Strengthening Phytosanitary Capacity in Bangladesh Project

Plant Quarantine Wing

Department of Agricultural Extension

Khamarbari, Farmgate, Dhaka-1205

Pest Risk Analysis (PRA) of Mealybug Spp. in Bangladesh

May 2017

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CONDUCTED BY

A Joint Venture of

House of Consultants Limited (HCL)
And

CRDP Consulting Services

House # 330 (1st Floor), Road # 22, DOHS, Mohakhali
Dhaka-1206, Bangladesh
Tel: +88-02-9894206, +88-02-9894209
HOTLINE: 01771-900600
E-mail: hcl@hclbd.org
Website: www.hclbd.ord

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Panel of Authors

Prof. Dr. Khandaker Shariful Islam
Team Leader

Prof. Dr. Md. Razzab Ali
Entomologist

Prof. Dr. Md. Alamgir Hossain
Entomologist

Prof. Dr. F. M. Aminuzzaman
Plant Pathologist

Prof. Dr. Md. Jafar Ullah
Agronomist

Prof. Dr. Md. Ferdous Alam
Economist

Sumon Saha
Chief Coordinator, Study Team

Kazi Md. Abdullah-Al-Mahamud
Study Coordinator

Reviewed by

Md. Ahsan Ullah
PRA Consultant

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Department of Agricultural Extension
Khamarbari, Farmgate, Dhaka-1205

FORWARD

The Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW), Department of Agricultural Extension (DAE), Ministry of Agriculture conducted the study for the "**Pest Risk Analysis (PRA) of Mealybug Spp. in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and A Joint Venture of House of Consultants Limited (HCL) and CRDP Consulting Services on 11 December 2016. The PRA study is a five-month assignment commencing from 20 January 2017 under the SPCB-DAE.

The overall objectives of this Pest Risk Analysis are to identify the more damaging species of mealybug, listing of major and minor crops that host mealybug species, identify the relevant pathways of mealybug species, to identify the quarantine species of mealybug for Bangladesh those are potentials for entry, establishment and spread into Bangladesh through the importation of agricultural products from exporting countries, analysis of uncertainties, identification of management options/system approach for control of regulated pests. To carry out the PRA study, the consulting firms conducted field investigations in 61 upazila under 26 major agricultural crop growing districts of Bangladesh. The study covered the interview 6100 crop farmers; 26 FGDs each of which conducted in one district; conducted 35 key informant interviews (KII) and physical inspection and visits of the crop fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of Mealybugs.

The study findings evidenced that the 14 damaging species of mealybug recorded in Bangladesh those were likely to be associated with the agricultural crops and other plants in Bangladesh. The study also revealed that a total number of one hundred three (103) host plants that host mealybugs were recorded in Bangladesh, of which 14 host plants under field crops, 10 weed hosts, 24 vegetable crops, 21 fruit plants, 9 woody plants, 5 medicinal plants,16 flower-ornamental plants and 4 hedge plants . Among these 103 host plants, 18 were recorded as major hosts and other 85 plants were recorded as minor hosts for mealybugs in Bangladesh. A total number of 13 mealybug species of quarantine importance had been identified that could be introduced into Bangladesh through importation of commercially produced plants and parts of plants. The consultant team also conducted the risk assessment for each quarantine species of mealybug individually based on the consequences and potential of introduction of each quarantine species and a risk rating was estimated for each. Based on the risk assessment and risk rating, four (4) quarantine species of mealybugs were identified as high risk potential, three (3) species of mealybug were identified as moderate risk rating and one (1) species of mealybug was identified as low risk rating and 5 were uncertain species of mealybug. The findings also suggested the risk management options for the quarantine species of mealybugs in line with the pre and post harvest management and phytosanitary measures.
The findings of the PRA study had been presented in the National Level Workshop organized by the SPCB-PQW of DAE. The concerned professionals represented from the country's reputed agricultural universities, research organizations and other relevant personnel from different organizations attended in the workshop. The online version of this report is available in the official website of DAE at www.dae.gov.bd

I would like to congratulate study team for conducting the PRA study successfully and also the concerned SPCB professionals in making the total endeavor a success. I express my heartfelt thanks to the officials of DAE, Ministry of Agriculture, BADC, BARI, Agricultural Universities and Research organizations for their assistance and cooperation extended in conducting the PRA study. Thanks are also due to all members of Technical Committees for cooperation. Special thanks to the Director General of DAE, Director (Plant Quarantine Wing) and other high officials of SPCB-DAE for providing us valuable advice and guidance. I hope that the report certainly would contribute to enhance the exports and imports of different commodities.

(Dr. Mohammad Ali)
Project Director
Strengthening Phytosanitary Capacity in Bangladesh Project
Plant Quarantine Wing
Department of Agricultural Extension
Ministry of Agriculture, Bangladesh

PREFACE

This report intends to respond to the national requirement to make a comprehensive list of more damaging species of mealybug and their hosts in Bangladesh as well as to identify the quarantine species of mealybug for Bangladesh, their pathways to be imported from exporting countries with agricultural commodities, to assess their risks and to identify their management options according to the provision of contract agreement signed between Project Director of Strengthening Phytosanitary Capacity in Bangladesh (SPCB) and the Joint Venture of House of Consultants Limited (HCL) and Center for Research and Development Professionals (CRDP) Consulting Services for **"Conducting Pest Risk Analysis (PRA) of Mealybug Spp. in Bangladesh"** under Plant Quarantine Wing (PQW), Department of Agricultural Extension (DAE), Ministry of Agriculture (MOA), Government of the Peoples Republic of Bangladesh. The PRA study is a four-month assignment commencing from 20 January 2017 under the SPCB-DAE.

Consultancy services for **"Conducting Pest Risk Analysis (PRA) of Mealybug Spp. in Bangladesh"** was provided by the Joint Venture of House of Consultants Limited (HCL) and CRDP Consulting Services. The study team consists of five senior level experts including field and office level support staffs. The major objectives of the study are to identify the more damaging species of mealybug in Bangladesh and listing of major and minor hosts of mealybugs, identification of mealybugs likely to be associated with pathway, identification of potential for entry, establishment and spread, identification of potential economic and environmental impact, identification of control measures and potential impacts of such measures, assessment of potential loss by the pests, preparation of report on risk analysis of the pests following the relevant ISPMs and make recommendation.

This report includes study design, sampling framework and data collection instruments, guidelines and checklists, details of survey and data collection method, data management and analysis and survey finding as well as the stages of PRA, risk assessment strategies of the pests likely to be associated with the commodity to be imported from the exporting countries and the risk management options as recommendations. The report had been reviewed and discussed thoroughly by the SPCB officials along with other experts and representatives through several discussion meetings. This report had been presented in the national level workshop for further comments and suggestions. The consultants finally revised and prepared this report of the PRA study based on comments and suggestions of the client and experts.

(Selim Reza)
CEO and Director
House of Consultants Limited (HCL)
Mohakhali, Dhaka

ACKNOWLEDGEMENTS

It is indeed a great honor for us that Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW) of Department of Agricultural Extension (DAE) has entrusted House of Consultants Limited (HCL) and CRDP Consulting Services to carry out the "**Conducting Pest Risk Analysis (PRA) of Mealybug Spp. in Bangladesh"**. The report has been prepared based on the past five months (January 2017 to May 2017) activities of the survey study in major 26 major agricultural crop growing districts of Bangladesh as well as on the review of secondary documents. In the process of working on the setting indicators and sampling as well as for revising the questionnaires for the field survey and data collection, monitoring and supervision, data analysis and report writing, we have enjoyed the support of SPCB-PQW. The principal author is Prof. Dr. Khandaker Shariful Islam, Team Leader with inputs from Prof. Dr. Md. Razzab Ali, Prof. Dr. Md. Alamgir Hossain, Prof. Dr. Md. Jafar Ullah, Prof. Dr. F. M. Aminuzzaman, Dr. B. A. A. Mustafi, Sumon Saha and Kazi Md. Abdullah-Al-Mahmud of the PRA study team.

The authors are grateful to all persons involved in the PRA study. Our special gratitude to Director General, DAE, Bangladesh, who provided his extended support and gave us an opportunity to meet Director of Plant Quarantine Wing (PQW) of DAE. Special thanks to Dr. Mohammad Ali, Project Director, Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project; Mr. Md. Ahsan Ullah, Consultant (PRA); Mrs. Marina Jebunehar, Senior Monitoring and Evaluation Officer, SPCB for their valuable cooperation, guidance and suggestions to the study team in line with the activities performed during study and report preparation. Our special grateful thanks are also given to Mr. Shoumen Saha, Director, PQW of DAE for his kind cooperation and suggestions during the study period. The active support of Selim Reza, CEO & Director of HCL and Kbd. Sumon Saha, Cheif Coordinator of the study to coordinate the survey team during data collection and monitoring activities also acknowledged with thanks.

(Prof. Dr. Khandaker Shariful Islam)
Team Leader

ACRONYMS

AEZ	:	AGRO-ECOLOGICAL ZONE
BADC	:	BANGLADESH AGRICULTURE DEVELOPMENT CORPORATION
BARI	:	BANGLADESH AGRICULTURAL RESEARCH INSTITUTE
BAU	:	BANGLADESH AGRICULTURAL UNIVERSITY
BBS	:	BANGLADESH BUREAU OF STATISTICS
CABI	:	CENTER FOR AGRICULTURE AND BIOSCIENCE INTERNATIONAL
DAE	:	DEPARTMENT OF AGRICULTURAL EXTENSION
DG	:	DIRECTOR GENERAL
DR.	:	DOCTOR
DTCL	:	DEVELOPMENT TECHNICAL CONSULTANTS PRIVATE LIMITED
e.g.	:	FOR EXAMPLE
EPPO	:	EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
et al.	:	AND ASSOCIATES
EU	:	EUROPEAN UNION
FAO	:	FOOD AND AGRICULTURE ORGANIZATION
FAOSTAT	:	FOOD AND AGRICULTURE ORGANIZATION STATISTICS
FGD	:	FOCUS GROUP DISCUSSION
GOB	:	GOVERNMENT OF BANGLADESH
IPPC	:	INTERNATIONAL PLANT PROTECTION CONVENTION
IPM	:	INTEGRATED PEST MANAGEMENT
ISPM	:	INTERNATIONAL STANDARD FOR PHYTOSANITARY MEASURES
J.	:	JOURNAL
KII	:	KEY INFORMANT INTERVIEW
LTD	:	LIMITED
MD	:	MANAGING DIRECTOR
NGO	:	NON-GOVERNMENT ORGANIZATION
NO.	:	NUMBER
NPPO	:	NATIONAL PLANT PROTECTION ORGANIZATION
^{o}C	:	DEGREE CELSIUS
PD	:	PROJECT DIRECTOR
PFA	:	PEST FREE AREA
PPW	:	PLANT PROTECTION WING
PQW	:	PLANT QUARANTINE WING
PRA	:	PEST RISK ANALYSIS
PROF.	:	PROFESSOR
PVT.	:	PRIVATE
RH	:	RELATIVE HUMIDITY
SAU	:	SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SCA	:	SEED CERTIFICATION AGENCY
SID	:	STATISTICS AND INFORMATICS DIVISION
SPCB	:	STRENGTHENING PHYTOSANITARY CAPACITY PROJECT IN BANGLADESH
UK	:	UNITED KINGDOM
USA	:	UNITED STATES OF AMERICA
USDA	:	UNITED STATES DEPARTMENT OF AGRICULTURE
%	:	PERCENTAGE

EXECUTIVE SUMMARY

The study “Pest Risk Analysis (PRA) of mealybug spp. in Bangladesh” documents the damaging species and their host plants recorded in Bangladesh and the risks associated. With the import pathway of plants or plant materials/flowers/fruits etc. from the exporting countries namely India, China, Thailand, Japan, Vietnam, Philippines, Indonesia, Sri Lanka, Bhutan, Nepal, Pakistan, U.S.A, Australia, France, Netherlands, Brazil, Chile and other countries.

The findings indicated that fourteen (14) species of mealybugs were recorded in Bangladesh and attacked several host plants. Mealybugs species were citrus mealybug (*Planococcus citri*), stripped mealy bug (*Ferrisia virgata*), pink hibiscus mealybug (*Maconellicoccus hirsutus*), spherical mealy bug (*Nipaecoccus viridis*), giant mealybug (*Drosicha mangiferae, Rastrococcus iceryoides*), papaya mealybug (*Paracoccus marginatus*), potato mealybug (*Phenacoccus solani*), brinjal mealybug (*Coccidohystrix insolita*), sugarcane mealybug *(Saccharicoccus sacchari*), palm mealybug (*Palmicultor palmarum*), rice mealybug (*Brevennia rehi*), pineapple mealybug (*Dysmicoccus brevipes*) and bread fruit mealybug (*Icerya aegyptiaca*).

In total, one hundred and three (103) host plants were recorded against mealybugs in Bangladesh, of which 14 host plants were of field crops, 10 weed hosts, 24 vegetable crops, 21 fruit plants, 9 woody plants, 5 medicinal plants, 16 ornamental plants and 4 hedge plants. Among these host plants, 18 were recorded as major hosts of which 2 field crops, 4 vegetable crops, 9 fruits plants and 3 flower and ornamental plants. On the other hand, out of 103 host plants, 85 were recorded as minor hosts for mealybugs, of which 12 field crops, 10 weeds, 20 vegetable crops, 12 fruit plants, 9 woody plants, 5 medicinal plants, 13 ornamental plants and 4 hedge plants.

Among field crops and weeds, fourteen (14) host plants were of field crops and ten (10) in weeds as observed as hosts of mealybugs. Among 14 crops that host mealybugs, two were recorded as major hosts namely cotton and tobacco; other 12 field crops were recorded as minor hosts for mealybugs namely jute, sugarcane, wheat, sesame, chickpea, garden pea, lentil, mungbean, mustard, groundnut, maize and rice. Among 10 weeds that host mealybugs, all of which were recorded as minor hosts of mealybugs namely dodder, bermuda grass, parthenium, spiny pigweed, fig tree, corn spurge, goat weed, goosefoot, Indian sorrel and black knight shade.

Total twenty four (24) vegetable crops were recorded in Bangladesh hosting mealybugs. Among 24 vegetable crops, four (4) were recorded as major hosts namely chili, 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.

Among fruits, woody and medicinal plants, twenty one (21) were fruit plants, nine (9) were woody plants and five (5) were medicinal plants. 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 twelve (12) fruit plants were recorded as minor hosts for mealybugs namely orange, pineapple, date palm, betel nut, pomegranate, olive, litchi, tamarind, almond, palm tree, blackberry and anona. Among 9 wood plants that host mealybugs, all of which were recorded as minor hosts namely rain tree, sisso, acasia, jarul (*Lagerstroemia speciosa*), royal poinciana (*Delonix regia*), debdaru/ false ashoka, pakur/ portia tree, shimul/ 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.

Sixteen (16) host plants under ornamental plants and four (4) host plants under hedge plants were infested by mealybugs. 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 recorded as minor hosts for mealybugs namely tuberose, gladiolus, lily, orchid, gardenia, sunflower, dahlia, jasmine, alocasia, boat-lily, dumb cane and cock's comb. Among 4 hedge plants that host mealybugs, all of which were recorded as minor hosts namely giga/Indian ash tree, streblus/toothbrush tree, lantana and duranto/ pigeon berry.

Information on quarantine species of mealybugs associated with plants or plant parts in the exporting countries like India, China, Japan, Thailand, Vietnam, Philippines, Indonesia, Sri Lanka, Pakistan, Bhutan, Nepal, U.S.A, Australia, France, Germany, Italy, Netherlands, Brazil, Chile and other countries revealed that the importance of mealy bug species for quarantine exists.

The study also revealed thirteen (13) mealybug species of quarantine importance those were identified for Bangladesh, of which eight (8) species were analyzed for risk assessment and other five (5) quarantine species of mealybugs were not analyzed for risk assessment those remained as uncertainty due to lack of their detail information. The quarantine species of mealybugs those had been further analyzed for risk assessment were obscure mealybug (*Pseudococcus affinis*), long-tailed mealybug (*Pseudococcus longispinus*), cassava mealybug (*Phenacoccus manihoti*), spiked mealybug (*Nipaecoccus nipae*), Mediterranean vine mealybug (*Planococcus ficus*), cotton mealybug (*Phenacoccus solenopsis*), banana mealybug (*Pseudococcus elisae*) and Madeira mealybug (*Phenacoccus madeirensis*). Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced agricultural crops/plants or parts of plants.

The consequences and potential/likelihood of introduction of each quarantine species of mealy bug was assessed individually, and a risk rating mechanism was estimated for each. The consequence and potential of introduction value was estimated by the assessing biology, host range, distribution, hazard identification, risk assessment, consequence assessment, risk estimation and risk management of the pests. The two values were summed to estimate an overall Pest Risk Potential, which is an estimation of the risk in the absence of mitigation.

Eight (8) quarantine species associated with the pathway risk were assessed. Of those, four (4) were identified with high risk potential viz. *Pseudococcus viburni*, *Phenacoccus solenopsis, Planococcus ficus* and *Phenacoccus madeirensis*; three (3) were of moderate risk potential viz. *Phenacoccus manihoti*, *Nipaecoccus nipae* and *Pseudococcus longispinus*; and one (1) was of low risk potential viz. *Pseudococcus elisae*. The high risk potential means that these species pose unacceptable phytosanitary risk. Visual inspection at port-of-entry for high risk potential pests is insufficient to safeguard Bangladesh and specific phytosanitary measures are strongly recommended. For the moderate and low risk potential pests, specific phytosanitary measures may be necessary to reduce pest risk.

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CHAPTER 1

SCOPE AND METHODOLOGY OF PEST RISK ANALYSIS

1.1. Background

Pest risk analysis (PRA) provides the rationale for phytosanitary measures for a specified PRA area. It evaluates scientific evidence to determine whether an organism is a pest. If so, the analysis evaluates the probability of introduction and spread of the pest and the magnitude of potential economic consequences in a defined area, using biological or other scientific and economic evidence. If the risk is deemed unacceptable, the analysis may continue by suggesting management options that can reduce the risk to an acceptable level. Subsequently, pest risk management options may be used to establish phytosanitary regulations.

For some organisms, it is known beforehand that they are pests, but for others, the question of whether or not they are pests should initially be resolved. The pest risks posed by the introduction of organisms associated with a particular pathway, such as a commodity, should also be considered in a PRA. The commodity itself may not pose a pest risk but may harbour organisms that are pests. Lists of such organisms are compiled during the initiation stage. Specific organisms may then be analyzed individually, or in groups where individual species share common biological characteristics. Less commonly, the commodity itself may pose a pest risk. When deliberately introduced and established in intended habitats in new areas, organisms imported as commodities (such as plants for planting, biological control agents and other beneficial organisms, and living modified organisms (LMOs)) may pose a risk of accidentally spreading to unintended habitats causing injury to plants or plant products. Such risks may also be analyzed using the PRA process.

The PRA process is applied to pests of cultivated plants and wild flora, in accordance with the scope of the Internation Plant Protection Convention (IPPC). It does not cover the analysis of risks beyond the scope of the IPPC. Provisions of other international agreements may address risk assessment (e.g. the Convention on Biological Diversity and the Cartagena Protocol on Bio-safety to that convention).

Bangladesh has been importing various agricultural commodities such as fruits, vegetables, flowers and ornamental plants, cuttings, saplings, and any other plants or parts of plants from different exporting counties such as India, China, Thailand, Japan, Vietnam, Phillipines, Indonesia, Malaysia, Myanmar, Sri Lanka, Pakistan, Bhutan, Nepal, Brazil, Australia, USA, Canda, Turkey, German, Netherlands, or any other counties of the world. But there is no risk analysis of imported agricultural commodities. So, there is a scope of introducing alien pest including mealybugs into Bangladesh which may potentially damage agricultural crops. In this context, the Pest Risk Analysis (PRA) of Mealybug spp. in Bangladesh is indispensable. Thus, the assignment on PRA of Mealybug spp. in Bangladesh was undertaken aiming to identify the major and minor hosts of mealybug in major crop growing areas of Bangladesh and more damaging species of mealybug of quarantine concern and evaluate their risk as well as to identify risk management options. However, assessment of the potential risk of introduction of mealybugs with these commodities to Bangladesh and the probability of their Establishment in Bangladesh condition has not yet been performed. Recently, Plant Quarantine Wing, Department of Agricultural Extension (DAE) felt that an analysis of the biosecurity risks of mealybug species is required. Hence, the present activities were taken up. Here, pests are referred to more damaging species of mealybugs of agricultural crops and the PRA areas were the selected 26 major agricultural crop growing districts of Bangladesh.

1.2. Scope of Pest Risk Analysis

The scope of this risk analysis is to determine the presence of mealybug species that attack host plants in Bangladesh and to ascertain the potential hazard species of mealybugs associated with associated with agricultural commodities imported from the India, China, Thailand, Japan, China, Pakistan, Vietnam, Philippines, Indonesia, Malaysia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, Chile or any other countries of the world. The various agricultural commodities like fruits, vegetables, flowers and ornamental plants, cuttings, saplings, and any other plants or parts of plants are imported for food, planting or seed purposes. Risk is defined as the likelihood of the entry of the hazards with the pathway or commodity, probability of establishment and the magnitude of the consequences of the hazards on economic, environment or health point of views. The framework of pest risk analysis associated with importation of agricultural commodities includes three PRA Stages such as initiation, pest risk assessment and pest risk management. The standard focuses on the initiation stage, gathering information, documentation, risk communication, uncertainty, consistency and management of hazards.

1.3. Objectives of the PRA study

The overall objective of a Pest Risk Analysis by the SPCB Project is to support National Plant Protection Organization (NPPO) of Bangladesh to identify the major and minor hosts of mealybug, more damaging species of mealybug in Bangladesh and/or pathways of quarantine mealybug species to be associated with agricultural commodities which brings along with them a certain risk of the introduction of mealybug species that are harmful to agriculture in Bangladesh.

According to the Terms and Reference (ToR) of the study, the consulting firm is required to identify the more damaging species of mealybugs in Bangladesh and their major and minor hosts with plant parts affected, to identify quarantine species of mealybugs for Bangladesh that follow the pathway(s), evaluate their risk, and risk management options etc.

1.4. PRA Areas

The entire Bangladesh is considered as PRA area in this risk analysis. But the major agricultural crops are not grown all over the country. Therefore, the major crop growings districts of Bangladesh have been considered as the PRA areas in the risk analysis process. Moreover, agricultural commodities are imported through different Sea port, Land port and Airports which are located all regions of Bangladesh. However, PRA study on mealybug species was done in major agricultural crop growing districts as well as different Sea port, Land port and Airports of Bangladesh through which agricultural crops/products are being imported into Bangladesh.

1.5. Methodology of Pest Risk Analysis

PRA process includes three major stages such as Initiation, Pest Risk Assessment and Pest Risk Management. The following methods were sequentially followed to conduct PRA of Guava.The process and methodology for undertaking import risk analyses are shown in the following figure.

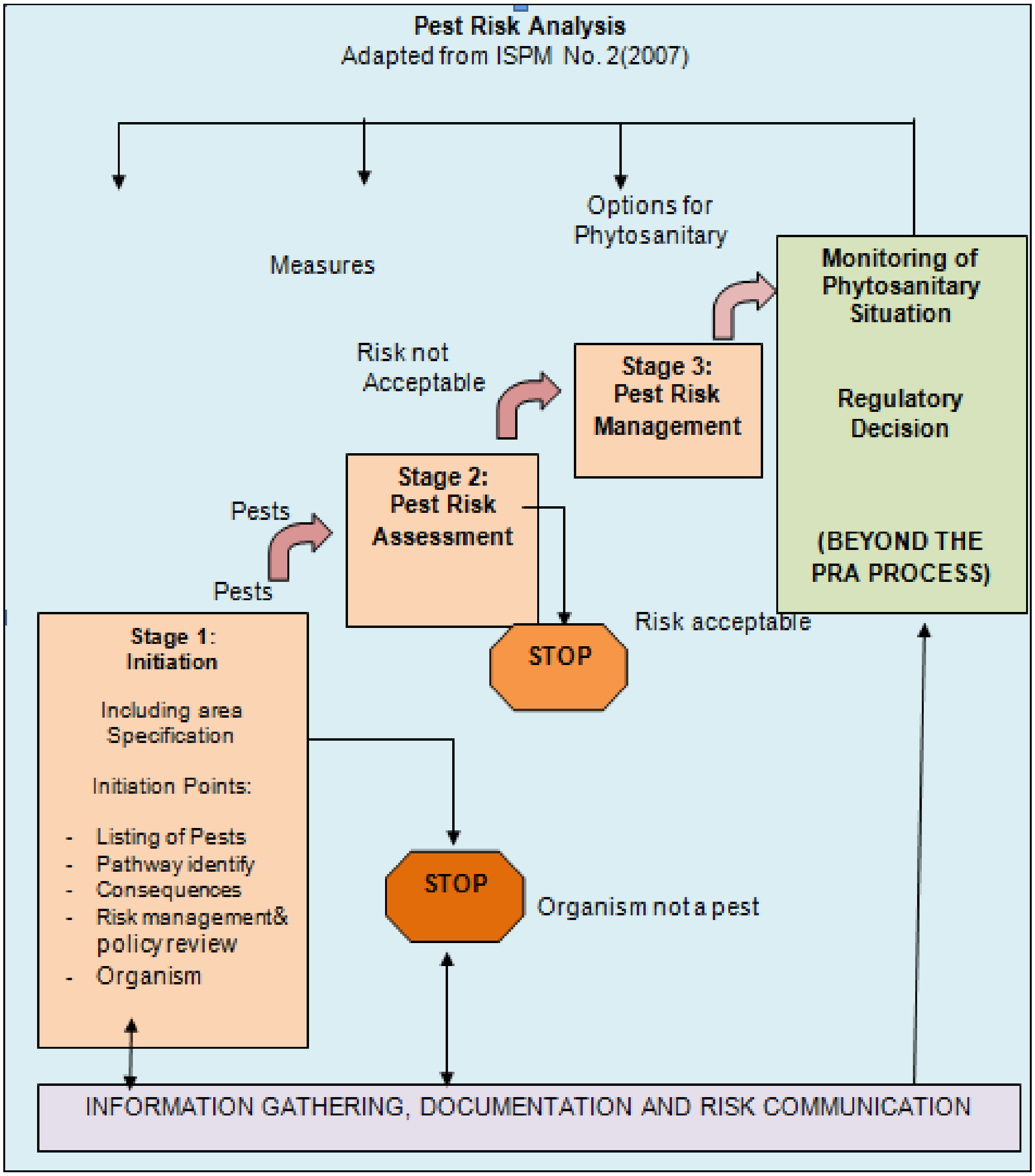


Figure 1: Schematic Diagram of Pest Risk Analysis

1.6. Methodology for data collection

1.6.1. Introduction

The methodology for the present PRA study used system-wide approach, which involved wide-ranging and sequenced discussion with relevant stakeholders aiming to identify the more damaging species of mealybug, major and minor hosts of mealybug, relevant pathways, their potential hazards, quarantine concern of mealybug, their risk and management options. The study involved the use of (i) field survey through structured questionnaire, (ii) semi-structured interviews by means of focus group discussions (FGD), (iii) formal and non-formal interviews through Key Informant Interview (KII); (iv) collection of primary and secondary information, reviewing the available literature and reports and (v) physical field visits to the sampled area.

1.6.2. PRA location and study sampling

The survey study was conducted in the 26 major agricultural crop growing districts of Bangladesh as selected by the client-Project Director, Strengthening Phytosanitary Capacity in Bangladesh (SPCB) under Plant Quarantine Wing (PQW), DAE, Bangladesh. A total 61 upazilas were selected under the 26 sampled districts, where 10 agricultural blocks were covered under each upazila and 10 crop farmers were interviewed in each block through pre-tested questionnaire. Thus, a total of 6100 farmers were interviewed from all of 26 sampled districts. The focus group discussion (FGD) meeting was also conducted for each of 26 sampled districts with the participation of at least 10 farmers aiming to gather qualitative data. Besides, one officer designated as Additional Deputy Director (Plant Protection) of DAE at field level for each district had also been interviewed through semi-structured key informant interview (KII) checklist. The district and upazila wise distribution of respondents is given below:

Table 1: Distribution of respondents in sampled crop growing districts of Bangladesh

SN	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII
1	Pabna	Sadar	10	100	1	1
		Ishawardi	10	100		
		Sujanagar	10	100		
2	Natore	Sadar i	10	100	1	1
		Baghatipara	10	100		
3	Rajghahi	Sadar	10	100	1	1
		Godagari	10	100		
4	Pirojpur	Nesarabad	10	100	1	1
		Nazirpur	10	100		
5	Jalokathi	Sadar	10	100	1	1
		Rajapur	10	100		
6	Chittagong	Chandanaish	10	100	1	1
		Patia	10	100		
		Chittagong City	10	100		
7	Comilla	Barura	10	100	1	1
		Sadar	10	100		
8	Gazipur	Kapasia	10	100	1	1
		Sreepur	10	100		
		Kaliakoir	10	100		
		Kaligonj	10	100		
9	Norsindhi	Sadar	10	100	1	1
		Shibpur	10	100		
		Raipura	10	100		
10	Sirajgonj	Sadar	10	100	1	1
		Kamarkhanda	10	100		
11	Sylhet	Goaingjat	10	100	1	1
		Jointapur	10	100		
12	Chapainwabgonj	Gomastapur	10	100	1	1
		Nachol	10	100		
		Sadar	10	100		
13	Bagerhat	Sadar	10	100	1	1
		Chitolmari	10	100		

SN	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII
14	Chuadanga	Jibon nagar	10	100	1	1
		Damurhuda	10	100		
15	Meherpur	Sadar	10	100	1	1
		Mujib nagar	10	100		
16	Sherpur	Sadar	10	100	1	1
		Sreebordi	10	100		
17	Mymensingh	Valuka	10	100	1	1
		Fulbaria	10	100		
		Gouripur	10	100		
18	Kishoregonj	Sadar	10	100	1	1
		Bhairab	10	100		
19	Noagaon	Manda	10	100	1	1
		Porsa	10	100		
20	Joypurat	Sadar	10	100	1	1
		Panchbibi	10	100		
21	Khagrachari	Sadar	10	100	1	1
		Matiranga	10	100		
22	Bandarban	Sadar	10	100	1	1
		Naikhangchari	10	100		
23	Bogra	Shibgonj	10	100	1	1
		Kahalu	10	100		
24	Dhaka	Savar	10	100	1	1
		Dhamrai	10	100		
		Dhaka city	10	100		
25	Tangail	Sukhipur	10	100	1	1
		Modhupur	10	100		
26	Moulvibazar	Sadar	10	100	1	1
		Sreemangal	10	100		
		Jokigonj	10	100		
Total	**26**	**61**	**610**	**6100**	**26**	**26**

1.6.3. Field survey

The study survey was conducted with the direct interview of major crop farmers in 26 major crop growing districts of Bangladesh for quantitative data aiming to identify more damaging species of mealybug; major and minor hosts of mealybug; their potential hazards and management options; quarantine pests with their entry, establishment, risk and their management. The qualitative data were also collected through focus group discussions (FGD) with crop farmers and through key informant interviews (KII) with Extension Personnel at field level, land port, Entomologist and Plant Pathologist of research and other agricultural organizations and Agricultural Universities. Information were also collected through field visit by the experts from the sampled areas.

