Government of the People's Republic of Bangladesh
Ministry of Agriculture
Department of Agricultural Extension (DAE)
Plant Quarantine Wing
Exportable Mango Production Project
Khamarbari, Farmgate, Dhaka-1215

Final Report

Pest Risk Analysis of Mango in Bangladesh

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Office of the Project Director
Exportable Mango Production Project
Plant Quarantine Wing
Department of Agriculture Extension
Khamarbari, Farmgate, Dhaka-1205

FINAL REPORT
ON

Pest Risk Analysis of Mango in Bangladesh

DTCL

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MESSAGE

It is my immense pleasure to know that the Exportable Mango Production Project (EMAP) under Plant Quarantine Wing (PQW), Department of Agricultural Extension (DAE), Ministry of Agriculture, Bangladesh has conducted a time demanding study on "Pest Risk Analysis (PRA) of Mango (Mangifera indica) in Bangladesh". The mango export growth from Bangladesh is still very insignificant when the country holds enormous potential as 8th biggest producer of the juicy edible mango fruit in the world. But the PRA of Mango is the prerequisite for exporting mango to foreign markets. However, the findings of this study will play an important role in increasing the export quantity of mango from Bangladesh by fulfilling the phytosanitary requirement of the mango to the importing countries in the world. Under the strong and visionary leadership of the Project Director, Exportable Mango Production Project (EMAP) has already undertaken measures and initiatives to conduct the PRA of Mango in Bangladesh that will enhance the exports of quality mango from Bangladesh to the buyer countries in the world. Considering the purview of this activity, I am confident that this PRA report will facilitate the trades of mango internationally that will contribute to the national economy of the country through export-earning.

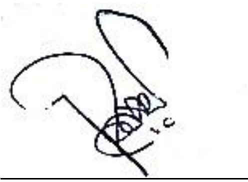
It is indeed a great pleasure that the PRA report is now ready for dissemination through publication in the DAE website. It is expected that the report will contribute immensely to the buyer countries in the world who are interested to import mango from Bangladesh. This report will also help and understanding the status of pests of mango for the quarantine officials, producers and other relevant stakeholders in Bangladesh. I look forward to the proper use of these PRA study findings for the effective performance in the arena of mango trade facilitation.

(Badal Chandra Biswas)
Director General
Department of Agriculture Extension
Ministry of Agriculture
Khamarbari, Dhaka, Bangladesh

MESSAGE

I am pleased to know that the Exportable Mango Production Project (EMAP) under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh has conducted the "Pest Risk Analysis (PRA) of Mango (*Mangifera indica*) in Bangladesh" through a third-party consulting firm named Development Technical Consultants Pvt. Ltd. (DTCL), Dhaka. As a part of National Plant Protection Organization (NPPO) of Bangladesh, Plant Quarantine Wing (PQW) is playing vital role in performing phytosanitary related activities during export-imports of agricultural products to and from Bangladesh. In this regard, the time demanding initiative of conducting 'Pest Risk Analysis (PRA) of Mango in Bangladesh' taken by Exportable Mango Production Project (EMAP) will fulfill the phytosanitary requirement of the buyer countries of the world to import mango from Bangladesh.

I hope that this PRA report will help the exporters to take initiative in exporting quality mango from Bangladesh that will contribute to the national economy of the country through export-earning. It is also expected that this report will help quarantine officials under Plant Quarantine Wing of DAE to understand the pest status of mango in Bangladesh as well as will help in decision making at port-of-entry in Bangladesh during export-import of mango. I look forward to the proper use of the present PRA findings for the effective performance in the arena of mango trade facilitation worldwide as well as export-earning in Bangladesh.



(Dr. Md. Rezaul Karim)
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FORWARD

The Exportation Mango Production Project (EMAP) under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh conducted the study on "**Pest Risk Analysis (PRA) of Mango (*Mangifera indica*) in Bangladesh"** according to the provision of contract agreement signed between EMAP-DAE and Development Technical Consultants Pvt. Limited (DTCL). The PRA study is a five-month assignment commencing from 8 February 2023 under the EMAP-DAE.

The overall objectives of this PRA study are to identify the pests of mango in Bangladesh as well as quarantine pests of mango for Bangladesh, assess the risks of quarantine pests and to identify their risk management options. For this purpose, the PRA team conducted field investigations in 46 upazila under 15 major mango growing districts of Bangladesh. The study covered the interviews of 2760 mango growers; 15 FGDs, 55 KIIs and field visits along with physical inspection of the mango orchards. PRA team also reviewed secondary information related to PRA of mango.

The PRA findings identified 35 arthropod pests, 19 diseases and 5 weeds associated with mango in Bangladesh. The study also identified 16 quarantine pests of mango that included 12 insect pests and 4 fungal diseases those could be introduced into Bangladesh through importation of mango. Based on the risk assessment and risk rating following relevant ISPMs, among 16 quarantine pests of mango, 8 pests were rated as high-risk potential, 5 pests as medium risk rating, one pest as low-risk rating and 2 pests were remarked as uncertainty. The findings also provided risk management options for these quarantine pests in line with pre- and post-harvest management and phytosanitary measures in line with the ISPMs. The findings of the PRA study were validated through a National Level Workshop organized jointly by the EMAP-DAE. The online version of this PRA report will be available at http://dae.portal.gov.bd

I would like to congratulate PRA Team of DTCL for conducting the PRA study successfully and thanks to the concerned officials of EMAP-DAE in making the total endeavor a success. I express my heartfelt thanks to the quarantine and other DAE officials, mango exporters for their assistance and cooperation extended in conducting the PRA study. Special thanks to the Secretary and Additional Secretary (Extension) of Ministry of Agriculture, Director General of DAE, Director of Plant Quarantine Wing, DAE for providing valuable advice and guidance.

I hope that this PRA report certainly would contribute to enhance the exports of mango from Bangladesh by fulfilling the requirement of buyer countries in the world. I am confident that this report will also contribute to the national economy of our country through export-earning.

(Mohammad Arifur Rahama)
Project Director
Exportable Mango Production Project
Department of Agriculture Extension
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PREFACE

This PRA report intends to respond to the requirement of the client according to the provision of contract agreement signed between Project Director, Exportable Mango Production Project (EMAP) and the Development Technical Consultants Pvt. Limited (DTCL) for conducting **"Pest Risk Analysis (PRA) of Mango (*Mangifera indica*) in Bangladesh"** under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture (MoA), Government of the Peoples Republic of Bangladesh. The PRA study is a five-months assignment commencing from 8 February 2023 under the EMAP-DAE.

The study team consists of five senior level experts along with field and office level support staffs. The major objectives of the study are to listing of major and minor pests of mango; identification of pests likely to be associated with pathway during importation of mango; identification of potential pests 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 losses caused by the pests; preparation of report on risk assessment and management options of the pests following relevant ISPMs and make recommendation.

The PRA report includes study design, sampling framework and data collection instruments, guidelines and checklists, details of survey and data collection method and analysis as well as risk assessment strategies of the pests, risk management options and recommendations. The report was thoroughly reviewed by the EMAP officials along with other experts as well as validated through several discussion meetings and a national level validation workshop. The PRA team finalized the report based on comments and suggestions given by the client and experts.

I hope that this PRA report will enhance the exports of mango from Bangladesh by fulfilling the requirements of the buyer countries of the world and thus, Bangladesh will be benefitted by increasing export growth of mango as well as through more export-earning.

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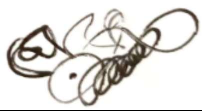
ACKNOWLEDGEMENT

It is indeed a great honor for us that the Exportable Mango Production Project (EMAP) under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE) has entrusted ISO Certified (ISO 9001:2015) consulting firm, the Development Technical Consultant Pvt. Ltd. (DTCL) to carry out the "**Pest Risk Analysis (PRA) of Mango (*Mangifera indica*) in Bangladesh"**. This PRA report has been prepared based on the past five-months (February 2023 to June 2023) activities of the study in 15 major mango growing districts of Bangladesh as well as based on the relevant literature reviews. In the process of working on the setting indicators and sampling as well as for formulating and revising the study tools and data collection, monitoring and supervision, data analysis and report writing, we have enjoyed the support of EMAP-DAE. The principal author is Prof. Dr. Md. Razzab Ali (Team Leader cum Entomologist) with inputs from Prof. Dr. M. Salahuddin M. Chowdhury (Plant Pathologist), Prof. Dr. Mohammed Sakhawat Hossain (Entomologist), Dr. Paresh Chandra Golder (Horticulturist), Dr. B. A. A. Mustafi (Agricultural Economist), Dr. Sumon Saha (Coordinator cum Entomologist) and Mr. Kazi Abdulla-Al-Mahmud (Entomologist) of the PRA study team.

The authors are grateful to the Director General, Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh, who provided his extended support and gave us an opportunity to meet the Director, Plant Quarantine Wing (PQW) of DAE. Special thanks to Mr. Mohammad Arifur Rahman, Project Director of Exportable Mango Production Project (EMAP); Mr. Md. Shahidullah and Mrs. Nishat Tabassum, Assistant Project Directors, EMAP-DAE for their valuable cooperation, guidance and suggestions to the study team in line with the activities performed during study period, report preparation and finalization. Our special grateful thanks also to Dr. Rezaul Karim, Director, Plant Quarantine Wing (PQW) of DAE for his kind cooperation and suggestions during study period. The active support of Dr. M. M. Amir Hossain, Managing Director of DTCL and Mr. Md. Monir Hossain, Chief Coordinator of the study team and Director of DTCL; Mr. Md. Mahabub Alam, General Manager of DTCL are also acknowledged with thanks.



