberry	19.9	15.6	17.8	21.2	14.1	11.4
20	Watermelon	18.1	20.2	15.3	25.1	11.9	9.4
Woody plants							
21	Rain tree	20.4	26.7	5.1	10.9	29.1	7.8
22	Neem	18.6	14.7	18.9	16.5	25.5	5.8
23	Sisso	17.4	19.1	16.6	17.3	19.8	9.8
24	Acasia	19.6	20.1	12.9	25.3	16.4	5.7
Multiple response							

4.1.24 Severity of different fruits and woody plants to mealybug pests in field condition

In fruit plants

According to the opinion expressed by the farmers, jackfruit, mango, guava and citrus showed the highest percentage of infestation as reported respectively by 96.2%, 95.5%, 93.3% and 92.8%. by mealybug in field condition. On the other hand, olive, pomegranate, coconut were the least infested fruit plants as reported respectively by 93.7%, 88.4% and 85.3% farmers (Table 24).

In woody plants

According to the opinion by the farmers, 54.2% farmers reported that sisso showed highest severity of infestation, which was followed by neem (44.5%). Whereas, 85.3% farmers reported that acasia showed low severity of infestation, which was followed by rain tree (49.6%) (Table 24).

Table 24. Severity of different fruits and woody plants to mealybug pests in field condition

Sl. No.	Name of plants	% response on severity of infestation		
		High	Medium	Low
Fruit plants				
1	Jujube	33.7	62.2	4.1
2	Mango	95.5	1.5	3
3	Jackfruit	96.2	2.6	1.2
4	Guava	93.3	4.7	2
5	Citrus	92.8	5.8	1.4
6	Orange	38.5	11.9	49.6
7	Pineapple	44.5	6.9	48.6
8	Date palm	54.2	2.8	43
9	Coconut	10.6	4.1	85.3
10	Betel nut	29.2	9.4	61.4
11	Pomegranate	8.7	2.9	88.4
12	Banana	15.8	5.7	78.5
13	Olive	4.9	1.4	93.7
14	Litchi	51.9	44.6	3.5
15	Tamarind	24	4.1	71.9
16	Almond	30	15	55
17	Grape	39.4	27.2	33.4

Sl. No.	Name of plants	% response on severity of infestation		
		High	Medium	Low
18	Palm	33.7	62.2	4.1
19	Strawberry	51.9	44.6	3.5
20	Watermelon	39.4	27.2	33.4
Woody plants				
21	Rain tree	38.5	11.9	49.6
22	Neem	44.5	6.9	48.6
23	Sisso	54.2	2.8	43
24	Acasia	10.6	4.1	85.3
Multiple response				

4.1.25 Extent of damage in different fruits and woody plants

In fruit plants

According to the opinion expressed by the farmers, highest entire crop damage found in jackfruit (21.2%), which was followed by date palm (19.8%). Whereas, least entire crop damage found in banana (8.7%), which was followed by pineapple (10.7%). Highest partial damage found in banana (87.8%), which was followed by pineapple (81.2%). Whereas, jackfruit showed lowest (60.2%) partial damage. Highest 20.6% farmers reported grape that it didn't damage so much, which was followed by palm (18.6%). Banana was assigned as least damage crops by 3.5% farmers (Table 25).

In woody plants

According to the opinion expressed by the farmers, highest (19.8%) amount of entire crop damage was observed in rain tree, which was followed by sisso (19.7%), acasia (14.3%) and neem (11.3%). Highest amount of partial damage found in neem (76.3%), which was followed by acasia (76%). Least (8.2%) damage was observed in rain tree by mealybug in field condition (Table 25).

Table 25. Idea about amount of damage of infestation of mealybug in different fruits and woody plants

Sl. No.	Name of fruit plants	% response on extent of damage		
		Entire crops	Partial damage	Not so much damage
Fruit plants				
1	Jujube	16.7	68.9	14.4
2	Mango	14.4	73.8	11.8
3	Jackfruit	21.2	60.2	18.6
4	Guava	12.1	74.7	13.2
5	Citrus	11.8	74.1	14.1
6	Orange	11.8	78.9	9.3
7	Pineapple	10.7	81.2	8.1
8	Date palm	19.8	72	8.2
9	Coconut	11.3	76.3	12.4
10	Betel nut	19.7	66.9	13.4
11	Pomegranate	14.3	76	9.7
12	Banana	8.7	87.8	3.5
13	Olive	12.9	76.6	10.5
14	Litchi	12.1	74.7	13.2
15	Tamarind	11.8	74.1	14.1
16	Almond	11.8	78.9	9.3
17	Grape	15.8	63.6	20.6
18	Palm	12.9	76.6	10.5
19	Strawberry	11.8	77.8	10.4
20	Watermelon	15.7	72.1	12.2
Woody plants				
21	Rain tree	19.8	72	8.2
22	Neem	11.3	76.3	12.4
23	Sisso	19.7	66.9	13.4
24	Acasia	14.3	76	9.7
Multiple response				

4.1.26 Pick period of infestation of mealybug in different fruits and woody plants

In fruit plants

According to the opinion expressed by the farmers, in summer, mango, jujube and jackfruit showed the highest (38.2%, 37.4% and 36.7%) damage. Guava, pineapple and orange showed the lowest (12.4%, 12.8% and 16.1%).

In winter, highest (32.8%) damage was observed in jackfruit, which was followed by almond (29.8%). Lowest (9.8%) damage was observed in pineapple.

In rainy season, highest (39%) damage was observed in pineapple, which was followed by date palm (28.5%). Whereas, lowest (16.7%) damage was found in jujubi, which was followed by guava (17.4%).

Guava (48.5%) showed highest damage whole the year round, which was followed by pineapple (38.4%) (Table 26).

In woody plants

According to the opinion expressed by the farmers acasia infested much in the summer as reported by 30.8% farmers, which was followed by rain tree (28.8%.).

In winter season, neem was mostly infested by mealybug as reported by 27.4% farmers, which was followed by sisso (23.4%).

In rainy season, neem and rain tree were infested most severely as reported by 23.8% and 23.6% farmers respectively.

Neem, sisso, rain tree and acasia got infested whole the year round as reported by 29.4%, 28.4%, 28.4% and 28.2% farmers respectively (Table 26).

Table 26. Pick period of infestation of mealybug in different fruits and woody plants

Sl. No.	Name of fruit plants	% response on extent pick period of damage			
		Summer	Winter	Rainy season	Whole year
Fruit plants					
1	Jujube	37.4	29.4	16.7	16.5
2	Mango	38.2	26.1	21.9	13.8
3	Jackfruit	36.7	32.8	19.1	11.4
4	Guava	12.4	21.7	17.4	48.5
5	Citrus	23.4	22.9	19.8	33.9
6	Orange	16.1	20.7	27.2	36
7	Pineapple	12.8	9.8	39	38.4
8	Date palm	27.1	20.7	28.5	23.7
9	Coconut	30.4	20.7	22.5	26.4
10	Betel nut	29.4	28.2	23.8	18.6
11	Pomegranate	19.8	25.4	23.4	31.4
12	Banana	28.7	20.4	22.4	28.5
13	Olive	26.9	29.1	20.2	23.8
14	Litchi	23.1	28.7	20.5	27.7
15	Tamarind	26.4	23.1	25.7	24.8
16	Almond	18.4	29.8	23.6	28.2
17	Grape	19.4	29.4	23.8	27.4
18	Palm	25.5	28.4	22.4	23.7
19	Strawberry	26.9	22.1	20.8	30.2
20	Watermelon	22.5	23.4	28.1	26
Woody plants					
21	Rain tree	28.8	19.4	23.6	28.2
22	Neem	19.4	27.4	23.8	29.4
23	Sisso	25.5	23.4	22.7	28.4
24	Acasia	30.8	19.4	21.6	28.2
Multiple response					

4.1.27 Incidence of mealybugon different flower plants

According to the opinion expressed by the farmers, out of 300 farmers, highest 155 farmers (51.57%) responded to mealybug incidence in rose, which was followed by 148 farmers (49.36%) in china rose. Whereas, lowest 87 farmers (29.05%) reported incidence of mealybug in lily, which was followed by 91 farmers (30.25%) in tuberose (Table 27).