1.6.4. Tools for data collection

The most appropriate tools used in this field study are discussed below:

Field survey questionnaire: For quantitative analysis, the field survey was conducted in 26 major agricultural crop growing districts of Bangladesh through face to face interview with

6100 crop farmers using a set of pre-designed and pre-tested questionnaire (**Appendix-1)** encompassing the relevant study indicators.

Focus Group Discussion (FGD): For qualitative analysis, 26 FGD meetings were organized considering one FGD for each sampled districts with the participation of at least 10 farmers for each. The FGD meetings were conducted using pre-designed FGD guidelines (**Appendix-2**).

Key Informant Interview (KII): The key informant interviews were conducted with the extension personnel at field level DAE office, officials of Plant Quarantine ports; Entomologist and exporters of research and other Agricultural organizations and Universities using a semi-structured KII Checklist (**Appendix 3)** encompassing the qualitative issues of the study.

Field visit/physical observation: In addition, the expert team of the study physically visited the sampled districts of the study area aiming to observe the physical status of the mealy bug infestation and other associated problems in field conditions**.**

1.6.5. Secondary data collection and review

The current PRA related secondary data were collected and gathered from secondary sources such as journals, books, proceedings, reports, CD-ROM (CABI) search, and others. The documents were then critically reviewed, synthesized in relation to identify the quarantine species of mealybugs available in the exporting counties of commodities namely India, China, Thailand, Japan, Pakistan, Bhutan, Nepal, Vietnam, Sri Lanka, Philippines, Indonesia, Malaysia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chile and other countries of the world as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

1.6.6. Internet browsing

The PRA related information for mealybug were alss collected and gathered through internet browsing especially through websites of CAB International, EPPO Bulletin and different LAB based e-Journals like TEEAL, HINARI, AGORA, OARE etc. The documents were then critically reviewed, synthesized in relation to identify the quarantine species of mealybugs available in the exporting counties of commodities as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

1.6.7. Listing of more damaging mealy bug species and their host plants

There is no comprehensive list of more damaging species of mealybug as well as list of hosts for mealybug in Bangladesh. Therefore, it is required to make a comprehensive list of more damaging species of mealybug to be associated with different major and minor hosts in Bangladesh. Thus, more damaging species of mealybug species and their major and minor host plants/crops grown in Bangladesh were identified through field survey and secondary data collection for conducting the risk analysis of mealybug species. Besides, focus group discussion, Key Informant Interview and direct field visit were also conducted and prepared a list of more damaging species of mealybug, and major and minor host plants/crops of mealybugs following the framework for pest risk analysis adopted by the IPPC in International Standard for Phytosanitary Measures (ISPMs) and other related ISPMs. The quarantine species of mealybugs of different host plants/crops in Bangladesh were also listed for their risk analysis.

1.7. Interpretation of results

The collected information on damaging species of mealybugs, their host plants, potential hazard species of mealybug, their risk and management options were analyzed and interpreted. The most vulnerable stage of plant growth as well as parts of plants affected by the mealybug was also determined based on both primary and secondary data. Finally, a check list was prepared based on locally available mealybug species in Bangladesh as well as quarantine species of mealybug recorded in exporting countries of the agricultural commodities into Bangladesh.

CHAPTER 2

METHODOLOGY OF RISK ANALYSIS

The overall pest risk analysis (PRA) process includes undertaking pest risk analysis, risk assessment and identify risk management of the pests. The process and methodology of the PRA are described below:

2.1. Undertaking of Pest Risk Analysis (PRA)

The study followed a systematic process of pest risk analysis framed as per ISPM No. 2. As per the 3 stages (I) Initiation (II) Pest Risk Assessment (III) Pest Risk Management, the study team evaluated the commodity and regulated articles and detection of pest for initiation stages.

PRA STAGE 1: INITIATION

Initiation is the identification of organisms and pathways that may be considered for pest risk assessment in relation to the identified PRA area.

Steps of initiation stage: The initiation stage involves four steps:

- Step 1: Determination whether an organism is a pest
- Step 2: Defining the PRA area
- Step 3: Evaluating any previous PRA
- Step 4: Conclusion

PRA STAGE 2: PEST RISK ASSESSMENT

The process for pest risk assessment can be broadly divided into five interrelated steps:

- Step 1: Pest categorization
- Step 2: Assessment of the probability of introduction, establishment and spread
- Step 3: Impacts
- Step 4: Overall assessment of risk
- Step 5: Uncertainty

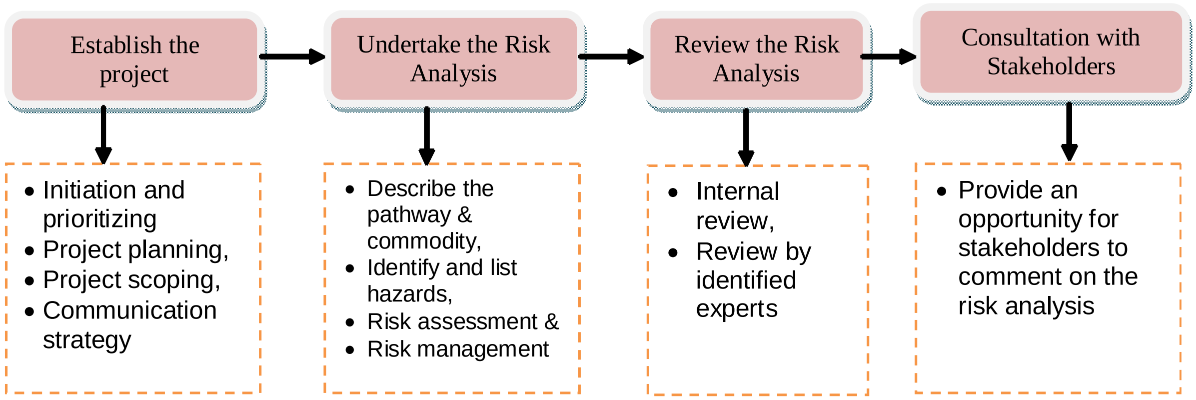
In most cases, these steps were applied sequentially in a PRA but it is not essential to follow a particular sequence. Pest risk assessment needs to be only as complex as is technically justified by the circumstances. This standard allows a specific PRA to be judged against the principles of necessity, minimal impact, transparency, equivalence, risk analysis, managed risk and non-discrimination set out in ISPM No. 1: Principles of plant quarantine as related to international trade (FAO, 1995).

PRA STAGE 3: PEST RISK MANAGEMENT

The conclusions from pest risk assessment are used to decide whether risk management is required and the strength of measures to be used. Since zero-risk is not a reasonable option, the guiding principle for risk management should be to manage risk to achieve the required degree of safety that can be justified and is feasible within the limits of available options and resources. Pest risk management (in the analytical sense) is the process of identifying ways to react to a perceived risk, evaluating the efficacy of these actions, and identifying the most appropriate options. The uncertainty noted in the assessments of economic consequences and probability of introduction should also be considered and included in the selection of a pest management option.

The following briefly describes the Biosecurity process and methodology for undertaking pathway risk analyses. The risk analysis process leading to the final risk analysis document is summarized in the following figure:

Figure 2: A summary of the risk analysis development process



2.2. Pathway Description

The first step in the risk analysis process is to describe the entry pathway of the mealybug species to be associated with different host plants/commodity. This includes relevant information on:

- the country of origin, including characteristics like climate, relevant agricultural practices, phytosanitary system;
- pre-export processing and transport systems of the host plants/commodity;
- export and transit conditions, including packaging, mode and method of shipping;
- nature and method of transport and storage on arrival in Bangladesh;
- characteristics of Bangladesh's climate, and relevant agricultural practices.

2.2.1. Pathways of mealybugs

For the purpose of this risk analysis, host plants or plant parts are presumed to be imported from anywhere in exporting countries such as India, China, Thailand, Japan, Bhutan, Nepal, Vietnam, Philippines, Indonesia, Malaysia, Sri Lanka, Pakistan, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, Chille and other countries of the world.

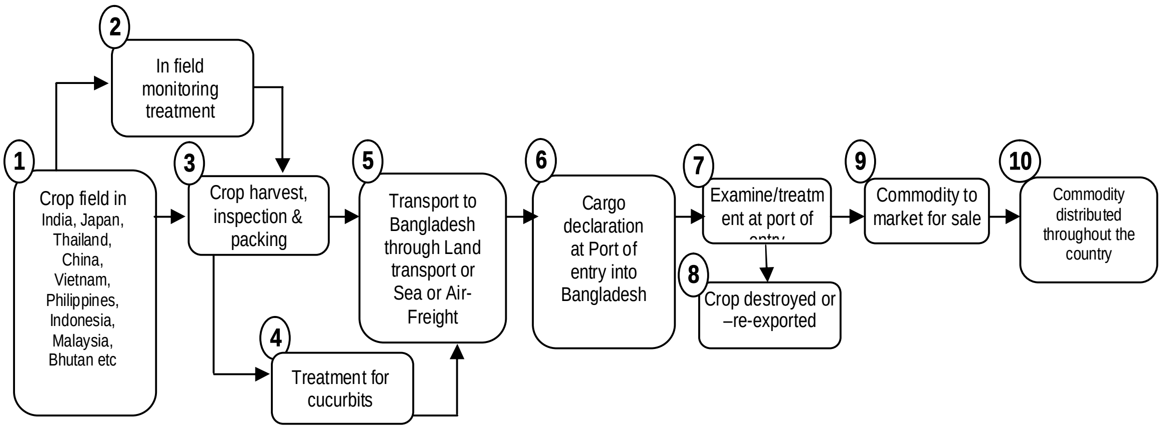
To comply with existing Bangladesh import requirements for host plants and or plant parts, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests (insect & mite pests, diseases, weeds or any other pests) are not associated with the product. Commodity would then be sea or land or air freighted to Bangladesh where it go to a holding facility before being distributed to dealers, distributors, markets, sellers and farmers for cultivation or users of the imported commodity.

2.2.2. Pathway Description

- Host plants and or plant parts in India, China, Thailand, Japan, Bhutan, Nepal, Vietnam, Philippines, Indonesia, Malaysia, Sri Lanka, Pakistan, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, Chille etc are being grown in the field, either as a single crop or beside other field or horticultural crops.
- Monitoring of the mealybugs and any other pests of host plants is undertaken, with appropriate controls applied.
- Host plants and or plant parts are being harvested, inspected and the best quality plants and or plant parts washed, pre-treated and packed in boxes.
- Post harvest disinfestations including fumigation or cold disinfestations are being undertaken either before or during transport of the commodity to Bangladesh.
- Transport to Bangladesh is by air or sea or land port.
- Each shipment must be accompanied by the appropriate certification, e.g. a phytosanitary certificate attesting to identity the commodities, any treatments completed, or other information required to help mitigate risks.
- Host plants and or plant parts are examined at the border to ensure compliance.

- Any plants and or plant parts not complying with Bangladesh bio-security requirements (e.g. found harboring pest organisms) are either treated re-shipped or destroyed.
- Host plants and or plant parts are stored before being distributed to market for sale.
- Dealers and sellers of commodities stock and these are bought to users and or farmers within the local area these are sold in. The linear pathway diagram of import risk of host plants and or plant parts is furnished below:

Figure 3: Linear Pathway Diagram



2.3. Hazard Identification

Hazard identification is the essential step conducted prior to a risk assessment. Unwanted organisms or pests, which could be introduced by risk commodities/goods into Bangladesh and potentially capable of causing unwanted harm must be identified. This process begins with the collection of a list of organisms that might be associated with the commodity in the country of origin. This list is further refined and species removed or added to the list depending on the strength of the association and the information available about its biology and life cycle. Each species of the pest is assessed mainly on its biological characteristics and its likely interaction with the Bangladesh environment and climate. Hitch-hiker organisms sometimes associated with a commodity but that don't feed on it or specifically depend on that commodity in some other way are also included in the analysis. This is because the potential for economic environmental and human health consequences can outweigh the low likelihood of the organism being associated with the commodity. The process of hazard identification of any organism has been represented diagrammatically as follows:

2.4. Risk Assessment

Risk assessment is the evaluation of the likelihood of entry, exposure and establishment of a potential hazard, and the environmental, economic, human and animal health consequences of the entry **(Sea Port, Land port and Airport)** within Bangladesh. The aim of risk assessment is to identify hazards which present an unacceptable level of risk, for which risk management measures are required.

A risk assessment consists of four inter-related steps:

- assessment of likelihood of entry;
- assessment of likelihood of exposure and establishment;
- assessment of consequences;
- risk estimation.

In this risk analysis hazards have been grouped to avoid unnecessary duplication of effort in the assessment stage of the project. Where there is more than one species in a genus for example, the most common or potentially damaging species is researched and analyzed in detail and used as an example to cover major biological traits within the group. Any specific differences between congeners are highlighted in individual analyses. The process for risk assessment and management of any potential hazard has been represented diagrammatically as follows:

2.5. Assessment of Uncertainties

The purpose of this section is to summarize the uncertainties and assumptions identified during the preceding hazard identification and risk assessment stages. An analysis of these uncertainties and assumptions can then be completed to identify which are critical to the outcomes of the risk analysis. Critical uncertainties or assumptions are considered for further research with the aim of reducing uncertainty or removing the assumption.

Where there is significant uncertainty in the estimated risk, a precautionary approach to risk management may be adopted. In these circumstances the measures should be consistent with other measures where equivalent uncertainties exist and be reviewed as soon as additional information becomes available.

2.6. Risk Management Options

Risk management in the context of risk analysis is the process of deciding measures to effectively manage the risks posed by the hazard(s) associated with the commodity or organisms under consideration. It is not acceptable to identify a range of measures that might reduce the risks. There must be a reasoned relationship between the measures chosen and the risk assessment so that the results of the risk assessment support the measure(s).

Since zero-risk is not a reasonable option, the guiding principle for risk management should be to manage risk to achieve the required level of protection that can be justified and is feasible within the limits of available options and resources. Risk management identifies ways to react to a risk, evaluating the efficacy of these actions, and presenting the most appropriate options.

The uncertainty noted in the assessments of economic consequences and probability of introduction should also be considered and included in the consideration of risk management options. Where there is significant uncertainty, a precautionary approach may be adopted.

However, the measures selected must nevertheless be based on a risk assessment that takes account of the available scientific information. In these circumstances the measures should be reviewed as soon as additional information becomes available. It is not acceptable to simply conclude that, because there is significant uncertainty, measures will be selected on the basis of a precautionary approach. The rationale for selecting measures must be made apparent.

Each hazard or group of hazards will be dealt with separately using the following framework:

2.7. Risk Evaluation

If the risk estimate determined in the risk assessment is non-negligible, measures can be justified.

2.8. Option Evaluation

a) Identify possible options, including measures identified by international standard setting bodies, where they are available.

b) Evaluate the likelihood of the entry, exposure, establishment or spread of the hazard according to the option(s) that might be applied.

Select an appropriate option or combination of options that will achieve a likelihood of entry, exposure, establishment or spread that reduces the risk to an acceptable level.

The result of outlining the risk management options will be either that no measures are identified which are considered appropriate, or the selection of one or more management options that have been found to lower the risk associated with the hazard(s) to an acceptable level. These management options form the basis of regulations or requirements specified with an import health standard.

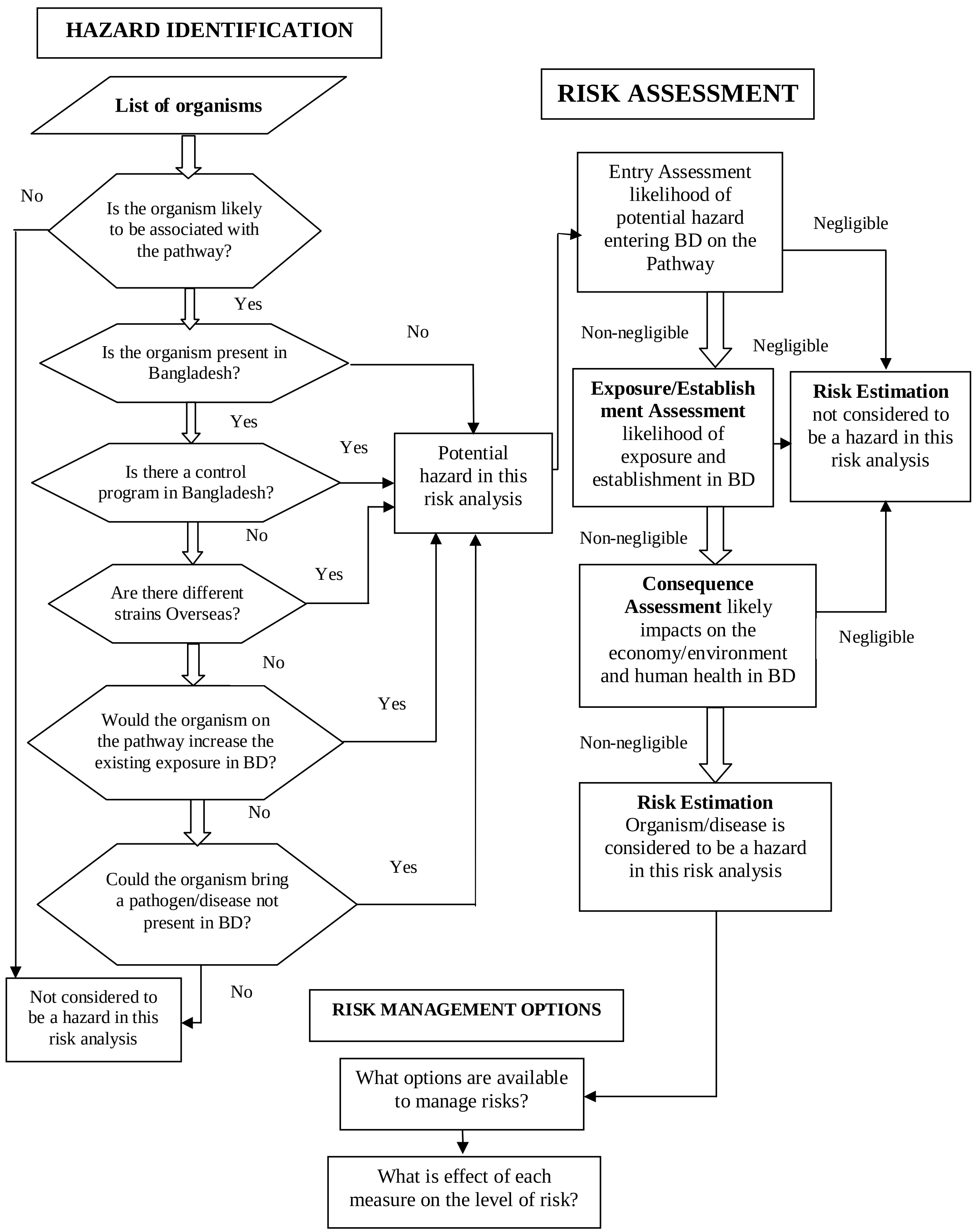
2.9. Review and Consultation

Peer review is a fundamental component of a risk analysis to ensure it is based on the most up-to-date and credible information available. Each analysis must be submitted to a peer review process involving appropriate staff within those government departments with applicable bio-security responsibilities, plus recognized and relevant experts from Bangladesh or overseas. The critique provided by the reviewers where appropriate, is incorporated into the analysis. If suggestions arising from the critique are not adopted the rationale must be fully explained and documented.

Once a risk analysis has been peer reviewed and the critiques addressed, the risk analysis is then published and released for public consultation. The period for public consultation is usually six weeks from the date of publication.

All submissions received from stakeholders are analyzed and compiled into a review. Either a document will be developed containing the results of the review or recommended modifications to the risk analysis itself will be edited to comply with the modifications.

Figure 4. Diagram of the Risk Analysis Process: the three main aspects of analysis include hazard identification, risk assessment and risk management



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CHAPTER 3

INITIATION

This section provides information on the pest and pathway that is relevant to the analysis of bio-security risks and common to organisms or mealybug species potentially associated with the pathway and commodity. This chapter also provides information on climate and geography of the country of origin as well as Bangladesh for assessing the likelihood of establishment and spread of potential hazard organisms when enter and exposed to Bangladesh. Organism-specific information is provided in subsequent chapters.

3.1. Pest Description

3.1.1. Introduction

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.

3.1.2. Taxonomic position

Kingdom: Animalia
- Phylum: Arthropoda
  - Class: Insecta
    - Order: Homoptera
      - Suborder: Sternorrhyncha
        - Superfamily: Coccoidea
          - Family: Pseudococcidae
            Monophlebidae

3.1.3. Geographical Distribution

Mealybugs occur in all parts of the world. Most occur naturally only in warmer parts, and get introduced into greenhouses and other buildings in cooler countries. It is unlikely that any live in the Arctic or Antarctic, except perhaps in buildings.

3.1.4. Morphology

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 (McKenzie, 1967; 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 (McKenzie, 1961; 1967; Kosztarab, 1996; Hodgson *et al.*, 2008). 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.*, 2009a). 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 mould, 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. Adult female mealybug

Plate 2. Adult male mealybug

Plate 3. Mealybug nymphs & adults

Plate 4. Mealybug eggs enclosed inside the egg sac

Plate 5. Mealybug eggs

Plate 6. Adult female mealybugs and crawlers

3.1.5. Biology

- Reproduction is mostly parthenogenetic but some species such as *M. hirsutus* are bi-parental.
- The mature female lays eggs in an egg sac of white wax, usually in clusters on the twigs, branches, or bark of the host plant but sometimes on the plant's leaves and terminal ends. Each egg sac may contain as many as 600 eggs, majority of which are female resulting in explosive outbreak. Some species such as *D. brevipes* are ovoviviparous i.e. the eggs hatch within the female and give births live larvae.
- Eggs are minute, varying from 0.3 to 0.4 mm in length. Egg development takes between 3 and 9 days.
- Eggs hatch into nymphs called crawlers and are very mobile. In appearance, nymphs of both sexes resemble female adults. There are three nymphal instars in female and four in males which lasts for 22–25 days. The last instar of the male is an inactive stage with wing buds within a cocoon of mealy wax.

- Individual mealybugs may take as long as 30 days to grow through all the nymphal stages under normal conditions.
- There may be as many as 15 generations per year.
- The species survives cold conditions as eggs or other stages, both on the host plant and in the soil. In warm climates, the insects stay active and reproduce round the year.

3.1.6. Diversity of mealybug species

There are numerous species of mealybugs found worldwide in different host plant species and some of these are presented below:

Table 2. Important mealybug species and their taxonomic position

Sl. No.	Common name	Species name	Family	Order
1	Striped mealybug	*Ferrisia virgata*	Pseudococcidae	Homoptera
2	Longtail mealybug	*Pseudococcus longispinus*	Pseudococcidae	Homoptera
3	Citrus mealybug	*Planococcus citri*	Pseudococcidae	Homoptera
4	Solanum mealybug	*Phenacoccus solani*	Pseudococcidae	Homoptera
5	Pink sugarcane mealybug	*Saccharicoccus sacchari*	Pseudococcidae	Homoptera
6	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Homoptera
7	Pink mealybug	*Maconellicoccus hirsutus;* synonyms-*Phenacoccus hirsutus*	Pseudococcidae	Homoptera
8	Solenopsis mealybug	*Phenacoccus solenopsis*	Pseudococcidae	Homoptera
9	Papaya mealybug	*Paracoccus marginatus*	Pseudococcidae	Homoptera
10	Madeira mealybug	*Phenacoccus madeirensis*	Pseudococcidae	Homoptera
11	Jack Beardsley mealybug	*Pseudococcus jackbeardsleyi*	Pseudococcidae	Homoptera
12	Obscure mealybug	*Pseudococcus viburni*	Pseudococcidae	Homoptera
13	Acute mealybug	*Oracella acuta*	Pseudococcidae	Homoptera
14	Noxious Bamboo mealybug	*Antonina pretiosa*	Pseudococcidae	Homoptera
15	Coconut mealybug	*Nipaecoccus nipae*	Pseudococcidae	Homoptera
16	Ground mealybugs	*Rhizoecus* spp. & *Ripersiella* spp.	Pseudococcidae	Homoptera
17	Lily bulb mealybug	*Vryburgia amaryllidis*	Pseudococcidae	Homoptera
18	Short-legged mealybug	*Vryburgia brevicruris*	Pseudococcidae	Homoptera
19	Orchid mealybug	*Pseudococcus microcirculus*	Pseudococcidae	Homoptera
20	Imported mealybug	*Pseudococcus importatus*	Pseudococcidae	Homoptera
21	Grape mealybug	*Pseudococcus maritimus*	Pseudococcidae	Homoptera
22	Banana mealybug	*Pseudococcus elisae*	Pseudococcidae	Homoptera
23	Mango mealybug	*Drosicha mangiferae*	Monophlebidae	Homoptera

3.1.7. Identification of important species

The identification of important species of mealybug (Tanwar *et al.,* 2010) is furnished below:

a. **Striped mealybug (*Ferrisia virgata*):** Species is associated with aerial portion of host plant. The body is grey in colour, covered with very long waxy filaments and is provided with long tails. Two dark stripes are present on dorsum and body fluid is light color. This species produces egg mass or ovisac.

b. **Longtail mealybug (*Pseudococcus longispinus*):** Anal wax filaments are as long as body and appear as long tails; 2nd to last pair of wax filaments are also long; dorsal median stripe is present on abdomen.

c. **Citrus mealybug (*Planococcus citri*):** Body is yellow to pink in color, covered with medium sized slightly curved waxy filaments and is not pyramid shaped. One dorsal median stripe is present on the back in adults and body fluid is clear. Anal filaments are less than one-eighth the length of the body. This species produces an egg mass or ovisac which is irregular and remains under body of female.

d. **Solanum mealybug (*Phenacoccus solani*):** The body is covered with very short waxy filaments. Long tails and stripes on the body are absent. This species does not produce an egg mass or ovisac.

e. **Pink sugarcane mealybug (*Saccharicoccus sacchari*):** The mealybug is light pink in colour and occurs underneath leaf sheaths on sugarcane. Adult females are provided with mobile legs.

f. **Pineapple mealybug (*Dysmicoccus brevipes*):** This species is associated with roots of host plants. Body colour is light pink to grey and is provided with 17 pair of wax filaments.

g. **Pink mealybug (*Maconellicoccus hirsutus; s*ynonyms - *Phenacoccus hirsutus*):** Mealybug colonies contain immature as well as mature females. Larger mealybugs are darker in color and covered with significantly more white waxy material. The body is edge, no stripes and this mealybug produces an egg mass. Ovisac is irregular and remains beneath the body. When squashed a pink to red fluid is observed.

h. **Solenopsis mealybug (*Phenacoccus solenopsis*):** The insect is provided with short to medium sized waxy filaments around the body, anal filaments about one-fourth the length of the body and the two dark stripes on either side of the middle “ridge” of the body. Long glassy rods are present on back. This species produces an egg mass or ovisac.

i. **Papaya mealybug (*Paracoccus marginatus)*:** The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, is a small hemipteran that attacks several genera of host plants, including economically important tropical fruits and ornamentals.

j. **Mango Mealybug (*Drosicha mangiferae*):** The females can be identified by their flat shape, covered with white mealy powder.

3.1.8. Host ranges

As a group mealybugs attack a very broad range of plants including fruits and vegetables, indoor plants and outdoor ornamentals like annuals, perennials, shrubs, palms, grasses and trees. In other words, almost all plant species present in a nursery can be fed upon by at least one mealybug species. Some mealybug species have a very wide host range and are more likely to be encountered in a production nursery. For example, citrus mealybug has been reported across plants from about 50 plant families and can be a pest on 4 begonia, boronia, cactus, calathea, canna lily, citrus, coleus, croton, cycads, cyclamen, dahlia, eriostemon, narcissus, tulip and many other plant species. Long tailed mealybug is reported from about 30 plant families and can be a pest of bromeliad, bulbs, citrus, custard apple, fern, fuschia, grapefruit, grape, hibiscus, Japanese maple, olive, orchid, palm, passion fruit, pine, pome fruit, stone fruit, Zamia and many other species. Fortunately, not all mealybugs have a very wide host range. For example, *M. albizziae* has only been reported feeding on

Acacia spp. and banana. As stated earlier, it is important to have mealybugs identified. This will allow investigating the host range of the species, its biology and information known on specific management of the pest.