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Team Leader cum Entomologist
PRA of Mango in Bangladesh

Acronyms

AEZ	:	Agro-Ecological Zone
BARI	:	Bangladesh agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
CABI	:	Center for Agriculture and bio-Sciences International
DAE	:	Department of Agriculture Extension
DD	:	Deputy Director
DG	:	Director General
Dr.	:	Doctor
DTCL	:	Development Technical Consultants Private Limited
e.g.	:	For Example
EMAP	:	Exportable Mango Production Project
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
GAP	:	Good Agricultural Practices
GoB	:	Government of Bangladesh
HRC	:	Horticulture Research Center
HWT	:	Hot Water Treatment
IAS	:	Invasive Alien Species
IPPC	:	International Plant Protection Convention
IPM	:	Integrated Pest Management
ISPM	:	International Standard For Phytosanitary Measures
J.	:	Journal
KII	:	Key Informant Interview
km	:	Kilometer
Ltd	:	Limited
MD	:	Managing Director
MoA	:	Ministry of Agriculture
MT	:	Metric Ton
No.	:	Number
NPPO	:	National Plant Protection Organization
^{o}C	:	Degree Celsius
PD	:	Project Director
PFA	:	Pest Free Area
PQW	:	Plant Quarantine Wing
PRA	:	Pest Risk Analysis
Prof.	:	Professor
Pvt.	:	Private
RH	:	Relative Humidity
SAAO	:	Sub-Assistant Agriculture Officer
SAU	:	Sher-e-Bangla Agricultural University
SPCB	:	Strengthening Phytosanitary Capacity Project in Bangladesh
UAO	:	Upazila Agriculture Officer
UK	:	United Kingdom
USA	:	United States of America
USDA	:	United States Department of Agriculture
VHT	:	Vapor Heat Treatment
WTO	:	World Trade Organization
%	:	Percentage

Executive Summary

The study "Pest Risk Analysis (PRA) of Mango (*Mangifera indica*) in Bangladesh" documents the pests of mango available in Bangladesh and the risks associated with the import pathway of mango from the exporting countries namely India, Thailand, Pakistan, Myanmar, Australia, etc. into Bangladesh.

The findings evidenced that the 59 pests of mango were recorded in Bangladesh, of which 35 arthropod pests that included 34 insect pests and 1 mite pest; 19 disease causing pathogens and 5 weeds. The incidences of insect pests of mango recorded in Bangladesh were mango hopper (*Amritodus atkinsoni*, *Idioscopus clypealis, I. nagpurensis*), oriental fruit fly (*Bactrocera dorsalis* (Hendel)), mango leaf-cutting weevil (*Deporaus marginatus*) and mango mealybug (*Drosicha mangiferae*), mango pulp weevil (*Sternochaetus frigidus*), mango stem borer (*Batocera rubus* (Linnaeus 1758)) caused infestation in the mango stone/seed weevil (*Sternochetus mangiferae* (Fabricius)), apple stem borer (*Trirachys holosericeus*), cucurbit fruit fly (*Bactrocera cucurbitae*), mango fruit fly (*Bactrocera tau* (Walker, 1849)), guava fruit fly (*Bactrocera correcta*), peach fruit fly (*Bactrocera zonata* (Saunders)), mango inflorescence midge (*Erosomyia indica*), mango leaf gall midge (*Procontarinia matteiana*), mango common scale (*Coccus mangiferae* (Green)), mango white scale (*Aulacaspis tubercularis*), coconut scale (*Aspidiotus destructor*), cottony cushion scale (*Icerya purchase*), mango shoot gall psyllid (*Apsylla cistellata* (Cockerell, 1893)), pineapple mealybug (*Dysmicoccus brevipes*), fruit tree mealybug (*Rastrococcus invadens*), mango aphid (*Toxoptera odinae*), mango leafhopper (*Idioscopus nitidulus*), mango leaf miner (*Acrocercops syngramma* Meyrick), mango defoliator (*Cricula trifenestrata* (Helfer 1837)), mango fruit borer (*Citripestis eutraphera Meyrick), mango leaf weber (Orthaga exvinacea* Hampson), mango leaf caterpillar (*Euthalia aconthea*), bark eating caterpillar (*Indarbela tetraonis*), cotton bollworm (*Helicoverpa armigera*), pink gypsy moth (*Lymantria mathura* Moore 1865), black tea thrips (*Heliothrips haemorrhoidalis*), chili thrips (*Scirtothrips dorsalis*) and melon thrips (*Thrips palmi*). The mango eriophyid mite (*Aceria mangiferae)* was also recorded as a major pest of mango. Among these insect and mite pests of mango, mango hopper, oriental fruit fly, mango leaf-cutting weevil and mango mealybug were more damaging than other arthropod pests and these insects were designated as major insect of mango and caused damage with high infestation intensity.

A total number of nineteen (19) diseases of mango, of which fourteen (14) fungal, one (1) algal, three (3) bacterial and one (1) nemic diseases were reported for field and storage condition of mango in Bangladesh as reported by different stakeholders such as mango growers, field level DAE officials and other experts as well as those were found in the field of mango and or storage condition. The incidences of major diseases of mango found in the study were anthracnose disease (*Colletotrichum gloeosporioides*) of mango fruits and leaves in the field condition. Other major diseases of mango as recorded were fruit end rot (*Phomopsis mangiferae*), charcoal/Diplodia rot (*Diplodia natalensis*), mango sooty mold (*Meliola mangiferae*). The incidences of minor diseases of mango were powdery mildew (*Oidium mangiferae*), mango malformation (*Fusarium moniliforme*), Alternaria leaf spot of mango (*Alternaria alternate*), blossom blight/ grey mould (*Botryosphaeria theobromae*), mango scab (*Elsinoë mangiferae*), mango tear stain (*Colletotrichum gloeosporioide*s), mango gummosis (*Lasiodiplodia theobromae*) caused by fungi. Among algal disease, leaf red rust of mango (*Cephaleuros virescens* Kunze 1827) was reported as minor disease in the field condition. Among bacterial diseases of mango, Asiatic canker (*Xanthomonas citri*) and bacterial leaf blight (*Pseudomonas syringae pv. syringae*) were also recorded as minor diseases of mango in Bangladesh. Among these diseases, the anthracnose diseases on leaves and fruits were more damaging than others.

A total number of 5 weeds were reported as the problem in the field of mango in Bangladesh and these were Loranthus/Indian mistletoe (*Dendrophthae falcate*), Dodder plant (*Cuscuta* spp.), Pathenium weed (*Parthenium hysterophorus* L.), Staghorn fern (*Platycerium* sp.) and Parasitic orchid (*Cleisostoma* sp.). The parthenium weed (*Parthenium hysterophorus*) was recorded and found only in some restricted areas of Bangladesh namely Rajshahi, Natore, Pabna, Kustia, Jessore districts. These districts are nearly attached with the Western border of Bangladesh and Eastern border of West Bengall of India. It was also reported that the parthenium weed might be entered into Bangladesh through cross boundary pathway from India by the transportation system of border trading.

Information on pests associated with mango in the exporting countries—India, Thailand, Pakistan, Myanmar, Australia, etc—reveal that pests of quarantine importance exist. The study also revealed sixteen (16) species of quarantine pests of mango for Bangladesh were identified those were present in India, Thailand, Pakistan, Myanmar, Australia, etc, but not in Bangladesh. Among these 16 species of quarantine pests, 12 species were insect pests and 4 disease causing fungi. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced mango. The quarantine insect pests are Queensland fruit fly (*Bactrocera tryoni*), Mexican fruit fly (*Anastrepha ludens*), A member of Oriental fruit (*Bactrocera caryeae*), Marula fruit fly (*Ceratitis cosyra*), Stellate scale (*Ceroplastes stellifer*), Morgan's scale (*Chrysomphalus dictyospermi*), Tapioca scale insect (*Aonidomytilus albus*), Spiked mealybug (*Nipaecoccus nipae*), Grey pineapple mealybug (*Dysmicoccus neobrevipes*), Peach scale (*Parthenolecanium persicae*), Shoot borer of mango (*Penicillaria jocosatrix*), and Rubber termite (*Coptotermes curvignathus*).

On the other hand, four (4) disease causing fungi have been identified as quarantine pests of mango for Bangladesh. These are: Leaf and stem blight (*Macrophoma mangiferae*), Twig canker/stem-end rot (*Cytosphaera mangiferae*), Soft brown rot (*Hendersonia creberrima*) and Mango black spot (*Actinodochium jenkinsii*).

The consequences and potential/likelihood of introduction of each quarantine pest were assessed individually, and a risk rating estimated for each. The consequence and potential of introduction value was estimated assessing biology, host, 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 risk in the absence of mitigation.