Table 27. Incidence of mealybug on different flower plants

Sl. No.	Name of flower plants	% response on pest incidence					
		Yes		No		No idea	
		Number	% response	Number	% response	Number	% response
Flower							
1	Rose	155	51.77	93	31.08	51	17.15
2	China rose	148	49.36	93	31.08	59	19.56
3	Marigold	119	39.69	124	41.3	57	19.02
4	Tuberose	91	30.25	145	48.33	64	21.43
5	Gladiolus	110	36.82	106	35.31	84	27.87
6	Garden croton	130	43.46	115	38.41	54	18.13
7	Lily	87	29.05	165	54.89	48	16.07
8	Orchid	139	46.28	85	28.38	76	25.34
9	Gardenia	142	47.23	91	30.38	67	22.39
10	Sunflower	141	47.07	94	31.48	64	21.46
11	Dahlia	94	31.49	119	39.59	87	28.92
12	Jasmine	138	46.11	82	27.39	79	26.49
Multiple response							

4.1.28 Infestation severity of different flower plants by mealybug in field condition

According to the opinion expressed by the farmers, most (47.9%) of the farmers reported that the china rose was most severely infested in the field by mealybug, which was followed by rose infestation (43.2%).Whereas, marigold is minorly infested by mealybug reported by 86.7% farmers, which was followed by orchid as reported by 83.2% farmers.

Table 28. Infestation severity of different flower plants by mealybug in field condition

Sl. No.	Name of flower plants	% response on pest status	
		Major	Minor
1	Rose	43.2	56.8
2	China rose	47.9	52.1
3	Marigold	13.3	86.7
4	Tuberose	29.1	70.9
5	Gladiolus	34.5	65.5
6	Garden croton	28.6	71.4
7	Lily	26.7	73.3
8	Orchid	16.8	83.2
9	Gardenia	21.4	78.6

Sl. No.	Name of flower plants	% response on pest status	
		Major	Minor
10	Sunflower	18.9	81.1
11	Dahlia	26.3	73.7
12	Jasmine	22.7	77.3
Multiple response			

4.1.29 Vulnerable stages of different flower plants by mealybug in field condition

After completion of the survey, out of 300 farmers, most of farmers (77.8%) reported flowering stage of rose as most devastating stage, which was followed by flowering stage of sunflower as reported by 76.9% farmers. Most vulnerable seedling stage found on marigold as reported by 20.6% farmers, dahlia seedling stage was reported as least vulnerable by 8.2% farmers. Most vulnerable vegetative stage found on china rose as reported by 26.1% farmers, whereas, vegetative stage of gardenia and rose were least vulnerable stages as reported by 11.8% and 11.9% farmers, respectively (Table 29).

Table 29. Vulnerable stages of different flower plants by mealybug in field condition

Sl. No.	Name of flower plants	% response on vulnerable stage		
		Seedling	Vegetative	Flowering
1	Rose	10.3	11.9	77.8
2	China rose	13.6	26.1	60.3
3	Marigold	20.6	25.8	53.6
4	Tuberose	15.2	12.7	72.1
5	Gladiolus	11.5	22.6	65.9
6	Garden croton	14.4	16.7	68.9
7	Lily	13.8	12.4	73.8
8	Orchid	18.6	21.2	60.2
9	Gardenia	14.1	11.8	74.1
10	Sunflower	10.3	12.8	76.9
11	Dahlia	8.2	19.8	72
12	Jasmine	16.9	15.2	67.9
Multiple response				

4.1.30 Vulnerable parts of different flower plants to mealybug pests in field condition

According to the opinion expressed by the farmers, in terms of leaf, garden croton was mostly infested (43.8%) by mealybug, which was followed by gardenia (34.8%). Whereas, orchid was least (14.3%) infested by mealybug, which was followed by tuberose (17.4%). In terms of stem, china rose was the most (38.4%) vulnerable crop, which was followed by garden croton (38.4%). jasmine was the least (12.8%) infested crop, which was followed by marigold (14.7%). In terms of inflorescence, rose was the most (23.5%) vulnerable crop, which was followed by orchid (22.6%). Whereas, garden croton was the least (2.9%) infested crop, which was followed by china rose (5.1%). In terms of flower, rose was the most (27.4%) vulnerable crop, which was followed by lily (21.6%). Whereas, garden croton was the least (4.1%) infested crop, which was followed by china rose (8.6%). In terms of fruit, dahlia was the most (29.1%) vulnerable crop, which was followed by jasmine (26.8%). Whereas, orchid was the least (9.5%) infested crop, which was followed by both lily and gardenia (10.9%). In terms of root, orchid was the most (25.6%) vulnerable crop. Whereas, all other flower root were least (2.3%-9.8%) infested by mealybug at all in the field condition (Table 30).

Table 30. Vulnerable parts of different flower plants to mealybug pests in field condition

Sl. No.	Name of flower plants	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
Flower							
1	Rose	18.9	15.7	23.5	27.4	8.8	5.7
2	China rose	28.1	38.4	5.6	8.6	15.9	3.4
3	Marigold	18.6	14.7	18.9	16.5	25.5	5.8
4	Tuberose	17.4	19.1	16.6	17.3	19.8	9.8
5	Gladiolus	19.6	20.1	12.9	25.3	16.4	5.7

Sl. No.	Name of flower plants	% response on vulnerable parts					
		Leaf	Stem	Inflorescence	Flower	Fruit	Root
6	Garden croton	43.8	29.4	2.9	4.1	17.5	2.3
7	Lily	25.4	24.7	11.5	21.6	10.9	5.9
8	Orchid	14.3	16.6	22.6	11.4	9.5	25.6
9	Gardenia	34.8	26.1	11.4	11.9	10.9	4.9
10	Sunflower	21.3	16.9	19.5	14.9	25.1	2.3
11	Dahlia	20.4	26.7	5.1	10.9	29.1	7.8
12	Jasmine	30.9	12.8	9.5	15.9	26.8	4.1
Multiple response							

4.1.31 Severity of different flower plants to mealybug pests in field condition

According to the opinion expressed by the farmers, china rose showed the highest (95.5%) percentage of infestation, which was followed by rose (93.3%) and garden croton (92.8%) infestation by mealybug in field condition. Whereas, 93.7% farmers reported that gardenia showed lowest severity of infestation, which was followed by 88.4% in lily (Table 31).

Table 31. Severity of different flower plants to mealybug pests in field condition

Sl. No.	Name of flower plants	% response on severity of infestation		
		High	Medium	Low
Flower				
1	Rose	93.3	4.7	2
2	China rose	95.5	1.5	3
3	Marigold	44.5	6.9	48.6
4	Tuberose	54.2	2.8	43
5	Gladiolus	10.6	4.1	85.3
6	Garden croton	92.8	5.8	1.4
7	Lily	8.7	2.9	88.4
8	Orchid	15.8	5.7	78.5
9	Gardenia	4.9	1.4	93.7
10	Sunflower	38.5	11.9	49.6
11	Dahlia	29.1	15.2	55.7
12	Jasmine	29.2	9.4	61.4
Multiple response				

4.1.32 Amount of damage of infestation of mealybug in different flower plants

According to the opinion expressed by the farmers, highest entire crop damage found in china rose (21.2%), which was followed by jasmine (19.8%). Whereas, least entire crop damage found in garden croton (8.7%), which was followed by rose (10.7%). Highest partial damage found in garden croton (87.8%), which was followed by rose (81.2%). Whereas, china rose showed lowest (60.2%) partial damage, which was followed by dahlia (63.6%). 20.6% farmers stated that dahlia faced not so much damage by mealybug in the field condition (Table 32).