3.1.9. Factors responsible for high population buildup

- With rapid development, high survival rate, and enormous reproductive capacity, *P. marginatus* population could potentially reach a high level.
- Wax layer and waxy fibres over the ovisac and body of mealybug nymphs and adult females protect them from adverse environmental conditions and routine chemical pesticides.
- Availability of alternate hosts / weeds around fields not cared by cultivators.
- Movement of crawlers through air, irrigation water or farm equipment helps in fast spread of the mealybug from infested field to healthy fields.
- No phytosanitation: free movement of infested fruits, vegetables and other material between States.
- Intensive cropping system.
- Wider acceptability of hosts by papaya mealybug and its subsequent adaptability on them.
- Ant association: providing protection from parasitoids and predators and aiding in dispersal of the pest.
- Piecemeal pruning of mulberry crop provides sufficient time for migration and settlement of crawlers from the old infested crop to the pruned crop.
- In certain crops like tapioca or cotton, stems which often carry mealybug infestation are stocked in the farm for propogation or other purposes. These stocks, near the newly planted crop act as reservoirs of papaya mealybug.

3.1.10. Association with ants

- Mealybugs are known to offer ants with their sugary excretion (honeydew) and in return ants help in spreading the mealybugs and provide protection from predator ladybird beetles, parasites and other natural enemies. Ants also keep the papaya mealybug colony clean from detritus that accumulate in the secreted honeydew, which may be harmful to the colony.
- Species of ant, Oecophylla smaragdina has been found attending papaya mealybug, feeding on honeydew on jatropha, papaya and other plants.

3.1.11. Means of Movement and Dispersal

From morphological and taxonomical studies, it may be determined that the solenopsis mealybug is native to the southwestern USA and material from Central or South America is similar to specimens collected and examined from West Africa (Hodgson *et al.*, 2008), whereas specimens from Thailand, Taiwan and New Caledonia appear more similar morphologically to specimens from India and Pakistan. Hodgson *et al.* (2008) inferred that material from all infested regions of Asia may have originated from international commerce. The species may be dispersed internationally over vast areas by transporting infested plants into new areas by air or sea cargo. Local and regional movement is primarily by wind, irrigation water and by attachment to other insects and birds. The solenopsis mealybug is an important invasive pest that has seriously damaged cotton [*Gossypium spp*.] in India and Pakistan and poses a severe threat to cotton production in China.

Natural Dispersal (Non-Biotic): The first instars or crawlers are the main dispersal stage of the solenopsis mealybug. The waxy strands covering the body serve a variety of functions including allowing the specimens to be transported by wind or water to new locations. The crawlers are commonly dispersed by wind for distances ranging from a few metres to several kilometres.

Vector Transmission (Biotic): Infested host material that is transported from one area to another is an important source of distribution for the mealybug. The waxy test covering the body can adhere to passing animals or the clothes of people, allowing individuals specimens to be transported extended distances from the original infestation site before becoming dislodged in new, previously uninfested sites.

Accidental Introduction: Commercial trade involving infested plants may often be the cause for spread of the invasive species over vast distances. Movement of equipment from an infested area to a non-infested area may also be involved in the accidental spread of the mealybugs.

3.1.12. Nature of damage

- Infested growing points become stunted and swollen which may vary depending upon the susceptibility of each host species.
- Heavy clustering of mealybugs can be seen under leaf surface giving the appearance of a thick mat with waxy secretion. Severe infestations resemble patches of cotton all over the plant.
- They excrete copious amount of honey dew that attracts ants and help in development of black sooty mould which inhibits the plants ability to manufacture food.
- Both nymphs and adults suck the sap from leaves causing withering and yellowing of leaves. Fruit may drop prematurely on crop plants. Heavy infestation can cause defoliation and even death of the plant.
- Mealybugs also affect the development of flowers and stems (especially in succulents with fleshy stems).
- When fruits are infested, they can be entirely covered with the white, waxy coating of the mealybug.
- Infestation can lead to fruit drop, or fruit may remain on the host in a dried and shriveled condition. Mealybug infected fruits are unfit for marketing.
- In cotton serious attack results in retarded growth and late opening of bolls, affecting the yield badly. It feeds on soft tissues and injects saliva that causes curling and contortion of leaves.
- Citrus mealybug (*P. citri*), commonly found associated with black pepper (*Piper nigrum*) plants in India was shown to transmit *Badnavirus* associated with stunted disease.
- Feeding of *Dysmicoccus* species on pineapple produces a toxic effect called mealybug stripe, expressed as green or black striped areas. The most predominant symptom is wilting of leaves, commencing from leaf tips. Reddish-yellow colour develops in the wilting areas and finally the plants rot and develop decaying.

3.1.13. Economic Impact

The solenopsis mealybug is an important plant pest worldwide (Williams and Granara de Willink, 1992; Hodgson *et al.*, 2008). Mealybug feeding may cause the leaves to turn yellow and results in defoliation, reduced plant growth or plant death. The presence of the solenopsis mealybug has the potential to inflict significant damage to field crops (i.e. cotton [*Gossypium* spp.] and tobacco [*Nicotiana* spp.]) in all growing regions. Also, it is a pest of commercial crops including a variety of vegetables, grapes [*Vitis vinifera*], jute [*Corchorus* spp.], mesta [*Hibiscus cannabinus*] and tobacco. The economy of Pakistan is heavily dependent on the production of cotton. Cotton production is reported to account for 8.2% of the value added in agriculture and 2% of the GDP of Pakistan. The significant damage to cotton caused by *P. solenopsis* can have significant impact on the economy of the nation. Economic crop losses of an estimated 14% occurred in Pakistan in 2005 and in Punjab, India in 2005-2006 and 2006-2007 (Anon., 2005; Hodgson *et al.,* 2008; Dhawan *et al.*, 2009a).

3.1.14. Environmental Impact

As a result of dispersal of mealybugs, reproductive and survival capacity, this invasive pest has the potential to damage or kill native plant species that could result in their displacement by other more aggressive species. Wang *et al.* (2009) projected that *P. solenopsis* could infest regions within 17 provinces of China and posed a pest risk analysis value of 0.856 to the area. Dhawan *et al.* (2009a) inferred that meteorological parameters influenced the presence and population size of the mealybug, with humidity and rainfall producing a negative effect.

3.1.15. Social Impact

The widespread infestation of the mealybug throughout the cotton [*Gossypium* spp.] growing regions often requires expensive and numerous applications of insecticides to produce and protect the crop. Because of the crop losses and damaged cotton bringing lower prices, many farmers in some areas are reported to be interested in cultivating other crops. As a result, the additional pest control requirements often lead to a reduced profit margin that affects the standard of living of producers and homeowners. *P. solenopsis* attacks and damages numerous ornamental plants, therefore it has the potential to affect the aesthetic appearance of the infested areas, reducing tourism trade to the region.

Some pictures of mealybug with their hosts are shown below:

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

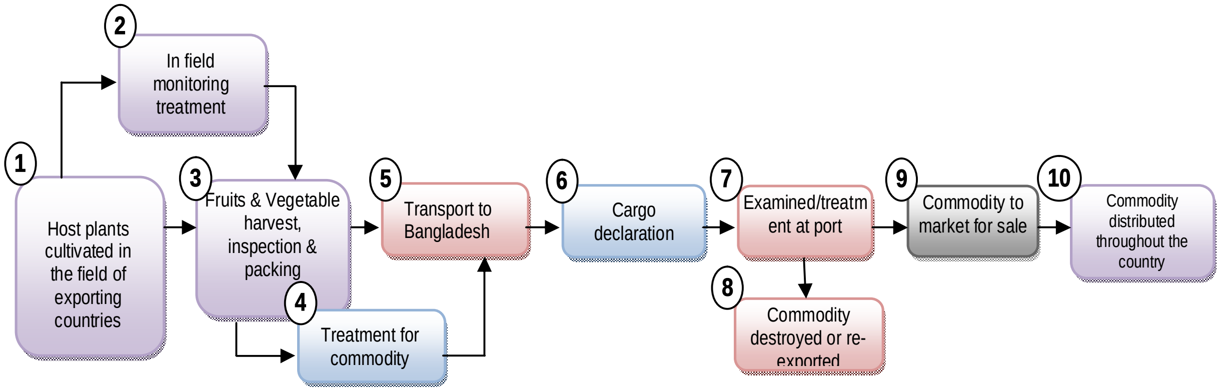
Plate 23. Mealybugs on jackfruits

Plate 24. Mealybugs on banana

3.2. Description of the Pathways of Mealybugs

For the purpose of this risk analysis, mealybug affected plants, seeds, fruits, flowers, seedlings and other planting materials are presumed to be imported or transported into Bagnaldesh from anywhere of exporting counties particularly India, China, Japan, Sri Lanka, Vietnam, Thailand, Indonesia, Malaysia, Myanmar, Bhutan, Nepal, Pakistan, Australia, South Africa, USA, Netherlands, Germany, France, Brazil, Chile and other countries of the world. To comply with existing Bangladesh import requirements for agricultural products/materials, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests (for example, different species of mealybug and or other pests) are not associated with the product. Commodity would then be sea or land or air freighted to Bangladesh where it will go to a holding facility before being distributed to dealers, distributors, markets, sellers and farmers for cultivation of the imported seeds, plant parts, seedlings and other planting materials.

Figure-5: Linear Pathway Diagram to Check Mealybug Infestation

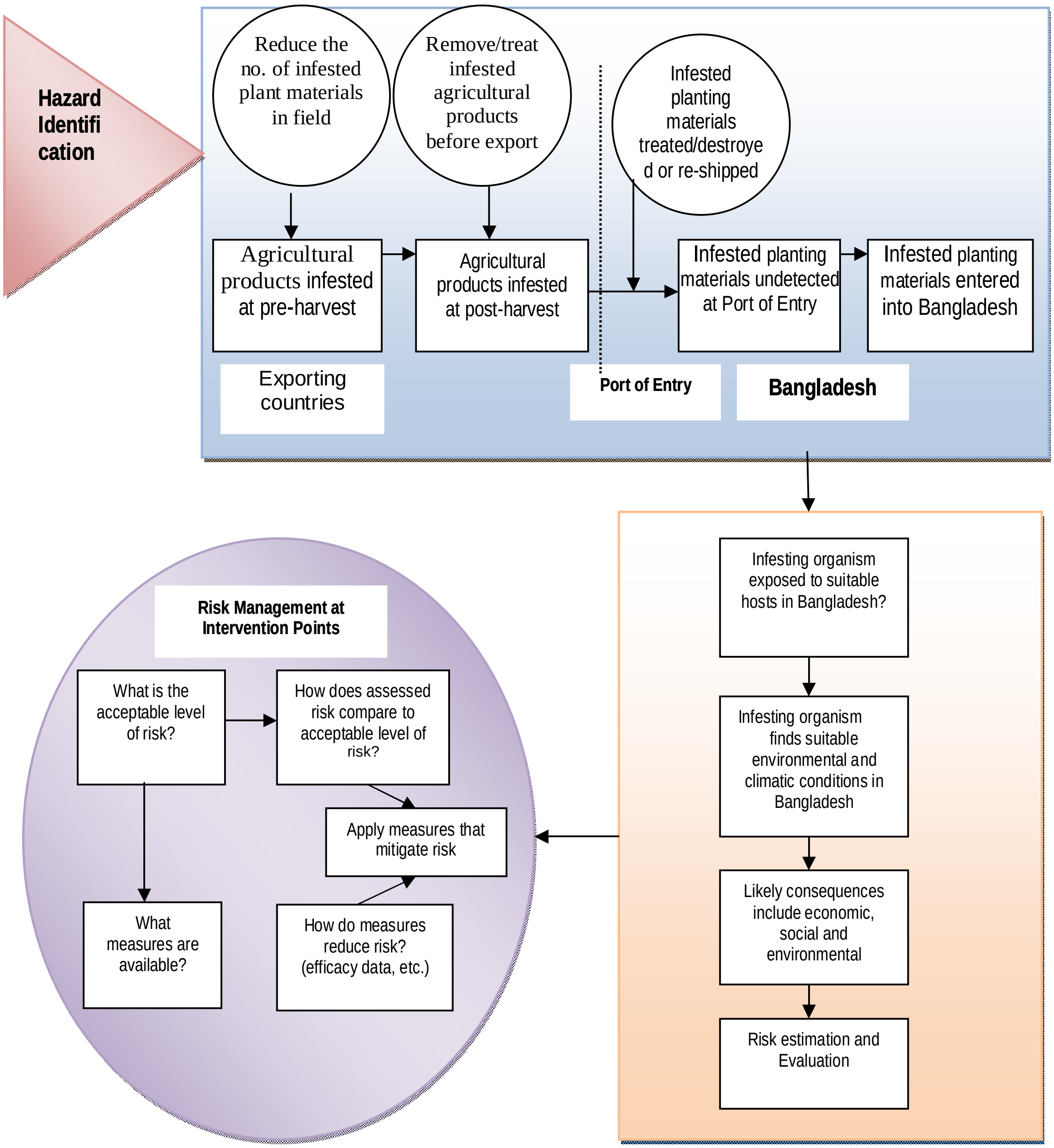


- Vegetables, fruits and other agricultural commodities are grown in the field of exporting country(ies);
- Monitoring of mealybugs and other exotic pests is undertaken, with appropriate controls applied.
- Fruits, vegetables and other agricultural productions or planting materials are harvested, inspected and the best quality fruits and vegetables washed, pre-treated and packed in boxes.
- Post harvest disinfestations including are undertaken either before or during transport of the fruits and vegetables to Bangladesh.
- Transport to Bangladesh is by land, air or sea freighted.
- Each shipment must be accompanied by the appropriate certification, e.g. a phytosanitary certificate attesting to identity the planting materials/products, any treatments completed, or other information required to help mitigate risks.
- Fruits, vegetables and other agricultural productions or planting materials are examined at the border and or port of entry to ensure compliance.
- Any fruit and or vegetable or other agricultural productions or planting materials not complying with Bangladesh biosecurity requirements (e.g. found harboring mealybugs or any other pest organisms) are either treated re-shipped or destroyed.
- Fruits, vegetables and other agricultural commodities are stored before being distributed to market for sale.
- Dealers and sellers of fruits and vegetables stock and they are bought by consumers within the local area they are sold in.

Figure-6: Synthesis of Figures 3 & 5

- Synthesis of figures 3 & 5 indicating how the risk analysis process is applied at the pathway level.

Pathway and Likelihood of Entry Assessment of Mealybugs



3.3. General Climate of Exporting Countries

3.3.1. India

General Climate: India's climate can be classified as a hot tropical country, except the northern states of Himachal Pradesh and Jammu & Kashmir in the north and Sikkim in the northeastern hills, which have a cooler, more continental influenced climate.

In most of India summer is very hot. It begins in April and continues till the beginning of October, when the monsoon rains start to fall. The heat peaks in June with temperatures in the northern plains and the west reach 45°C and more. The monsoons hit the country during this period too, beginning 1st of June when they are supposed to find the Kerala coast, moving further inland from day to day. Moisture laden trade winds sweep the country bringing heavy rains and thunderstorms; sometimes these monsoon rains can be very heavy, causing floodings and damage, especially along the big Rivers of India, Bramaputhra and Ganges.

The plains in the north and even the barren countryside of Rajasthan have a cold wave every year in December-January. Minimum temperatures could dip below 5°C but maximum temperatures usually do not fall lower than 12°C. In the northern high altitude areas of the northern mountains it snows through the winter and even summer months are only mildly warm.

Typhoons are usually not an danger, these tropical storms are quite seldom in India. The Typhoon Season is from August to November; the East coast of India has the highest Typhoon risk.

The Climate of India can be divided in different climate zones. The eastern part of India and the west coast can be classified as Aw climate, a hot, tropical climate with all months above 18°C and a dry period in the winter. The southern Tip of India can be classified as Am climate, a hot tropical Rainforest climate with monsoon rains and all months above 18°C. Central and Northwest India have a BSh climate, a dry Steppe climate with an annual average Temperature above 18°C. Finally, the northern mountainous areas can be classified as Cfa climate; a Temperated, humid climate with tha warmest month above 22°C (WeatherOnline, 2015a)

3.3.2. China

China's extreme size means it has a great diversity of climates, but being located entirely in the northern hemisphere means its seasonal timings are broadly comparable to those in Europe and the US.

The northeast experiences hot and dry summers and bitterly cold harsh winters, with temperatures known to reach as low as -20°C (-4°F). The north and central region has almost continual rainfall, temperate summers reaching 26°C (79°F) and cool winters when temperatures reach 0^{o}C (32°F). The southeast region has substantial rainfall, and can be humid, with semi-tropical summer. Temperatures have been known to reach over 40°C (104°F) although this is highly unusual, but during summer temperatures over 30°C (86°F) are the norm. Winters are mild, with lows of around 10°C (50°F) in January and February. Central, Southern and Western China are also susceptible to flooding, and the country is also periodically subject to seismic activity.

Early autumn around September and October, when temperatures are pleasant and rainfall is low, is generally seen as an optimum time to visit. Spring is also popular, for similar reasons, and the many tourists visit in March or April.

3.3.3. Thailand

Thailand's Climate can be described as tropical monsoon climate. It is characterized by strong monsoon influences, has a considerable amount of sun, a high rate of rainfall, and high humidity that makes it sometimes feel quite uncomfortable.

The annual average temperature ranges from 22°C to 27°C year-round. There are two distinguishable seasons in Thailand, a dry period in the winter and a humid rain period in the summer.

Koeppen-Geiger classification: The Climate of Thailand can be classified as Aw climate, a hot, tropical climate with all months above 18°C and a dry period in the winter. The southern coast of Thailand has an Af climate, a hot, humid climate with all months above 18°C (WeatherOnline, 2015c).

3.3.4. Japan

Japan is located at the northeastern edge of the Asian monsoon climate belt, which brings much rain to the country. The weather is under the dual influence of the Siberian weather system and the patterns of the southern Pacific; it is affected by the Japan Current (Kuroshio), a warm stream that flows from the southern Pacific along much of Japan's Pacific coast, producing a milder and more temperate climate than is found at comparable latitudes elsewhere. Northern Japan is affected by the Kuril Current (Oyashio), a cold stream flowing along the eastern coasts of Hokkaido and northern Honshu. The junction of the two currents is a bountiful fishing area. The Tsushima Current, an offshoot of the Japan Current, transports warm water northward into the Sea of Japan / East Sea.

Throughout the year, there is fairly high humidity, with average rainfall ranging by area from 100 cm to over 250 cm (39–98 in). Autumn weather is usually clear and bright. Winters tend to be warmer than in similar latitudes except in the north and west, where snowfalls are frequent and heavy. Spring is usually pleasant, and the summer hot and humid. There is a rainy season that moves from south to north during June and July.

Average temperature ranges from 17° C (63° F) in the southern portions to 9° C (48° F) in the extreme north. Hokkaido has long and severe winters with extensive snow, while the remainder of the country enjoys milder weather down to the southern regions, which are almost subtropical. The Ryukyus, although located in the temperate zone, are warmed by the Japan Current, giving them a subtropical climate. The typhoon season runs from May through October, and each year several storms usually sweep through the islands, often accompanied by high winds and heavy rains.

3.3.5. Pakistan

Pakistan has recorded one of the highest temperatures in the world – 53.5 °C – on 26 May 2010. It is not only the hottest temperature ever recorded in Pakistan, but also the hottest reliably measured temperature ever recorded in the continent of Asia. As Pakistan is located on a great landmass north of the tropic of cancer (between latitudes 25° and 35° N), it has a continental type of climate characterized by extreme variations of temperature, both seasonally and daily. Very high altitudes modify the climate in the cold, snow-covered northern mountains; temperatures on the Balochistan Plateau are somewhat higher. Along the coastal strip, the climate is modified by sea breezes. In the rest of the country, temperatures reach great heights in the summer; the mean temperature during June is 38 °C in the plains, the highest temperatures can exceed 47 °C. In the summer, hot winds called Loo blow across the plains during the day. Trees shed their leaves to avoid loss of moisture. The dry, hot weather is broken occasionally by dust storms and thunderstorms that temporarily lower the temperature. Evenings are cool; the diurnal variation in temperature may be as much as 11^{o}C to 17^{o}C. Winters are cold, with minimum mean temperatures in Punjab of about 4 °C in January, and sub-zero temperatures in the far north and Balochistan.

Fog occurs during the winter season and remains for weeks in upper Sindh, central Khyber Pakhtunkhwa and Punjab. Southwest Monsoon occurs in summer from the month of June till September in almost whole Pakistan excluding western Balochistan, FATA, Chitral and Gilgit–Baltistan. Monsoon rains bring much awaited relief from the scorching summer heat. These monsoon rains are quite heavy by nature and can cause significant flooding, even severe flooding if they interact with westerly waves in the upper parts of the country. Tropical Storms usually form during the summer months from late April till June and then from late September till November. They affect the coastal localities of the country.

Pakistan has four seasons: a cool, dry winter from December through February; a hot, dry spring from March through May; the summer rainy season, or southwest monsoon period, from June through September; and the retreating monsoon period of October and November. The onset and duration of these seasons vary somewhat according to location. http://en.wikipedia.org/wiki/Climate_of_Pakistan

3.3.6. Taiwan

The north part of Taiwan belongs to sub-tropical climate zone, while the south part belongs to the tropical climate zone. Winters are warm and summers are hot and wet, with typhoons and thunderstorms. Because Taiwan is a relatively small island, the ocean breezes have a cooling effect so it never feels too hot. Please note that the high alpine areas like Alishan do get cold.

The annual average temperature is a comfortable 22 °C, with lowest temperatures ranging from 12 to 17 °C (54-63 °F). The average amount of rainfall is about 2,500 mm per year, most of which come in the form of typhoons. At least three to four typhoons hit Taiwan every year, providing much of the water supply, but also causing damage, flooding, and landslides. Generally, typhoons happen frequently from July to September.

Because Taiwan is on the tropical zone, it is subject to more rain than most other areas, but showers are short lived and blue skies prevail on most days.

3.3.7. Indonesia

The main variable of **Indonesia's** climate is not temperature or air pressure, but rainfall. Split by the equator, Indonesia has an almost entirely tropical climate, with the coastal plains averaging 28°C, the inland and mountain areas averaging 26°C, and the higher mountain regions, 23°C. The area's relative humidity is quite high, and ranges.

The extreme variations in **rainfall** are linked with the monsoons. Generally speaking, there is a dry season (June to September), and a rainy season (December to March). Western and northern parts of Indonesia experience the most precipitation, since the north- and westward-moving monsoon clouds are heavy with moisture by the time they reach these more distant regions. Western Sumatra, Java, Bali, the interiors of Kalimantan, Sulawesi, and Irian Jaya are the most predictably damp regions of Indonesia, with rainfall measuring more than 2,000 millimeters per year.

3.3.8. Vietnam

Vietnam`s Climate can be divided a tropical and a temperate zone. It is characterized by strong monsoon influences, has a considerable amount of sun, a high rate of rainfall, and high humidity that makes it sometimes feel quite uncomfortable. Regions located near the tropics and in the mountainous regions have a slightly cooler, more temperated climate.

The annual average temperature ranges from 22°C to 27°C year-round. There are almost no significant differences in temperature in the southern parts of Vietnam, while the northern regions can be quite cold in the winter. There are essentially four distinct seasons, which are most evident in the Northern provinces.

There are two distinguishable seasons in the southern areas. The cold season occurs from November to April and the hot season from May to October. The northern parts of Vietnam have essentially four distinct seasons; it can be quite **cool** in the winter there, but very warm in summer. [http://www.weatheronline.co.uk/reports/climate/Vietnam.htm]

3.3.9. Philippines

The main variable of the Phillippines climate is not temperature or air pressure, but rainfall. In general, the climate of the Phillippines can be decribed as tropical, with the coastal plains averaging year-round temperatures about 28°C. The area's relative humidity is quite high, and ranges between 70 and 90 percent.

The extreme variations in rainfall are linked with the monsoons. Generally speaking, there is a dry season (June to September), and a rainy season (December to March). Western and northern parts of the Phillippines experience the most precipitation, since the north- and westward-moving monsoon clouds are heavy with moisture by the time they reach these more distant regions. [http://www.weatheronline.co.uk/reports/climate/Phillippines.htm]

3.3.10. Australia

Due to the huge size of the continent, Australia has serveral different climate zones. The northern section of Australia has a more tropical influenced climate, hot and humid in the summer, and quite warm and dry in the winter, while the southern parts are cooler with mild summers and cool, sometimes rainy winters.

The seasons are the opposite of those in the Northern Hemisphere-when it's summer in the north, it's winter south of the equator. December and January are the hottest months in Australia, July and August the coldest.

The southern areas of the australian Continent are generally more temperate to warm, with summer daytime temperatures usually between 25 and 30°C and winter Temperatures between 5 and 10°C The Tasmanian mountains and the "Australian Alps" in the southeast of Australia have a typical mountain climate; the winter can be very harsch there, and the highest peaks are usually covered by snow year-round.

Another extreme, but completely different are the conditions in the desert and bush areas in central Australia; the temperature reaches sometimes 50°C and more, and rain may not fall for years. Most rain falls in the northeastern coastal parts of Australia (Darvin), with an annual average of 100 inches and more. Sometimes tropical cyclones can occur in the northern coastal areas, causing heavy wind and rainstorms; these storms usually occur in the Southern summer months between November and April. Extratropical storms can occur in the southern coastal areas during this time. [http://www.weatheronline.co.uk/reports/climate/Australia.htm]

3.3.11. *The Netherlands*

The Netherlands have a temperate maritime climate influenced by the North Sea and Atlantic Ocean, with cool summers and moderate winters. Daytime temperatures variy from 2°C-6°C in the winter and 17°C-20°C in the summer.

Since the country is small there is little variation in climate from region to region, although the marine influences are less inland. Rainfall is distributed throughout the year with a dryer period from April to September.

Especially in fall and winter strong Atlantic low-pressure systems can bring gales and uncomfortable weather. Sometimes easterly winds can cause a more continental type of weather, warm and dry in the summer, but cold and clear in the winter with temperatures sometimes far below zero. The Netherlands is a flat country and has often breezy conditions, although more in the winter than in the summer, and more among the coastal areas than inland.

Koeppen-Geiger classification: The climate of The Netherlands can be classified as **Cfb** Climate; a warm temperated humid climate with the warmest month lower than 22°C over average and four or more months above 10°C over average.

3.3.12. Germany

Germany's climate is moderate and has generally no longer periods of cold or hot weather. Northwestern and coastal Germany have a maritime influenced climate which is characterized by warm summers and mild cloudy winters. During January, the coldest month, the average temperature is about 1.5°C in the north and about -2°C in the south. In

July, the warmest month, it is cooler in the north than in the south. The northern coastal region has July temperatures averaging between 16°C and 18°C; at some locations in the south, the average is almost 20°C or even slightly higher.

Especially in fall and winter strong Atlantic low-pressure systems can bring gales and uncomfortable weather with showers, thunderstorms and heavy rain, especially in the western coastal parts and the mountainous regions of Germany; in summer times weaker low pressure systems can cause showery weather, and sometimes even (severe) thunderstorms. Winters in Germany are generally mild, but can sometimes be harsh with heavy snowfall and temperatures far below zero, especially in the eastern, southern and mountainous regions.

3.3.13. France

France has four broad climatic zones: the humid seaboard zone west of the line Bayonne-Lille with cool summers; a semi-continental zone with cold winters and hot summers in Alsace-Lorraine, along the rhodanian corridor and in the mountainous massifs (Alps, Pyrenees, Massif Central); an intermediate zone with cold winters and hot summers in the North, the Paris region and the central region; and a Mediterranean zone with mild winters and quite hot summers in the south of France.

Climate in the Paris area is variable. There is a chance of a downpour in spring or a thunderstorm in summer. Temperature ranges between 20°C and 26°C from May through October. Springtime in Paris is mild and relatively dry, and the autumn is equally extended. July and August are the warmest months. Daily average maximum temperatures range from 6°C in January to 26°C in August. The wettest month on average is October (71 mm), when heavy Thunderstorms are possible. Brittany in the far west is the wettest French locale, especially between October and November. July is the driest month for the Bretons.

In the South, the Mediterranean coast has the driest climate with any noticeable rain coming in spring and autumn. Provence (in the southeast) occasionally plays reluctant host to le mistral, a strong, cold and dry wind that blows in over the winter for periods of only a few days up to a couple of weeks.The Mediterranean coastline and Corsica have plenty of sunshine during the summer months, and refreshing sea breezes. Average daily maximum temperatures reach a warm 27°C in August, and an average of 12 hours of sunshine per day. 25-30 dry days per month can be expected during the summer season. On the Atlantic Coast and in Bordeaux, the climate is generally mild with temperatures averaging 11°C in winter, up to 27°C in summer, and rainfall distributed throughout the year. With the days fresh and possibly damp in the spring and often sunny in the autumn, the climate is one of the most important factors behind Bordeaux's high quality wine it produces.