Out of 16 quarantine pests associated with the pathway risk assessed. Out of 16 potential hazard organisms, 8 hazard organisms were identified with high-risk potential, 5 moderate, 1 low and 2 uncertain species was found which likely to be associated with host plants during importation from exporting countries, but remained as uncertain hazards due to lack of detail information. These mean that these pests pose unacceptable phytosanitary risk to Bangladesh's agriculture. The risk assessment of regulated non-quarantine pests, including the Mango Pulp Weevil, Mango Seed Weevil, and Mango Anthracnose, is crucial for protecting mango cultivation and the agricultural ecosystem in Bangladesh. Following ISPM 21 guidelines, this assessment aims to identify potential impacts, pathways of introduction, and effective management strategies to mitigate risks. Visual inspection at ports-of-entry for high-risk potential pests is insufficient to safeguard Bangladesh's mango industry and specific phytosanitary measures are strongly recommended. The consignment could re-export or destroy, if quarantine pests with high-risk potential are found during an inspection. While for moderate risk potential pest, specific phytosanitary measures may be necessary to reduce pest risk. While for low-risk potential pests, unnecessary trade barrier is not recommended. PRA for potential crops should be continued to maintain and develop our market access by fulfilling the requirement of byer countries in the world.

Table of Contents

Executive Summary ... i
Table of Contents ... iv
1 CHAPTER 1: SCOPE AND METHODOLOGY OF PEST RISK ANALYSIS ... 1
1.1 Background ... 1
1.2 Reasons for conducting PRA ... 2
1.3 Scope of the Pest Risk Analysis ... 3
1.4 Objectives of the Current PRA study ... 3
1.5 PRA Areas ... 4
1.6 Methodology of Pest Risk Analysis ... 4
1.7 Methodology for data collection ... 6
1.7.1 Introduction ... 6
1.7.2 Major Activities for data collection ... 6
1.7.2.1 Tools development: ... 6
1.7.2.2 Quantitative field survey: ... 6
1.7.2.3 Qualitative survey ... 8
1.7.2.4 Literature review ... 12
1.7.2.5 Field visit and observation by PRA team ... 12
1.7.2.6 Listing of pests of mango ... 15
1.7.3 PRA location and study sampling ... 15
1.7.4 Interpretation of results ... 18
1.7.5 Pictorial presentation of mango pests ... 18
2 CHAPTER 2: RISK ANALYSIS PROCESS AND METHODOLOGY ... 19
2.1 Undertaking of Pest Risk Analysis (PRA) ... 19
2.2 Import Pathway Description ... 22
2.2.1 Import pathways of mango ... 22
2.2.2 Pathway Description ... 22
2.3 Hazard Identification ... 24
2.4 Risk Assessment of Potential Hazards ... 25
2.5 Assessment of Uncertainties ... 25
2.6 Risk Management ... 26
2.7 Risk Evaluation ... 26
2.8 Option Evaluation ... 26
2.9 Review and Consultation ... 28
3 CHAPTER 3: INITIATION ... 29
3.1 Introduction ... 29
3.2 Commodity Description ... 29
3.2.1 Mango and its origin ... 29
3.2.2 Botanical identity ... 29
3.2.3 Mango variety ... 30

3.2.4 Climate 30
3.2.5 Soil 31
3.2.6 Land preparation 31
3.2.7 Planting system 31
3.2.8 Mango production in Bangladesh 31
3.2.9 Export-imports of mango in Bangladesh 31
3.3 Description of the Import Pathway 32
3.4 Geographic Position and General Climate of Importing Countries—Bangladesh 33
3.5 Geographic Position and General Climate of Exporting Countries 34
3.5.1 India 34
3.5.2 Thailand 35
3.5.3 Pakistan 36
3.5.4 Philippines 37
3.5.5 Australia 37
3.6 Pests of Mango in Exporting Countries 38
3.6.1 India 38
3.6.1.1 Insect and mite pests of mango 38
3.6.1.2 Diseases of Mango 40
3.6.1.3 Weeds of Mango 41
3.6.2 Thailand 41
3.6.2.1 Insect pests of mango 41
3.6.2.2 Diseases of Mango 42
3.6.2.3 Weeds of Mango 43
3.6.3 Pakistan 43
3.6.3.1 Insect and mite pests of mango 43
3.6.3.2 Diseases of Mango 44
3.6.3.3 Weeds of Mango 45
3.6.4 The Philippines 45
3.6.4.1 Insect and mite pests of mango 45
3.6.4.2 Diseases of Mango 46
3.6.4.3 Weeds of Mango 46
3.6.5 Australia 46
3.6.5.1 Insect and mite pests of mango 46
3.6.5.2 Diseases of Mango 47
3.6.5.3 Weeds of Mango 47
4 CHAPTER 4: HAZARD IDENTIFICATION 48
4.1 Introduction 48
4.2 Potential Hazard Groups 48
4.3 Interception of Pests on Mango from Existing Pathways 49
4.4 Review of earlier PRA 49
4.5 Other Risk Characteristics of the Commodity 49
4.5.1 Unlisted Pests 49

4.5.2 Latent micro-organisms 49
4.6 Assumptions and Uncertainties 50
4.7 Assumptions and Uncertainties around hazard biology 50
4.8 Assumption and Uncertainties around the Inspection Procedure 51
4.9 Assumption around Transit Time of Commodity on the Air Pathway 51
4.10 Assumption around Commodity Grown in Bangladesh 51
5 CHAPTER 5: REVIEW OF MANAGEMENT OPTIONS 52
5.1 Introduction 52
5.2 Insect pests of mango 52
5.2.1 Mango weevil 52
5.2.2 Stem borer 53
5.2.3 Fruit flies 53
5.2.4 Mango leaf gall midge 55
5.2.5 Mango hopper 56
5.2.6 Morgan's scale 57
5.2.7 Shoot gall psyllid 58
5.2.8 Spiked mealybug 58
5.2.9 Mango Aphid 59
5.2.10 Mango fruit borer 60
5.2.11 Mango caterpillar 61
5.2.12 Thrips 62
5.2.13 Termite 63
5.3 Management options for mite pests of mango 65
5.4 Management options for diseases of mango 66
5.4.1 Ceratocystis blight 66
5.4.2 Anthracnose 66
5.4.3 Powdery mildew 70
5.4.4 Alternaria leaf spot 72
5.4.5 Grey mould 72
5.4.6 Die-back 73
5.4.7 Mango scab 73
5.4.8 Leaf red rust 74
5.4.9 Bacteria Canker 74
5.4.10 Bacterial black spot 76
5.4.11 Root-knot nematode 76
5.5 Management options for weeds of mango 77
5.5.1 Parthenium weed 77
5.6 References 78
6 CHAPTER 6: IDENTIFICATION OF PESTS 95
6.1 Introduction 95
6.2 Pests of mango recorded in Bangladesh 95
6.3 Insect and mite pests of mango in Bangladesh 95

6.3.1 Insect pests recorded ... 95
6.3.2 Mite pests recorded ... 96
6.3.3 Damage potential of insect and mite pests ... 96
6.3.4 Identification of fruit fly and its diversity ... 101
6.3.5 Comparison of recorded arthropod pests identified through present PRA study (2023) with the previous PRA report (2015) ... 102
6.3.6 Pictorial presentation of insect and mite pests of mango ... 102
6.4 Diseases of mango in Bangladesh ... 114
6.4.1 Incidence of diseases as recorded ... 114
6.4.2 Damage potential of diseases ... 115
6.4.3 Comparison of recorded diseases of mango identified through present PRA study (2023) with the previous PRA study report (2015) ... 119
6.4.4 Pictorial presentation of diseases of mango ... 119
6.5 Weeds of mango in Bangladesh ... 127
6.5.1 Incidence of weeds as recorded ... 127
6.5.2 Damage potentiality of weeds ... 127
6.5.3 Pictorial presentation of weeds of mango ... 128
6.6 Endangered areas of serious pests of mango ... 129
6.7 Management options for mango pests ... 130
6.7.1 Management options for insect pests ... 130
6.7.2 Management options for diseases ... 130
6.7.3 Management options for weeds ... 130
6.8 Possible ways of entry of quarantine pests into Bangladesh ... 130
6.9 Effective ways to prevent the entry of quarantine pests of mango into Bangladesh 130
6.10 Options to prevent the spread of quarantine pests of mango within Bangladesh ... 131
6.11 Measures need to be taken by the exporters to export mangoes ... 131
7 CHAPTER 7: POTENTIAL HAZARD ORGANISM: RISK ASSESSMENT ... 132
7.1 Introduction ... 132
7.2 Pest Categorization: Identification of Quarantine Pests Likely to Follow the Pathway ... 132
7.2.1 Pests of mango in the world ... 132
7.2.2 Quarantine pests of mango for Bangladesh ... 132
7.3 References ... 151
7.4 Risk assessment ... 169
7.4.1 A. Arthropod: Insect and mites pests ... 169
7.4.1.1 A. Queensland fruit fly, *Bactrocera tryoni* ... 169
7.4.1.2 A. Mexican fruit fly, *Anastrepha ludens* (Loew) ... 176
7.4.1.3 A. A member of Oriental fruit fly, *Bactrocera caryeae* (Kapoor) ... 182
7.4.1.4 A. Marula fruit fly, *Ceratitis cosyra* (Walker) ... 186
7.4.1.5 A. Stellate scale, *Ceroplastes stellifer* (Westwood, 1871) ... 191
7.4.1.6 A. Morgan's scale, *Chrysomphalus dictyospermi* (Morgan, 1889) ... 197
7.4.1.7 A. Tapioca scale, *Aonidomytilus albus* (Cockerell, 1893) ... 202