Table 32. Idea about amount of damage of infestation of mealybug in different flower plants

Sl. No.	Name of flower plant	% response on extent of damage		
		Entire crops	Partial damage	Not so much damage
Flower				
1	Rose	10.7	81.2	8.1
2	China rose	21.2	60.2	18.6
3	Marigold	11.3	76.3	12.4
4	Tuberose	19.7	66.9	13.4
5	Gladiolus	14.3	76	9.7
6	Garden croton	8.7	87.8	3.5
7	Lily	12.9	76.6	10.5
8	Orchid	12.1	74.7	13.2
9	Gardenia	11.8	74.1	14.1
10	Sunflower	11.8	78.9	9.3
11	Dahlia	15.8	63.6	20.6
12	Jasmine	19.8	72	8.2
Multiple response				

4.1.33 Pick period of infestation of mealybug in different flower plants

According to the opinion expressed by the farmers, in summer, highest (23.5%) damage was observed in garden croton, which was followed by dahlia (23.1%). Whereas, lowest (13.4%) damage was observed in rose in summer (Table 33).

In winter, highest (24.1%) damage was observed in both marigold and garden croton, which was followed by both sunflower and dahlia (22.2%). Lowest (9.7%) damage was observed in gladiolus (Table 33).

In rainy season, highest (27.3%) damage was observed in china rose, which was followed by both tuberose and orchid (23.1%). Whereas, lowest (11.8%) damage was found in gladiolus, which was followed by sunflower (17.4%). Garden croton showed highest (60.4%) damage whole the year round, which was followed by rose (47.2%). Whereas, lowest (35.6%) damage was found in marigold, which was followed by dahlia (36.2%).

Table 33. Pick period of damage of infestation of mealybug in different flower plants

Sl. No.	Name of flower plant	% response on pick period of damage			
		Summer	Winter	Rainy season	Whole year
Flower					
1	Rose	13.4	17.5	21.9	47.2
2	China rose	19.4	14.5	27.3	38.8
3	Marigold	20.5	24.1	19.8	35.6
4	Tuberose	19.4	18.2	23.1	39.3
5	Gladiolus	18.1	9.7	11.8	60.4
6	Garden croton	23.5	24.1	22.2	30.2
7	Lily	22.1	17.4	19.5	41
8	Orchid	21.2	18.6	23.1	37.1
9	Gardenia	22.1	17.4	19.8	40.7
10	Sunflower	20.1	22.2	17.4	40.3
11	Dahlia	23.1	22.2	18.5	36.2
12	Jasmine	18.4	19.4	22.7	39.5
Multiple response					

4.1.34 Present mealybug infestation status

Out of 300 farmers, 208 farmers (69%) responded to present mealybug infestation, and only 92 farmers (31%) didn't respond to mealybug infestation in the field (Figure 3).

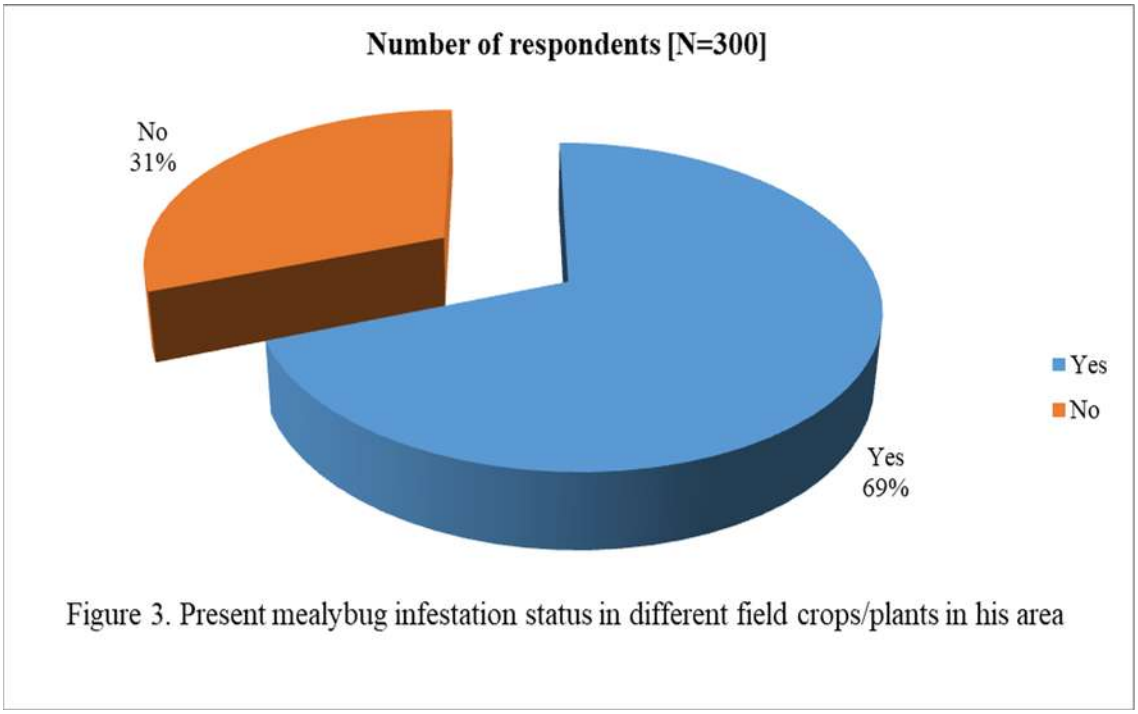

Figure 3. Present mealybug infestation status in different field crops/plants in his area

4.1.35 Response on the virus or diseases which are transmitted by mealybug

Out of 300 farmers interviewed, all of the farmers reported that mealybug didn't transmit any virus or disease (Table 34).

Table 34. Response on the virus or diseases which are transmitted by mealybug

Type of response	Number of respondents [N=300]	% response
Yes	0	0
No	300	100
Total	300	100

4.1.36 Crops those are currently more damaged by mealybug

According to the opinion expressed by 300 farmers, the highest number 179 farmers (59.56%) reported that papaya mealybug caused more damage than earlier, same respondent also found mealybug infestation in brinjal, chilli, mango, guava, china rose, marigold, lemon, okra and coconut as reported by 158 (52.67%), 144 (47.84%), 133 (44.34%), 123 (41.16%), 113 (37.69%), 109 (36.31%), 98 (32.59%), 64 (21.49%) and 55 (18.23%) farmers, respectively (Table 35).

Table 35. Name of the crop plants which are currently more damaged by mealybug insect

Sl. No.	Name of crop plants	Frequency of response	% response
1	Brinjal	158	52.67
2	Chilli	144	47.84
3	Mango	133	44.34
4	Papaya	179	59.56
5	Guava	123	41.16
6	Lemon	98	32.59
7	Okra	64	21.49
8	Marigold	109	36.31
9	Coconut	55	18.23
10	China rose	113	37.69
Multiple response			

4.1.37 Idea about currently seen mealybug

According to the opinion expressed by the farmers, out of 300 farmers, 54 farmers (18%) responded to have seen mealybug recently, those were not seen earlier (Figure 4).