The weather in the French Alps varies from north to south. The northern Alps (the Savoy) are subject to oceanic influences resulting in abundant precipitation year round with low temperatures, and cold winters with sometimes heavy snowfall. Briancon, in the Alps, has a mean temperature of -2°C in January, and 17°C in July. During the warm season, local winds blow along this region's wide valleys and by midday, warm air rises from the valleys, causing clouds to form around most mountain summits. The heights can sometimes attract storms that are both violent and spectacular. The Southern Alps (Provence and the Cote D'Azur) enjoy a typical Mediterranean climate, with lots of sunshine, dry weather, clear skies and no mist or fog. Autumn is the best time of year in this region. Occasionally, violent storms may occur, but they are always followed by sunny spells.

3.3.14. United States of America

The climate of the United States varies due to differences in latitude, and a range of geographic features, including mountains and deserts. West of the 100th meridian, much of the US is semi-arid to arid; even desert in the far southwestern US. East of the 100th meridian, the climate is humid continental in the northern areas (locations above 40 north latitude), to humid temperate in the central and middle Atlantic coast regions, to humid subtropical in the Gulf and south Atlantic regions. The southern tip of Florida is tropical. The climate along the coast of California is Mediterranean, while upper West Coast areas in coastal Oregon and Washington are cool temperate oceanic. The state of Alaska, on the northwestern corner of the North American continent, is largely subarctic, but with a cool oceanic climate in the southeast (Alaska Panhandle), southwestern peninsula and Aleutian Islands, and a polar climate in the north. The archipelago state of Hawaii, in the middle of the Pacific Ocean, is tropical, with rainfall concentrated in the cooler season (November to March).

As in most land masses located in the middle and lower-middle latitudes, the primary drivers of weather in the contiguous United States are the seasonal change in the solar angle, the migration north/south of the subtropical highs, and the seasonal change in the position of the polar jet stream. In the Northern Hemisphere summer, the "Bermuda High" over the subtropical Atlantic Ocean typically sends warm, humid air over the eastern, southern and central United States - resulting in southerly airflow, warm to hot temperatures, high humidity and occasional thunderstorm activity. In summer, high pressure over the North-Central Pacific typically results in Northwesterly airflow, stable conditions and cool to mild conditions along most of the immediate Pacific coast, from Washington state to San Diego, CA. In the Northern Hemisphere winter, the subtropical highs retreat southward. The polar jet stream (and associated conflict zone between cold, dry air masses from Canada and warm, moist air masses from the Gulf of Mexico) drops further southward into the United States - bringing major rain, ice and snow events, and much more variable, and sometimes dramatically colder, temperatures. Areas in the extreme southern US (Florida, the Gulf Coast, the Desert Southwest, and southern California) however, often have more stable weather, as the polar jet stream’s impact does not usually reach that far south.

In the cold season (generally November to March), most precipitation occurs in conjunction with organized low-pressure systems and associated fronts, especially in the east-central, eastern and southeastern states. Average winter-season precipitation is especially heavy in Tennessee, Kentucky and the northern Gulf Coast states, and coastal North Atlantic districts. In the summer, storms are much more localized, with short-duration thunderstorms common in many areas east of the 100th meridian. In the warm season, storm systems affecting a large area are less frequent, and weather conditions are more solar controlled, with the greatest chance for thunderstorm and severe weather activity during peak heating hours, mostly between 3 PM and 9 PM local time. From May to August especially, often-overnight mesoscale-convective-system (MCS) thunderstorm complexes, usually associated with frontal activity, can deliver significant to flooding rainfall amounts from the Dakotas/Nebraska eastward across Iowa/Minnesota to the Great Lakes states. From late summer into fall (mostly August to October), tropical cyclones sometimes approach or cross the Gulf and south Atlantic states, bringing high winds, heavy rainfall, and storm surges (often topped with battering waves) to coastal areas. More rarely, tropical cyclones can affect the mid-Atlantic and Northeastern states, such as with the "Long Island Express" hurricane in September 1938, and Superstorm Sandy in October 2012.

3.3.15. Brazil

The climate of Brazil varies considerably mostly from tropical north (the equator traverses the mouth of the Amazon) to temperate zones south of the Tropic of Capricorn (23°26' S latitude). Temperatures below the equator are high, averaging above 25 °C (77 °F), but not reaching the summer extremes of up to 40 °C (104 °F) in the temperate zones. There is little seasonal variation near the equator, although at times it can get cool enough to need to wear a jacket, especially in the rain. Average temperatures below the Capricorn Tropic are mild, ranging from 13 °C (55 °F) to 22 °C (72 °F).

At the country's other extreme, there are frosts south of the Tropic of Capricorn and during the winter (June–September), and in some years there are snowfalls on the high plateau and mountainous areas of some regions. Snow falls in the mountains of the states of Rio Grande do Sul, Santa Catarina, and Paraná and it is possible but very rare in the states of São Paulo, Rio de Janeiro, Minas Gerais, and Espírito Santo. The cities of Belo Horizonte and Brasília have moderate temperatures, usually between 15 and 30 °C (59 and 86 °F), because of their elevation of approximately 1,000 metres (3,281 ft). Rio de Janeiro, Recife, and Salvador on the coast have warm climates, with average temperatures of each month ranging from 23 to 27 °C (73 to 81 °F), but enjoy constant trade winds. The cities of São Paulo, Curitiba, Florianópolis and Porto Alegre have a subtropical climate similar to that of southern United States, and temperatures can fall below freezing in winter.

Precipitation levels vary widely. Most of Brazil has moderate rainfall of between 1,000 and 1,500 mm (39 and 59 in) a year, with most of the rain falling in the summer (between December and April) south of the Equator. The Amazon region is notoriously humid, with rainfall generally more than 2,000 mm (79 in) per year and reaching as high as 3,000 mm (118 in) in parts of the western Amazon and near Belém. It is less widely known that, despite high annual precipitation, the Amazon rain forest has a three- to five-month dry season, the timing of which varies according to location north or south of the equator.

High and relatively regular levels of precipitation in the Amazon contrast sharply with the dryness of the semiarid Northeast, where rainfall is highly erratic and there are severe droughts in cycles averaging seven years. The Northeast is the driest part of the country. The region also constitutes the hottest part of Brazil, where during the dry season between May and November, temperatures of more than 38 °C (100 °F) have been recorded. However, the sertão, a region of semidesert vegetation used primarily for low-density ranching, turns green when there is rain. Most of the Center-West has 1,500 to 2,000 mm (59 to 79 in) of rain per year, with a pronounced dry season in the middle of the year, while the South and most of the East is without a distinct dry season.

3.3.16. Chile

The climate of Chilli comprises a wide range of weather conditions across a large geographic scale, extending across 38 degrees in latitude, making generalizations difficult. According to the Köppen system, Chile within its borders hosts at least seven major climatic subtypes, ranging lowdesert in the north, to alpine tundra and glaciers in the east and southeast, humid subtropical in Easter Island, Oceanic in the south and Mediterranean climate in central Chile. There are four seasons in most of the country: summer (December to February), autumn (March to May), winter (June to August), and spring (September to November).

On a synoptic scale, the most important factors that controls the climate in Chile are the Pacific Anticyclone, the southern circumpolar low pressure area, the cold Humboldt current, the Chilean Coast Range and the Andes Mountains. Despite Chile's narrowness, some interior regions may experience wide temperature oscillations and cities such as San Pedro de Atacama, may even experience a continental climate. In the extreme northeast and southeast the border of Chile extends beyond the Andes into the Altiplano and the Patagonian plains, giving these regions climate patterns similar to those seen in Bolivia and Argentina respectively.

3.4. General Climate of Bangladesh

Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures and humidity. There are three distinct seasons in Bangladesh: a hot, humid summer from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March. In general, maximum summer temperatures range between 30°C and 40°C. April is the warmest month in most parts of the country. January is the coldest month, when the average temperature for most of the country is about 10°C. http://www.weatheronline.co.uk/reports/climate/Bangladesh.htm

The minimum termperature in different locations of the country ranges from 10.0°C to 15.40°C and lowest recorded Srimangal under Habiganj district and highest recorded in Cox's Bazar district on the bank of Bay of Bengal. The maximum normal temperature in different locations of the country ranges from 31.80°C in Mymenshing district to 36.10°C in Chuadanga district.

Heavy rainfall is characteristic of Bangladesh. Most rains occur during the monsoon (June-September) and little in winter (November-February). With the exception of the relatively dry western region of Rajshahi, where the annual rainfall is about 1600 mm, most parts of the country receive at least 2000 mm of rainfall per year. Because of its location just south of the foothills of the Himalayas, where monsoon winds turn west and northwest, the regions in northeastern Bangladesh receives the greatest average precipitation, sometimes over 4000 mm per year. About 80 percent of Bangladesh's rain falls during the monsoon season (WeatherOnline, 2015). http://www.weatheronline.co.uk/reports/climate/Bangladesh.htm

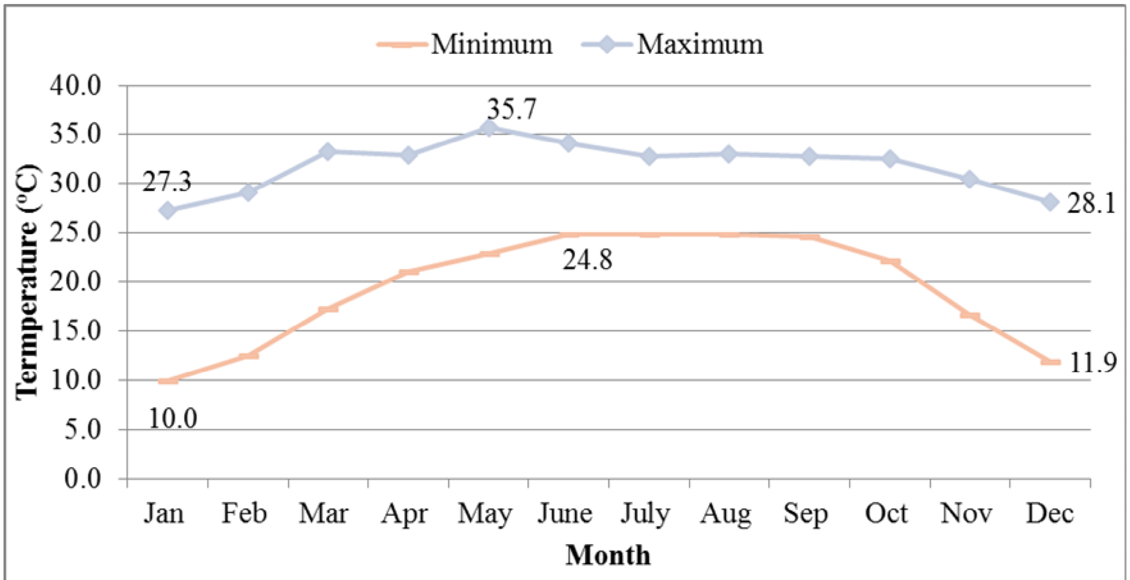


Figure 7. Monthly distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

Köppen climate classification

The Climate of Bangladesh can be divided in different climate zones. The central and southern part can be classified as **Aw** climate, a hot, tropical climate with all months above 18°C and a dry period in the winter. The northern mountainous areas can be classified as **Cwa** climate; a Temperated, humid climate with the warmest month above 22°C and a dry period in the winter (Arnfield, 2014).

http://www.weatheronline.co.uk/reports/climate/Bangladesh.htm

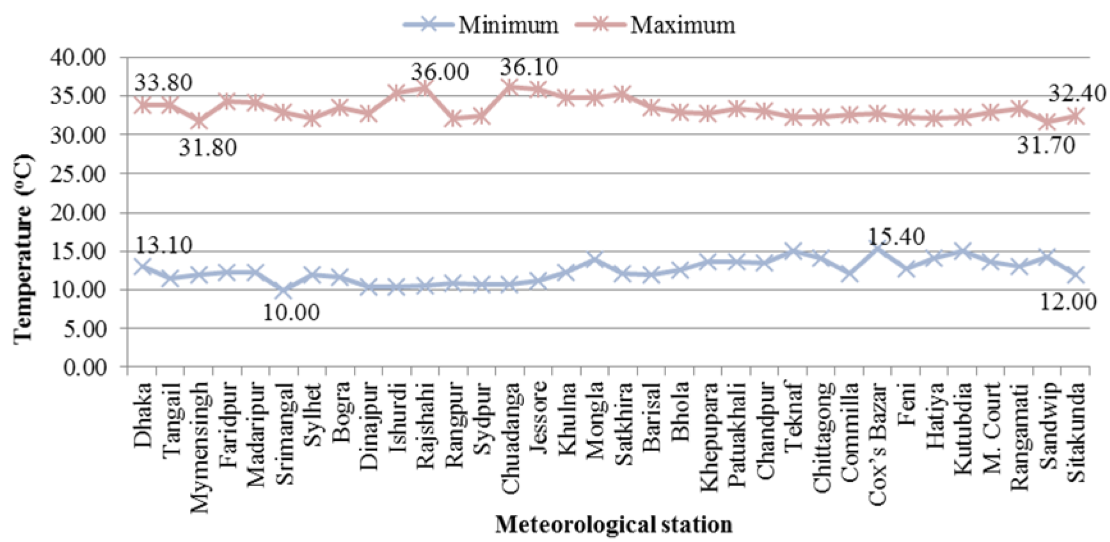


Figure 8. Location-wise distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

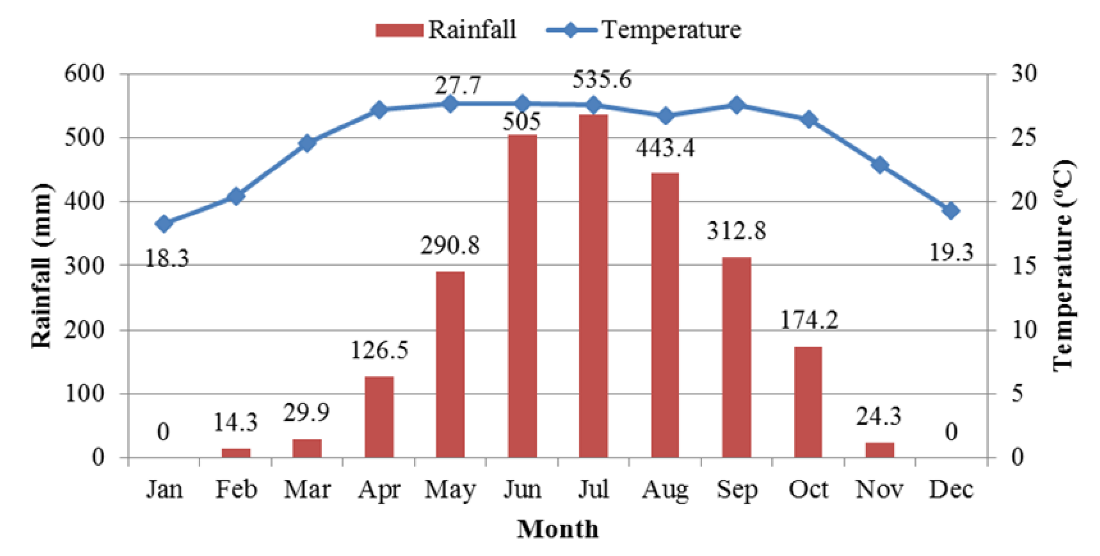


Figure 9. Average monthly Temperature and Rainfall for Bangladesh from 1960-1990

Source: World Bank Group (2015)

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CHAPTER 4

HAZARD IDENTIFICATION

4.1. Introduction

This chapter outlines the mealybug species as potential hazards associated with agricultural crops/plants and or plant parts in India, China, Japan, Thailand, Vietnam, Philippines, Indonesia, Malaysia, Myanmar, Nepal, Bhutan, Pakistan, Sri Lanka, U.S.A, Australia, France, Germany, Italy, Netherlands, Brazil, Chile and any countries of the world; and considers the major risk characteristics of the mealybug and its hazards.

An initial hazard list of mealybug species was made associated with agricultural crops/plants and or plant parts in exporting countries. Some hitch-hiker species of mealybug are included in the risk analyses where entry and establishment of a species into the country would cause potential economic, environmental or health consequences. The following a list of these mealybug species assessed and discarded as likely hazards based on biology, and lack of association with the commodity. Then all potential hazard mealybug species and individual species risk assessments and recommend measures where required.

4.2. Potential Hazard Groups

All the hazardous species of mealybug are in the Homoptera order under Class Insecta regarding their taxonomic identification. Under their taxonomic category or within the trophic role they play in their association, and what structures or part of the plants they attack. In this risk analysis hazard organisms are grouped according to their general taxonomic category. Where a genus contains more than one species, information on all species is contained within one pest risk assessment.

4.3. Interception of mealybugs on commodities from existing pathways

In the past, there was no previous pest risk assessment on mealybug species from any of the exporting countries including the India, China, Japan, Thailand, Pakistan, Sri Lanka, Bhutan, Nepal, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Netherlands, Belgium, Brazil, and Chile etc. As reported by the Plant Quarantine Wing (PQW) under Department of Agricultural Extension (DAE), Bangladesh, during inspection in port of entry of agricultural crops/plants and or plant parts from these exporting counties, not a pest had been intercepted yet today on the commodity imported into Bangladesh.

4.4. Review of earlier PRA

No PRA on mealybug species had been done in Bangladesh earlier. However, damage assessment and other studies on mealybug species in Bangladesh and abroad helped to prepare this PRA report.

4.5. Other Risk Characteristics of the Commodity

Although many pests dealt with in this risk analysis have adequate information for assessment, we can not predict future or present risks that currently escape detection for a variety of reasons.

4.5.1 Unlisted Pests

These include pests that are not yet identified. With a trend towards decreasing use of chemical products in agriculture and further reliance on Integrated Pest Management strategies it is assumed that new species of mealybug or any other pests enter the system at some time in the future.

Prolonged use of large doses of pesticides and fertilizers can lead to previously non pest species becoming economically important through resistance to pest treatments. Any of these types of organism could initially appear in very small numbers associated with the commodity, and may not be identified as hazards before their impacts become noticeable.

4.5.2 Symptomless stages of the pest

Any symptomless stages of mealybug such as eggs and crawlers infest plants or plant parts before transit and may not produce symptoms making them apparent only when they reach a suitable climate to reproduce. The eggs and crawlers can infest plants or plant parts after arrival making it difficult to distinguish without adequate identification, so there is little data on post entry appearance of “invisible mealybugs”.

4.6 Assumptions and Uncertainties

The purpose of this section is to summarize the uncertainties and assumptions identified during the preceding hazard identification and risk assessment stages. An analysis of these uncertainties and assumptions can then be completed to identify which are critical to the outcomes of the risk analysis. Critical uncertainties or assumptions are considered for further research with the aim of reducing uncertainty or removing the assumption. Where there is significant uncertainty in the estimated risk, a precautionary approach to managing risk may be adopted. In these circumstances the measures should be consistent with other measures where equivalent uncertainties exist and be reviewed as soon as additional information becomes available.

There is a major uncertainty concern regarding the prevalence of above mentioned high and moderate rated mealybug species in the exporting countries.

The assessment should have included information on export volumes and frequency to other countries, the average size of export lots, the number of lots found infested with mealybugs in the importing countries, and preferably, any information on incidence level in mealybug infested plants or plant parts consignments or lots would be valuable.

Thus, the assessment of uncertainties and assumptions for each organism often covers similar areas of information or lack of information, with key factors or variables being relevant across different organism groups. The following sections outline these considerations. The uncertainties and assumptions are covered in these sections rather than individually in each pest risk assessment.

4.7. Assumptions and Uncertainties around Hazard Biology

- The species of mealybug (*Pseudococcus* spp.) are the well known hitch-hiker species, and has been associated with plants or parts of plants in India, China, Japan, Thailand, Pakistan, Bhutan, Nepal, Sri Lanka, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Netherlands, Brazil, and Chile etc. Currently there are no data demonstrating this association between this hitch-hiker pest and the pathway imported from these countries into Bangladesh. Interception data rather than biological information would be required to clarify this issue.
- The biology of insects that have been reared in the laboratory for several generations is often different to wild counterparts established in greenhouses or in field conditions (Mangan & Hallman 1998). Aspects such as life cycle, pre-ovipositional period, fecundity and flight ability (Chambers 1977), as well as cold or heat tolerance can be influenced by the highly controlled laboratory environment. Laboratory reared insects may differ in their responses to environmental stress and exhibit tolerances that are exaggerated or reduced when compared with wild relatives.

4.8. Assumption and Uncertainties around the Inspection Procedure

- There are distinct temperature requirements for optimum development and reproduction for the different biotype of mealybugs. Therefore, the molecular data on race detection of the mealybug species rather than occurrence of biological information would be required to clarify this issue.

4.9. Assumption around Transit Time of Commodity on the Air Pathway

- An assumption is made around the time the fresh plants or parts of plants take to get from the field in India, China, Japan, Thailand, Pakistan, Bhutan, Nepal, Sri Lanka, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Netherlands, Brazil, and Chile etc to Bangladesh ready for wholesale if it is transported by Land port or Sea shipment.

4.10. Assumption around Commodity Grown in Bangladesh

Section of PRA	Uncertainties	Further work that would reduce uncertainties
Taxonomy	None	-
Pathway	Presence of a pathway from imported produce to suitable protected environments, such as botanical gardens.	• Monitor all suitable protected environments which are near points of entry of infested produce. • Check reports of finds by other exporting countries of agricultural crop plants or parts of plants
Distribution	None	-
Hosts	None	-
Establishment	Establishment potential under glasshouse in the PRA area.	Continue to monitor the literature for reports of establishment in protected environments.
Spread	Rate of potential spread in areas at risk within the PRA area	Continue to monitor the literature for reports on ability to spread.
Impact	Potential to cause damage in protected environments	Continue to monitor the literature for reports on damage caused in protected environments
Management	None	-

CHAPTER 5

REVIEW OF MANAGEMENT OPTIONS

5.1. Introduction

The following assessment of pre- and post-harvest practices reflects the current systems approach for risk management employed for mealybugs that attack on commercially produced agricultural crops/plants or parts of plants. It is proposed that these practices combined with specific post-harvest treatment (such as fumigation and other requirements e.g. phytosanitary inspection) are used to manage the risks to importing countries posed by regulated organisms associated with the importation of agricultural crops/plants or parts of plants from exporting countries. The management options for mealybug pests of agricultural crops/plants or parts of plants have been reviewed and presented below: commodity

5.2. Management Strategies for Mealybugs

Mealybug control often involves the control of attendant ants that are important for the proper development of mealybugs. Without the ants, mealybug populations are small and slow to invade new areas and the field would be free of a serious mealybug infestation. Therefore, management of mealybugs often includes the control of ant species.

For management of mealybugs, it is important to know the species present as management programs for the various mealybugs may differ. Plant protection products are of limited effectiveness against mealybugs because of the presence of waxy covering of its body. Management of mealybug involves the following tactics:

5.2.1. Cultural and Mechanical Control

- Physical barriers such as ant fences can be applied parallel to the field periphery to keep ants away from field, and subsequently help in controlling mealybug populations.
- All crop residues in previously infested fields should be removed and burnt. Crop residues and grass left in the field may harbor mealybug populations which may invade the new crop.
- Field borders should be free from weeds and debris that may support mealybugs (Fig. 8) between plantings. Weeds also provide alternative host for ant populations between periods where mealybug infestations are small.
- Remove alternate host plants like *Hibiscus*, okra, custard apple, guava, Parthenium etc. in and nearby crop surrounding.
- Equipments should be sanitized before moving to uninfested portions in a crop.
- Manual picking of bugs can be done in plants that are not severely infested in small conservatory or kitchen gardens or apply strong jet of water to remove bugs (avoid the damage to plants).
- In case of perennial crop remove loose bark to expose hiding population of mealybugs and swab stem and arms with dichlorvos 76 EC @ 2 ml +2 g of fish oil resin soap in a litre of water.
- Apply sticky bands like ‘Track-trap’ or ‘Bird Tangle Foot’ on arms or on main stem to prevent crawlers of mealybugs reaching the bunch.
- Destroy ant colonies during land preparation because their nests are located near the soil surface.
- Monitoring and scouting to detect early presence of the mealybug
- Pruning of infested branches and burning them
- Avoiding the movement of planting material from infested areas to other areas
- Avoiding flood irrigation
- Prevention of the movement of ants and destruction of already existing ant colonies
- Sanitization of farm equipment before moving it to the uninfested crop
- Preventive: In tapioca, stems are stocked for propagative purpose in the farms.

- These planting materials often carry mealybug infestation, if the previous year's crop was already infested. Generally, before planting, setts, in parts, are soaked for 1 hr in dichlorvos (76%EC; @10 ml/litre of water) to disinfest the mealybugs.
- But the major drawback in this methodology is that the treatment of planting material by chemical insecticide is done only in parts as per the requirement, and therefore, the chances of the movement of crawlers of mealybug from the main stock to the newly planted crop always exist. The stock near the tapioca fields acts as a reservoir of papaya mealybug. There is a need that in the infected areas of all the planting material before stocking should be treated with chemical insecticides. A small barrier of insecticide dust (chlorpyriphos 1.5% dust or malathion 5% DP) can also be made around the stocks to check the movement of crawlers as well as ants from/to the stock.

5.2.2. Biological control

- Biological control is considered the most effective long-term solution to the mealybug infestation because the parasites and predators are self perpetuating, persist even when the mealybug is at low population densities, and they continue to attack the mealybugs, keeping populations below economicinjury levels. The coccinellid beetles such as *Cheilomenes sexmaculata*, *Rodolia fumida*, *Scymnus coccivora* and *Nephus regularis* are important predators of mealybug nymphs. Biological control by release of natural enemies has proved very successful. Among the biological control agents introduction of *Cryptolaemus montrouzieri* (Australian Ladybird), *Anagyrus pseudococci*, *Leptomastix dactylopii, Hypoaspis* sp., *Verticillium lecanii* and *Beauveria bassiana* are effective in managing the infestation. *Hypoaspis* is a small mite that feeds on crawlers.

- Coccinellids generally respond positively to some extent to the increasing densities of mealybugs; at the initial level a sigmoidal increase may be seen whereas in the later stage it may exhibit negative density dependence due to satiation. Therefore, the entire population of mealybugs may not be suppressed by coccinellids. There is a need to integrate other control tactics along with conservation and augmentation of cocinellids to manage mealybugs.

- ***Cryptolaemus montrouzieri:*** *Cryptolaemus montrouzieri*, commonly called the redheaded ladybird beetle or the mealybug destroyer, is a black lady beetle. *C. montrouzieri* has been used successfully in Karnataka to reduce large populations of *M. hirsutus*. It is considered a predator of citrus and long-tailed mealybug in greenhouses and interior plantscapes and has already been introduced in a biocontrol program to control pink mealybug. The adult female beetle lays an egg among the cottony egg sac of an adult female mealybug. The larvae of the beetle grow up to 1.3 cm in length and have wooly appendages of wax, which makes them superficially resemble the mealybug. The larvae feed on mealybug eggs and young crawlers. The lifespan of the *C. montrouzieri* is two months. During this time, the mealybug destroyer can lay up to 400 eggs. It is capable of eating 3,000–5,000 mealybugs in various life stages. Biological control in grapes includes one to three releases of *C. montrouzieri* at 10 per tree or @ 5,000 beetles/ha, two times in a season especially during August–September and December–January. It is better to release a mixed population of grubs and adults rather than only adults.

  There is a need to conserve the native predators of the pest. Australian ladybird beetle (*C. montrouzieri*) predates on mealybugs, eating 3,000-5,000 mealybugs in various life stages and is released @ 10 beetles per tree or @ 5000 beetles/ ha.

- ***Anagyrus kamali:*** *Anagyrus kamali* is a parasite from China and is being currently used to manage pink mealybug. It has also been recorded in India on mulberry plant. It attacks the mealybugs in two ways. The adult wasp punctures a mealybug and extracts fluid from the wound. The female wasp feeds on the fluid of the dying mealybug, which provides nutrient to wasp's eggs for development. The female wasp also lays an egg inside mealybug, which hatches and feeds internally, killing the mealybug. Fully developed adult wasp comes out of the "mummy" of the mealybug by cutting a circular hole in the end of the mummy and crawls out. The process can take place in half the time it takes for the entire life cycle of the mealybug. *A. kamali* typically has a 15-day life cycle in tropical climates. During its lifetime, a female wasp can lay single eggs inside 40–60 mealybugs.

- ***Verticillium lecanii* and *Beauveria bassiana*:** Foliar spray of *Verticillium lecanii* or *Beauveria bassiana* (2 × 10^8 cfu/ml) @ 5 g/ml per litre of water is effective during high humid months in reducing the population of mealybugs.

- ***Spalgis epius* (Lycaenidae):** In the nature, lepidopteran predator, *Spalgis epius* (Lycaenidae) is a well known representative of carnivorous butterfly feeding on various species of pseudococcids and coccids. *S. epius*, being the dominant predator, feeds efficiently on the ovisacs, nymphs and adult of papaya mealybug. Newly hatched larvae of *S. epius* are pale pink in colour and remain inside the mealybug ovisac devouring the eggs of the mealybug. The creamy white second instar larvae come out of the ovisac. As the larvae of S. epius is slug like coated with wax coating and camouflaged with mealybug population, therefore, it is very difficult to distinguish the predator from its prey. The total life cycle lasts for 14.83 ± 0.44 days with the larval life span of 9.83±2.39 (I instar: 2.5±0.5 days; II instar: 1.75±0.25 days; III instar : 1.41±0.38 days; IV instar : 2±0.5 days; V instar : 2.1±0.76 days). The larvae pupate on the under surface of the leaves to form the characteristic rhesus monkey face chrysalis.

  The pupal period is about 5.45 ±0.50 days. Ex situ confinement studies have shown that the fifth instar larvae consumed as much as 18 to 26 (22.33±3.21) ovisacs and 112 to 132 (121.66 ± 8.86) nymphs and adults of the mealybugs. During the whole larval period the predatory larvae devoured about 42 to 53 (48.15±4.08) ovisacs and 196 to 222 (210.99 ± 10. 77) nymphs and adults of *P. marginatus* (Thangamalar *et al.*, 2010).