7.4.1.8 A. Spiked mealybug, *Nipaecoccus nipae* (Maskell, 1893) 208
7.4.1.9 A. Grey pineapple mealybug, *Dysmicoccus neobrevipes* Beardsley 212
7.4.1.10 Peach scale, Parthenolecanium persicae (Fabricius) 217
7.4.1.11 A. Mango shoot borer, *Penicillaria jocosatrix* (Guenée, 1852) 224
7.4.1.12 A. Rubber termite, *Coptotermes curvignathus* Holmgren.......................... 229
7.4.2 B. Disease Causing Pathogen: Fungi 235
7.4.2.1 B. Twig Canker: Cytosphaera mangiferae (Died 1916) 235
7.4.2.2 B. Soft brown rot*: Hendersonia creberrima* (Syd. & P. Syd. & E.J. Butler) 238
7.5 C. Conclusion: Pest Risk Potential and Pests Requiring Phytosanitary Measures ... 241
7.6 Uncertainty 242
7.7 Risk Analysis of Regulated Non-quarantine pest 243
7.7.1 Mango seed weevil, *Sternochetus mangiferae* (Fabricius, 1775) 243
7.7.2 Mango pulp weevil, *Sternochetus frigidus* (Fabricius)..................................... 248
7.7.3 Mango anthracnose, Colletotrichum gloeosporioides...................................... 252
8 CHAPTER 8: RISK MANAGEMENT 258
8.1 Risk Management Options and Phytosanitary Procedures 258
8.1.1 Pre-harvest Management Options.. 258
8.1.2 Post-Harvest Procedures 259
8.1.3 Visual Inspection 259
8.1.4 Treatment for arthropods 259
8.1.5 Phytosanitary Inspection and Certification 260
8.1.6 Post-inspection Product Security 260
8.1.7 Verification inspection on arrival in importing country 260
8.1.8 Biosecurity clearance 261
8.1.9 Audit and review of Policy 261
8.1.10 Feedback on non-compliance 261
8.2 Risk Management Conclusions... 261
8.3 Recommendation.. 261
Appendixes.. 262
Appendix 1: Questionnaire for Interview of mango producer 263
Appendix 2: Questionnaire for Focus Group Discussion for PRA 278
Appendix 3: Questionnaire for Interview of Field Level Officers for PRA......................... 285
Appendix 4: Data Tables of Field Survey Study 289

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 is the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any Phytosanitary measures to be taken against it. The unwanted pests may be introduced into the country through potential carriers such as people, commodities and conveyances. For excluding foreign pests, recognition of these risks' measures should be reflected in quarantine legislation to control the movement of consignments as a way of protecting plant life and health. All these quarantine policy and risk management measures should be based on risk analysis to minimize the trade barrier. As a contracting party to the International Plant Protection Convention (IPPC), Bangladesh is committed to follow the principles and guidelines of the IPPC. One of the main tasks of the contracting party is to conduct Pest Risk Analysis for safeguarding the country's agriculture from entering the Invasive Alien Species (IAS) that are usually destructive pests (WTO, 1994[1]). The PRA includes list of pests of specific crops which are usually required for exporting agricultural commodities because on the basis of presence of pests, climate and other criteria importing countries consider importing agricultural commodities from other countries.

Now more than 300 Destructive Insects and Pests are prevailing in the world, where Bangladesh is exclusively free from most of these pests. But we are afraid of maintaining such situations because Bangladesh has to import a huge quantity (about 1 crore MT.) of plants and plant products every year. So, we are at the highest risk of entering those destructive pests because these pests are usually brought in along with imported Agricultural commodities. On the contrary Bangladesh has successfully entered into the highly competitive international export market. We are earning a good amount of valuable foreign currency through exporting 10-12 lakhs metric tons of agricultural products. Bangladesh is one of the major mango-producing countries along with India, China, Thailand, Indonesia, Pakistan, Mexico, Brazil, Nigeria, the Philippines, etc. (Alexander, 1989)[2]. In Bangladesh, mango occupies about an area of 2,86,823 acres with a production of 12,14,597 metric tons during 2020-21 according to (BBS, 2022[3]). Based on the FAO Statistical Database, there are top 15 countries who are leading in the production of mango, among which Bangladesh stands 8th in position in terms of production. Bangladesh exports mango to Middle East, United Kingdom, Canada, Switzerland and European countries usually (DAE, 2022). Bangladesh's mango export volume, 1757 tons nearly trebled in 2021-22 financial year from that 791 tons

[1] WTO (1994). Agreement on the Application of Sanitary and Phytosanitary Measures, 1994. World Trade Organization (WTO), Geneva.

[2] Alexander, D. McE. 1989. The mango in Australia, Common-wealth Scientific and Industrial Research Organization, Australia. pp. 1-28.

[3] BBS. 2022. Yearbook of Agricultural Statistics of Bangladesh, 2021. Bangladesh Bureau of Statistics, Ministry of Planning, Bangladesh. pp. 212-213.

in the previous fiscal (DAE, 2022[4]). But if one put the $1.5 billion global mango trade into perspective, Bangladesh's export growth is still very insignificant when the country holds enormous potential as 8th biggest producer of the juicy edible mango fruit (Amber Pariona, 2018[5]). For many years, Bangladesh's potential, however, remained largely untapped as the regulators wasn't mindful of implementing good agricultural practices (GAP), a prerequisite for exporting mango to foreign markets. Bangladesh also imports mangoes from different countries viz. Thailand, India, Australia, Pakistan, the Philippines, etc. (DAE, 2022). The amount of mango imports in Bangladesh is neglectable compared to the total production in Bangladesh and export that is almost near to zero (FAOSTAT, 2018[6]). The introduction of insect pests, plant diseases and weeds is brought about mainly during the accelerated agricultural development in different countries, when plants and plant materials were brought into, or sent out with little or no concern for the insect pests, diseases and weeds that were transported along with them. There are many instances of accidental introductions of insect pests and diseases from one country to another. Extensive damages, often sudden in nature, have been caused not by indigenous pests, but with exotic ones introduced along with plants, plant parts or seeds in the normal channel of trade or individual interest. So, to safeguard our agriculture from entering IAS by imported commodities as well as maintain and develop our market access by fulfilling the importing countries' requirement conducting PRA is most essential. Considering this situation, the project will conduct PRA on mango and prepare a GAP-guidelines for the farmers. The review and analysis of the fruits has been furnished below:

1.2 Reasons for conducting PRA

Pest risk analysis (**PRA**) is a form of risk analysis conducted by regulatory plant health authorities to identify the appropriate phytosanitary measures required to protect plant resources against new or emerging pests and regulated pests of plants or plant products. Specifically, pest risk analysis is a term used within the International Plant Protection Convention 1997 (Article 2.1) (IPPC, 1997)[7] and is defined within the glossary of phytosanitary terms (FAO, 2015)[8] as "the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it". In a phytosanitary context, the term plant pest, or simply pest, refers to any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products and includes plant pathogenic bacteria, fungi, fungus-like organisms, viruses and virus like organisms, as well as insects, mites, nematodes and weeds.

[4] DAE, 2022. Bangladesh's Mango Export. Retrieved on 11 February 2023: https://www.thedailystar.net/business/economy/news/mango-exports-hit-five-year-high-3060026

[5] Amber Pariona, 2018. The Top Mango Producing Countries in the World. The World Atlas Economics: Retrieved on 11 February 2023: https://www.worldatlas.com/articles/the-top-mango-producing-countries-in-the-world.html#:~:text=Mango%20Producing%20Countries-,India,of%20the%20global%20mango%20supply.

[6] FAOSTAT, 2018. Land use. http://www.fao.org/faostat/en/#country/16 Accessed 4 February 2021

[7] IPPC (1997). International Plant Protection Convention 1997. Food and Agriculture Organization (FAO), Rome.

[8] FAO (2015). ISPM No. 5. Glossary of phytosanitary terms. Food and Agriculture Organization (FAO), Rome, 34 pp.

In accordance with the WTO Sanitary and Phytosanitary Agreement, the IPPC aims to protect plants while limiting interference with international trade (Work *et al.*, 2005)[9]. A key principle of the IPPC is that contracting parties (signatories) provide 'technical justification' to support phytosanitary decision-making affecting trade (FAO, 2002)[10]. The IPPC recognizes pest risk analysis as the appropriate format for such technical justification. The responsibility for conducting pest risk analysis sits within government, specifically within a country's National Plant Protection Organization (NPPO) and comes as an obligation when countries become contracting parties to the IPPC (IPPC Article IV, 2a).

IPPC standards, referred to as International Standards for Phytosanitary Measures (ISPM), have been developed to assist NPPOs. The primary ISPMs relevant to pest risk analysis are ISPM 2, Framework for pest risk analysis (FAO, 2007)[11], ISPM 11, Pest risk analysis for quarantine pests (FAO, 2013)[12] and ISPM 21, Pest risk analysis for regulated non-quarantine pests (FAO, 2004)[13].