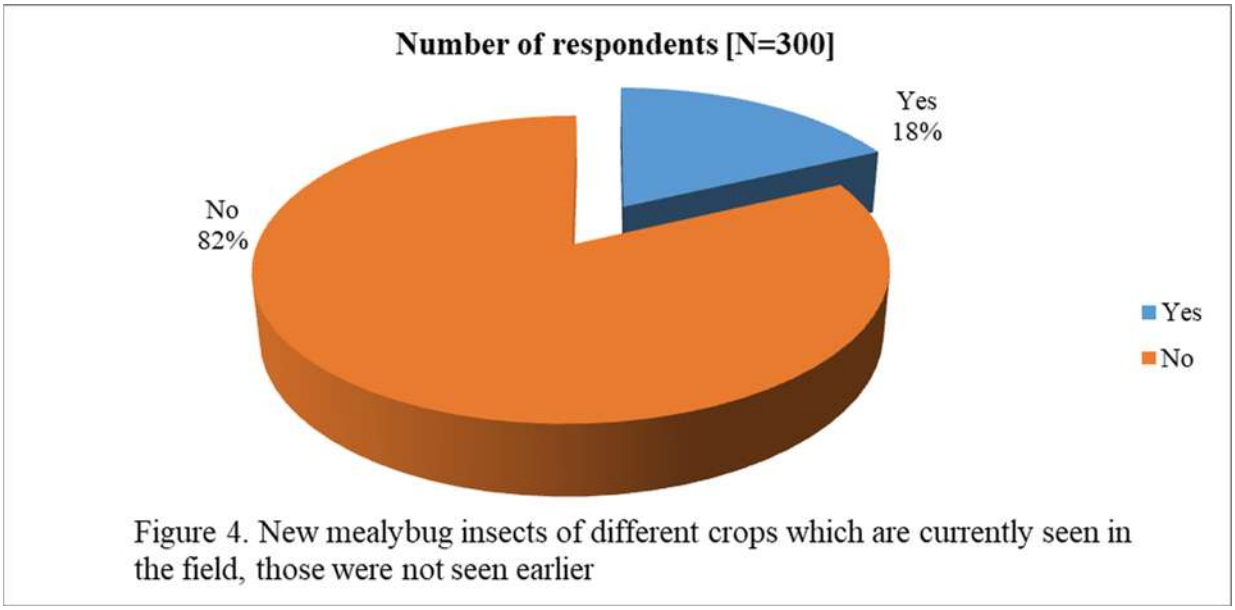

Figure 4. New mealybug insects of different crops which are currently seen in the field, those were not seen earlier

4.1.38 Newly seen mealybug insects of different crops

According to the opinion expressed by the farmers, out of currently mealybug seen 54 farmers, 45 farmers (83.75%) seen mango mealybug, 43 farmers (80.53%) responded to papaya mealybug, 32 farmers (59.23%) responded to okra mealybug, 26 farmers

(47.57%) responded to rice mealybug and 24 farmers (44.44%) responded to chilli mealybug (Table 36).

Table 36. Newly seen mealybug insects of different crops, those were not seen earlier

Sl. No.	Name of mealybug species	Frequency of response [N= 54]	% response
1	Mango mealybug	45	83.75
2	Papaya mealybug	43	80.53
3	Okra mealybug	32	59.23
4	Rice mealybug	26	47.57
5	Chilli mealybug	24	44.44
Multiple response			

4.1.39 Currently more damaging mealybug species

Out of 300 farmer's opinion, 239 farmers (79.59%) responsed about mealybug of mango, which was followed by 183 farmers (61%) response about mealybug of papaya. Whereas, lowest 109 farmers (36.33%) responded about mealybug infesting marigold, which was followed by 120 farmers (39.85%) response about mealybug infesting okra (Table 37).

Table 37. Currently more damaging mealybug species of different agricultural crops

Sl. No.	Name of mealybug species	Frequency of response	% response
1	Mealybug of Brinjal	153	50.87
2	Mealybug of Chilli	143	47.67
3	Mealybug of Mango	239	79.59
4	Mealybug of Papaya	183	61
5	Mealybug of Guava	174	58.1
6	Mealybug of Lemon	143	47.75
7	Mealybug of Banana	139	46.3
8	Mealybug of Okra	120	39.85
9	Mealybug of Marigold	109	36.33
10	Mealybug of China rose	142	47.34
Multiple response			

4.1.40 Actions taken for mealybug control

All of the 300 farmers took action for controlling mealybug (Table 38).

Table 38. Actions taken for mealybug control

Type of response	Number of respondents [N=300]	% response
Yes	300	100
No	0	0
Total	300	100

4.1.41 Options for controlling mealybug

According to the opinion expressed by 300 farmers, 97.08% farmers (291) sprayed insecticides on their plants to control mealybug, about 81.64% farmers (245) removed weeds for controlling mealybug, 69.03% farmers (207) practiced hand picking as their control option, 62.98% farmers (189) used soap water as control option, 53.34% farmers (160) sprayed water as control method, 18.44% farmers (55) used IPM as control tacties, and only 20.23% farmers (61) didn't take any control option (Table 39).

Table 39. Options for controlling mealybug

Sl No.	Control options	Number of respondents [N=300]	% response
1	Spraying of insecticides on the plant	291	97.08
2	Remove of weeds	245	81.64
3	By hand picking	207	69.03
4	Using soap water	189	62.98
5	Spraying water	160	53.34
6	IPM	55	18.44
7	Cannot control	61	20.23
Multiple response			

4.1.42 Effective insecticides for controlling mealybug

According to the opinion expressed by 300 farmers, 88.92% farmers (267) used fighter as an effective insecticide, malathion applied by 85.48% farmers (256), ethrin sprayed by

83.97% farmers (252), imidachloprid applied by 81.51% farmers (245), darsban applied by 77.46% farmers (232), sumithion applied by 69.03% farmers (207), native applied by 65.93% farmers (198), mipsin applied by 53.18% farmers (160), ripcord applied by 40.41% farmers (121), cypermethrin applied by 39.52% farmers (119) and aktara applied by 32.39% farmers (97) for suppresing mealybug (Table 40).

Table 40. Name of the effective insecticide which are used to control mealybug

Sl.	Name of effective insecticides	Frequency of response	% response
1	Fighter	267	88.92
2	Malathion	256	85.48
3	Ethrin	252	83.97
4	Imidachloprid	245	81.51
5	Darsban	232	77.46
6	Sumithion	207	69.03
7	Nativo	198	65.93
8	Mipsin	160	53.18
9	Ripcord	121	40.41
10	Cypermethrin	119	39.52
11	Aktara	97	32.39
Multiple response			

4.1.43. Some plates of different important crops those were infested by mealybug in the field condition:

Plate 7. Mealybug on okra plant

Plate 8. Mealybug on cotton boll

Plate 9. Mealybug on brinjal

Plate 10. Mealybugs on china rose

Plate 11. Mealybugs on sugarcane

Plate 12. Mealybugs on citrus

Plate 13. Mealybugs on jujube

Plate 14. Mealybugs on papaya

Plate 15. Mealybugs on pineapple

Plate 16. Mealybugs on coconut leaf

Plate 17. Mealybugs on grape

Plate 18. Mealybugs on orchid plant

Plate 19. Mealybugs on lily plant

Plate 20. Mealybugs on crotons

Plate 21. Mealybugs on guava leaf

Plate 22. Mealybugs on mango

Plate 23. Mealybugs on jackfruits

Plate 24. Mealybugs on banana

4.2 Host plants of mealybugs in Bangladesh

The major and minor hosts of mealybug in Bangladesh along with plant parts affected were identified through the field survey conducted in 10 sampled districts. From the field survey and review of secondary documents, the precise findings of the study in-line with the presence of host plants along with plant parts affected of the crops have been presented below (Table 41):

4.2.1. Hosts of mealybugs recoded on field crops and weeds in Bangladesh

Fourteen (14) host plants of field crops while ten (10) host plants under weeds were recorded in Bangladesh that host mealybugs. Among 14 crops that host mealybugs, two were recorded as major hosts namely cotton and tobacco; other 12 field crops were recored as minor hosts for mealybugs namely jute, sugarcane, wheat, sesame, chickpea, garden pea, lentil, mungbean, mustard, groundnut, maize and rice (Table 41).

Among 10 weeds that host mealybugs, all of which were recorded as minor hosts of mealybugs namely dodder, barmuda grass, parthenium, spiny pigweed, fig tree (*Ficus hispida*), corn spurge, goat weed, goosefoot (*Chenopodium album*), Indian sorrel and blackknight shade (Table 41).