  When high activity of S. epius and other natural enemies is observed, care should be taken to delay spraying operations and measures should be taken to conserve them.

- **Exotic parasitoids/predators** such as *Anagyrus loecki* Noyes and Menazes, *Acerophagous papayae* Noyes and Schauff and *Pseudleptomastrix Mexicana* Noyes and Schauff (Hymenoptera: Encyrtidae) were released in Sri Lanka in May 2009 (imported from Puerto Rico) and resulted in 95 to 100% control of the papaya mealybug in some parts of that country by August 2009. There is a need to introduce such exotic parasitoids in India to contain the pest without harming the environment.

5.2.3. Chemical control

Any insecticide used against *M. hirsutus* should be carefully selected to avoid injury to its natural enemies. IPM using both coccinellid beetle predators and insecticides has been achieved on grapevine.

- Plant protection products are of limited effectiveness against mealybug because of its habit of hiding in crevices, and the waxy covering of its body. Most granular insecticides are ineffective; therefore, systemic insecticides are used to control heavy infestations.
- Locate ant colonies and destroy them with drenching of chlorpyriphos 20 EC @ 2.5 ml/l or apply 5% malathion dust @ 25 kg/ha as the ants provide them protection from parasitoids and predators and also helps in spreading the crawlers to non-infested plants.
- Inorganic oil emulsion sprays gave good control of *M. hirsutus* on guava. IPM using both coccinellid beetle predators and insecticides (dichlorvos and chlorpyriphos) has been achieved on grapevine.
- Spray dichlorvos 76 EC 2 ml/l, monocrotophos 36 WSC 1.5 ml/l, methyl demeton 25 EC 2 ml/l, chlorpyriphos 20 EC 2 ml/l, imidacloprid 200 SL 1ml/l or malathion 2.5ml/l of water at 15 days intervals.
- Use dichlorovos (0.2%) in combination with fish oil rosin soap (25 g/l) as spray or for dipping the fruits for two minutes
- Regular monitoring of the crop for mealybug infestation and its natural enemies.

- Spot application of insecticide immediately after noticing mealybug on some plants in the crop field.
- If the activities of natural enemies are not observed, use of botanical insecticides such as neem oil (1 to 2%), NSKE (5%), or Fish Oil Rosin Soap (25g/litre of water) should be the first choice.
- Chemical control is only partially effective and requires multiple applications.
- Apply recommended chemical insecticides as the last resort such as profenophos 50 EC (2 ml/litre), chlorpyriphos 20 EC (2ml/litre), buprofezin 25 EC (2 ml/litre), dimethoate 30 EC (2 ml/litre), thiomethoxam 25 WG (0.6 g/litre), imidacloprid 17.8 SL (0.6 ml/litre)
- Spray profenophos @ 2 ml / litre on stumps immediately after pruning in mulberry followed by second spray, 15 days after pruning, with dichlorvos @ 2 ml/litre along with azadirachtin (10000 ppm) @ 1 ml /litre. Stickers should always be added in spray solutions.
- Avoid repeating the use of the same chemical insecticide as there are chances for development of resistance in the pest.
- Drenching soil with chlorpyriphos around the collar region of the plant to prevent movement of crawlers of mealybug and ant activity is useful.
- Insecticide resistance and non-target effects on natural enemies make chemical control a less desirable control option.

5.2.4. Phytosanitary measures

It is relatively easy to detect mealybugs by inspection, so the basic requirement that imported consignments of plants for planting should be free from the pest can be fulfilled by inspection. Monitoring the movement of fresh farm produce, including flowers, between countries as well as between States of our country is the first step in controlling any spread within the region. This applies to both the import/export trade and to passenger traffic. M. hirsutus was added in 2003 to the European and Mediterranean Plant Protection Organization (EPPO) A1 Action List, and endangered EPPO member countries have recommended regulating it as a quarantine pest. Similar case is required for papaya mealybug.

5.2.5. Guidelines and cautions

- Do not move any plant material with suspected mealybugs to pest free fields.
- Moving infested plants is the fastest way to spread the pest.
- After pruning, the cuttings of infested shrubs or trees lying around must be immediately burnt.
- Do not shake or scatter the infested material.
- Proper phytosanitation of planting material, harvested produce etc., before moving to other States is required.
- Intensive regular survey would be necessary to find out efficient parasitoids/ predators/ pathogens of the pest.
- Piecemeal harvesting of mulberry crop need to be avoided/monitored for preventing spread of the pest.
- Do not spray any chemical insecticide unless mealybug infestation is confirmed; unnecessary spraying may destroy natural enemies which keep mealybug populations under control.
- Follow the waiting period of 2-3 weeks after the last spray to release the mealybug destroyers. Water infested plants well before releasing mealybug destroyers.
- Predator beetles should be released in spots having adequate mealybug population to ensure the best effectiveness.
- Apply safer pesticides like dichlorvos, chlorpyriphos, fish oil, rosin soap, azadirachtin, buprofezin etc. during the activity of ladybird beetle.
- If chemical control is chosen, always wear protective clothing and safety gear

5.2.6. Integrated Pest Management for Mango Mealybugs

- Flooding of orchards with water in October kills the eggs.
- Ploughing the orchards in November exposes the eggs to sun's heat.
- Fasten 400 gauge alkathene sheet of 25 cm width to the tree trunk besides raking the soil around the tree trunk and mixing of 2 per cent methyl parathion dust or 1.5% chlorpyriphhos dust @ 250 gm per tree in the middle of December.
- Sprinkle the recommended insecticide dust below the alkathene band on the tree to kill the congregated nymphs below the band.
- Spray 0.04% monocrotophos or 0.06% dimehoate if nymphs have already ascended the tree.
- Spray of neem products and soil application of the spores of the fungus, *B. bassiana* will ensure further reduction of the pest population.

5.2.7. Integrated Pest Management for Grape Mealybugs

IPM in grapes has been achieved successfully in grapevine by involving both coccinellid beetle predators and insecticides. IPM includes the following practices after forward pruning (October–April):

- Collection and proper destruction of the pruned material from mealybug infested grape garden.
- Removal and destruction of loose bark after pruning and swabbing of stem and arms with 2 ml of dichlorvos 76 EC + 2 g of fish oil resin soap in a litre of water to expose hiding population of mealybugs and destroy them.
- Application of sticky bands like 'Track-trap' or 'Bird Tangle Foot' on arms or on main stem before appearance of mealybugs on canes or bunches to prevent crawlers of mealybugs reaching the bunch and also to prevent movement of ants.
- Removal of weeds and alternate host plants like *Hibiscus*, okra, custard apple, guava etc in and nearby vineyards which harbor mealybugs.
- Locating of ant colonies and destroy them with drenching of chlorpyriphos 20 EC @ 2.5 ml/l of water or by application of 5% malathion dust @ 25 kg/ha. This operation can be carried out round the year.
- Soil drenching with imidacloprid 200 SL @1.5 ml/l of water/plant on the base of the plant around the trunk.
- Foliar spray of dichlorvos 76% EC @ 2 ml/l of water after 30–45 of days pruning.
- Spraying of buprofezin 25 SC @ 1,000–1,125 ml/ha after 45–60 days of pruning.
- Release of Australian lady beetle adult/grub *C. montrouzieri* @ 5,000 beetles/ha, two times in a season especially during August–September and December–January.
- Foliar spray of *V. lecanii*/*B. bassiana* ($2{\times}10_8$ cfu/ml) @ 5 g/ml/l of water after 90–105 days of pruning during high humid months to reduce the population of mealybugs.
- Spraying of buprofezin 25 SC @ 1,000–1,125 ml/ha after 105–120 days of pruning.
- Foliar spray of azadirachtin 1% @ 2 ml/l or 5% @ 1 ml/l of water after 120–135 days of pruning.

5.2.8. Integrated Pest Management for Cotton Mealybugs

- Prepare the land thoroughly so that eggs may be destroyed.
- Host plants like congress grass, *guputna*, *bhakhra* and *itsit* act as carrier for mealybugs, therefore weeding in and around fields should be done on time.
- Locating of ant colonies and destroy them with drenching of chlorpyriphos 20 EC @ 2.5 ml/l of water or by application of 5% malathion dust @ 25 kg/ha. This operation can be carried out round the year.
- Mealybugs at initial stage appear in small pockets, therefore, recommended insecticide are applied only in the infested spot, not in the entire crop.
- Recommended doses of insecticides of carbamate (carbaryl 50 WP @2.5 kg/ha or thiodicarb 75 WP @ 625 gm/ha) and organophosphate (profenofos 50 EC @ 1,250

ml/ha, quinalphos 25 EC @ 2,000 ml/ha, acephate 75 SP @ 2,000 gm/ha or chlorpyriphos 25 EC @ 5l/ha) could be sprayed rotation-wise in consecutive sprays.

- Sufficient quantity of water should be used for spray so as to drench the whole plant.
- Soil around the stem must be sprayed.
- Use of soap oil or fish oil resin soap twice at an interval of 15–20 days.
- Most affected plants should be uprooted and burnt.
- This pest mostly spreads in other areas of field during the picking time, therefore, cotton pickers should be guided accordingly.
- Encourage the activity of predators like *C. sexmaculata*, *B. suturalis, S. coccivora* and C. *montrouzieri*.

5.2.9. Integrated Pest Management for Papaya Mealybugs

- Monitoring and scouting to detect early presence of the mealybug on papaya plants
- Pruning of infested branches and burning them
- Removal and burning of crop residues
- Removal of weeds/alternate host plants like Hibiscus, Parthenium etc. in and nearby crop
- Avoiding the movement of planting material from infested areas to other areas
- Avoiding flood irrigation
- Prevention of the movement of ants and destruction of already existing ant colonies
- Application of sticky bands or alkathene sheet or a band of insecticide on arms or on main stem to prevent movement of crawlers
- Natural enemies of the papaya mealybug include the commercially available mealybug destroyer *Cryptolaemus montrouzieri*, ladybird beetles, lacewings, hover flies, *Scymnus* sp. and certain hymenopteran and dipteran parasitoids. Conservation of these natural enemies in nature plays important role in reducing the mealybug population.
- Locate ant colonies and destroy them with drenching of chlorpyriphos 20 EC @ 2 .0 ml/litre of water.
- Spot application of insecticide immediately after noticing mealybug on some plants in the crop field.
- If the activities of natural enemies are not observed, use of botanical insecticides such as neem oil (1 to 2%), NSKE (5%), or Fish Oil Rosin Soap (25g/litre of water) should be the first choice.
- Apply recommended chemical insecticides as the last resort such as profenophos 50 EC (2 ml/litre), chlorpyriphos 20 EC (2ml/litre), buprofezin 25 EC (2 ml/litre), dimethoate 30 EC (2 ml/litre), thiomethoxam 25 WG (0.6 g/litre), imidacloprid 17.8 SL (0.6 ml/litre)
- Spray profenophos @ 2 ml / litre on stumps immediately after pruning in mulberry followed by second spray, 15 days after pruning, with dichlorvos @ 2 ml /litre along with azadirachtin (10000 ppm) @ 1 ml /litre. Stickers should always be added in spray solutions.

CHAPTER 6

IDENTIFICATION OF MEALYBUG SPECIES AND HOSTS

6.1. Damaging species of mealybugs recorded in Bangladesh

The study for “Conducting Pest Risk Analysis (PRA) of Mealybug spp. in Bangladesh” was done in 26 major agricultural crop growing districts of Bangladesh. From the field survey and review of secondary documents, the precise findings of the study in-line with the presence of more damaging species of mealybugs in Bangladesh have been presented recorded:

Fourteen (14) damaging species of mealybugs were recorded in Bangladesh that attacked many of the host plants. These species of mealybugs were citrus mealybug (*Planococcus citri*), stripped mealybug (*Ferrisia virgata*), pink hibiscus mealybug (*Maconellicoccus hirsutus*), spherical mealybug (*Nipaecoccus viridis*), mango mealybug (*Drosicha mangiferae, Rastrococcus iceryoides*), papaya mealybug (*Paracoccus marginatus*), potato mealybug (*Phenacoccus solani*), mango mealybug (*Rastrococcus iceryoides*), brinjal mealybug (*Coccidohystrix insolita*), sugarcane mealybug *(Saccharicoccus sacchari*), palm mealybug (*Palmicultor palmarum*), rice mealybug (*Brevennia rehi*), pineapple mealybug (*Dysmicoccus brevipes*) and bread fruit mealybug (*Icerya aegyptiaca*).

Table 3. Mealybug species recorded in Bangladesh

Sl. No.	Common name	Scientific name	Family and Order	Reference
1	Citrus mealybug	*Planococcus citri*	Pseudococcidae (Homoptera)	Ullah & Parveen, 1993; CABI/EPPO, 1999; Williams and Watson, 1988
2.	Stripped mealybug	*Ferrisia virgata*	Pseudococcidae (Homoptera)	CIE, 1966; APPPC, 1987; Williams, 2004
3.	Pink hibiscus mealybug	*Maconellicoccus hirsutus*	Pseudococcidae (Homoptera)	EPPO, 2014; CABI/EPPO, 2015
4.	Spherical mealybug	*Nipaecoccus viridis*	Pseudococcidae (Homoptera)	CABI/EPPO, 2005; EPPO, 2014
5.	Mango mealybug	*Drosicha mangiferae*	Margarodidae (Homoptera)	Rahman, 2011
6.	Papaya mealybug	*Paracoccus marginatus*	Pseudococcidae (Homoptera)	Ronald *et al.,* 2007
7.	Potato mealybug	*Phenacoccus solani*	Pseudococcidae (Homoptera)	ITIS, 2017
8.	Mango mealybug	*Rastrococcus iceryoides*	Pseudococcidae (Homoptera)	Williams, 1989
9.	Brinjal mealybug	*Coccidohystrix insolita*	Pseudococcidae (Homoptera)	Veilleux *et al*., 2001
10.	Sugarcane mealybug	*Saccharicoccus sacchari*	Pseudococcidae (Homoptera)	Ben-Dov, 1994
11.	Palm mealybug	*Palmicultor palmarum*	Pseudococcidae (Homoptera)	CABI, 2008
12.	Rice mealybug	*Brevennia rehi*	Pseudococcidae (Homoptera)	Alam, 1975; Hatai, 1973; Alam, 1977; Alam & Karim, 1981
13	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae (Homoptera)	Ben-Dov Y, 1994
14	Bread fruit mealybug	*Icerya aegyptiaca*	Monophlebidae (Homoptera)	CABI/EPPO, 2003; EPPO, 2014; NHM, 1980

6.2. Host plants of mealybugs in Bangladesh

The major and minor hosts of mealybug species in Bangladesh along with plant parts affected of the crops were identified through the field survey conducted in 26 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:

6.2.1. 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.

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 4. 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
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

Sl. No.	Name of host plant	Scientific name and family	Host status	Vulnerable stage	Plant parts affected	Infestation severity	Damage potential
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	Blackknight shade	*Solanum nigrum* Solanaceae	Minor	Vegetative	Leaf, stem	Low	Little bit

6.2.2. 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 5. 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	Infestation 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
10	Potato	*Solanum tuberosum* Solanaceae	Minor	Vegetative	Leaf, stem	Low	Little bit
11	Sweet potato	*Ipomea batatus* Convulvulaceae	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*	Minor	Vegetative &	Leaf, stem,	Low	Little bit

Sl. No.	Name of host plants	Scitific name and Family	Host status	Vulnerable stages	Plant parts affected	Infestation severity	Damage potential
		Fabaceae		fruiting	inflorescence		
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
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

6.2.3. 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.

Among 9 wood 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 6. 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	Infestation 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	Leaf, stem	Low	Little bit
9	Coconut	*Cocos nucifera* Palmae	Major	Seedling, vegetative & fruiting	Leaf, stem, flower & fruits	Low	Little bit

Sl. No.	Name of host plants	Scientific name and family	Host status	Vulnerable stages	Plant parts affected	Infestation severity	Damage potential
10	Betel nut	*Areca catechu* Palmae	Minor	Seedling & vegetative	Leaf, stem	Low	Little bit
11	Pomegranate	*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		
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
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	Gandhabhadule	*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

6.2.4. 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. 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.

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 7. 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	Infestation 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
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

6.3. Management options for mealybugs in Bangladesh

Common practices: The crop farmers usually sprayed insecticides on the plant to control mealybugs. Other management options practiced by the farmers for controlling mealybugs were pruning of mealybug infested branches or parts of plants and burnt them, hand picking and destruction of mealybugs from the infested plants, removal of weeds from the fields or nearby the fields. Farmers also controlled mealybugs by spraying soap water on mealybug infested plants. They also sprayed only water using hose pipe with high speed on the mealybug infested plants in the garder or orchard. Integrated Pest Management (IPM) tools were also practiced by the farmers to control mealybugs that attack crop plants.

Effective measures against mealybugs: The effective control measures against mealybugs as practice by the farmers were spraying of systemic insectices, pruning of infested branch or plant parts and burning them, hand picking of mealybug colonies from the infested twigs or branches or parts of plants. Other means of effective control of mealybugs were IPM practices and spraying of water using hosepipe with high speed on the plants like papaya, guava etc in the garden or orchards.

Commonly used insecticides: Farmers usually used systemic insecticides as effective control measures against mealybugs while infesting plants. The effective insecticides were Ethrin, Imidachloprid, Fighter, Malathion, Aktara, Darsban, Sumithion, Nativo, Mipsin, Ripcord, Cypermethrin etc.

6.4. Mealybug species in Exporting Countries

The most common mealybug species that attack agricultural crops/plants and or plant parts recorded in India, China, Japan, Thailand, Vietnam, Myanmar, Philippines, Indonesia, Malaysia, Nepal, Pakistan, Sri Lanka, U.S.A, Australia, France, German, Italy, Netherlands, Brazil, Chile etc are listed below based on their scientific name, taxonomic position, common name, host attacked, geographical distribution and their quarantine status for Bangladesh.

Twenty seven (27) mealybug species were recorded in the exporting countries including Bangladesh that attacked commercially important plants or plants parts **(Table 8).** Among these 27 mealybug species, 14 species were recorded in Bangladesh and the rest 13 mealybug species were not recorded in Bangladesh those were identified as quarantine species for Bangladesh likely to be imported with unmitigated shipments of plants and or plant parts of agricultural crops/plants, possibly requiring phytosanitary measures to mitigate risk.

Table 8. Mealybug species associated with host plants in the world and identification of quarantine species

Sl. No.	Common name	Scientific name	Family and Order	Hosts	Distribution	Presence in Bangladesh	Quarantine pest	Reference
01.	Obscure mealybug	*Pseudococcus affinis*	Pseudococcidae: Homoptera	Tea, Citrus, Apple, Orchids, European pear, Potato, Grapevine	Afghanistan, China, Indonesia, Korea, Philippines, Sri Lanka, Turkey, Australia, New Zealand	No	Yes	EPPO, 2014; Williams, 2004; Kozar et al., 1996; Gimpel & Miller, 1996
02.	Longtailed mealybug	*Pseudococcus longispinus*	Pseudococcidae: Homoptera	Avocado, Banyan, Begonia, Betel-nut, Coconut, Citrus, Coffee, Gardenia, Guava, Hibiscus, Lily, Mango, Orchid, Pineapple, Potato, Sugarcane, Soyabean	America, Europe, Africa	No	Yes	McKenzie 1967; Zimmerman 1948; Furness 1976
03.	Citrus mealybug	*Planococcus citri*	Pseudococcidae: Homoptera	Citrus, Cocoa, Banana, Tobacco, Pineapple, Jujube	Bangladesh, China, India, Indonesia, Japan, Korea, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam, South Africa, USA, Argentina, UK, Australia, New Zealand	Yes	No	Ullah & Parveen, 1993; CABI/EPPO, 1999; Williams and Watson, 1988
04.	Cassava mealybug	*Phenacoccus manihoti*	Pseudococcidae: Homoptera	Cassava, Citrus, Chili, Poinsettia, Tomato, Soyabean, Maize	Indonesia, Malaysia, Thailand, Vietnam, South Africa, Argentina	No	Yes	Parsa et al., 2012; EPPO, 2014; Herren & Neuenschwander, 1991
05.	Stripped mealybug	*Ferrisia virgate*	Pseudococcidae: Homoptera	Cocoa, Coffee, Citrus, Cotton, Jute, Pome grenade, Guava, Jackfruit	Bangladesh	Yes	No	CIE, 1966; APPPC, 1987; Williams, 2004
06.	Pink hibiscus mealybug	*Maconellicoccus hirsutus*	Pseudococcidae: Homoptera	Okra, Allamanda, Sugar apple, Carambola, Bougainvillea, Pigeon pea, Citrus, Soyabean, Cotton, Kenaf, China rose, Passion fruit, Avocado, Rain tree, Teak, Cocoa, Grapevine, Neem	Bangladesh	Yes	No	EPPO, 2014; CABI/EPPO, 2015
07.	Spherical mealybug	*Nipaecoccus viridis*	Pseudococcidae: Homoptera	Citrus, Coffee, Cotton, Avocado	Bangladesh	Yes	No	CABI/EPPO, 2005; EPPO, 2014
08.	Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae: Homoptera	Bullock's heart, Sugar apple, Palms, Pigeon pea, Coconut, Fig, Mango, Cassava, Guava, Potato, Olive, Banana, Grape, Ginger	China, India, Philippines, Turkey	No	Yes	APPPC, 1987; CABI/EPPO, 2005

Sl. No.	Common name	Scientific name	Family and Order	Hosts	Distribution	Presence in Bangladesh	Quarantine pest	Reference
09.	Comstock mealybug	*Pseudococcus comstocki*	Pseudococcidae: Homoptera	Coffee, Litchi, Apple, Mulberry	China, Japan, Korea, Thailand, Italy, Russia, USA, South Africa	No	Yes	EPPO, 2016
10.	Mediterranean vine mealybug	*Planococcus ficus*	Pseudococcidae: Homoptera	Fig, Grape vine, Jujube, Bamboo, Walnut, Apple, Date palm, Dahlia, Avocado	India, Pakistan, South Africa, Argentina, France, Italy	No	Yes	Fallahzadeh et al., 2011; Moghaddam, 2006; Kol-Maimon et al., 2010; Walton et al., 2009; Duso, 1989
11.	Grape mealybug	*Pseudococcus maritimus*	Pseudococcidae: Homoptera	China berry, Peach, Apple, Grapevine	USA, Mexico, Chile, Netherlands	No	Yes	Golan & Górska-Drabik, 2006, CABI, 2011
12.	Cotton mealybug	*Phenacoccus solenopsis*	Pseudococcidae: Homoptera	Okra, Cashew nut, Neem tree, Chili, Water melon, Ghoos grass, China rose, Jute, Pointed gourd, Biter gourd	China, India, Indonesia, Japan, Pakistan, Sri Lanka, Thailand, Turkey, Vietnam, USA, Argentina, Chile, Ausstralia	No	Yes	CABI/EPPO, 2012; EPPO, 2011; Ministry of Agriculture, 2010:
13.	Mango mealybug	*Drosicha mangiferae*	Pseudococcidae: Homoptera	Mango, Jackfruit, Banana, Red gram, Papaya, Cotton, Mulberry, Guava, Tomato, Turkey, Berry, Brinjal, Teak, Chilli, Marigold	Bangladesh	Yes	No	Rahman, M. B. 2011
14.	Papaya mealybug	*Paracoccus marginatus*	Pseudococcidae: Homoptera	Papaya, Avocado, Citrus, Tomato, Eggplant, Peppers, Beans, Peas, Sweet potato, Mango	Bangladesh	Yes	No	Ronald *et al.,* 2007
15.	Potato mealybug	*Phenacoccus solani*	Pseudococcidae: Homoptera		Bangladesh	Yes	No	ITIS, 2017
16.	Wheat mealybug	*Trionymus haancheni*	Pseudococcidae: Homoptera	Wheat, Barley	USA	No	Yes	Alvarez, J. M., 2004
17.	Alazon mealybug	*Dysmicoccus grassii*	Pseudococcidae: Homoptera	Bottle gourd, Mango, Pineapple, Papaya, Pomegranate, Banana, Coffee	South America, Malaysia, France, Italy, Sicily, Niger	No	Yes	Leathers, J., 2016
18.	Banana mealybug	*Pseudococcus elisae*	Pseudococcidae: Homoptera	Banana, Sugar apple, Coffee	Mexico, Guatemala, Brazil, Chile, Cuba, Japan, Korea, Paraguay	No	Yes	Leathers, J., 2015
19.	Mango mealybug	*Rastrococcus iceryoides*	Pseudococcidae: Homoptera	Mango, Indian siris, Citrus, Lime, Coffee, Cotton, Cocoa	Bangladesh	Yes	No	Williams, 1989
20.	Brinjal	*Coccidohystrix*	Pseudococcidae:	Brinjal	Bangladesh	Yes	No	Veilleux et al., 2001

Sl. No.	Common name	Scientific name	Family and Order	Hosts	Distribution	Presence in Bangladesh	Quarantine pest	Reference
	mealybug	*insolita*	Homoptera					
21.	Sugarcane mealybug	*Saccharicoccus sacchari*	Pseudococcidae: Homoptera	Sugarcane	Bangladesh	Yes	No	Ben-Dov, 1994
22.	Palm mealybug	*Palmicultor palmarum*	Pseudococcidae: Homoptera	Date palm, Coconut	Bangladesh	Yes	No	CABI, 2008
23.	Rice mealybug	*Brevennia rehi*	Pseudococcidae: Homoptera	Rice, Grasses, Sugarcane, sorghum	Bangladesh	Yes	No	Alam, 1975; Hatai, 1973; Alam, 1977; Alam & Karim, 1981
24.	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae: Homoptera	Pineapple, groundnut, cucumber, carrot, coconut, guava, maize	Bangladesh	Yes	No	Ben-Dov Y, 1994
25.	Bread fruit mealybug	*Icerya aegyptiaca*	Monophlebidae: Homoptera	Breadfruit, Jackfruit, Citrus, Mango,	Bangladesh	Yes	No	CABI/EPPO, 2003; EPPO, 2014; NHM, 1980
26.	Lantana mealybug	*Phenacoccus parvus*	Pseudococcidae: Homoptera	Potato, aubergine, guava, Lantana, chilli	China, India, Japan, Singapore, USA,	No	Yes	UK CAB International, 1990
27.	Madeira mealybug	*Phenacoccus madeirensis*	Pseudococcidae: Homoptera	Pigeon pea, bell pepper, citrus, cotton, aubergine, potato	India, Japan, Philippines, Taiwan, Thailand, Turkey, USA	No	Yes	EPPO, 2014: CABI/EPPO, 2000

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6.5. Quarantine mealybug species for Bangladesh

Thirteen (13) quarantine mealybug species identified for Bangladesh those were recorded in India, China, Japan, Thailand, Sri Lanka, Pakistan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Netherlands, Brazil, Chile etc, but not in Bangladesh. Among these quarantine species of mealybug, eight (8) species were further analyzed and rest five (5) species were not analyzed due to lack of detailed information (**Table 9**).

The quarantine mealybug species those had been further analyzed for risk assessment were Obscure mealybug (*Pseudococcus affinis*), Long-tailed mealybug (*Pseudococcus longispinus*), Cassava mealybug (*Phenacoccus manihoti*), Spiked mealybug (*Nipaecoccus nipae*), Mediterranean vine mealybug (*Planococcus ficus*), Cotton mealybug (*Phenacoccus solenopsis*), Banana mealybug (*Pseudococcus elisae*) and Madeira mealybug (*Phenacoccus madeirensis*). The taxonomic identity, hosts and distribution of these species are given in the **Table 9**.

The quarantine mealybug species those had not been further analyzed for risk assessment due to lack of detail information were Comstock mealybug (*Pseudococcus comstocki*), Grape mealybug (*Pseudococcus maritimus*), Wheat mealybug (*Trionymus haancheni*), Alazon mealybug (*Dysmicoccus grassii*), and Lantana mealybug (*Phenacoccus parvus*). The taxonomic identity, hosts and distribution of these species are given in the **Table 9**.