As per ISPM No. 11 and ISPM No. 21, the specific objectives for conducting any Pest Risk Analysis (PRA) of quarantine and regulated non-quarantine pests for a crop or commodity are given below:

- To evaluate and manage risk from specific pests and internationally traded commodities;
- To identify and assess risks to agricultural and horticultural crops, forestry and the environment from plant pests.
- To create lists of regulated pests
- To identify the quarantine pests of crops
- To assess probability of entry, establishment, spread and consequences – economic, environment and health impact.
- To overcome unnecessary barrier on international trade,
- To assist in identifying appropriate management options.

1.3 Scope of the Pest Risk Analysis

The scope of Pest Risk Analysis (PRA) of mango (*Mangifera indica*) in Bangladesh is to assess present status of pests in the country and to find out the potential hazard organisms like insect and mite pests, diseases and other pests associated with mango imported from different exporting countries such as Thailand, India, Australia, Pakistan, the Philippines, etc. (DAE, 2022). Risk in this context is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.

1.4 Objectives of the Current PRA study

The overall objective of the Pest Risk Analysis of Mango in Bangladesh is to update present pest list of mango and categorize risk as high, medium, low and minimum and determine of an organism as a pest; create list of regulated pests of mango for the purpose of import regulation; recommend appropriate pest risk management and assess options and prepare Good Agricultural Practices guideline of Mango (Mango GAP) in line with Global GAP and

9 Work, T.T., McCullough, D.G., Cavey, J.F. & Komsa, R. (2005). Arrival rate of nonindigenous insect species into the United States through foreign trade. Biological Invasions 7, 323–332.

10 FAO (2002). Guide to the International Plant Protection Convention (IPPC). FAO, Rome, 20 pp.

11 FAO (2007) ISPM No. 2: Framework for pest risk analysis, FAO Rome, 35 pp.

12 FAO (2013) ISPM No. 11: Pest risk analysis for quarantine pests, FAO Rome, 26 pp.

13 FAO (2004) ISPM No. 21: Pest risk analysis for regulated non-quarantine pests, FAO Rome18pp.

getting approval from the concerned authority. The consulting Firm is required to identify the pests, pathway/s, evaluate their risk, endangered areas, and risk management options, etc.

The specific objectives of the Pest Risk Analysis of Mango in Bangladesh (according to ISPM No. 11 in the framework of ISPM No. 2) are:

- Listing of major and minor pests mentioning plant parts affected (creating pictorial pest list)
- Listing of regulated pests (Quarantine and Non-Quarantine Pests)
- Identification and categorization of pests likely to be associated with a pathway
- Determination of pests up to species level
- Identification of potentials for entry, establishment and spread of regulated pests
- Identification of probability of survival during transport or storage & transfer of hosts
- Nature of damage
- Identification of probability of pest surviving existing pest management procedures
- Identification of availability of suitable hosts, alternate hosts and vectors in the PRA areas
- Identification of potential economic and environmental impacts
- Assessment of potential loss by the pests
- Analysis of uncertainties
- Identification of management options/system approach for control of regulated pests
- Preparation of report on risk analysis of the pests following the relevant ISPMs
- Identification of host plants and more damaging host plant species if any
- Identification of Risk management options
- To detect pest, it is recommended to follow relevant ISPMs where procedures are being described, and
- Perform pest risk analysis and other responsibilities assigned by PD of EMAP

1.5 PRA Areas

The entire Bangladesh is considered as the PRA area in this risk analysis. But the mangoes are not grown all over Bangladesh. Therefore, the major mango growing districts, here 15 districts, of Bangladesh are considered as the PRA area in this Pest Risk Analysis Process. Moreover, the mango/saplings of mangoes are imported through different air, sea and land ports which are located all regions of Bangladesh that are also considered as PRA areas. However, survey on insect and mite pests, diseases, weeds and other hazard organisms associated with mango was done in major mango growing districts of Bangladesh as well as ports through which mangoes/saplings of mango are being imported into Bangladesh.

1.6 Methodology of Pest Risk Analysis

PRA process includes three major stages such as Initiation, Pest Risk Assessment and Pest Risk Management as adopted from ISPM No. 2 (2007). The following methods were sequentially followed to conduct PRA of Mango. The process and methodology for undertaking import risk analyses are shown in Figure 1.

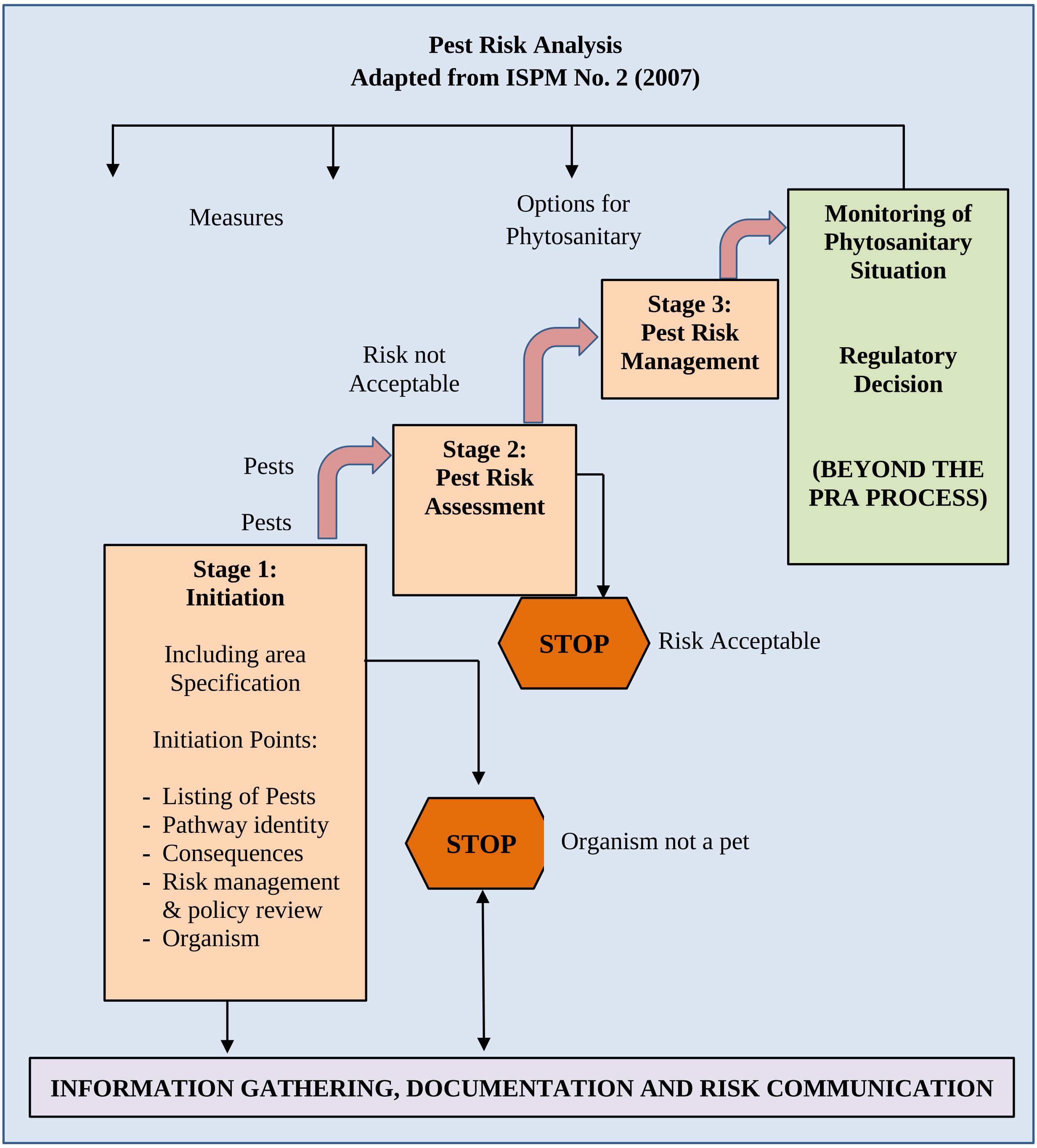


Figure 1: Schematic Diagram of Pest Risk Analysis Process

1.7 Methodology for data collection

1.7.1 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 insect and mite pests, diseases and other associated pests of mango, their potential hazards, quarantine concern of the pests, their risk and management options. The study involved the use of (i) quantitative field survey by means of interview of mango growers using structured questionnaire, (ii) semi-structured interviews by means of focus group discussions (FGD), (iii) interviews of key stakeholders by means of Key Informant Interview (KII); (iv) review of secondary documents and reports and (v) visits of mango orchards and observations.

1.7.2 Major Activities for data collection

1.7.2.1 Tools development:

The data collection tools for field survey appropriate for different stakeholders were developed in line with the scope and objectives of the pest risk analysis of mango in Bangladesh. The most appropriate tools used in this field study were structured questionnaire for direct interview of mango growers, FGD guidelines, KII checklists for DAE personnel, quarantine personnel, mango exporters and importers, Entomologists and Plant Pathologists of research organization and Agricultural Universities, etc. as well as field observation checklist.