Table 41. Field crops and weeds recorded in Bangladesh that host mealybugs

Sl. No.	Name of host plant	Scientific name and family	Host status	Vulnerable stage	Plant parts affected	Infestation severity	Damage potential
Field crops							
1	Cotton	*Gossypium herbaceum* Malvaceae	Major	Vegetative & fruiting	Leaf, stem, flower, boll	High	Partial
2	Jute	*Corchorus* spp. Tiliacae	Minor	Vegetative	Leaf, stem	Low	Little bit
3	Sugarcane	Sacarum officinarum Poaeae	Minor	Vegetative	Leaf, stem	Low	Little bit
4	Wheat	*Triticum aestivum* Poacae	Minor	Vegetative	Leaf, stem	Low	Little bit
5	Sesame	*Sesamum indicum* Pediliaceae	Minor	Vegetative & fruiting	Leaf, stem & pod	Low	Little bit
6	Tobacco	*Nicotiana tabacum* Solanaceae	Major	Vegetative	Leaf, stem	Low	Partial
7	Chickpea	*Cicer arietinum* Fabaceae	Minor	Vegetative & fruiting	Leaf, stem & pods	Low	Little bit
8	Garden pea	*Pisum sativum* Fabaceae	Minor	Vegetative & fruiting	Leaf, stem & pods	Low	Little bit
9	Lentil	*Lens culinaris* Fabaceae	Minor	Vegetative & fruiting	Leaf, stem & pods	Low	Little bit
10	Mungbean	*Vigna mungo* Fabaceae	Minor	Vegetative & fruiting	Leaf, stem & pods	Low	Little bit
11	Mustard	*Brassica spp.* Brassicaceae	Minor	Vegetative	Leaf & stem	Low	Little bit
12	Groundnut	*Arachis hypogea* Fabaceae	Minor	Vegetative & fruiting	Leaf & stem	Low	Partial

Sl. No.	Name of host plant	Scientific name and family	Host status	Vulnerable stage	Plant parts affected	Infestati-on severity	Damage potential
13	Maize	*Zea mays* Poaceae	Minor	Vegetative & fruiting	Leaf, stem & cobs	Low	Partial
14	Rice	*Oryza sativa* Poaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
Weeds							
1	Dodder	*Cuscuta reflexa* Convulvulaceae	Minor	Vegetative	Vine	Low	Little bit
2	Barmuda grass	*Cynodon dactylon* Poaceae	Minor	Vegetative	Leaf & creeper	Low	Little bit
3	Parthanium	*Hysterophorus phorus* Asteraceae	Minor	Vegetative & fruiting	Leaf, stem & flowers	Low	Little bit
4	Spiny pigweed	*Amaranthus palmeri* Amaranthaceae	Minor	Vegetative & fruiting	Leaf, stem & flowers	Low	Little bit
5	Kak-dumur/ fig tree	*Ficus hispida* Moraceae	Minor	Vegetative	Leaf, stem	Low	Little bit
6	Corn spurge	*Phyllanthus niruri* Phyllanthaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
7	Goat weed	*Ageratum conyzoides* Asteraceae	Minor	Vegetative	Leaf, stem	Low	Little bit
8	Bothua/ goosefoot	*Chenopodium album* Amaranthaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
9	Indian sorrel	*Oxalis acetosella* Oxalidaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
10	Blackknig-ht shade	*Solanum nigrum* Solanaceae	Minor	Vegetative	Leaf, stem	Low	Little bit

4.2.2. Hosts of mealybugs as observed on vegetable crops in Bangladesh

Twenty four (24) host plants under vegetable crops were recorded in Bangladesh that host mealybugs. Among 24 vegetable crops, four (4) were recorded as major hosts namely chilli, brinjal, papaya and okra; other 20 vegetable crops were recorded as minor hosts for mealybugs namely onion, sweet gourd, ridge gourd, bottle gourd, bitter gourd, pointed gourd, tomato, potato, sweet potato, carrot, radish, amaranth, bean, sponge gourd, coriander, spinach, Indian spinach, cabbage,red amaranth and aram (Table 42).

Table 42. Vegetable crops recorded that host mealybugs in Bangladesh

Sl. No	Name of host plants	Scitific name and Family	Host status	Vulnerable stages	Plant parts affected	Infestat-ion severity	Damage potential
1	Chilli	*Capsicum annum* Solanaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Entire plant
2	Onion	*Allium cepa* Alliaceae	Minor	Vegetative	Leaf, stem	Low	Partial
3	Sweet gourd	*Cucrbita moschata* Cucurbitacae	Minor	Vegetative & fruiting	Leaf, stem & fruits	Low	Partial
4	Ridge gourd	*Luffa acutangula* Cucurbitacae	Minor	Vegetative & fruiting	Leaf, stem & fruits	Low	Little bit
5	Bottle gourd	*Lageneria vulgaris* Cucurbitacae	Minor	Vegetative & fruiting	Leaf, stem & fruits	Low	Little bit
6	Bitter gourd	*Momordica charantia* Cucurbitacae	Minor	Vegetative & fruiting	Leaf, stem & fruits	Low	Little bit
7	Pointed gourd	*Trichosanthes dioica* Cucurbitacae	Minor	Vegetative & fruiting	Leaf, stem & fruits	Low	Little bit
8	Tomato	*Lycopersicon esculentum* Solanaceae	Minor	Vegetative & fruiting	Leaf, stem	Low	Partial
9	Brinjal	*Solanum melongena* Solanaceae	Major	Vegetative & fruiting	Leaf, stem, flower & fruits	High	Entire plant

Sl. No	Name of host plants	Scitific name and Family	Host status	Vulnerable stages	Plant parts affected	Infestat-ion severity	Damage potential
10	Potato	*Solanum tuberosum* Solanaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
11	Sweet potato	*Ipomea batatus* Convulvulac-eae	Minor	Vegetative	Leaf & stem	Low	Partial
12	Papaya	*Carica papaya* Caricaceae	Major	Vegetative & fruiting	Leaf, stem, flower & fruits	High	Entire plant
13	Carrot	*Daucus carota* Umbelliferae	Minor	Vegetative	Leaf, stem	Low	Little bit
14	Radish	*Raphanus sativus* Cruciferae	Minor	Vegetative & fruiting	Leaf & stem	Low	Little bit
15	Okra	*Abelmoschus esculentus* Malvaceae	Major	Vegetative & fruiting	Leaf, stem, flower & fruits	High	Entire plant
16	Amaranth	*Amaranthus oleraceae* Amaranthaceae	Minor	Vegetative & fruiting	Leaf, stem	Low	Little bit
17	Bean	*Dolichos lablab* Fabaceae	Minor	Vegetative & fruiting	Leaf, stem, inflorescence	Low	Little bit
18	Sponge gourd	*Luffa acutangula* Cucurbitaceae	Minor	Vegetative & fruiting	Leaf, stem, inflorescence	Low	Little bit
19	Coriender	*Coriandrum sativum* Apiaceae	Minor	Vegetative & fruiting	Leaf, stem, petiol	Low	Little bit
20	Spinach	*Spinacia oleracea* Amaranthaceae	Minor	Vegetative & fruiting	Leaf, stem, petiol	Low	Little bit
21	Indian spinach	*Basella alba* Basellaceae	Minor	Vegetative & fruiting	Leaf, stem, petiol, inflorescence	Low	Little bit
22	Cabbage	*Brassica oleracea* Brassicaceae	Minor	Seedling & vegetative	Leaf, stem	Low	Little bit

Sl. No	Name of host plants	Scitific name and Family	Host status	Vulnerable stages	Plant parts affected	Infestat-ion severity	Damage potential
23	Red amaranth	*Amaranthus cruentus* Amaranthaceae	Minor	Seedling & vegetative	Leaf, stem	Low	Little bit
24	Aram	*Colocasia esculenta* Araceae	Minor	Seedling & vegetative	Leaf, stem	Low	Little bit

4.2.3. Hosts of mealybugs recorded on fruits, woody and medicinal plants in Bangladesh

Twenty one (21) host plants under fruit plants, nine (9) host plants under woody plants and five (5) host plants under medicinal plants were recorded in Bangladesh that host mealybugs. Among 21 fruit plants that host mealybugs, nine (9) were recorded as major hosts namely jujube, mango, jackfruit, guava, citrus, coconut, banana, grape, and strawberry; other ten (12) fruit plants were recorded as minor hosts for mealybugs namely orange, pineapple, date palm, betelnut, pomegranate, olive, litchi, tamarind, almond, palm tree, baclberry and anona (Table 43).