Table 9. Mealybug species likely to be associated with host plants in the exporting countries, but not in Bangladesh

Sl. No.	Common name	Scientific name	Family and Order	Hosts	Distribution	References
01.	Obscure mealybug	*Pseudococcus affinis*	Pseudococcidae: Homoptera	Tea, Citrus, Apple, Orchids, European pear, Potato, Grapevine	Afghanistan, China, Indonesia, Korea, Philippines, Sri Lanka, Turkey, Australia, New Zealand	EPPO, 2014; Williams, 2004; Kozar *et al.*, 1996; Gimpel & Miller, 1996
02.	Long-tailed mealybug	*Pseudococcus longispinus*	Pseudococcidae: Homoptera	Avocado, Banyan, Begonia, Betel-nut, Coconut, Citrus, Coffee, Gardenia, Guava, Hibiscus, Lily, Mango, Orchid, Pineapple, Potato, Sugarcane, Soyabean	America, Europe, Africa	McKenzie 1967; Zimmerman 1948; Furness 1976
03.	Cassava mealybug	*Phenacoccus manihoti*	Pseudococcidae: Homoptera	Cassava, Citrus, Chili, Poinsettia, Tomato, Soyabean, Maize	Indonesia, Malaysia, Thailand, Vietnam, South Africa, Argentina	Parsa *et al.*, 2012; EPPO, 2014; Herren & Neuenschwander, 1991
04.	Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae: Homoptera	Bullock's heart, Sugar apple, Palms, Pigeon pea, Coconut, Fig, Mango, Cassava, Guava, Potato, Olive, Banana, Grape, Ginger	China, India, Philippines, Turkey	APPPC, 1987; CABI/EPPO, 2005
05.	Comstock mealybug	*Pseudococcus comstocki*	Pseudococcidae: Homoptera	Coffee, Litchi, Apple, Mulberry	China, Japan, Korea, Thailand, Italy, Russia, USA, South Africa	EPPO, 2016
06.	Mediterranean vine mealybug	*Planococcus ficus*	Pseudococcidae: Homoptera	Fig, Grape vine, Jujube, Bamboo, Walnut, Apple, Date palm, Dahlia, Avocado	India, Pakistan, South Africa, Argentina, France, Italy	Fallahzadeh *et al.*, 2011; Moghaddam, 2006; Kol-Maimon *et al.*, 2010; Walton *et al.*, 2009; Duso, 1989
07.	Grape mealybug	*Pseudococcus maritimus*	Pseudococcidae: Homoptera	China berry, Peach, Apple, Grapevine	USA, Mexico, Chile, Netherlands	Golan & Górska-Drabik, 2006, CABI, 2011
08.	Cotton mealybug	*Phenacoccus solenopsis*	Pseudococcidae: Homoptera	Okra, Cashew nut, Neem tree, Chili, Water melon, Ghoos grass, China rose, Jute, Pointed gourd, Biter gourd	China, India, Indonesia, Japan, Pakistan, Sri Lanka, Thailand, Turkey, Vietnam, USA, Argentina, Chile, Ausstralia	CABI/EPPO, 2012; EPPO, 2011; Ministry of Agriculture, 2010:
09.	Wheat mealybug	*Trionymus haancheni*	Pseudococcidae: Homoptera	Wheat, Barley	USA	Alvarez, J. M., 2004
10.	Alazon mealybug	*Dysmicoccus grassii*	Pseudococcidae: Homoptera	Bottle gourd, Mango, Pineapple, Papaya, Pomegranate, Banana, Coffee	South America, Malaysia, France, Italy, Sicily, Niger	Leathers, J., 2016
11.	Banana mealybug	*Pseudococcus elisae*	Pseudococcidae: Homoptera	Banana, Sugar apple, Coffee	Mexico, Guatemala, Brazil, Chile, Cuba, Japan, Korea, Paraguay	Leathers, J., 2015
12.	Lantana mealybug	*Phenacoccus parvus*	Pseudococcidae: Homoptera	Potato, aubergine, guava, Lantana, chilli	China, India, Japan, Singapore, USA,	UK CAB International, 1990
13.	Madeira mealybug	*Phenacoccus madeirensis*	Pseudococcidae: Homoptera	Pigeon pea, bell pepper, citrus, cotton, aubergine, potato	India, Japan, Philippines, Taiwan, Thailand, Turkey, USA	EPPO, 2014: CABI/EPPO, 2000

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CHAPTER 7

RISK ASSESSMENT

The risk analysis of quarantine mealybug species include the use of a developing or evolving process (PPQ, 2000; Orr *et al.*, 1993), the approach used to combine risk elements (Bier, 1999; Morgan and Henrion, 1990), and the evaluation of risk by comparisons to lists of factors within the guidelines (Kaplan, 1992; Orr *et al*., 1993). The risk assessment was done in accordance with International Plant Protection Convention (IPPC) and the International Standards for Phytosanitary Measures (ISPM 2 and ISPM 11). The risk analysis of quarantine pests of cucurbits identified for Bangladesh has been analyzed details as follows:

7.1.	Osbcure mealybug, *Pseudococcus viburni* Signoret

7.1.1. Hazard identification

Scientific Name: *Pseudococcus viburni* Signoret
Synonyms:
Dactylopius affinis Maskell, 1894
Dactylopius indicus Signoret, 1875
Pseudococcus affinis (Maskell, 1894)

Common names: Osbcure mealybug

7.1.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Pseudococcus
Species: *Pseudococcus viburni*

EPPO Code: PSECOB

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI, 2016]

7.1.3. Identification characteristics

- The obscure mealybug has longer, thinner, and more crooked filaments than does the vine mealybug, making the obscure mealybug look comparatively untidy.
- The most distinctive feature of the obscure mealybug is the set of two to four exceptionally long caudal filaments growing from the posterior of large nymphs and adult females.
- The insect's waxy secretion accumulates heavily on these filaments, making it appear to have several long "tails".
- The obscure mealybug more closely resembles the grape mealybug than it does the vine mealybug, but the two can be distinguished by the color of the defensive fluid they secrete

when disturbed; grape mealybugs secrete reddish-orange fluid, while obscure mealybugs secrete clear fluid.

- When crushed, the obscure mealybug's body contents (guts) are pinkish-grey.

Fig: Adult osbcure mealybug

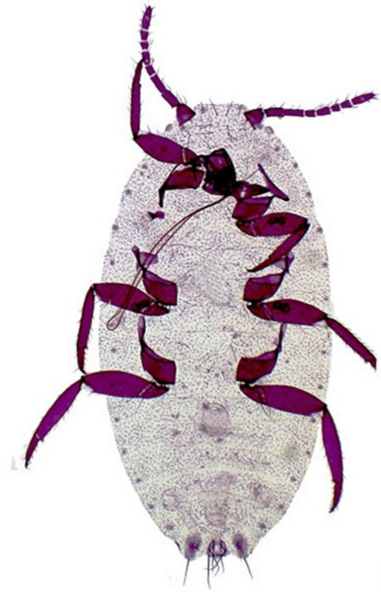

Fig: Adult osbcure mealybug (ventral view)

Source: CABI, 2016

7.1.4. Biology

P. viburni reproduces sexually and there are 2-3 generations each year. Overwintering occurs under the bark, mostly as eggs and first instars, although there is no true dormancy; however, eggs will not hatch while conditions are too cold (UC IPM, 2015). The overwinter mortality of nymphs is high, but a few individuals (normally the ones quickest to hatch) survive and feed and develop on the first spring leaves. Usually the adult females return to the bark on old wood, to each lay several hundred yellow to orange eggs in an ovisac of white wax filaments formed beneath and behind the abdomen. The eggs hatch into first-instar crawlers in 5-10 days depending on temperature. Females of the first generation often take 6-9 weeks to reach maturity, although at high temperatures maturation may take only about 22 days. Adult females emit a sex pheromone to attract the ephemeral, winged males; pheromone production ceases once mating has occurred.

7.1.5. Hosts

P. viburni is a polyphagous pest attacking a wide range of host plants. Some host plants are seriously attacked by this pest and some are minor.

a) Major host: *Camellia sinensis* (tea), Citrus, *Malus domestica* (apple), Orchidaceae (orchids), *Pyrus communis* (European pear), *Solanum tuberosum* (potato), *Vitis vinifera* (grapevine) etc.

b) Minor host: Bambusa (bamboo), Brassica, Cucurbita pepo (marrow), *Ficus carica* (fig), *Glycine max* (soyabean), *Prunus domestica* (plum), *Punica granatum* (pomegranate), *Zea mays* (maize) etc.

7.1.6. Distribution

Asia: Afghanistan (Kozar *et al.,* 1996; EPPO, 2014), China (Gimpel & Miller, 1996), Indonesia (Williams, 2004), Korea, Republic of (Gimpel & Miller, 1996), Philippines (Williams, 2004), Sri Lanka (Gimpel & Miller, 1996), Turkey (Uygun *et al.,* 1998).
Africa: South Africa (Gimpel & Miller, 1996), Zimbabwe (EPPO, 2014), Morocco (Gimpel & Miller, 1996)
North America: Canada (Gimpel & Miller, 1996), Mexico and USA (Gimpel & Miller, 1996)
South Amrica: Brazil (EPPO, 2014; Williams & Willink, 1992), Uruguay (Granara *et al.,* 1997)
Europe: Denmark, France, Germany, UK, Netherlands (Gimpel & Miller, 1996), Italy (Tranfaglia, 1973; EPPO, 2014)
Ocenia: Australia (Gullan, 2000; EPPO, 2014), New Zealand (Ward, 1966; EPPO, 2014)

7.1.7. Hazard Identification Conclusion

Considering the facts that *P. viburni* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI, 2016];
- will be potentially economic important to Bangladesh because it is a major pest of several crops like tea, citrus, orchids, potato etc which are also important crops in our country.
- The degree of polyphagy of *P. viburni,* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *P. viburni,* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.1.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 1.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years? Yes, • In recent years *P. viburni,* been established in different country especially in Asian countries like Sri-Lanka,Turkey, Philippines. It is now thought that *P. viburni* probably originated from South America, possibly from south-central Chile (Charles, 2011), but by the late 1800s it had spread to France and Australia, and by the early 1900s it was present in California, South Africa, Italy and England. It then spread into the Middle East (Bodenheimer, 1944) and has continued extending its geographical range to the present day. **b. Possibility of survival during transport, storage and transfer? Yes** • The eggs hatch into first-instar crawlers in 5-10 days depending on temperature. Females of the first generation often take 6-9 weeks to reach maturity, although at high temperatures maturation may take only about 22 days. The transport, storage and transfer duration is about 20 days in our country, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The pathway appear good for this pest to enter into Bangladesh and establishment because pest or symptoms not visible to the naked eye but usually visible under light microscope so it is very difficult to detect them. The adults, eggs, nymphs and pupae may transported through bark, bulbs,	**YES and HIGH**

tubers, rhizomes, flowers, inflorescence, fruits, leaves, roots and stems. So, this insect can enter in our country through any of this imported material. • **Natural spread:** Dispersal of *P. viburni* within the host-plant is mostly the result of walking by first-instar crawlers and other developmental stages of the female. Passive dispersal over greater distances may be aided by wind. • **Vector Transmission:** Ants attending the mealybugs for their honeydew may carry them to other parts of the plant, particularly when conditions are unfavorable**.** Passive dispersal over greater distances may be aided by animal agencies such as birds or humans. • **Accidental Introduction:** Passive dispersal over long distances may be aided by transport on dirty agricultural equipment, or by the movement of infested plant material from one place to another. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *P. viburni,* is a major pest of several crops like tea, citrus, orchids, potato etc • Host range of *P. viburni,* available in Bangladesh. • These climatic requirements for growth and development of *P. viburni,* is more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.1.9. Determine the Consequence establishment of this pest in Bangladesh

Table 1.2: Which of these descriptions best fit of this pest?

Description	**Consequen ce potential**
a. Is this a serious pest of Bangladesh? - Yes. • Because it is a major pest of several crops like tea, citrus, orchids, potato etc which are also important crops in our country. • *P. viburni* is also minor pest of soyabean, bamboo, maize, brassica, fig etc which are also common in our country. **b. Economic impact and yield loss** • *P. viburni* is the commonest greenhouse mealybug in the UK (Williams, 1962), and is a pest of tomatoes under glass in the Netherlands (Schoen and Martin, 1999). Under glass it weakens plants by extracting sap, and honeydew fouling with associated sooty mould growth spoils the appearance of fruit and nursery plants and may cause leaf drop, especially on orchids, coleus, cacti and Solanum species. • In vineyards and fruit orchards, *P. viburni* is the most important underground mealybug pest in Australia (Williams, 1985); it is a pest on apples in New Zealand (Ward, 1966) and Israel (Ben-Dov, 1990), on citrus in the French Riviera (Panis, 1986); on tea in Iran, on grapevines in California (Phillips and Sherk, 1991) and New Zealand (Charles *et al.,* 2006), and in intensive horticulture in Chile (González, 2003).	**Yes and High**

<table>
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- Obscure mealybug has caused particularly substantial damage to vineyards in the north and central parts of California (UC IPM, 2015), where it is an introduced species and has no effective natural enemies (Charles, 2011).
- *P. viburni* has been recorded transmitting plant virus diseases like the ampelovirus Grapevine Leafroll Associated Virus type III (GRLaV-3), which has seriously affected grapes in New Zealand, reducing crop yield by up to 60% (Charles *et al.,* 2006).
- This is also a problem in California. Physiological symptoms of GLRaV-3 infected vines include degeneration of phloem cells in leaves, stems and fruit petioles, usually accompanied by an accumulation of starch in infected leaves, which may be the feedback mechanism whereby photosynthetic activities are shut down. Photosynthesis is reduced by 25-65%, depending on cultivar and environment, directly affecting growth and yield even in vines that do not reveal visual symptoms. Cane weight, stem girth and even root growth may be reduced (Charles *et al.,* 2006).

c. Environmental Impact

- This insect has a great environmental impact. Due to its great economic importance farmers are used different types of insecticide to control it. Obscure mealybug's waxy coating and habit of seeking sheltered feeding sites protect it from water-based contact pesticides (Charles, 2004), oil-based organophosphate pesticides are more effective in reducing population density in orchards, though such pesticides can harm plants if applied after the first budding.
- However, some New Zealand obscure mealybug populations have developed resistance to organophosphate pesticides (Charles, 2004).
- Moreover use of this chemical insecticide may harm to the environment and destroying the natural control system in the field.

</td><td></td></tr>
<tr><td>

- Not as above or below

</td><td>Moderate</td></tr>
<tr><td>

- This is a **not** likely to be an important pest of common crops grown in Bangladesh.

</td><td>Low</td></tr>
</table>

7.1.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table1.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – High

7.1.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *P. viburni* not already present, the enforcement of strict phytosanitary regulations as required for *P. viburni* may help to reduce the risk of this osbcure mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. viburni* present.

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7.2. Cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero, 1977

7.2.1. Hazard identification

Scientific Name: *Phenacoccus manihoti* Matile-Ferrero, 1977

Common names: Cassava mealybug

7.2.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Phenacoccus
Species: *Phenacoccus manihoti*

EPPO Code: PHENMA

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI, 2017]

7.2.3. Identification characteristics

The taxonomically identifying characteristics of the Casava Mealybug (*Phenacoccus manihoti*) are given below:

- antennae often 9-segmented, occasionally with 7 or 8 segments
- denticle usually present on claw - body generally with 18 pairs of cerarii
- quinquelocular pores usually present on venter - dorsal and cerarian setae lanceolate
- cerarii usually each with 2 lanceolate setae and no auxillary setae, except on anal lobes

All of the microscopic features listed above as typical for genus Phenacoccus are present in *P. manihoti*. Other important characters of *P. manihoti* are:

- underside of head with 32-68 quinquelocular pores immediately anterior to the clypeolabral shield
- circulus 'ox-yoke' shaped
- no translucent pores on hind tibiae

Fig: Adult female cassava mealybug

Fig: Cassava mealybug egg

Source: CABI, 2017

7.2.4. Biology

P. manihoti reproduces by parthenogenetic oviparity. The life cycle consists of an egg and four instar stages with the fourth being the adult mealybug. Various laboratory experimental results (Nwanze *et al.,* 1979; Iheagwam, 1981; Lema and Herren, 1985; Le Rü and Fabres, 1987; Schulthess *et al.,* 1987) summarize that the insect has a lower thermal threshold of 14.7°C, an optimal temperature of about 28°C, no development above 35°C and a net reproductive rate of about 500 eggs in an average life span of 20 days. Egg incubation lasts approximately 8 days and the insect usually dies 1-3 days after it ceases egg production (Nwanze, 1978). The average development period of egg to adult lasts for about 33 days. The most favoured sites for oviposition are terminal shoot tips, lower leaf surfaces and leaf petioles. The eggs hatch into crawlers (first instars) and the insect moults thrice in its development to a fourth instar (= adult mealybug). Except for crawlers, all instars prefer the lower surfaces of fully expanded leaves (Nwanze, 1978) from where they move sluggishly to the stems and shoot tips. At low population densities, therefore, the insect is most abundant in the shoot tips (Schulthess *et al.,* 1987; Neuenschwander and Hammond, 1988).

7.2.5. Hosts

P. manihoti is a polyphagous pest attacking a wide range of host plants. Some host plants are seriously attacked by this pest and some are minor.

a) Major host: *Manihot esculenta (*cassava*)*, *Glycine max* (soyabean), *Solanum lycopersicum* (tomato) etc.

b) Minor host: Citrus, *Capsicum* spp., *Boerhavia diffusa* (red spiderling), Cyperus (flatsedge), *Ipomoea batatas* (sweet potato), *Sida acuta* (sida), Solanum (nightshade) etc.

7.2.6. Distribution

Asia: Cambodia (Parsa *et al.,* 2012; EPPO, 2014), Indonesia (Restricted distribution) (EPPO, 2014), Malaysia (Dewi Sartiami *et al*., 2015), Thailand (Parsa *et al.,* 2012; EPPO, 2014), Vietnam (Parsa *et al.,* 2012; EPPO, 2014).

Africa: Benin (Akinlosotu & Leuschner, 1981; Zeddies *et al.,* 2001), Congo (Zeddies *et al.,* 2001; EPPO, 2014), Zimbabwe (Giga, 1994; EPPO, 2014), Sudan (Neuenschwander, 2003)
South Amrica: Brazil (Restricted distribution) (EPPO, 2014), Argentina (de Santis, 1963) Colombia (Milena Varela *et al.,* 1979), Paraguay (Löhr *et al.,* 1990)

7.2.7. Hazard Identification Conclusion

Considering the facts that *P. manihoti* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI, 2017];
- It will be potentially economic important to Bangladesh because it is a major pest of several crops like soyabean, tomato, cassava etc which are also important crops in our country.
- *P. manihoti* poses a threat to other cassava-growing regions of the world, such as Indonesia.
- Accidental introduction to new territories is possible through the movement of infested living cassava material for propagative purposes through shipping or air transport/mail.
- The degree of polyphagy of *P. manihoti* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *P. manihoti* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.2.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 2.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years- Yes**, • Cassava mealybug spread across the width of Africa in a period of 16 years. Its accidental introduction damaged a staple crop that is particularly important in times of drought, during a time of drought, leading to famine (Herren and Neuenschwander, 1991). In 1973, *P. manihoti* was reported as an introduced arthropod species on cassava in Congo (Sylvestre, 1973; Matile-Ferrero, 1978) and Congo Democratic Republic (Hahn and Williams, 1973). Within a few years after these first reports, the insect became the major cassava pest and spread rapidly through most of the African cassava belt. By the end of 1986, for example, it had reached about 25 countries and covered 70% of the African cassava belt (Neuenschwander and Herren, 1988). In recent years *P. manihoti* been established in different country especially in Asian countries like Indonesia, Malaysia, Thailand and Vietnam. **b. Possibility of survival during transport, storage and transfer? Yes** • The insect has a lower thermal threshold of 14.7°C, an optimal temperature of about 28°C, no development above 35°C and a net reproductive rate of about 500 eggs in an average life span of 20 days. The transport, storage and transfer duration is about 20 days in our country, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The pathway appear good for this pest to enter into Bangladesh and establishment because the adults, eggs, nymphs and pupae may transported through bark, bulbs, tubers, rhizomes, flowers, inflorescence, fruits, leaves,	**YES and Moderate**

roots and stems. So, this insect can enter in our country through any of this imported material from any of imported country where this insect is already present. But careful inspection can prevent its entry because colonies of this mealybug occur on the undersides of cassava leaves and on the shoot tips, and these will readily be seen during inspection. Minute crawlers, which may be present on plants before colonies are established, will only be detected by careful examination with the aid of a strong light and magnification. • **Natural spread:** The dispersal stage of mealybugs is the first-instar crawler stage; these are often dispersed passively in the wind. • **Vector Transmission:** Crawlers may also be carried passively by passing animals and people that brush past the host plant. • **Accidental Introduction:** Harvesting infested plant material aids dispersal by scattering the crawlers into the air, where the wind may carry them away. Pruning of infested plants, and the clothing, tools and vehicles of agricultural workers can become contaminated with the crawlers and so aid in their dispersal. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– No** • *P. manihoti* is a major and minor pest of several crops like cassava, soyabean, tomato, red spiderling, sida etc • Most of the major and minor hosts are not common in our country. • The insect has a lower thermal threshold of 14.7°C, an optimal temperature of about 28°C, no development above 35°C. The climatic requirement for growth and development of P. manihoti is only favorable at winter season but at summer season it is very difficult for the pest to survive.	
• NOT AS ABOVE OR BELOW	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.2.9. Determine the Consequence establishment of this pest in Bangladesh

Table 2.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - No. • Because it is a major pest of several crops like cassava, soyabean, tomato etc most of which are not common crops in our country. • *P. manihoti* is also minor pest of Citrus, Capsicum spp,, flatsedge, sweet potato, sida etc most of which are not major crops in our country. **b. Economic impact and yield loss** • In 1973, *P. manihoti* was reported as an introduced arthropod species on cassava in Congo (Sylvestre, 1973; Matile-Ferrero, 1978) and Congo Democratic Republic (Hahn and Williams, 1973). Within a few years after these first reports, the insect became the major cassava pest and spread rapidly through most of the African cassava belt. • By the end of 1986, for example, it had reached about 25 countries and covered 70% of the African cassava belt (Neuenschwander and Herren, 1988). • In most countries the mealybug caused severe damage by stunting the growth	**Yes and Moderate**

points of cassava plants, sometimes totally defoliating the plants. Storage root yield losses of 84% have been reported (Nwanze, 1982). The pest-induced defoliation reduces availability of healthy leaves which are consumed as leafy vegetables in most of West and Central Africa. After the pest cripples plant growth, weed and erosion problems sometimes lead to total destruction of the crops. Additionally, pest-infested plants produce poor quality stem cuttings for use as planting material. • The insect is more abundant and its damage severity is greater in the dry than in the wet season. • Zeddies *et al.* (2001) analysed the cost benefits of the biological control programme against cassava mealybug in Africa over a period of 40 years. Losses of cassava yield in the year of introduction were estimated at 80%; within 5 years, more tolerant varieties of cassava were cultivated and indigenous predators adapted to a new diet, so reducing annual losses to 20% (in rain forest) to 40% (in highlands and savanna). • The accidental introduction of *P. manihoti* to Africa damaged a staple crop that is particularly important in times of drought, during a time of drought, leading to famine (Herren and Neuenschwander, 1991). **c. Environmental Impact** • On the basis of the exotic origin and rapid spread of the cassava mealybug in Africa, no appropriate approach is effective against this pest problem. • This insect has a great environmental impact. Due to its great economic importance farmers are used different types of insecticide to control it. The performance of chemical insecticide is not appreciable due to waxy coating and habit of seeking sheltered feeding sites protects it from water-based contact pesticides (Charles, 2004). • Moreover use of the chemical insecticide may harm to the environment and destroying the natural control system in the field.	
• Not as above or below	**Moderate**
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.2.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 2.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	**Moderate**	**Moderate**
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – Moderate

7.2.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *P. manihoti* not already present, the enforcement of strict phytosanitary regulations as required for *P. manihoti* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. manihoti* present.

7.2.12. References

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7.3. Cotton mealybug, *Phenacoccus solenopsis* Tinsley

7.3.1. Hazard identification

Scientific Name: *Phenacoccus solenopsis* Tinsley
Synonyms:

Phenacoccus cevalliae Cockerell 1902

Phenacoccus gossypiphilous Abbas *et al.* 2005; 2007; 2008

Common names: Cotton mealybug

7.3.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Phenacoccus
Species: *Phenacoccus solenopsis*

EPPO Code: PHENSO.
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2012; EPPO, 2014]

7.3.3. Identification characteristics

- *Phenacoccus solenopsis* (cotton mealybug); live adult female has pale yellow body. Dorsum with a dark bar, spots on intersegmental areas of thorax and abdomen, with 18 pairs of lateral wax filament.

- *Phenacoccus solenopsis* (cotton mealybug); antennae each 9 (rarely 8) segmented. Cerrarii numbering 18 pairs, each cerarius with 2 lanceolate spinose setae. On metafemur and metatibia showing translucent pore.

Fig: Adult cotton mealybug

Fig: Adult cotton mealybug (ventral view)

Source: CABI, 2016

7.3.4. Biology

Females of this ovoviviparous, bisexual species have been reported as capable of producing from 150 to 600 eggs, protected within a waxy ovisac (Lu *et al.,* 2008). Upon hatching, females undergo three immature stages prior to reaching adulthood, whereas males undergo first, second, prepupa and pupa stages prior to adulthood. The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This species is capable of producing multiple generations annually. Suresh and Kavitha (2008b) concluded that maximum temperature and sunshine hours had a positive influence, whereas relative humidity and rainfall had a negative influence on the mealybug.

Climate	**Status**	**Description**
Af - Tropical rainforest climate	Tolerated	> 60mm precipitation per month
Am - Tropical monsoon climate	Tolerated	Tropical monsoon climate (< 60mm precipitation driest month but > (100 - [total annual precipitation(mm}/25]))
As - Tropical savanna climate with dry summer	Preferred	< 60mm precipitation driest month (in summer) and < (100 - [total annual precipitation{mm}/25])
Aw - Tropical wet and dry savanna climate	Preferred	< 60mm precipitation driest month (in winter) and < (100 - [total annual precipitation{mm}/25])
B - Dry (arid and semi-arid)	Preferred	< 860mm precipitation annually
BW - Desert climate	Tolerated	< 430mm annual precipitation
C - Temperate/Mesothermal climate	Preferred	Average temp. of coldest month > 0°C and < 18°C, mean warmest month > 10°C
Cf - Warm temperate climate, wet all year	Preferred	Warm average temp. > 10°C, Cold average temp. > 0°C, wet all year
Cs - Warm temperate climate with dry summer	Preferred	Warm average temp. > 10°C, Cold average temp. > 0°C, dry summers
Cw - Warm temperate	Preferred	Warm temperate climate with dry winter (Warm average

climate with dry winter		temp. > 10°C, Cold average temp. > 0°C, dry winters)
D - Continental/Microthermal climate	Tolerated	Continental/Microthermal climate (Average temp. of coldest month < 0°C, mean warmest month > 10°C)
Df - Continental climate, wet all year	Tolerated	Continental climate, wet all year (Warm average temp. > 10°C, coldest month < 0°C, wet all year)
Ds - Continental climate with dry summer	Tolerated	Continental climate with dry summer (Warm average temp. > 10°C, coldest month < 0°C, dry summers)
Dw - Continental climate with dry winter	Tolerated	Continental climate with dry winter (Warm average temp. > 10°C, coldest month < 0°C, dry winters)

7.3.5. Hosts

The solenopsis mealybug has been recorded on 202 host plant species that include field crops, ornamentals, trees and vegetables. In Pakistan, *P. solenopsis* obtained the status of a serious pest on a wide host range. In a field survey, Arif *et al.* (2009) identified the mealybug from 154 plant species, the majority of which belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. Significant economic damage was determined to occur on cotton [*Gossypium* spp.], brinjal [*Solanum melongena*], okra [*Abelmoschus esculentus*], tomato [*Solanum lycopersicum*], sesame [Sesamum *indicum*], sunflower [*Helianthus annuus*] and China rose [*Hibiscus rosa-sinensis*] (Sharma, 2007; Arif et al., 2009; Jagadish et al., 2009b). Several cultivated plants, as well as weeds, have been used as trap crops to suppress the population numbers in an area.

a) **Major hosts:** *Abelmoschus esculentus* (okra), *Carica papaya* (pawpaw), *Gossypium hirsutum* (Bourbon cotton), *Helianthus annuus* (sunflower), Hibiscus (rosemallows), *Hibiscus rosa-sinensis* (China-rose), *Nicotiana tabacum* (tobacco), *Ocimum basilicum* (basil), *Parthenium hysterophorus* (parthenium weed), *Sesamum indicum* (sesame), *Simmondsia chinensis* (jojoba), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum muricatum* (melon pear) etc.

b) **Minor hosts:** *Solanum tuberosum* (potato), *Solanum nigrum* (black nightshade), Punica granatum (pomegranate), *Morus alba* (mora), *Mentha piperita* (Peppermint), *Mangifera indica* (mango), *Ipomoea batatas* (sweet potato), *Cucurbita moschata* (pumpkin), *Cuscuta reflexa* (dodder), *Citrullus lanatus* (watermelon), *Capsicum frutescens* (chilli), *Azadirachta indica* (neem tree), *Zea mays* (maize) etc.

7.3.6. Distribution

The occurrence of *P. solenopsis* is widespread with the species damaging plants in a variety of habitats ranging from dry arid areas to tropical regions. Dhawan *et al.* (2009b) reported that the population density of this invasive pest varied on cotton [*Gossypium* spp.] in surveyed regions in Pakistan.