1.7.2.2 Quantitative field survey:

The quantitative field survey was conducted with the direct interview of mango growers in 46 upazila under 15 major mango growing districts of Bangladesh aiming to collect primary data in terms of identifying insect and mite pests, diseases, weeds and other pests of mango, their damaging status including incidence and severity, and management options. This study also identified quarantine pests with their entry, establishment, risk and their management. The activities of quantitative data collection by means of face-to-face interview of mango growers are shown in the following photographs:

Photographic presentation of quantitative survey activities by means of face-to-face interview of mango producers at field level under Exportable Mango Production Project (EMAP), DAE

Plate-1: Face-to-face interview of mango producer at Chapainawabganj district

Plate-2: Face-to-face interview of mango producer at Rajshahi district

Plate-3: Face-to-face interview of mango producer at Natore district

Plate-4: Face-to-face interview of mango producer at Naogaon district

Plate-5: Face-to-face interview of mango producer at Dinajpur district

Plate-6: Face-to-face interview of mango producer at Thakurgaon district

Plate-7: Face-to-face interview of mango producer at Meherpur district

Plate-8: Face-to-face interview of mango producer at Kushtia district

Plate-9: Face-to-face interview of mango producer at Chauadanga district

Plate-10: Face-to-face interview of mango producer at Satkhira district

Plate-11: Face-to-face interview of mango producer at Khagrachari district

Plate-12: Face-to-face interview of mango producer at Rangamati district

1.7.2.3 Qualitative survey

In addition of quantitative data collection, qualitative data were also collected through by means of focus group discussions (FGD) with mango growers and key informant interviews (KII) with extension personnel at field and headquarter level of DAE, Plant Quarantine Officials at port of entry and Central Packing House, mango exporters and importers, Entomologists and Plant Pathologists of Agricultural Research Organizations and Agricultural Universities, etc. The activities of qualitative data collection by means of FGD sessions with mango growers and KII with DAE officials are shown in the following photographs:

(a) **Focus Group Discussion with Mango Growers at Field Level:** Photographic presentation of qualitative survey activities by means of FGDs with the participation of mango producers at field level under Exportable Mango Production Project (EMAP), DAE

Plate-13: FGD conducted with the participation of mango producers at Chapainawabganj district

Plate-14: FGD conducted with the participation of mango producers at Rajshahi district

Plate-15: FGD conducted with the participation of mango producers in presence of PRA team at Charghat Upazila under Rajshahi district

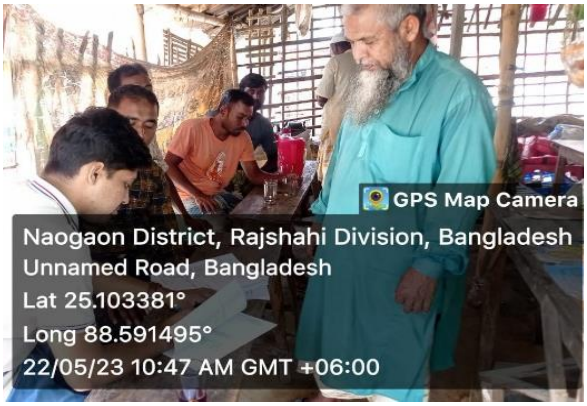


Plate-16: FGD conducted with the participation of mango producers at Naogaon district

Plate-17: FGD conducted with the participation of mango producers at Dinajpur district

Plate-18: FGD conducted with the participation of mango producers at Thakurgaon district

Plate-19: FGD conducted with the participation of mango producers at Meherpur district

Plate-20: FGD conducted with the participation of mango producers at Jashore district

Plate-21: FGD conducted with the participation of mango producers at Satkhira district

Plate-22: FGD conducted with the participation of mango producers at Bandarban district

(b) Key Informant Interview with DAE Officials at Field Level: Photographic presentation of qualitative survey activities by means of KIIs with the participation of field level DAE officials under Exportable Mango Production Project (EMAP), Department of Agriculture Extension (DAE)

Plate-23: KII conducted with Deputy Director (DD), DAE, Chapainawabganj district

Plate-24: KII conducted with Upazila Agriculture Officer (UAO), Shipganj, Rajshahi district

Plate-25: KII conducted with Deputy Director (DD), DAE, Dinajpur district

Plate-26: KII conducted with Upazila Agriculture Officer (UAO), Birol, Dinajpur district

Plate-27: KII conducted with Deputy Director (DD), DAE, Naogaon district

Plate-28: KII conducted with Upazila Agriculture Officer (UAO), Sapahar, Naogaon district

Plate-29: KII conducted with Upazila Agriculture Officer (UAO), Mohonpur Upazila, Rajshahi district

Plate-30: KII conducted with Upazila Agriculture Officer, Satkhira Sadar, Satkhira district

Plate-31: KII conducted with Deputy Director (DD), DAE, Khagrachari district

Plate-32: KII conducted with Upazila Agriculture Officer, Khagrachari Sadar, Khagrachari district

Plate-33: KII conducted with Deputy Director (DD), DAE, Natore district

Plate-34: KII conducted with Upazila Agriculture Officer, Bandarban Sadar, Bandarban district

1.7.2.4 Literature review

The current PRA related literatures and information were collected from different secondary sources such as journals, books, proceedings, internet browsing especially through websites of CAB International, EPPO Bulletin and different LAN based e-Journals namely TEEAL, HINARI, AGORA, OARE, etc. The documents were then critically reviewed and synthesized in relation to identify the quarantine pests of mango available in the country of mango exports to Bangladesh namely Thailand, India, Australia, Pakistan, the Philippines, etc. as well as to get the information regarding PRA related activities performed there. Ultimately, study team formulated all these synthesized information based on the requirement of the current PRA.

1.7.2.5 Field visit and observation by PRA team

Experts of the PRA study team physically visited the mango field at sampled districts of the study areas. They observed the infestation status of the insect and mite pests, diseases, weeds and other pests associated with the mango at field level and recorded the information as required for this study. In addition of field visit, they also conducted Key Informant Interviews with field level DAE officials as well as FGDs with the participation of mango producers. The activities of field visit and observations as conducted by PRA study team members are shown in the following photographs:

Photographic presentation of field visit and observation related activities by means of field inspection, FGDs with mango producers and KIIs with field level DAE officials under Exportable Mango Production Project (EMAP), Department of Agriculture Extension (DAE)

Plate-35: Farmer's field visit conducted by PRA team members at Chapainawabganj Sadar Upazila under Chapainawabganj district

Plate-36: Farmer's field visit conducted by PRA team members at Shibganj Upazila under Chapainawabganj district

Plate-37: Farmer's field visit conducted by PRA team members at Charghat Upazila under Rajshahi district

Plate-38: Farmer's field visit conducted by PRA team at Khagrachari Sadar under Khagrachari district

Plate-39: Farmer's field visit conducted by PRA team member at Shibganj Upazila, Chapainawabganj

Plate-40: Visit of Central Packing House under Plant Quarantine Wing, DAE at Shampur, Dhaka

Plate-41: PRA team conducted KII with UAO, Shibganj Upazil, Chapainawabganj district

Plate-42: PRA team conducted KII with UAO, Khagrachari Sadar, Khagrachari district

Plate-43: PRA team conducted KII with mango producer cum exporters at Shibganj Upazila, Chapainawabganj district

Plate-44: KII with senior scientist of Mango Research Center, Chapainawabganj conducted by PRA team

Plate-45: PRA team member conducted KII with Quarantine Pathologist, Plant Quarantine Wing (PQW), DAE at Hazrat Shah Jalal International Air, Dhaka

Plate-46: PRA team conducted KII with Additional DD (mid) and exporter (left) at Central Packing House, Plant Quarantine Wing, DAE Shampur, Dhaka

Plate-47: FGD with mango producers at Shibganj Upazil, Chapainawabganj conducted by PRA team

Plate-48: FGD with mango producers at Charghat Upazil, Rajshahi conducted by PRA team

1.7.2.6 Listing of pests of mango

The insect and mite pests, diseases, weeds and other pests associated with mango were identified through the field survey, focus group discussion, Key Informant Interview, direct field visit and secondary literature survey. Subsequently, study team prepared a list of insect and mite pests, diseases, weeds and other pests associated with mango following the relevant framework for pest risk analysis adopted by the IPPC in International Standard for Phytosanitary Measures (ISPMs) and other related ISPMs. The quarantine pests of mango for Bangladesh were also listed.