Among 9 woody plants that host mealybugs, all of which were recorded as minor hosts namely rain tree, sisso, acasia, jarul (*Lagerstroemia speciosa*), royal Poinciana, debdaru (*Polyalthia longifolia*), portia tree, silk cotton and banyan tree.

Among 5 medicinal plants that host mealybugs, all of which were recorded as minor hosts namely neem, devil's cotton, gandhabhadule (*Paederia foetida*), coral tree and henna (Table 43).

Table 43. Hosts of mealybugs on fruit, woody and medicinal plants recorded in Bangladesh

Sl. No	Name of host plants	Scientific name and family	Host status	Vulnerable stages	Plant parts affected	Infestati-on severity	Damage potential
Fruit plants							
1	Jujube	*Ziziphus jujuba* Rhamnaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	Medium	Partial
2	Mango	*Mangifera indica* Anacardicaeae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Partial
3	Jackfruit	*Artocarpus heterophyllus* Moraceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Partial
4	Guava	*Psidium guajava* Myrtaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Partial
5	Citrus	*Citrus limon* Rutaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Partial
6	Orange	*Citrus reticulate* Rutaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Partial
7	Pineapple	*Annanus comosus* Bromeliaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	Low	Partial
8	Date palm	*Phoenix sylvestris* Palmae	Minor	Seedling, vegetative& fruiting	Leaf, stem	Low	Little bit
9	Coconut	*Cocos nucifera* Palmae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower & fruits	Low	Little bit
10	Betel nut	*Areca catechu* Palmae	Minor	Seedling & vegetative	Leaf, stem	Low	Little bit

Sl. No	Name of host plants	Scientific name and family	Host status	Vulnerable stages	Plant parts affected	Infestati-on severity	Damage potential
11	Pome-granate	*Punica granatum* Lythraceae	Minor	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	Medium	Partial
12	Banana	Musa sapientum Musaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	Medium	Partial
13	Olive	*Olea europea* Oliaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
14	Litchi	*Litchi sinensis* Sapindaceae	Minor	Seedling, vegetative & fruiting	Leaf & stem	Low	Little bit
15	Tamarind	*Tamarindus indicus* Fabaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
16	Almond	*Prunus amygdalus* Rosaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
17	Grape	*Vitis vineferae* Vitaceae	Major	Seedling, vegetative & fruiting	Leaf, vine, flower, fruits	High	Entire plant
18	Palm tree	*Elaeis guinennsis* Palmae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
19	Strawberry	*Fragagaria annanasa* Rosaceae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower, fruits	High	Entire plant
20	Blackberry	*Syzygium cumini* Myrtaceae	Minor	Seedling, vegetative & fruiting	Branch, stem, leaf, petiole	Low	Little bit
21	Anona	*Annona squamosal* Annonaceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
Woody plants							
1	Rain tree	*Albizia samon* Fabaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
2	Sisso	*Dalbergia sisso* Leguminosae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit

Sl. No	Name of host plants	Scientific name and family	Host status	Vulnerable stages	Plant parts affected	Infestati-on severity	Damage potential
3	Acasia	*Acacia catechu* Fabaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
4	Gaint Crape-myrtle/ Jarul	*Lagerstroemia speciosa* Lythraceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
5	Royal Poinciana	*Delonix regia* Fabaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
6	False Ashoka/ Debdaru	*Polyalthia longifolia* Annonaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
7	Portia tree/ Pakur	*Thespesia populnea* Malvaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
8	Silk cotton/ Shimul	*Ceiba pentandra* Malvaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
9	Banyan tree	*Ficus benghalensis* Moraceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
Medicinal plants							
1	Neem	*Azadirachta indica* Meliaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
2	Devil's cotton/ Ulatkombal	*Abroma augusta* Stereculiaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
3	Gandhabha dule	*Paederia foetida* Rubiaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
4	Coral tree	*Erythrina lysistemon* Fabaceae	Minor	Seedling, vegetative & fruiting	Leaf, stem	Low	Little bit
5	Henna	*Lawsonia inermis* Lythraceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit

4.2.4. Flower/ornamental and hedge plants that host mealybugs in Bangladesh

Sixteen (16) host plants under flower-ornamental plants and four (4) host plants under hedge plants were recorded in Bangladesh that host mealybugs (Table 44). Among these 16 flower-ornamental plants, three (3) were recorded as major hosts namely China rose, marigold, garden crotons; other thirteen (13) flower and ornamental plants were recored as minor hosts for mealybugs namely tuberose, gladiolus, lily, orchid, gardenia, sunflower, dahlia, jasmine, alocasia, boat-lily, dumb cane and cock's comb (Table 44). Among 4 hedge plants that host mealybugs, all of which were recorded as minor hosts namely giga/ Indian ash tree (*Lannea coromandelica*), streblus/toothbrush tree (*Streblus asper*), lantana and duranto/pigeon berry (*Duranta erecta*) (Table 44).

Table 44. Flower-ornamental and hedge plants recorded in Bangladesh that host mealybugs

Sl. No	Name of host plant	Scientific name and family	Host status	Vulnerable stage	Plant parts affected	Infestati-on severity	Damage potential
1	Rose	*Rosa sinensis* Rosaceae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
2	China rose	*Hibiscus rosa chinensis* Malvaceae	Major	Seedling, vegetative & flowering	Leaf, stem & flower	High	Entire plant
3	Marigold	*Tagetes erecta* Compositae	Major	Seedling, vegetative & flowering	Leaf, stem & flower	High	Entire plant
4	Tuberose	*Polianthes tuberose* Asparagaceae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
5	Gladiolus	*Gladiolus palustris* Iridaceae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
6	Garden croton	*Codiaeum variegatum* Euphorbiaceae	Major	Seedling, vegetative & flowering	Leaf & stem	High	Entire plant

Sl. No	Name of host plant	Scientific name and family	Host status	Vulnerable stage	Plant parts affected	Infestati-on severity	Damage potential
7	Lily	*Lilium lancifolium* Liliaceae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
8	Orchid	*Orchis spp*. Orchidaceae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
9	Gardenia	*Gardenia jasminoides* Rubicaeae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
10	Sunflower	*Helianthus annus* Compositae	Minor	Vegetative & flowering	Leaf, stem	Low	Little bit
11	Dahlia	*Dahlia hybrida* Compositae	Minor	Seedling, vegetative & flowering	Leaf, stem & flower	Low	Little bit
12	Jasmine	*Jasminum sambac* Oleaceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
13	Alocasia	*Alocasia* Sp. Araceae	Minor	Vegetative & flowering	Leaf, stem	Low	Little bit
14	Boat-lily	*Tradescantia spathacea* Commelinaceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
15	Dumb cane	*Dieffenbachia seguine* Araceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
16	Cock's comb	*Celosia cristata* Amaranthaceae	Minor	Seedling, vegetative & flowering	Leaf, stem	Low	Little bit
Hedge plants							
1	Giga/ Indian ash tree	*Lannea coromandelica* Anacardiaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
2	Streblus/ toothbrush	*Streblus asper* Moraceae	Minor	Vegetative	Leaf, stem	Low	Little bit
3	Lantana	*Lantana camara* Verbenaceae	Minor	Vegetative	Leaf, stem, inflorescence	Low	Little bit
4	Duranto/ pigeon berry	*Duranta erecta* Verbenaceae	Minor	Vegetative	Leaf, stem	Low	Little bit