Asia: China (Muniappan, 2009), India (localized) (Prishanthini & Vinobaba, 2009), Japan (localized) (Tanaka & Tabata, 2014), Pakistan (localized) (Arif *et al.,* 2009), Sri Lanka (localized) (Prishanthini & Vinobaba, 2009), Taiwan (Ghulam *et al.,* 2009), Thailand (Muniappan, 2009), Turkey (Kaydan *et al.,* 2013), Vietnam (Nguyen & Huynh, 2008)
Africa: Egypt (Beshr *et al.,* 2016), Cameron (Hodges *et al.,* 2008), Ghana (CABI/EPPO, 2012)
North America: Canada (CABI/EPPO, 2012), Mexico and USA (CABI/EPPO, 2012; EPPO, 2014)
South Amrica: Brazil (Vinobaba, 2009), Chile (Prishanthini & Vinobaba, 2009)
Europe: Netherlands (Jansen, 2004)
Ocenia: Australia (CABI/EPPO, 2012; EPPO, 2014)

7.3.7. Hazard Identification Conclusion

Considering the facts that *P. solenopsis* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI, 2016];
- will be potentially economic important to Bangladesh because it is a major pest of several crops like okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc which are also important crops in our country.
- The degree of polyphagy of *P. solenopsis* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- This mealybug species has the ability to increase rapidly in population size and spread to cover vast areas where host plants occur, in a relatively short period of time.
- Based on the range of climates and high number of hosts available on which the solenopsis mealybug can survive and the damage inflicted on the host plants, this species poses the serious threat of expanding its range.
- The hydrophobic waxy test, cryptic small size, feeding on all parts of the plant, multiple overlapping generations and high reproductive rates, allow *P. solenopsis* the opportunity to disperse over extended areas.
- *P. solenopsis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 3.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. **Has this pest been established in several new countries in recent years-Yes**, • In recent years *P. solenopsis* been established in different country especially in Asian countries like China, India, Sri-Lanka, Pakistan, Thailand, Vietnam, Japan. This mealybug species has the ability to increase rapidly in population size and spread to cover vast areas where host plants occur, in a relatively short period of time. It has been reported from over 200 hosts. Since the original description of P. *solenopsis* from Atriplex canescens in New Mexico, USA in 1898, no reports on its presence were reported until 1967. Later, Fuchs *et al.* (1991) reported small, sporadic populations on cotton in Runnels County, Texas, USA in 1988 that spread 75 to 200 miles from the original site with contiguous populations by 1990. With the increase in international trade over the last few decades, this invasive pest has been collected and identified on host material at international ports and in greenhouses outside its native range (Jansen, 2004). As such, *P. solenopsis* has become established in the Afrotropical, Australasian, Nearctic, Neotropical, and Oriental regions. **b. Possibility of survival during transport, storage and transfer? Yes** • The eggs hatch into first-instar crawlers in 6-8 days depending on temperature. The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This mealybug has been reported to be capable of surviving temperatures ranging from 0-45°C, throughout the year (Sharma, 2007).The transport, storage and transfer duration from exporting countries to our countries is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and**	**YES and HIGH**

<table>
<tr><td>
establishment and spread? - Yes,

The pathway appear good for this pest to enter into Bangladesh and establishment because pest or symptoms not visible to the naked eye but usually visible under light microscope so it is very difficult to detect them. The adults, eggs, nymphs and pupae may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material.
The species may be dispersed internationally over vast areas by transporting infested plants into new areas by air or sea cargo. Local and regional movement is primarily by wind, irrigation water and by attachment to other insects and birds. The solenopsis mealybug is an important invasive pest that has seriously damaged cotton [Gossypium spp.] in India and Pakistan and poses a severe threat to cotton production in China.
Natural spread: The first instars or crawlers are the main dispersal stage of the solenopsis mealybug. The waxy strands covering the body serve a variety of functions including allowing the specimens to be transported by wind or water to new locations. The crawlers are commonly dispersed by wind for distances ranging from a few meters to several kilometers.
Vector Transmission: Infested host material that is transported from one area to another is an important source of distribution for the mealybug. The waxy test covering the body can adhere to passing animals or the clothes of people, allowing individuals specimens to be transported extended distances from the original infestation site before becoming dislodged in new, previously uninfested sites.
Accidental Introduction: Commercial trade involving infested plants may often be the cause for spread of the invasive species over vast distances. Movement of equipment from an infested area to a non-infested area may also be involved in the accidental spread of the mealybugs..

d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes

P. solenopsis is a major pest of several crops like okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc
P. solenopsis is also attacked several minor crops and fruits like potato, maize, chili, pumpkin, mango
Also, it is a pest of commercial crops including a variety of vegetables, grapes, jute, mesta and tobacco
Almost all the major and minor hosts are important crops and fruit in our country.
These climatic requirements for growth and development of P. solenopsis is more or less similar with the climatic condition of Bangladesh.

</td><td></td></tr>
<tr><td>NOT AS ABOVE OR BELOW</td><td>Moderate</td></tr>
<tr><td>
This pest has not established in new countries in recent years, and
The pathway does not appears good for this pest to enter Bangladesh and establish, and
Its hosts are not common in Bangladesh and climate is not similar to places it is established.
</td><td>Low</td></tr>
</table>

7.3.9. Determine the Consequence establishment of this pest in Bangladesh

Table 3.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Because it is a major pest of several crops like okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc which are also important crops in our country. • *P. solenopsis* is also minor pest of potato, maize, chili, pumpkin, mango etc which are also common in our country. • Also, it is a pest of commercial crops including a variety of vegetables, grapes [*Vitis vinifera*], jute [*Corchorus* spp.], mesta [*Hibiscus cannabinus*] and tobacco which are also important cash crops in our country. **b. Economic impact and yield loss** • Based on the range of climates and high number of hosts available on which the solenopsis mealybug can survive and the damage inflicted on the host plants, this species poses the serious threat of expanding its range. • The hydrophobic waxy test, cryptic small size, feeding on all parts of the plant, multiple overlapping generations and high reproductive rates, allow *P. solenopsis* the opportunity to disperse over extended areas. Its cryptic colouration and small size mean that it can be overlooked in infested vegetables and fruits, along with other crops, allowing transport into other regions of the country. As an introduced species, *P. solenopsis* has the capability to cause direct economic and ecological damage to native fauna and flora with heavy infestations reducing plant vigour and causing plant death. • Once the species has established on a host plant within a region, it has the capability of rapid growth resulting in significant damage to the crop. Sharma (2007) documented a seasonal outbreak of *P. solenopsis* on okra in 2007, which developed into a heavy infestation on the crop by the end of the season and resulted in a 90% loss of seeds. • Economic crop losses of an estimated 14% occurred in Pakistan in 2005 and in Punjab, India in 2005-2006 and 2006-2007 (Hodgson *et al.,* 2008; Dhawan et al., 2009a) due to this pest attacked. In the 2005 growing season, this invasive pest was responsible for a 44% reduction in seed-cotton yields in Pakistan (Dhawan *et al.,* 2009b). • The intense attack by the mealybug on Bt cotton resulted in significant economic losses to growers in the Punjab region (Dutt, 2007). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • As a result of *P. solenopsis* dispersal, reproductive and survival capacity, this invasive pest has the potential to damage or kill native plant species that could result in their displacement by other more aggressive species. Wang *et al*. (2009) projected that *P. solenopsis* could infest regions within 17 provinces of China and posed a pest risk analysis value of 0.856 to the area. Dhawan *et al.* (2009a) inferred that meteorological parameters influenced the presence and population size of the mealybug, with humidity and rainfall producing a negative effect. • The widespread infestation of the mealybug throughout the cotton growing	**Yes and High**

regions often requires expensive and numerous applications of insecticides to produce and protect the crop. Because of the crop losses and damaged cotton bringing lower prices, many farmers in some areas are reported to be interested in cultivating other crops. As a result, the additional pest control requirements often lead to a reduced profit margin that affects the standard of living of producers and homeowners. *P. solenopsis* attacks and damages numerous ornamental plants, therefore it has the potential to affect the aesthetic appearance of the infested areas, reducing tourism trade to the region.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 3.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – High

7.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *P. solenopsis* not already present, the enforcement of strict phytosanitary regulations as required for *P. solenopsis* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. solenopsis* present.

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7.4.	Mediterranean vine mealybug, *Phenacoccus ficus* Signoret 1875

7.4.1. Hazard identification

Scientific Name: *Planococcus ficus* Signoret 1875

Common names: Mediterranean vine mealybug, Vine mealybug, Grapevine mealybug

7.4.2. Taxonomic tree

Kingdom	Animalia
Subkingdom	Eumetazoa
Phylum	Arthropoda
Subphylum	Hexapoda
Class	Insecta
Order	Hemiptera
Suborder	Sternorrhyncha
Superfamily	Coccoidea
Family	Pseudococcidae
Genus	*Planococcus*
Species	*Planococcus ficus*

EPPO Code: PLANFI.

Bangladesh status: Not present in Bangladesh [ADW, 2014]

7.4.3. Identification characteristics

- The adult female is mobile, with extended legs. Body 2-4 mm in length, depending on the host plant, the feeding site and the density of the infestation.
- It bears 18 pairs of short wax filaments (excreted from the cerarii) around the body's margin; the anal pair is up to one quarter of body length, but usually becomes detached.
- The body is covered with white-grayish wax produced by different glandular organs and secreted through various pores. Antennae 8-segmented. The female larvae and the two early male instars resemble the female, but are smaller.

The emerging dark-brown male is about 1.5 long and has only one pair of wings.

Fig: Adult Vine mealybug

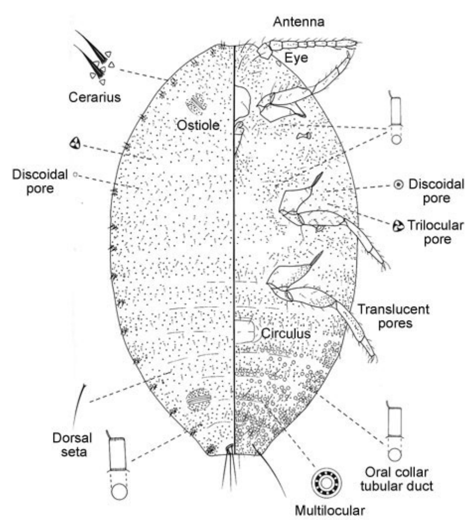

Fig: Adult Vine mealybug (ventral view)

Source: ADW, 2014

7.4.4. Biology

During autumn, as temperatures drop, the scales seek shelter, overwintering as adult females, hiding in stem cracks, under strips of dry bark and on the main upper roots. On fig trees they usually hide in old wounds on the trunk and at the bases of branches. In spring scales infesting grapevines begin to oviposit, migrating upwards on the vines, first colonizing the bark and later Young canes, leaf bases, blossoms and new growth. Egg laying starts 1-3 days after mating, and lasts 5-15 days. A female lays 50-500 eggs, dependent on body size, host plant and temperatures (maximum at 20-22°C). The eggs are wrapped in wax filaments. In late spring the pests occur on the lower sides of leaves. Large populations that may harm grape bunches develop during the second half of summer. The early bunch colonization enables the pest to raise two successive generations on the green and early ripening grapes, resulting in dense populations. Intensive population growth ends on the mature grapes in autumn, but the pests can reproduce while feeding on the stem cortex and leaves. The pest raises up to 7 annual generations in warm areas, about 4-5 in cooler regions. Generation time in the laboratory lasts about 4-5 weeks. During development the female rarely changes its feeding site until adulthood, when it tends to leave that position. The male has two larval stages, as well as prepupal and pupal stages, during which it stops feeding. Male emergence coincides with the appearance of young females, who soon after emergence emit a sex pheromone. The males live only for 1-2 days. The pests may be found all over the plant; at moderate infestations the population has a clumped distribution. Density on the stem increases progressively from the ground level up, the scales preferring to settle on the shaded side of the stem. There is more crawler migration in mid-summer and many young scales scatter between vines.

7.4.5. Hosts

Planococcus ficus are herbivores. They feed on several agricultural and weedy plant species. Grapevines are, however, the preferred host of the vine mealybug. They also feed on apples, avocado, banana, date palm, fig, mango and citrus as well. They feed on the phloem sap of the plants they live on, which is why these tropical and subtropical fruits are prime targets for P. ficus colonies. (Daugherty, 2013; Malakar-Kuenen and Daane, 2014)

7.4.6. Distribution

The vine mealybug, *Planococcus ficus*, is predominantly found in tropical and subtropical regions of the world. This species is commonly found throughout South Africa, the Mediterranean and Mexico. It is unclear which populations are native and which have been introduced to these regions. Transportation of contaminated nursery plant material and field equipment has allowed the vine mealybug species to rapidly spread out all over different regions of the world. They are difficult to see, and since they came into California in 1994 they have colonized 17 different counties, including the San Joaquin Valley, foothills of the Sierra Nevada, Central Coast, and North Coast vineyards (Daugherty, 2013).

Asia: Pakistan (Williams, 2004), India (Varshney, 1992), Afghanistan (Kozár *et al.,* 1996), Saudi Arabia (Ben-Dov, 1994), Turkey (Kaydan *et al.,* 2005)
Africa: Egypt (Ben-Dov, 1994), South Africa (Ben-Dov, 1994)
North America: Mexico (Arroyo, 2002), United States (Daane *et al.,* 2004)
South America: Argentina (Granara de Willink and Claps, 2003), Brazil (Ben-Dov, 1994), Chile.
Europe: France (Ben-Dov, 1994), Italy (Ben-Dov, 1994), Russia (Danzig, 2010), Spain (Ben-Dov, 1994)

7.4.7. Hazard Identification Conclusion

Considering the facts that *Planococcus ficus* -

- is not known to be present in Bangladesh [ADW, 2014];
- will be potentially economic important to Bangladesh because it is a major pest of several crops like grapevine, apples, avocado, banana, date palm, fig, mango and citrus which are also important crops in our country.
- Vine mealybugs are pests that invade various fruit crops and ornamental plants wherever they are found in the world, and are of serious economic importance.
- The degree of polyphagy of *Planococcus ficus* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction..
- The hydrophobic waxy test, cryptic small size, feeding on all parts of the plant, multiple overlapping generations and high reproductive rates, allow *Planococcus ficus* the opportunity to disperse over extended areas.
- *Planococcus ficus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 4.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years- Yes**, • *Planococcus ficus*, which was first recorded as being a problem in the vineyards of the Western Cape province in 1930, had spread to the Hex River Valley by 1935, as well as to all other major vineyards in the Western Cape (Walton, 2003; Walton & Pringle, 2004b; De Villiers, 2006; Holm, 2008). It is currently regarded as a key pest insect of the South African table grape and wine industries. It is uncertain how and when P. ficus was introduced to South African agriculture, and where it originates from. Presumably being native to the Mediterranean region, it is assumed to have entered the South African system via plant material (Walton & Pringle, 2004b; De Villiers, 2006). • In recent years this pest has been established in different country especially in Asian countries like India, Pakistan, Turkey, Saudi Arab and Afghanistan (Daugherty, 2013). **b. Possibility of survival during transport, storage and transfer? Yes** • It takes about 31.6 days for both the males and the females to reach full maturity, and they live on average about 68 days total depending on environmental conditions, food supply and predators. (Mustu and Kilincer, 2006). The transport, storage and transfer duration from exporting countries to our countries is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The pathway appear good for this pest to enter into Bangladesh and establishment because pest or symptoms not visible to the naked eye but usually visible under light microscope so it is very difficult to detect them. The adults, eggs, nymphs and pupae may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables,	**YES and HIGH**

fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • Mealybugs have a limited ability to move and to disperse, as females are wingless, with their movement being restricted to only minor distances (Holm, 2008). Female crawlers (first-instar nymphs) and adult males are mostly mobile and display dispersal activity. The immobility of the female adults sets in when old individuals experience the deterioration and loss of their legs (Franco *et al*., 2009). Poor pruning and harvesting techniques, along with the distribution of fruit, rootstock and grafting material, are responsible for the long-distance dispersal of *P. ficus* (Holm, 2008). Other shorter-distance dispersal mechanisms include adhering to wild and domestic animals, or moving along in water and wind (Holm, 2008; Franco *et al*., 2009). Distribution is mostly aggregative, as crawlers tend to settle close to the females on the natal host plant (Franco *et al*., 2009). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • They feed on several agricultural and weedy plant species. Grapevines are, however, the preferred host of the vine mealybug. They also feed on apples, avocado, banana, date palm, fig, mango and citrus as well. • These climatic requirements for growth and development of *P. solenopsis* is more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.4.9. Determine the Consequence establishment of this pest in Bangladesh

Table 4.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • Because it is a major pest of several fruits like grapevine, apples, avocado, banana, date palm, fig, mango and citrus etc which are also important fruits in our country. **b. Economic impact and yield loss** • Mealybugs are pests of serious economic importance, infesting various fruit crops and ornamental plants around the world (Wakgari & Giliomee, 2003). The grape mealybugs *P. maritimus* and *P. ficus* are two key pest species that cause great economic losses in South African, Californian, Spanish, Pakistani and South American vineyards (Greiger *et al.,* 2001; De Villiers & Pringle, 2007; Cid *et al.,* 2010). • Mealybug infestations contaminate grapes. Their waxy secretions, egg-sacs and honeydew production, on which sooty mould grows, result in the fruit being unmarketable as the tolerance levels for cosmetic damage in the table grape industry are very low (Greiger & Daane, 2001; De Villiers & Pringle, 2007; Holm, 2008). Many consignments are rejected prior to shipment as a result of infestations and phytosanitary concerns. The market also has legislative restrictions on the presence of insecticidal residues on fruits, making the	**Yes and High**

management of such pests increasingly more complicated (De Villiers & Pringle, 2007; Walton *et al.,* 2009). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • The widespread infestation of the mealybug throughout the vein growing regions often requires expensive and numerous applications of insecticides to produce and protect the crop. Because of the crop losses and damaged grape bringing lower prices, many farmers in some areas are reported to be interested in cultivating other crops. As a result, the additional pest control requirements often lead to a reduced profit margin that affects the standard of living of producers and homeowners. • The tremendous use of insecticide causes disruption of natural control system in the field and harm to our environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 4.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – High

7.4.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *P. ficus* not already present, the enforcement of strict phytosanitary regulations as required for *P. solenopsis* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. ficus* present.

7.4.12. References

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7.5. Spiked mealybug, *Nipaecoccus nipae* (Maskell, 1893)

7.5.1. Hazard identification

Scientific Name: *Nipaecoccus nipae* (Maskell, 1893)

Synonyms:

*Ceroputo nipae (*Maskell), Lindinger, 1904

Dactylopius dubia Maxwell-Lefroy, 1903

Dactylopius nipae Maskell, 1893

Common names: Spiked mealybug, coconut mealybug,

7.5.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Nipaecoccus
Species: *Nipaecoccus nipae*

EPPO Code: NIPANI.
Bangladesh status: Not present in Bangladesh [APPPC, 1987; CABI/EPPO, 2005]

7.5.3. Identification characteristics

- The adult female is generally the best life stage for identification. Final, confirmatory species-level identification of a mealybug is often based on slide-mounted morphological features associated with adult females.
- Adult females range between 0.059 and 0.98 inches (1.5 and 2.5 mm) long, are oval in shape and reddish-brown to orange in color, covered by a yellowish-orange thick wax and with 10 to 12 pairs of marginal pyramid-shaped wax filaments. The dorsal surface of the body contains five to eight waxy filaments similar to the ones present on the side or lateral areas of the body. No ovisac or egg-containing sac within the female is present.
- Males are oblong and smaller than females. Males develop in very thin white cottony wax cocoons prior to emerging as adults (Hodges et.al. 2008, Miller et. al. 2007).

Fig: Adult coconut mealybug with egg and nymph

Fig: Adult coconut mealybug

Source: CABI, 2016

7.5.4. Biology

N. nipae is sexually reproductive but its biology and ecology are poorly known.

7.5.5. Hosts

N. nipae is polyphagous and attacks 80 genera of plants belonging to 43 families (Ben-Dov, 1994). It is recorded feeding on a wide range of economically important plants, mostly fruit crops and ornamentals, including avocados, bananas, citrus, cocoa, coconuts, custard apples (*Annona reticulata*), edible figs, guavas, mangoes, oil palm, orchids, pawpaws, pineapples, seaside grapes and soursop (*Annona muricata*). *N. nipae* seems to prefer palms, such as species of Areca, Cocos, Kentia, Kentiopsis and Sabal. In temperate regions in Europe and North America, *N. nipae* often attacks ornamental palms grown under glass.

a) Major host: *Annona squamosa* (sugar apple), *Artocarpus altilis* (breadfruit), *Cajanus cajan* (pigeon pea), *Cocos nucifera* (coconut), *Ficus carica* (fig), *Ficus elastica* (rubber plant), *Ipomoea batatas* (sweet potato), *Mangifera indica* (mango), Musa (banana), *Psidium guajava* (guava)

7.5.6. Distribution

N. nipae is found in Europe, Asia, Africa, North, Central and South America and Oceania (Ben-Dov, 1994; CABI/EPPO, 2005).

Asia: China (Ben-Dov, 1994), India (Josephrajkumar *et al.,* 2012), Indonesia (CABI/EPPO, 2005), Korea, Republic of (CABI/EPPO, 2005), Philippines (Caasi-Lit *et al.,* 2012), Turkey (CABI/EPPO, 2005)
Africa: Morocco (CABI/EPPO, 2005), South Africa (CABI/EPPO, 2005)
North America: Mexico and USA (CABI/EPPO, 2005)
South Amrica: Brazil, Chile, Argentina, Peru, Colombia (Ben-Dov, 1994; CABI/EPPO, 2005)
Europe: Belgium, Italy, Portugal, Russian federation, Spain, UK (Ben-Dov, 1994; CABI/EPPO, 2005)
Ocenia: Fiji (Hodgson & Agowska, 2011)

7.5.7. Hazard Identification Conclusion

Considering the facts that *N. nipae* -

- is not known to be present in Bangladesh [APPPC, 1987; CABI/EPPO, 2005];
- will be potentially economic important to Bangladesh because it is a major pest of several crops, fruits and ornamental plants like avocados, bananas, citrus, cocoa, coconuts, custard apples, edible figs, guavas, mangoes, oil palm, orchids, pawpaws, pineapples, seaside grapes etc which are also important crops in our country.
- The degree of polyphagy of *P. solenopsis* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *P. solenopsis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.5.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 5.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. **Has this pest been established in several new countries in recent years- Yes**, • In recent years *N. nipae* been established in different country especially in Asian countries like China, India, Indonesia, Korea, Republic of, Philippines, Turkey. **b. Possibility of survival during transport, storage and transfer? No** • Due to lack of information about their biology, we can't predict about their survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The pathway appear good for this pest to enter into Bangladesh and establishment because the adults, eggs, nymphs and pupae may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • Immature and adult female N. nipae are readily carried on plants and plant produce and may be injurious when introduced to new geographical areas where they have no natural enemies. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *N. nipae* is polyphagous and attacks 80 genera of plants belonging to 43 families (Ben-Dov, 1994). It is recorded feeding on a wide range of economically important plants, mostly fruit crops and ornamentals, including bananas, citrus, cocoa, coconuts, custard apples (*Annona reticulata*), edible figs, guavas, mangoes, oil palm, orchids, pawpaws, pineapples, most of them are important plants in our country • These climatic conditions of these countries where this pest has already estabilished are more or less similar with the climatic condition of **Bangladesh**.	**YES and Moderate**

• NOT AS ABOVE OR BELOW	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.5.9. Determine the Consequence establishment of this pest in Bangladesh

Table 5.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • Because it is a major pest of several economically important plants, mostly fruit crops and ornamentals, including bananas, citrus, cocoa, coconuts, custard apples (Annona reticulata), edible figs, guavas, mangoes, oil palm, orchids, pawpaws, pineapples etc which are also important crops in our country. **b. Economic impact and yield loss** • *N. nipae* is generally of little economic importance, but it has become a pest of avocados and guavas in Hawaii, Bermuda and Puerto Rico (see Ben-Dov, 1994 for further references). Ant-attended infestations of *N. nipae* have been recorded causing damage to coconut plantations in Guyana, together with the coconut scale Aspidiotus destructor (Raj, 1977). *N. nipae* is also a pest of ornamental palms. The damage caused by *N. nipae* may result in ornamental plants, fruit, cut flowers and foliage losing their market value. **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • The excessive use of toxic chemical insecticides have a negative impact to our environment, natural life, wild life, even aquatic life and disrupting the natural control system in the field.	**Yes and Moderate**
• Not as above or below	**Moderate**
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.5.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 5.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	**Moderate**	**Moderate**
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – Moderate

7.5.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *N. nipae* not already present, the enforcement of strict phytosanitary regulations as required for *N. nipae* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *N. nipae* present.

7.5.12. References

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7.6.	Long-tailed mealybug, ***Pseudococcus longispinus*** **Targioni Tozzetti**

7.6.1. Hazard identification

Scientific Name: *Pseudococcus longispinus* Targioni Tozzetti

Synonyms:

*Boisduvalia lauri (*Boisduval) Signoret

Coccus adonidum various authors (not Linnaeus)

Coccus laurinus Boisduval

*Dactylopius adonidum (*Linnaeus)

Dactylopius longifilis Comstock

Common names: Long-tailed mealybug

7.6.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Pseudococcus
Species: *Pseudococcus longispinus*

EPPO Code: PSECAD.
Bangladesh status: Not present in Bangladesh [CABI, 2017]

7.7. Identification characteristics

- The long-tailed mealybug has wax thread "tails" that are as long as or longer than the body.
- Two long, waxy filaments protruding from the last abdominal segment, which is diagnostic for this species.

Fig: Adult long-tailed mealybug

Fig: Adult long-tailed mealybug with eggs and nymph

Source: CABI, 2016

7.6.4. Biology

The female lays 75-200 eggs (dependent on the host plant) and a generation is completed in about six weeks at 26ºC. Third-stage nymphs may also be inseminated, but oviposit only after having molted to females. Pest numbers peak in early summer, declining in autumn and winter. First instar nymphs may disperse by becoming wind-borne. Large populations are often attended by ants, which do not seem to affect the numbers of *P. longispinus* but hinder its natural enemies.

7.6.5. Hosts

The longtailed mealybug has a relatively wide host range that includes many economically important crops, such as avocado, citrus, grapes, pear, persimmon, and pineapple (Faber *et al*. 2007, Furness 1976, Dentener *et al*. 1997, Williams and Watson 1988). Valuable ornamental plants, especially those adapted to tropical and subtropical environments are also hosts. These include species of cycads (Culbert 1995) and orchids (Kot *et al*. 2015, Ray and Hoy 2014). Plants kept inside homes or in greenhouses seem to be especially at risk for mealybug infestation, due to the relatively stable temperature and humidity of these environments (Blumberg and Van Driesche 2001).

a) **Major host:** *Albizia julibrissin* (silk tree), Citrus, *Colocasia esculenta* (taro), *Diospyros kaki* (persimmon), *Persea americana* (avocado), *Psidium guajava* (guava), *Pyrus communis* (European pear), *Solanum melongena* (aubergine), *Vitis vinifera* (grapevine)

b) **Minor host:** *Alpinia purpurata* (red ginger), *Ananas comosus* (pineapple), *Cocos nucifera* (coconut), Coffea (coffee), *Malus domestica* (apple), *Manihot esculenta* (cassava), *Prunus domestica* (plum), *Solanum tuberosum* (potato) etc.

7.6.6. Distribution

Longtailed mealybug is widespread throughout the world. It is found outdoors in the warmer parts of America, Europe, and Africa. In northern latitudes it occurs in greenhouses (McKenzie 1967). First collected in Hawaii before 1900, it is present on the six major Islands (Zimmerman 1948, Hawaiian Terrestrial Arthropod Chlecklist 1992).

Asia: China (CIE, 1984), India (Ben-Dov, 1994), Indonesia (Ben-Dov, 1994), Iran (CIE, 1984), Japan (Ben-Dov, 1994), Malaysia (CIE, 1984), Philippines (Lit & Calilung, 1994), Singapore (AVA, 2001), Sri Lanka (CIE, 1984), Taiwan (CIE, 1984), Turkey (CIE, 1984), Vietnam (CIE, 1984).
Africa: Egypt (CIE, 1984), Cameron (CIE, 1984), Ghana (CIE, 1984), Zimbabwe (CIE, 1984)
North America: Canada (CIE, 1984), Mexico (Ben-Dov, 1994) and USA (CIE, 1984).
South Amrica: Brazil (Culik *et al*., 2009), Chile (CIE, 1984), Argentina (CIE, 1984), Uruguay (CIE, 1984).
Europe: Netherlands, Belgium, Denmark, Finland, France, Sweden, UK, Germany, Greece, Italy (CIE, 1984), Russian Federation (Ben-Dov, 1994).
Ocenia: Australia (CIE, 1984), Fiji (CIE, 1984), New Zealand (CIE, 1984).

7.6.7. Hazard Identification Conclusion

Considering the facts that *P. longispinus* -

- is not known to be present in Bangladesh [CABI,2017];
- The longtailed mealybug has a relatively wide host range that includes many economically important crops, such as avocado, citrus, grapes, pear, persimmon, and pineapple.
- Valuable ornamental plants, especially those adapted to tropical and subtropical environments are also hosts. These include species of cycads and orchids. Plants kept

inside homes or in greenhouses seem to be especially at risk for mealybug infestation, due to the relatively stable temperature and humidity of these environments

- will be potentially economic important to Bangladesh because it is a major pest of several crops like okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc which are also important crops in our country.
- The degree of polyphagy of *P. longispinus* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *P. longispinus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.6.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 6.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. **Has this pest been established in several new countries in recent years- Yes**, • Longtailed mealybug is widespread throughout the world. It is found outdoors in the warmer parts of America, Europe, Asia and Africa. • In recent years *P. longispinus* been established in different country especially in Asian countries like China, India, Sri-Lanka, Japan, Malaysia, Philippines, Singapore, Vietnam and Turkey. This mealybug species has the ability to increase rapidly in population size and spread to cover vast areas where host plants occur, in a relatively short period of time. **b. Possibility of survival during transport, storage and transfer? Yes** • The female lays 75-200 eggs (dependent on the host plant) and a generation is completed in about six weeks at 26ºC. The transport, storage and transfer duration from exporting countries to our country is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The pathway appear good for this pest to enter into Bangladesh and establishment because pest or symptoms not visible to the naked eye but usually visible under light microscope so it is very difficult to detect them. The adults, eggs, nymphs and pupae may transport through fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– No** • *P. longispinus* is a major pest of several fruit crops like Avocado, citrus, guava, grapevine, European pear, aubergine, silk tree, taro, persimmon etc, most of the crops are not cultivated in our country. They only imported from different countries. • *P. longispinus* is a minor pest of red ginger, pineapple, coconut, coffee, apple, cassava, plum, potato etc. Most of which are not common in our country,	**YES and Moderate**

• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.6.9. Determine the Consequence establishment of this pest in Bangladesh

Table 6.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - no. • Because it is a major pest of several fruit crops like Avocado, citrus, guava, grapevine, European pear, aubergine, silk tree, taro, persimmon etc. Most of which are not common in our county, Those type of fruits only imported in our country from different countries. **b. Economic impact and yield loss** • Mealybugs and other insects with piercing-sucking mouthparts, like aphids, feed directly from the host plant vascular system. This food source is plentiful but somewhat dilute, meaning the insect must take in an abundance of plant sap to get adequate nutrition. • Honeydew, a sugary substance periodically excreted from the insect's body, is a waste product of this feeding behavior. Honeydew itself is not harmful to the plant, but can coat the leaves and nearby objects and encourage growth of a fungus known as sooty mold. Sooty mold, like honeydew, is not directly injurious to the plant, but it is unsightly, hard to remove, and can diminish the plant's photosynthetic capabilities. It also reduces or eliminates the economic value of fruits grown for fresh consumption and plants grown for ornamental value. • Sometimes honeydew-producing insects are first noticed because of the presence of another insect species taking advantage of their sugary excretions. Colonies of longtailed mealybug have been observed being tended by white-footed ants, *Technomyrmex difficilis* Forel (Warner *et al.* 2002). • In addition to typical feeding damage*, Pseudococcus longispinus,* as well as several related mealybug species, is an efficient vector of Grapevine leafroll-associated virus 3 (GLRaV-3), a major causal agent of Grapevine leafroll disease (Douglas and Krüger 2008). The causal agents of Grapevine leafroll disease are distributed worldwide and this disease reduces yield and quality of grapes used for juice, wine, and table consumption (Maree *et al.* 2013). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • The extreme use of harmful chemical insecticides may harm to natural environment, disrupting the natural control system in our crop field and may causes resistance, resurgence and upset.	**Yes and Moderate**
• Not as above or below	**Moderate**
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.6.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 6.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	**Moderate**	**Moderate**
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – Moderate

7.6.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *Phenacoccus solenopsis* not already present, the enforcement of strict phytosanitary regulations as required for *P. solenopsis* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. solenopsis* present.