1.7.3 PRA location and study sampling

The survey study was conducted in the 15 major mango growing districts of Bangladesh as selected by the client—Project Director, Exportable Mango Production Project (EMAP) of Department of Agricultural Extension (DAE), Bangladesh. A total of 46 upazila under 15 selected mango growing districts were covered as PRA areas, where two agricultural blocks for each upazila and 30 mango growers for each block were selected for face-to-face interview. Thus, a total of 2,760 mango growers were interviewed through a pre-designed structured questionnaire from all of 15 sampled districts. The district and upazila-wise distribution of respondents are given below:

Table-1: Distribution of the respondents in major mango growing districts of Bangladesh

Sl. No.	District	Upazila	No. of mango growers interviewed	No. of FGD conducted	No. of KII completed
1	Rajshahi	Bagha	60	1	1
		Charghat	60		1
		Putia	60		1
		Tanor	60		1
		Mohanpur	60		1
2	Naogaon	Badalgachi	60	1	1
		Sapahar	60		1
		Porsa	60		1
		Manda	60		1
3	Natore	Natore Sadar	60	1	1
		Baraigram	60		1
		Bagatipara	60		1
		Lalpur	60		1
4	Chapainawabganj	Sadar	60	1	1
		Shibganj	60		1
		Nachol	60		1
		Bholahat	60		1
		Gomostapur	60		1
5	Rangpur	Sadar	60	1	1
		Pirganj	60		1
		Mithapukur	60		1
		Badarganj	60		1

Sl. No.	District	Upazila	No. of mango growers interviewed	No. of FGD conducted	No. of KII completed
6	Thakurgaon	Sadar	60	1	1
		Pirganj	60		1
7	Dinajpur	Sadar	60	1	1
		Birol	60		1
		Birganj	60		1
		Nawabganj	60		1
8	Jessore	Manirampur	60	1	1
		Sharsha	60		1
9	Satkhira	Sadar	60	1	1
		Kaiaroa	60		1
		Debhata	60		1
10	Kushtia	Mirpur	60	1	1
		Daulatpur	60		1
11	Chuadanga	Damurhuda	60	1	1
12	Meherpur	Sadar	60	1	1
		Mujibnagar	60		1
13	Rangamati	Sadar	60	1	1
		Nanyarchar	60		1
		Barokal	60		1
14	Bandarban	Sadar	60	1	1
		Ruma	60		1
		Lama	60		1
15	Khagrachari	Sadar	60	1	1
		Dighinala	60		1
Total	15	46	2,760	15	46

In addition of quantitative survey, to get the qualitative information, a total of 15 focus group discussion (FGD) meetings was also conducted considering one FGD for each of 15 sampled districts with the participation of at least 10 mango growers for each FGD to gather qualitative data regarding pests of mango available in Bangladesh. Besides, one officer designated as Additional Deputy Director (Plant Protection) from each of 15 mango growing districts and one Upazila Agricultural Officer (UAO) of DAE from each of 46 sampled upazila, three quarantine officials of DAE, two mango exporters and two mango importers, and two entomologists and two plant pathologists were also interviewed using semi-structured key informant interview (KII) checklists.

The sample districts selected for PRA study are shown as indicated by red colored star marks in the Bangladesh map.

Bangladesh Map showing PRA sample districts indicated through red colored star marks

1.7.4 Interpretation of results

The collected information on pests of mango, their risk assessment and management options were analyzed and interpreted. The most vulnerable stages of plant growth as well as parts of plants affected by the pests of mango were also determined based on both primary and secondary data. Subsequently, a comprehensive list of pests of mango was prepared based on locally available in Bangladesh as well as quarantine pests of mango for Bangladesh as recorded in countries of mango to be exported. Finally, the necessary interpretation of the findings and risk analysis of the quarantine pests of mango was done as per requirement of the PRA study following relevant ISPMs.

1.7.5 Pictorial presentation of mango pests

During field inspection, the pictures of insect and mite pests, diseases, weeds and other pests associated with the mango and its plants as well as plant parts were captured by the camera. These pictures have been presented in this PRA report to recognize the mango pests available in Bangladesh.

CHAPTER 2
RISK ANALYSIS PROCESS AND METHODOLOGY

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

2.1 Undertaking of Pest Risk Analysis (PRA)

The PRA study team followed a systematic process of pest risk analysis according to ISPM 11 in the framework of ISPM No. 2. The PRA study team followed a systematic process of pest risk analysis according to ISPM 11 in the framework of ISPM No. 2. The PRA process is a technical tool used for identifying appropriate phytosanitary measures. The PRA process may be used for organisms not previously recognized as pests (such as plants, biological control agents or other beneficial organisms, living modified organisms), recognized pests, pathways and review of phytosanitary policy. The process consists of three stages: 1: Initiation; 2: Pest risk assessment; and 3: Pest risk management. As per the three (3) stages of PRA, 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

When the PRA process has been triggered by a request to consider a pathway, the above steps are preceded by assembling a list of organisms of possible regulatory concern because they are likely to be associated with a pathway.

At the initiation stage of conducting PRA study, the report on “Pest Risk Analysis (PRA) of Mango in Bangladesh” previously conducted by the “Strengthening Phytosanitary Capacity in Bangladesh (SPCB) of DAE” has been considered to prepare the report of current PRA study. As per requirement of the international standard, in every three to five years interval, PRA of any commodity need to be updated by the NPPO. Considering these, the present PRA study has been initiated for conducting Pest Risk Analysis of Mango in Bangladesh.

PRA STAGE 2: PEST RISK ASSESSMENT

Pest risk assessment (for quarantine pests): Evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences [FAO, 1995[14]; revised ISPM No. 11 (FAO, 2013)[15]; ISPM No. 2 (FAO, 2007)[16]]

Pest risk assessment (for **regulated non-quarantine pests**): Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact [ISPM No. 21 (FAO, 2004)[17]]
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)[18].

Analytical framework of risk analysis of potential pest/hazards is described below:

Pest categorization: The purpose of pest categorization is to determine whether a pest identified during the initiation stage satisfies the criteria of being a quarantine pest. A quarantine pest is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2013)[19]. In this step, potential hazards/organisms are categorized along with their hosts, distributions, and finally, conclusion is drawn whether the categorized potential hazards/organisms are present or not in the PRA areas as well as in country of export from where the commodities associated with categorized hazards/pests might be transported.

Assessment of the probability of introduction and spread: According to ISPM No. 11 in the framework of ISPM No. 2, the probability of introduction and spread of quarantine pests was assessed considering the following criteria:

Establishment Potential of this Pest in Bangladesh

Description	**Establishment Potential**

[14] FAO (1995). ISPM No. 1: Principles of plant quarantine as related to international trade, Food and Agriculture Organization (FAO), Rome, Italy.
[15] FAO (2013) ISPM No. 11: Pest risk analysis for quarantine pests, FAO Rome, 26 pp.
[16] FAO (2007) ISPM No. 2: Framework for pest risk analysis, FAO Rome, 35 pp.
[17] FAO (2004) ISPM No. 21: Pest risk analysis for regulated non-quarantine pests, FAO Rome18pp.
[18] FAO (1995). ISPM No. 1: Principles of plant quarantine as related to international trade, Food and Agriculture Organization (FAO), Rome, Italy.
[19] FAO (2013) ISPM No. 11 Pest risk analysis for quarantine pests, FAO Rome, 26 pp.

a. Has this pest been established in several new countries in recent years? b. Possibility of survival during transport, storage and transfer? c. Does the pathway appear good for this pest to enter Bangladesh and establish? d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?	**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 appear good for this pest to enter your country and establish, and • Its host(s) are not common in your country and your climate is not similar to places it is established	Low

Assessment of potential economic consequences: According to ISPM 11 in the framework of ISPM-2, the potential economic consequences including environmental impacts of the quarantine pests were assessed considering the following criteria:

Consequence Potential of the Pest in Bangladesh

Description	Consequence potential
a. Is the organism a serious pest of Bangladesh? b. Economic Impact and Yield Loss c. Environmental Impact	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in your country.	Low

Overall Assessment of Risk for Bangladesh

Based on the establishment potential and consequence potential as assessed using the above-mentioned criteria, the overall assessment of risk of the pests for Bangladesh is calculated using the following Risk Matrix of the Quarantine Pest(s):

Establishment Potential X Consequence Potential = Risk

Risk Matrix of Mango Pests for Bangladesh

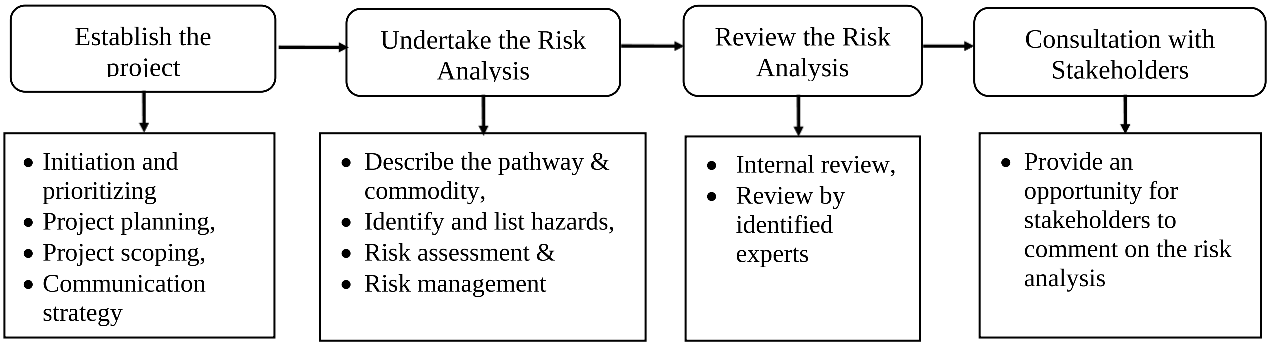
Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

PRA STAGE 3: PEST RISK MANAGEMENT

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 were also considered and included in the selection of a pest management option.

The following figure briefly describes the risk analysis process and methodology for undertaking pathway risk analyses. The risk analysis process leading to the final risk analysis document is summarized in following Figure-2:

Figure-2: A summary of the risk analysis development process



2.2 Import Pathway Description

2.2.1 Import pathways of mango

For the purpose of this risk analysis, in Bangladesh mangoes are imported from anywhere of exporting countries such as Thailand, India, Pakistan, Australia, the Philippines, etc.