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in 30 upazillas of 10 selected major crop growing districts of Bangladesh during the period from January to May, 2017 to find out the present status and diversity of mealybug pest, their risks and management options. The data were collected through interview of 300 crop growing farmers considering 10 farmers from each upazilla and 100 farmers participated in focus group discussion (FGD). The results obtained from the studies have been summarized and concluded below:

SUMMARY

The field study that was conducted among 300 farmers, mejority (82%) were male farmers, while only 18% farmers were female. Among them 106 farmers (35.21%) were field crop farmers, whereas 26.16% farmers (78) were vegetable growers, whereas 20.72% farmers (62) were fruit growers and the lowest proportion 17.9% farmers (54) were flower cultivars. About 95% of them (286) responded about mealybug infestation in their crop field. According to the opinion expressed by the farmers, out of 300 farmers, highest 160 farmers (53.41%) responded to mealybug incidence in cotton. Most (56.8%) of the farmers reported cotton as a major host of mealybug. According to the opinion expressed by the farmers, cotton showed the highest (62.2%) percentage of infestation. In seedling stage, cotton was severely (20.6%) infested by mealybug. Cotton inflorescence was mostly infested by mealybug in the field condition as reported by 25.3% farmers and that's why its inflorescence was the most vulnerable part for cotton. Jute showed highest (41.3%) damage whole the year round.

Out of 300 farmers, most (46.11%) of the farmers (138) reported that the bermuda grass was infested in the field by mealybug followed by dodder infestation as reported by 31.49% farmers (94). Dodder was reported as a major host only by (22.7%) farmers. In seedling stage, dodder was mostly (16.9%) infested by mealybug. In fruiting stage, dodder was severely infested by mealybug as reported by 67.9% farmers. Dodder stem was the most (43.8%) vulnerable stage in all types weed. 76.3% farmers reported dodder showed highest amount of partial damage. Dodder responded highest damage in the rainy season as reported by 28.4% farmers.

In vegetables, 51.03% farmers reported mealybug incidence occurred in papaya, followed by brinjal (48.34%). 55.6% farmers stated papaya as a major infested. Most of farmers (75.7%) reported fruiting stage of papaya as most devastating stage. Papaya root found as the most vulnerable part by 25.6% farmers. Highest partial damage found in papaya reported by 81.2% farmers. Most 47.4% farmers stated summer as the pick period of mealybug infestation in papaya.

In fruit plants, according to the opinion expressed by the farmers, out of 300 farmers, highest 155 farmers (51.57%) responded to mealybug incidence in mango, followed by 150 farmers (49.97%) in jackfruit. Most (82.6%) of the farmers reported that mango was mostly infested in the field by mealybug. In vegetative stage, both mango and jujube were mostly (62.3%) infested by mealybug. In fruiting stage, banana was mostly (75.7%) infested by mealybug. Mango stem was the most vulnerable part as reported by 41.9% farmers. In terms of root, banana was the most (25.6%) vulnerable crop. Highest partial damage found in banana (87.8%). Fruiting stage found as the most devastating stage for

banana as reported by 75.7% farmers. Banana root was the most vulnerable part as reported by 25.6% farmers.

In woody plants, most (51.57%) of the farmers (155) reported that the sisso plant was infested by mealybug. Most 54.2% farmers reported that sisso showed highest severity of infestation. Most 66.2% farmers reported fruiting stage as most devastating and 66.9% farmers stated partial damage occur in sisso plant. Mealubug infestation occurred in whole the year round as reported by 28.4% farmers.

In flower plants, according to the opinion expressed by the farmers, out of 300 farmers, highest 155 farmers (51.57%) responded to mealybug incidence in rose, which was followed by 148 farmers (49.36%) in china rose. About 47.9% farmers reported china rose as a major host of mealybug. Most vulnerable stage of rose was flowering stage as reported by 77.8% farmers. Most 47.2% farmers reported whole the year as the pick period of mealybug infestation on rose. Flower part of rose was the most (27.4%) vulnerable part. Highest partial damage found in rose as reported by 81.2% farmers.

Out of 300 farmers, 208 farmers (69%) responded to mealybug present infestation, and only 92 farmers (30%) didn't respond to mealybug infestation in the field. All of the farmers reported that mealybug didn't transmit any virus or disease.

Out of 300 farmers, highest 179 farmers (59.56%) reported that papaya caused more damage than earlier. Out of 300 farmers, 54 farmers (17.85%) responded to have seen mealybug infestation currently, those were not seen earlier. Out of currently mealybug seen 54 farmers, 45 farmers (83.75%) have seen mango mealybug, 43 farmers (80.53%) have seen papaya mealybug, 32 farmers (59.23%) reported to okra mealybug, 26 farmers (47.57%) reported to rice mealybug and 24 farmers (44.44%) reported to chilli mealybug.

All of the 300 farmers took action for controlling mealybug. Most 97.08% farmers (291) sprayed insecticides on their plants to control mealybug, removing weeds, hand picking, soap water, IPM also used as control option.

Most 88.92% farmers (267) used fighter as an effective insecticide, several insecticides like malathion, ethrin, imidachloprid, darsban, sumithion, native, mipsin, ripcord, cypermethrin and aktara were also used for controlling of mealybug.

CONCLUSIONS

- About 95% of them (286) responded about mealybug infestation in their crop field.
- Among 14 crops that host mealybugs, two were recorded as major hosts namely cotton and tobacco; other 12 field crops were recored as minor hosts for mealybugs namely jute, sugarcane, wheat, sesame, chickpea, garden pea, lentil, mungbean, mustard, groundnut, maize and rice
- Most (56.8%) of the farmers reported cotton as a major host of mealybug.
- Among all weeds that host mealybugs, all of which were recorded as minor hosts of mealybugs namely dodder, barmuda grass, parthenium etc.
- Out of 300 farmers, most (46.11%) of the farmers (138) reported that the bermuda grass was infested in the field by mealybug followed by dodder infestation as reported by 31.49% farmers (94).
- Among twenty four (24) host plants under vegetable crops were recorded in Bangladesh that infested by mealybugs. Among 24 vegetable crops, four (4) were recorded as major hosts namely chilli, brinjal, papaya and okra.

- 51.03% farmers reported mealybug incidence occurred in papaya. Most of the farmers (75.7%) reported fruiting stage of papaya as most devastating stage and highest amount partial damage found in papaya reported by 81.2% farmers.
- In fruit plants, jujube, mango, jackfruit, guava, citrus, coconut, banana, grape, and strawberry were recorded as major fruit plants.
- In fruiting stage, banana was most severely (75.7%) infested by mealybug and highest partial damage found in banana (87.8%).
- On the other hand, rain tree, sisso, acasia and neem were recorded as major woody plants.
- About 51.57% of the farmers (155) reported that the sisso plant was infested by mealybug. Most of the (54.2%) farmers reported that sisso showed highest severity of infestation.
- Among all pf the flowering plants, three (3) were recorded as major hosts namely China rose, rose and garden crotons. Most (47.9%) of the farmers reported that the china rose was mostly infested in the field by mealybug.
- Most 97.08% farmers (291) sprayed insecticides on their plants to control mealybug, removing weeds, hand picking, soap water, IPM also used as control option.
- Most 88.92% farmers (267) used fighter as an effective insecticide, several insecticides like malathion, ethrin, imidachloprid, darsban, sumithion, native, mipsin, ripcord, cypermethrin and aktara also used for controlling of mealybug.

CHAPTER VI

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CHAPTER VII
APPENDICES
Appendix I: Questionnaire for farmer

Sher-e-Bangla Agricultural University
Department of Entomology
Sher-e-Bangla Nagar, Dhaka-1207.