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7.7. Madeira mealybug, *Phenacoccus madeirensis* Green, 1923

7.7.1. Hazard identification

Scientific Name: *Phenacoccus madeirensis* Green, 1923

Synonyms:

Phenacoccus gossypii Townsend & Cockerell (misidentification)

Phenacoccus grenadensis Green & Laing, 1924

Phenacoccus harbisoni Peterson, 1965

Common names: Madeira mealybug

7.7.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera

Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Phenacoccus
Species: *Phenacoccus madeirensis*

EPPO Code: PHENMD.

Bangladesh status: Not present in Bangladesh [CABI, 2017, EPPO, 2014]

7.7.4. Identification characteristics

- Body oval; somewhat flattened dorsoventally; body gray; legs red; covered by thin, white, mealy wax, with dark dorsosubmedial bare spots on intersegmental areas of thorax and abdomen, these areas forming 1 pair of dark longitudinal lines on dorsum; ovisac covering entire dorsum; with 18 pairs of lateral wax filaments, posterior pairs longest, about or less of length of the body.
- Primarily occurring on foliage of host. Specimens in alcohol with 1 pair dorsosubmedial dark lines on thorax and abdomen. Surface of lateral filaments rough.
- Cerarii-like aggregations on anterior abdomen, thorax, and head, but not on dorsomedial areas of abdominal segments VI and VII; multilocular pores on dorsum of abdomen, absent from thorax and head; dorsal oral-collar tubular ducts scattered over surface; quinquelocular pores abundant on ventral surface; denticle on claw; antennae 9-segmented.

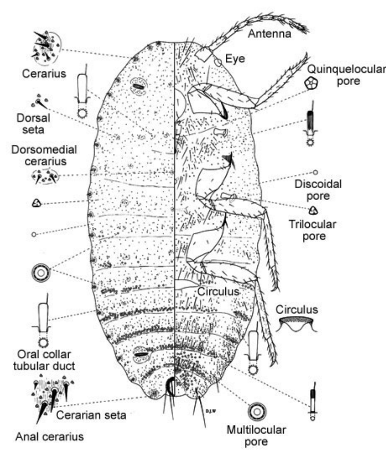

Fig: Adult Madeira mealybug

Fig: Adult Madeira mealybug (ventral view)

Source: CABI, 2016

7.7.5. Biology

The biology of the mealybug, *Phenacoccus madeirensis* Green, was observed in various temperature regimes, and in the combinations of elevated carbon dioxide (CO_2) levels and temperature. The total duration of development of female *P. madeirensis* was 30 days at 25 C, 46 days at 20 C, and 66 days at 15 C. Males had longer duration of development than females. Survival rates of both males and females were not influenced by temperature. A female produced more than 280 eggs in every temperature regime. In an environment of elevated CO_2 levels and temperature, the development of *P. madeirensis* was temperature-dependent. Duration of development was shortened in higher temperature. Elevated CO_2 levels had no effect on the development of *P. madeirensis*. The effects of feeding by *P. madeirensis* on the whole-plant gas exchange of chrysanthemum were also studied. Mealybug population of less than 100 individuals did not cause noticeable damage to host plant gas exchange processes.

7.7.6. Hosts

The Madeira mealybug has been recorded on different host plant species that include field crops, ornamentals, trees and vegetables like cassava (*Manihot esculenta*) and many other crops including aubergine (*Solanum melongena*), oat (*Avena sativa*), cotton (*Gossypium* spp.), Coleus, Hibiscus, potato (*Solanum tuberosum*), *Capsicum annuum* and Citrus spp. Several cultivated plants, as well as weeds, have been used as trap crops to suppress the population numbers in an area.

a) Major host: *Avena sativa* (oats), *Capsicum annuum* (bell pepper), Citrus, Gossypium (cotton), Hibiscus (rosemallows), *Lantana camara* (lantana), *Manihot esculenta* (cassava), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato).

b) Minor host: *Ricinus communis* (castor bean), *Parthenium hysterophorus* (parthenium weed), *Mikania micrantha* (bitter vine), Fabaceae (leguminous plants), *Codiaeum variegatum* (croton), Codiaeum (ornamental croton), *Cestrum nocturnum* (night jessamine), *Artocarpus altilis* (breadfruit), *Ananas comosus* (pineapple) etc.

7.7.6. Distribution

Asia: India (EPPO, 2014), Japan (Kondo *et al.,* 2001; EPPO, 2014), Taiwan (Chen *et al.,* 2012), Thailand (EPPO, 2014), Turkey (Kaydan *et al.,* 2013), Vietnam (Nguyen & Huynh, 2008), Philippines (EPPO, 2014)
Africa: Egypt (Beshr *et al.,* 2016), Cameron (Williams, 1987; CABI/EPPO, 2000), Ghana (CABI/EPPO, 2000; NHM, 1982), Zimbabwe (CABI/EPPO, 2000), Congo Democratic Republic (CABI/EPPO, 2000)
North America: Mexico (Restricted distribution) (Miller, 1996) and USA (CABI/EPPO, 2000; EPPO, 2014)
South Amrica: Brazil (EPPO, 2014), Colombia (Castillo & Bellotti, 1990)
Europe: France (Matile-Ferrero & Germain, 2004), Spain (Beltrà & Soto, 2011), Italy (Restricted distribution) (EPPO, 2014)
Ocenia: Micronesia, Federated states of (CABI/EPPO, 2000)

7.7.7. Hazard Identification Conclusion

Considering the facts that *P. madeirensis* -

- is not known to be present in Bangladesh [CABI, 2017, EPPO, 2014];
- will be potentially economic important to Bangladesh because it is a major pest of several crops like oats, citrus, cotton, lantana, cassava, aubergine, potato, bell pepper, rosemallows etc which are also important crops in our country.
- This species has the potential to cause serious damage to the host plant if introduced without its natural enemies.
- *P. madeirensis* attacks a variety of host plants, several of which are of economic value such as cassava, pineapple, citrus and potatoes, as well as numerous ornamentals.
- The degree of polyphagy of *P. madeirensis* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *P. madeirensis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.7.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years- Yes**, • In recent years *P. madeirensis* been established in different country especially in Asian countries like India, Japan, Taiwan, Thailand, Turkey, Vietnam, Philippines from a lot of crops, vegetables, fruits and ornamental plants, planting materials are imported to our country. **b. Possibility of survival during transport, storage and transfer? Yes** • The total duration of development of female P. madeirensis was 30 days at 25 C, 46 days at 20 C, and 66 days at 15 C. Males had longer duration of development than females. Survival rates of both males and females were not influenced by temperature. The transport, storage and transfer duration from exporting countries to our countries is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - Yes,** • The adults, eggs, nymphs and pupae may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • This species was intercepted 600 times at U. S. ports-of-entry between 1995 and 2012, with specimens originating from different country. • The species may be dispersed internationally over vast areas by transporting infested plants into new areas by air or sea cargo. Local and regional movement is primarily by wind, irrigation water and by attachment to other insects and birds. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *P. madeirensis* it is a major pest of several crops like oats, citrus, cotton, lantana, cassava, aubergine, potato, bell pepper, rosemallows etc most ot them are very common and important crops in our country. • These climatic requirements for growth and development of •*P. madeirensis* is more or less similar with the climatic condition of **Bangladesh**.	**YES and HIGH**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.7.9. Determine the Consequence establishment of this pest in Bangladesh

Table 7.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • *P. madeirensis* it is a major pest of several crops like oats, citrus, cotton, lantana, cassava, aubergine, potato, bell pepper, rosemallows etc most ot them are very common and important crops in our country. • Most of the crops which are infested by *P. madeirensis,* imported in our country from those country where this pest is already present. • This species has the potential to cause serious damage to the host plant if introduced without its natural enemies. **b. Economic impact and yield loss** • *P. madeirensis* attacks a variety of host plants, several of which are of economic value such as cassava, pineapple, citrus and potatoes, as well as numerous ornamentals. However, it is often economically insignificant. Williams (1987) noted that it is occasionally a serious pest of potatoes in Peru. • This species was intercepted 600 times at U. S. ports-of-entry between 1995 and 2012, with specimens originating from American Samoa, Canada, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Hawaii, India, Italy, Jamaica, Mexico, Nicaragua, Nigeria, Peru, The Philippines, South Africa, St. Kitts and Nevis, St. Maarten, Thailand, The U.S. Virgin Islands, Vietnam, and Yemen. • It is one of the most polyphagous of all mealybug species (Williams 2004); therefore, we have not recorded older quarantine records. ScaleNet lists the species from more than 45 families of host plants. It is found in nearly all warm areas of the world but has limited distribution in the Australasian and Oriental regions. **c. Environmental Impact** • Due to lack of information about the environmental impact of this insect, it is difficult to predict about the exact effect of this insect on the environment. • Bur to control this insect farmers use different type of harmful chemical insecticides which have negative impact to our environment.	**Yes and Moderate**
• Not as above or below	**Moderate**
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.7.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table7.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	**Moderate**	**High**
Moderate	High	High
High	Low	Moderate
Low	High	Moderate

Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – High

7.7.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *P. madeirensis* not already present, the enforcement of strict phytosanitary regulations as required for *P. madeirensis* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. madeirensis* present.

7.7.12. References

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7.8.	Banana mealybug, *Pseudococcus elisae* Borchsenius, 1947

7.8.1. Hazard identification

Scientific Name: *Pseudococcus elisae* Borchsenius, 1947

Common names: Banana mealybug

7.8.2. Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Pseudococcus
Species: *Pseudococcus elisae*

EPPO Code: PSECEL.

Bangladesh status: Not present in Bangladesh [CABI, 2013]

7.8.3. Identification characteristics

- This species has 16 or 17 pairs of thin waxy filaments around the body margin that are short on the head and long on the posterior end of the abdomen. Body length is about 2.5 mm and is approximately twice as long as the longest waxy filament.
- The female is covered with a thin layer of powdery white wax, but this does not completely hide the pale orange body colour. The crushed body is reddish brown. A white waxy ovisac is produced that is longer than or equal to the length of the body of the adult and encloses the eggs.

Fig: Adult Banana mealybug

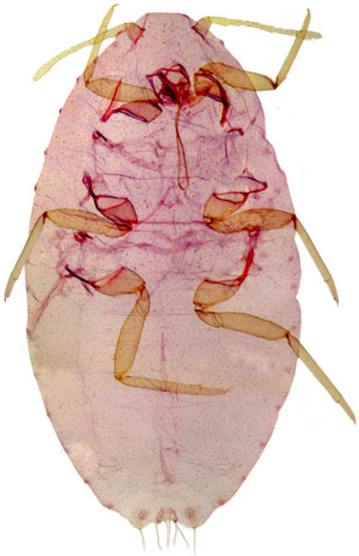

Fig: Adult Banana mealybug (ventral view)

Source: CABI, 2013

7.8.4. Biology

There is no published information on the biology of *P. elisae*. In Ecuador, it is reported to have multiple generations each year and to occur primarily on the leaves and fruit of the host (GV Manley, Standard Fruit Co., San Jose, Costa Rica, personal communication, 1985). Mealybugs in general have four female and five male instars (including the adults). The first instar is usually more mobile than the rest. The adult female lays her eggs in a waxy sac called an ovisac attached to the host-plant. The eggs usually hatch in a few hours to a few days and the first instars escape from the ovisac and crawl on the host searching for a suitable feeding site. First-instar larvae are sometimes transported by wind. Male first instars are similar to female first instars, but male second instars form a waxy sac and pass through two more non-feeding instars (the prepupa and pupa) before becoming winged adults. Females do not form an ovisac until they are adults. Adult males cannot feed and usually survive for no more than a day. It is assumed that most mealybug males locate females by a pheromone. Males can often be seen in flight early in the morning or late in the day when winds are generally calm. Mealybugs have from one to eight or nine generations a year depending on the weather conditions and species of mealybug.

7.8.5. Hosts

Because of confusion about the identity of this species, the only reliable reference about *P. elisae* hosts is Gimpel and Miller (1996). Most (but not all) published records of *P. elisae* pertain to *P. jackbeardsleyi*. Unfortunately, the only way to validate the records is to re-examine voucher specimens, if they exist. This species is most commonly found on banana. It has been reported on only six host genera in five families, but it is anticipated that a much wider range of hosts will be found when it is studied in the banana-growing areas of Central and South America.
The *P. elisae* attacks a wide range of host plants, including: banana, aglaonema, dieffenbachia, tomato, potato, pepper, hibiscus, anthurium, orchids, floral ginger, Annona, dracaena, and ivy gourd.

7.8.6. Distribution

Although many of the records of *P. elisae* are quarantine records primarily from USA ports-of-entry, the repetitive nature of these interceptions suggest that the species is well established in most of the countries listed. The species has a fairly limited distribution in Central America and northern South America. It is reasonable to expect it to continue to expand its distribution.

North America: Mexico (Tokihiro, 2006) and USA (Tokihiro, 2006)
Central America: Costa Rica (Gimpel & Miller, 1996), Cuba (Niebla et al., 2010), Panama (Gimpel & Miller, 1996)
South Amrica: Brazil (NHM, 1982), Chile (Tokihiro, 2006), Colombia (Gimpel & Miller, 1996)

7.8.7. Hazard Identification Conclusion

Considering the facts that *P. elisae* -

- is not known to be present in Bangladesh [CABI, 2013];
- will be potentially economic important to Bangladesh because it is a major pest of several crops like banana, aglaonema, dieffenbachia, tomato, potato, pepper, hibiscus, anthurium, orchids, floral ginger, Annona, dracaena, and ivy gourd etc most of which are important crops in our country.
- This mealybug feeds on many different hosts and is injurious in the absence of efficient natural enemies.
- This species was intercepted 2626 times at U. S. ports-of-entry between 1995 and 2012, with specimens originating from Brazil

- *P. elisae,* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.8.8. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 8.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years- No**, • Although many of the records of P. elisae are quarantine records primarily from USA ports-of-entry, the repetitive nature of these interceptions suggest that the species is well established in most of the countries listed. The species has a fairly limited distribution in Central America and northern South America. • The distribution of this insect is only restricted in South, central and north America. The insect is not found in any Asian countries. In 1996-2006, the insect is found in those areas. **b. Possibility of survival during transport, storage and transfer? Yes** • The eggs hatch into first-instar crawlers in 5-10 days depending on temperature. Females of the first generation often take 6-9 weeks to reach maturity, although at high temperatures maturation may take only about 22 days. The transport, storage and transfer duration from exporting countries in our country is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establishment and spread? - No,** • Best detected by visual inspection of host, particularly on the undersides of leaves and in the developing fruit bunches. The large white ovisacs are the most easily seen structure on the host. • Contamination of fruit for export may cause rejection at ports-of-entry in countries where this mealybug does not occur. • Mealybugs are capable of rapid reproduction and can be transported long distances when infested plants or fresh plant parts are moved. They may also disperse locally by crawling, wind, or by hitchhiking on clothing, equipment, or animals. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *Pseudococcus elisae* is known to feed on 10 species of plants in 5 families. • The *P. elisae* attacks a wide range of host plants, including: banana, aglaonema, dieffenbachia, tomato, potato, pepper, hibiscus, anthurium, orchids, floral ginger, Annona, dracaena, and ivy gourd. Most of the host crops are very common in our country. • These climatic requirements for growth and development of *P. elisae,* is more or less similar with the climatic condition of **Bangladesh**.	**YES and Low**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and	**Low**

• The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	

7.8.9. Determine the Consequence establishment of this pest in Bangladesh

Table 8.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • *Pseudococcus elisae* is a tropical species with a host range that includes some plants grown outdoors in the warmer regions of California (e.g. key lime, banana). If the mealybug were to enter the country it would likely be limited to regions where these host plants are available. • It is possible that the host range of *Pseudococcus elisae* could be greater than is presently known. It is also possible that most of the climate of Bangladesh could be unsuitable for establishment of the species. **b. Economic impact and yield loss** • *Pseudococcus elisae* may lower the value of nursery stock by disfiguring plants with its presence. Several of California's trading partners consider the mealybug a harmful organism. It is possible that Pseudococcus elisae could disrupt markets for nursery stock and fresh fruit. • The banana mealybug has been reported to cause damage to bananas in Central America (Beardsley, 1986). **c. Environmental Impact** • The pest could trigger additional official or private treatment programs. • *Pseudococcus elisae* is not expected to lower biodiversity, disrupt natural communities, or change ecosystem processes. It is not expected to directly affect threatened or endangered species or disrupt critical habitats. It may trigger new treatment programs in the nursery industry and by residents who find infested plants unsightly. It is not expected to significantly impact cultural practices, home/urban gardening, or ornamental plantings.	**Yes and Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.8.10. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 8.3 – Calculation of risk rating

Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	**Moderate**	**Low**
Low	Low	Low

Calculated Risk Rating – Low

7.8.11. Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- *Pseudococcus elisae* has never been found in Bangladesh. If it were to enter the country significant economic impacts could be expected on the nursery and fruit industries.
- In countries where *P. elisae* not already present, the enforcement of strict phytosanitary regulations as required for *P. elisae* may help to reduce the risk of this mealybug becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *P. elisae* present.

7.8.12. References

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7.9. Conclusion: Pest Risk Potential and Pests Requiring Phytosanitary Measures

The Pest Risk Assessment (PRA) is based on the International Standard for Phytosanitary Measures No 11 (2004) and the PRA scheme developed by CAB Internation (2007) and EPPO (European and Mediterranean Plant Protection Organization) (1997).

From the quantitatively risk analysts of quarantine mealybug species likely to be associated and follow the pathways of agricultural crops/plants importation to Bangladesh from India, China, Pakistan, Japan, Thailand, Sri Lanka, Bhutan, Nepal, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Netherlands, Brazil, Chille etc and other exporting countries, out 8 potential hazard mealybug species, four (4) hazard mealybug species were identified with high risk potential namely *Pseudococcus viburni*, *Phenacoccus solenopsis, Planococcus ficus* and *Phenacoccus madeirensis*; three (3) mealybug species were identified with moderate risk potential namely *Phenacoccus manihoti*, *Nipaecoccus nipae* and *Pseudococcus longispinus*; and one (1) species was identified with low risk potential namely *Pseudococcus elisae*. The overall pest risk potential ratings of eight (8) quarantine mealybug species of agricultural crops/plants for Bangladesh have been presented in the following table:

Table 10: The Overall Pest Risk Potential Rating

Sl. No.	Potential Hazard species of mealybug	Common name	Family	Order	Pest Risk Potential
1	*Pseudococcus viburni*	Obscure mealybug	Pseudococcidae	Homoptera	High
2	*Phenacoccus manihoti*	Casava mealybug	Pseudococcidae	Homoptera	Moderate
3	*Phenacoccus solenopsis*	Cotton mealybug	Pseudococcidae	Homoptera	High

4	*Planococcus ficus*	Mediterranean vine mealybug	Pseudococcidae	Homoptera	High
5	*Nipaecoccus nipae*	Spiked mealybug	Pseudococcidae	Homoptera	Moderate
6	*Pseudococcus longispinus*	Long-tailed mealybug	Pseudococcidae	Homoptera	Moderate
7	*Phenacoccus madeirensis*	Madeira/cotton mealybug	Pseudococcidae	Homoptera	High
8	*Pseudococcus elisae*	Banana mealybug	Pseudococcidae	Homoptera	Low

Uncertainity

The quarantine mealybug species those remained uncertainity as potential hazards due to lack of their detail information were Comstock mealybug (*Pseudococcus comstocki*), Grape mealybug (*Pseudococcus maritimus*), Wheat mealybug (*Trionymus haancheni*), Alazon mealybug (*Dysmicoccus grassii*), and Lantana mealybug (*Phenacoccus parvus*). The taxonomic identity, hosts and distribution of these uncertain species are given in the Table 11.

Table 11. Quarantine mealybug species for Bangladesh likely to be associated with host plants during importation from exporting countries, but remained as uncertain hazards due to lack of detail information

Sl. No.	Common name	Scientific name	Family	Order
01.	Comstock mealybug	*Pseudococcus comstocki*	Pseudococcidae	Homoptera
02.	Grape mealybug	*Pseudococcus maritimus*	Pseudococcidae	Homoptera
03.	Wheat mealybug	*Trionymus haancheni*	Pseudococcidae	Homoptera
04.	Alazon mealybug	*Dysmicoccus grassii*	Pseudococcidae	Homoptera
05.	Lantana mealybug	*Phenacoccus parvus*	Pseudococcidae	Homoptera

CHAPTER 8

RISK MANAGEMENT

8.1. Risk Management Options and Phytosanitary Procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine mealybug species assessed to pose an unacceptable level of risk to Bangladesh via the importation of commercially produced agricultural plants or planting materials from India, China, Thailand, Japan, Sri Lanka, Pakistan, Bhutan, Nepal, Malaysia, Indonesia, Australia, Europe, USA, Brazil, Chile or any other exporting countries of agricultural crops/plants or parts of plants (i.e. produced under standard cultivation, harvesting and packing activities). Plant Quarantine Wing under Department of Agricultural Extension of Bangladesh considers that the risk management measures proposed below is commensurate with the identified risks.

8.1.1. Pre-harvest Management Options

The in-field pest management practises for the production of crop plants are in brief:

- Pre harvest pesticide treatments for mealybugs above threshold levels;
- Plant protection products are of limited effectiveness against mealybug because of its habit of hiding in crevices, and the waxy covering of its body. Most granular insecticides are ineffective; therefore, systemic insecticides are used to control heavy infestations.
- Crop field hygiene which involves removal of fallen leaves and crop residues under a Good Agricultural Practise (GAP).

8.1.2. Post-Harvest Procedures

The procedure is to sorting/grading to remove damaged/infested plants or parts of plants/flowers/fruits. The grading process is likely to remove plant parts showing obvious signs of mealybug infestation as well as the presence of mealybugs.

8.1.3. Visual Inspection

Visual inspection of mealybugs occurs at several points during the routine production and post-harvest pathway for plants and planting materials/flowers/fruits. These include:

- In-field monitoring during the growing season
- Harvesting
- Post-harvesting sorting and grading
- Packaging plants and planting materials/flowers/fruits for treatment
- Packaging of plants for export
- Visual phytosanitary inspection

8.1.4. Application of phytosanitary measures

A number of different phytosanitary measures may be applied to pests based on the outcome of an import or pest risk analysis. Required measures may include:

- Surveillance for pest freedom;
- Specific pre-shipment pest control activities to be undertaken by the supply contracting party;
- The application of a pre-shipment treatment;
- Inspection of the export consignment;
- Treatment on arrival in Bangladesh.

8.1.5. Pre-shipment requirements

8.1.5.1. Inspection of the consignment: It is relatively easy to detect mealybugs by inspection, so the basic requirement that imported consignments of plants and planting materials/flowers/fruits should be free from the pest including mealybugs can be fulfilled by inspection.

8.1.5.2. Treatment of the consignment

The plants from which the planting materials/flowers/fruits and branches were collected, should be treated as specified by PQW of Bangladesh.

Documentation

- Bilateral quarantine arrangement: Required.
- Phytosanitary certificate: Required.
- Import permit/Authorisation to import: Required.

8.1.6. Phytosanitary certification

A completed phytosanitary certificate issued by the NPPO of the country of origin must accompany with all plants and planting materials/flowers/fruits exported to Bangladesh.

Before a phytosanitary certificate is to be issued, the NPPO of the country of origin must be satisfied that the following activities required by Ministry of Agriculture, Bangladesh have been undertaken.

The planting materials/flowers/fruits have:

i) been inspected in accordance with appropriate official procedures and found to be free of any visually detectable regulated pests including mealybug specified by PQW of Bangladesh.

AND, ONE OR MORE OF THE FOLLOWING;

ii) been sourced from a pest free area that is, as verified by pest surveillance methods (in accordance with the International Standards for Phytosanitary Measures; Requirements for the Establishment of Pest Free Areas, IPPC, FAO, Publication 4, 1996), free from mealybugs.

iii) been sourced from a pest free place of production that is, as verified by pest surveillance methods (in accordance with the International Standards for Phytosanitary Measures; Requirements for the Establishment of Pest Free Places of Production and Pest Free Production Sites, IPPC, FAO, Publication 10, 1996), free from mealybugs.

AND;

iv) been devitalised (rendered non-propagable) using an effective devitalisation treatment or process.

8.1.7. Additional declarations to the phytosanitary certificate

If satisfied that the pre-shipment activities have been undertaken, the NPPO of the country of origin must confirm this by providing the following additional declarations to the phytosanitary certificate:
"The plants or planting materials/flowers/fruits in this consignment have been:

- inspected according to appropriate official procedures and are considered to be free from the regulated pests specified by Plant Quarantine Wing (PQW) under the Department of Agricultural Extension (DAE) of Bangladesh, and to conform with Bangladesh’s current phytosanitary requirements”.

AND, ONE OR MORE OF THE FOLLOWING;

- sourced from a pest free area that is, as verified by pest surveillance methods, free from______ **(named regulated pest(s))** _____.
- sourced from a pest free place of production that is, as verified by pest surveillance methods, free from ______ **(named regulated pest(s))** _____.
- fumigated with methyl bromide within 5 days of shipping at __________ **(Temperature /Initial dosage/Exposure time)** _____, and under vacuum (88 kPa) gradually returning to atmospheric pressure by the end of the fumigation period.
- treated by hot-water immersion for ____ **(Exposure time)** ___ at a minimum of ___ **(Temperature)** __, within 5 days of shipping.
- treated with vapour heat for ______ **(Exposure time)** ______ at _____ **(Temperature)** ____ and ___ **(% Relative humidity)** _____, within 5 days of shipping.
- harvested from plants that have been sprayed with __________ **(Active ingredient and dosage rate)** _____, 14 and 5 days prior to harvesting for export to Bangladesh.

AND;

- subjected to an effective devitalisation treatment [details of treatment must be included on the phytosanitary certificate] rendering the consignment non-propagatable."

8.1.8. Transit requirements

The plants or planting materials/flowers/fruits must be packed and shipped in a manner to prevent infestation and/or contamination by regulated pests including mealybugs.

Where a consignment is split or has its packaging changed while in another country (or countries) *en route* to Bangladesh, a "Re-export Certificate" is required. Where a consignment is held under bond as a result of the need to change conveyances and is kept in the original shipping container, a "Re-export Certificate" is not required.

8.1.9. Inspection on arrival in Bangladesh

Plant Quarantine Wing of DAE of Bangladesh will check the accompanying documentation on arrival to confirm that it reconciles with the actual consignment.

8.1.10. Actions undertaken on the interception/detection of organisms/contaminants

If regulated pests including mealybugs are intercepted/detected on the commodity, or associated packaging, the following actions will be undertaken as appropriate (depending on the pest identified):

- Treatment (where possible) at the discretion of the PQW of Bangladesh;
- Reshipment of the consignment;
- Destruction of the consignment;
- The suspension of trade, until the cause of the non-compliance is investigated, identified and rectified to the satisfaction of PQW of DAE of Bangladesh.

8.1.11. Biosecurity clearance

If regulated pests including mealybugs are not detected, or are successfully treated following interception/detection, and there is no evidence to suggest the plant material is propagatable, biosecurity clearance will be given.

8.1.12. Feedback on non-compliance

The NPPO will be informed by the Director, Plant Quarantine Wing of Bangladesh, of the interception (and treatment) of mealybugs or any regulated pests, "unlisted" pests, or non-compliance with other phytosanitary requirements.

8.2. Risk Management Conclusions

All potential mealybug species assessed requires mitigative measures, however, due to the diverse nature of these pests, it is unlikely that a single mitigative measure will be adequate to reduce the risk to acceptable levels. Consequently, a combination of measures is being suggested as a feasible approach.