HOST DIVERSITY AND RISK ASSESSMENT OF MEALYBUG IN BANGLADESH

Prepared by:
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Set-1: Questionnaire for farmer

Code:						**Mobile**											

A.0 Personal Information of Farmer

A.1 Name: ----------

A.2 Village ---------- **A.3** Agri Block: ----------

A.4 Upazilla: ---------- **A.5** District: ----------

A.6 Educational qualification: ---------- **A.7** Age: ----------

A.8 Occupation:[Code: 1= Field Crop farmer, 2= Vegetable farmer, 3= Fruit farmer, 4= Flower farmer] ☐ ☐☐☐

A.9 Sex: (Code: 1= Male, 2= Female) ☐

B.0 Information about Crop cultivation and Mealybug:

B.1. Do you have any idea about mealybug? (Code: 1=Yes, 2=No) ☐

B.2. Have you ever seen the attack of mealybug your or neighboring field/plant? (Code: 1=Yes, 2=No) ☐

B.3. Information about mealybug Infestation in field crops and weeds:

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
Field crops							
1. Cotton							
2. Jute							

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
3. Sugarcane							
4. Wheat							
5. Sesame							
6. Tobacco							
7. Chickpea							
8. Pea							
9. Lentil							
10. Mungbean							
11. Mustard							
12. Peanut							
13. Maize							
Weed							
14. Dodder plant							
15. Burmuda grass							
16. Parthenium							
17. Kata Begun							
18. Others							

B.4. Information about mealybug Infestation in Vegetables:

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
Vegetables							
1. Chilli							
2. Onion							
3. Sweet gourd							
4. Ridge gourd							
5. Bottle gourd							

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
6. Bitter gourd							
7. Pointed gourd							
8. Tomato							
9. Brinjal							
10.Potato							
11. Sweet Potato							
12. Papaya							
13. Carrot							
14. Reddish							
15. Ladies Finger							
16. Amaranth							
17. Others							

B.5. Information about mealybug Infestation in fruits and woody plants:

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
Fruit Plants							
1. Jujubi							
2. Mango							
3. Jackfruit							
4. Guava							
5. Lemon							
6. Orange							
7. Pineapple							
8. Datepalm							
9. Coconut							

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
10. Beetle Nut							
11. Pomegranate							
12. Banana							
13. Olive							
14. Lichti							
15. Tamarind							
16.Cashew nuts							
17. Grape							
18. Palm							
19. Strawberry							
20. Water Melon							
21. Others							
Woody Plants							
22. Koroi							
24. Neem							
25. Shishu							
26. Acasia							
27. Others							

B.6. Information about mealybug Infestation in flower plants:

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
Flower Plants							
1. Rose							
2. China rose							

Name of crops	Infestation (1=Yes, 2=No, 3=No Idea)	Host plant condition (1=Primary host, 2=Secondary host)	Growing stage of infested plant (1=Seedling stage, 2=Vegetative stage, 3=Reproductive stage)	Infected parts (1=Leaf, 2=Stem, 3=Inforescences, 4=Flower, 5=Fruit, 6=Root)	Severity of infestation (1=High, 2=Medium, 3=Low)	Amount of loss (1=Whole crop, 2=Partial, 3=No loss)	Much affected in season (1=Summer, 2=Winter, 3=Rainy, 4=All the year round)
3. Marigold							
4. Tuberose							
5. Gladiolus							
6. Croton							
7. Lili							
8. Orchid							
9. Cape Jasmine							
10. Sun flower							
11. Dahlia							
12. Beli							
13. Others							

B.7. **Is there any mealybug infestation in your agricultural crops or in your area? (Code: 1=Yes, 2=No)** ☐

B.8. **How long do you think the infestation occurred?** ☐

[Code: = 1 year (2015-16), 2= Last 5 years (2011-16), 3= Last 10 years (2006-16), 4= Last 15 years (2001-2016), 5= More than 15 years age (Before 2000)]

B.9. **Does mealybug spread any viral disease or other diseases of agricultural crops in your area? (Code: 1=Yes, 2=No)** ☐

B.10. **If the answer is yes, which diseases are spread by mealybug? Mention their names:**

1 ----------, 2 ----------, 3 ----------.

B.11. **What are the agricultural crops that are much more infested than earlier by mealybug? Mention their names:**

1 ----------, 2 ----------, 3 ----------, 4 ----------.

B.12. **What are the species of mealybug of different crops, which incidences are being seen in recent years, but not seen earlier in your area? (Code: 1=Yes, 2=No)** ☐

B.13. **If the answer is yes, then mention their general names and species names:**

1 ----------, 2 ----------, 3 ----------.

B.14. **What are the species of mealybug, which incidences are being more in recent years than earlier? Mention the names:**

1| ----------, 2| ----------, 3| ----------|

B.15. Do you take any control measure against mealybug infestation in agricultural crops? ☐

(Code: 1=Yes, 2=No)

B.16. How do you control mealybug infestation generally? Put code in the box:

(Code: 1= By spraying insecticide in plants, 2= By weeding, 3= By Hand picking, 4= By sprinkling of soapy water, 5= By sprinkling water only, 6= By Percing stick, 7= Integrated Pest Management (IPM), 8= Can't be controlled, 9= others……..(mention it).)

B.17. Which insecticides are generally used to control mealybug?

1 ----------, 2 ----------, 3 ----------, 4 ----------.

B.18. Mention the most effective control measure against mealybug:

1 ----------, 2 ----------, 3 ----------, 4 ----------.

Name of Data Collector: **Signature & Date:**

Name of Field Supervisor: **Signature & Date:**

Appendix 2: F.G.D for agricultural crop farmer

Sher-e-Bangla Agricultural University

Department of Entomology

Sher-e-Bangla Nagor, Dhaka-1207.

HOST DIVERSITY AND RISK ASSESSMENT OF MEALYBUG IN BANGLADESH

Prepared by:

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Set 2: Directions for F.G.D.

Code:				

A.0 Location of F.G.D. ----------.

A.2 Village: ----------. A.3 Agri Block: ----------.

A.4 Upazila: ----------. A.5 District: ----------.

B.1 How many years you have been seen mealybug infestation?

B.2 Which crops that are grown in your area have been affected by mealybug? (Mention their names)

B.3 Which stage of crops is more infested mealybug? (Mention the stage)

B.4 Which parts of crops are more infested by mealybug?

B.5 In which season of a year the infestation of the insect is generally more?

B.6. Is there any infestation of mealybug in the agricultural crops currently in your area?

B.7. How long do you think the infestation is being seen?

B.8. Does mealybug spread any viral disease or other diseases of agricultural crops in your area? (Code: 1=Yes, 2=No) ☐

B.9. If the answer is yes, then which diseases are spread by mealybug? Mention their names:

1 ----------, 2 ----------, 3 ----------.

B.10. **What are the agricultural crops that are much more infested than earlier by mealybug? Mention their names:**

1 ----------, 2 ----------, 3 ----------, 4 ----------.

B.11. **What are the species of mealybug of different crops, which incidences are being seen in recent years, but not seen earlier in your area? (Code: 1=Yes, 2=No)** ☐

B.12. **If the answer is yes, then mention their general names and species names:**

1 ----------, 2 ----------, 3 ----------.

B.13. **What are the species of mealybug, which incidences are being more in recent years than earlier? Mention the names:**

1 ----------, 2 ----------, 3 ----------.

B.14. **Do you take any control measure against mealybug infestation in agricultural crops? (Code: 1=Yes, 2=No)** ☐

B.15. **How do you control mealybug infestation generally?**

1 ----------, 2 ----------, 3 ----------, 4 ----------.

B.16. **Which insecticides are generally used to control mealybug?**

1 ----------, 2 ----------, 3 ----------, 4 ----------.

B.17. **Mention the most effective control measure against mealybug:**

1 ----------, 2 ----------, 3 ----------, 4 ----------.

LIST OF PARTICIPANTS IN FOCUS GROUP DISCUSSION (FGD)

Sl. No.	Name	Village	Occupation	Mobile No.	Signature
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Name of Superintendent of FGD----------

Signature and date----------

Mobile No. ----------