To comply with existing Bangladesh's import requirements for mango, the commodity would need to be prepared for exporting to Bangladesh by ensuring certain pests such as insect and mite pests, diseases, weeds or any other pests are not associated with the mango and/or saplings of mango. Commodity would then be sea or land or air freighted to Bangladesh where it goes to a holding facility before being distributed to dealers, distributors, markets, sellers and growers for cultivation or users of the imported mango and/or saplings.

2.2.2 Pathway Description

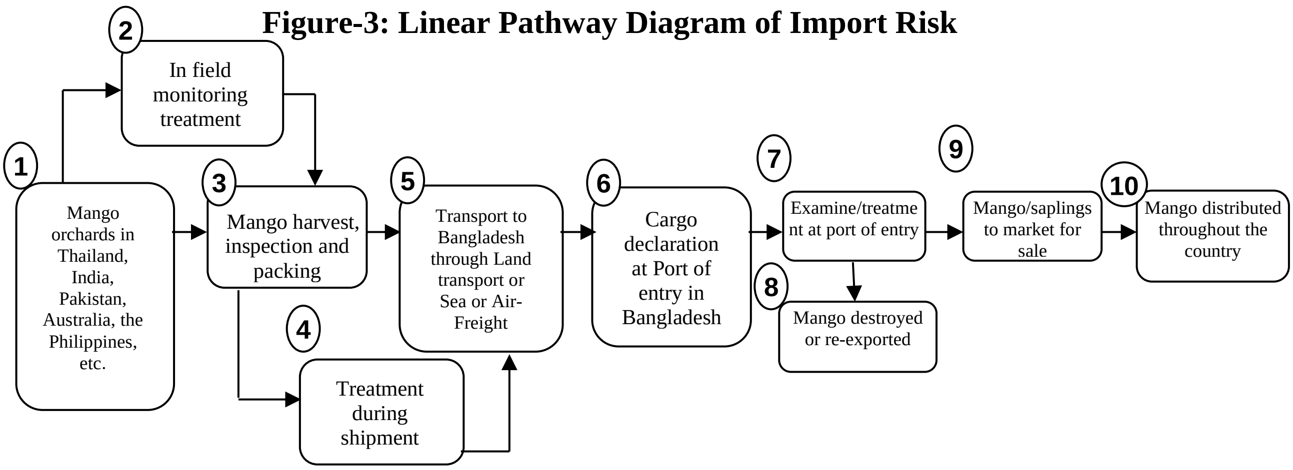
The first step in the risk analysis process is to describe the entry pathway of the commodity. This includes relevant information on:

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

The import pathways of the mango and/or mango saplings from any country of export to Bangladesh is described below:

- Mango and/or mango saplings in the countries of export such as Thailand, India, Pakistan, Australia, the Philippines, etc. are being grown in the orchard, either as a single crop or beside other field or horticultural crops;
- Monitoring of insect and mite pests, diseases, weeds and any other pests of mango is undertaken, with appropriate controls applied in mango orchard in the country of export;
- Mango are being harvested, inspected and after necessary sorting and grading the best quality mango washed, pre-treated and packed in boxes;
- Post harvest disinfestations including fumigation or cold disinfestations are being undertaken either before or during transport of mango and/or mango saplings to the country of import—here, Bangladesh;
- Transport of commodity to Bangladesh is by airfreighted or sea or land port;
- Each shipment must be accompanied by the appropriate certification, e.g., a phytosanitary certificate attesting to identity the mango, any treatments completed, or other information required to help for mitigating the risks;
- Mango and/or its saplings are examined at the border to ensure compliance;
- Any mango and/or saplings not complying with Bangladesh biosecurity requirements (e.g., found harboring pest organisms) are either treated or re-shipped or destroyed;
- Beside these, natural entry of some pests of mango may occur as cross-boundary pests from other neighboring country(ies) into Bangladesh. This should be considered as pathway of pest entry.
- Possibility of entry of pests of mango from exporting country(ies) into Bangladesh through transportation of commodities by escaping the phytosanitary inspection in the port of entry.
- Mango and/or its saplings are stored before being distributed to market for sale.
- Dealers and sellers of mango and/or its saplings stock and these are bought to users and or growers within the local area these are sold in. The linear pathway diagram of import risk of mango is shown in the following Figure-3:

Figure-3: Linear Pathway Diagram of Import Risk

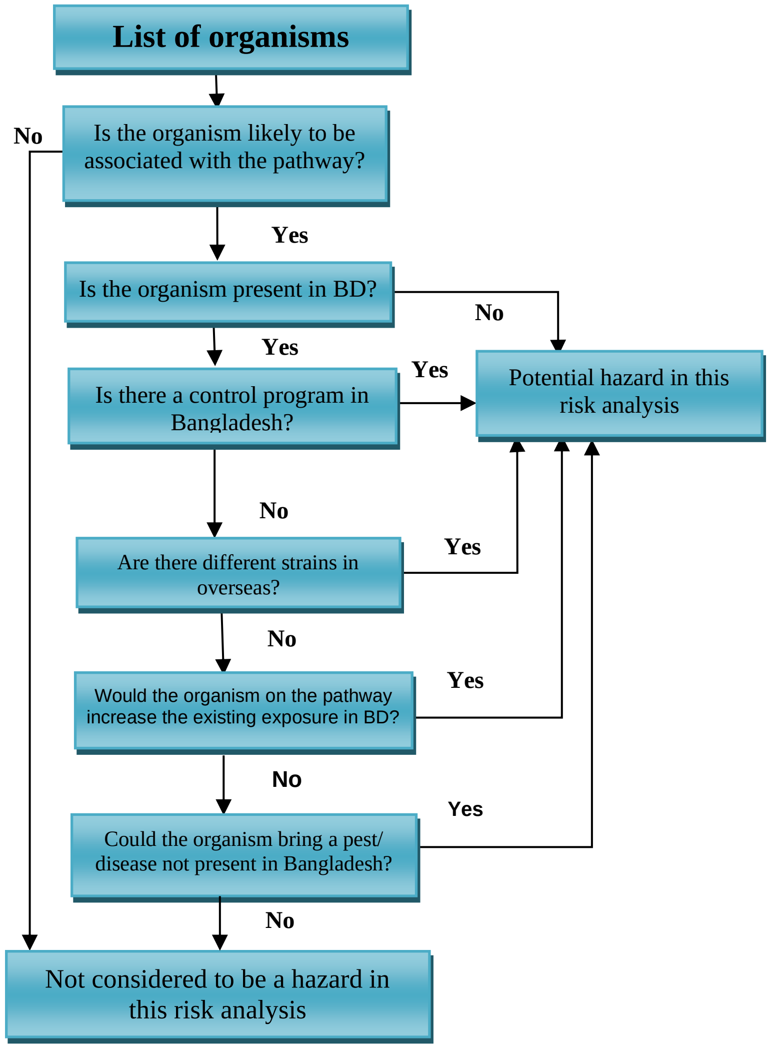


2.3 Hazard Identification

The first step for any risk assessment is to identify the hazard as the risk is related to hazard. Hazards are the unwanted insect pests, diseases (pathogen) or weeds or any other pests of mango which could be introduced into Bangladesh by risk goods, and are potentially capable of causing harm to mango production, must be identified. This process begins with the collection of information on insect pests, diseases (pathogen) or weed or any other pests of mango present in the country of origin. Such list is compared with the existing pests present in Bangladesh to prepare a list of exotic pests that might be associated with the commodity harmful for Bangladesh, if introduce.

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 pest or pathogen 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 which do not feed on it or specifically depend on that commodity in some other ways are also included in the analysis. This is because there may be economic, environmental and human health consequences of these organisms entering and/or establishing. Diagrammatic representation of hazard identification is shown in the following Figure-4:

Figure-4: Diagrammatic representation of hazard identification



2.4 Risk Assessment of Potential Hazards

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 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 assessment, hazards were 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.

2.5 Assessment of Uncertainties

Estimating the likelihood of pest introduction and of the consequences that could result involves many uncertainties. Uncertainty is always part of pest risk analysis (Griffen, 2012)[20]; very often there is a lack of data necessary to reach secure conclusions. The subjective nature of pest risk analysis is also a source of uncertainty. ISPM No. 11 recognizes that pest risk analysis involves many uncertainties, largely since estimates and extrapolations are made from real situations where the pest occurs to a hypothetical situation in the pest risk analysis area. In most cases analyses performed during pest risk analysis use historical data to forecast potential future events. It is important to document the areas of uncertainty and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs (Sansford, 1999)[21].

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 also adopted. In these circumstances, the measures should be consistent with

[20] Griffen, R. (2012) Uncertainty in pest risk analysis, p209-222. In: Devorshak, C. (Ed.) Plant Pest Risk Analysis Concepts and Application. CABI, Wallingford. 296pp.

[21] Sansford CE (1999). Pest Risk Analysis in the UK: Its use to identify research opportunities for exotic plant pathogens. Proceedings of the National Office of Animal and Plant Health, Australia Workshop Plant Health in the New Global Trading Environment: Managing Exotic Insects, Weeds and Pathogens, February 23 –24, 1999, 99–111.

other measures where equivalent uncertainties exist and be reviewed as soon as additional information becomes available.

2.6 Risk Management

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 was also considered and included in the consideration of risk management options. Where there is significant uncertainty, a precautionary approach was adopted.

2.7 Risk Evaluation

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

2.8 Option Evaluation

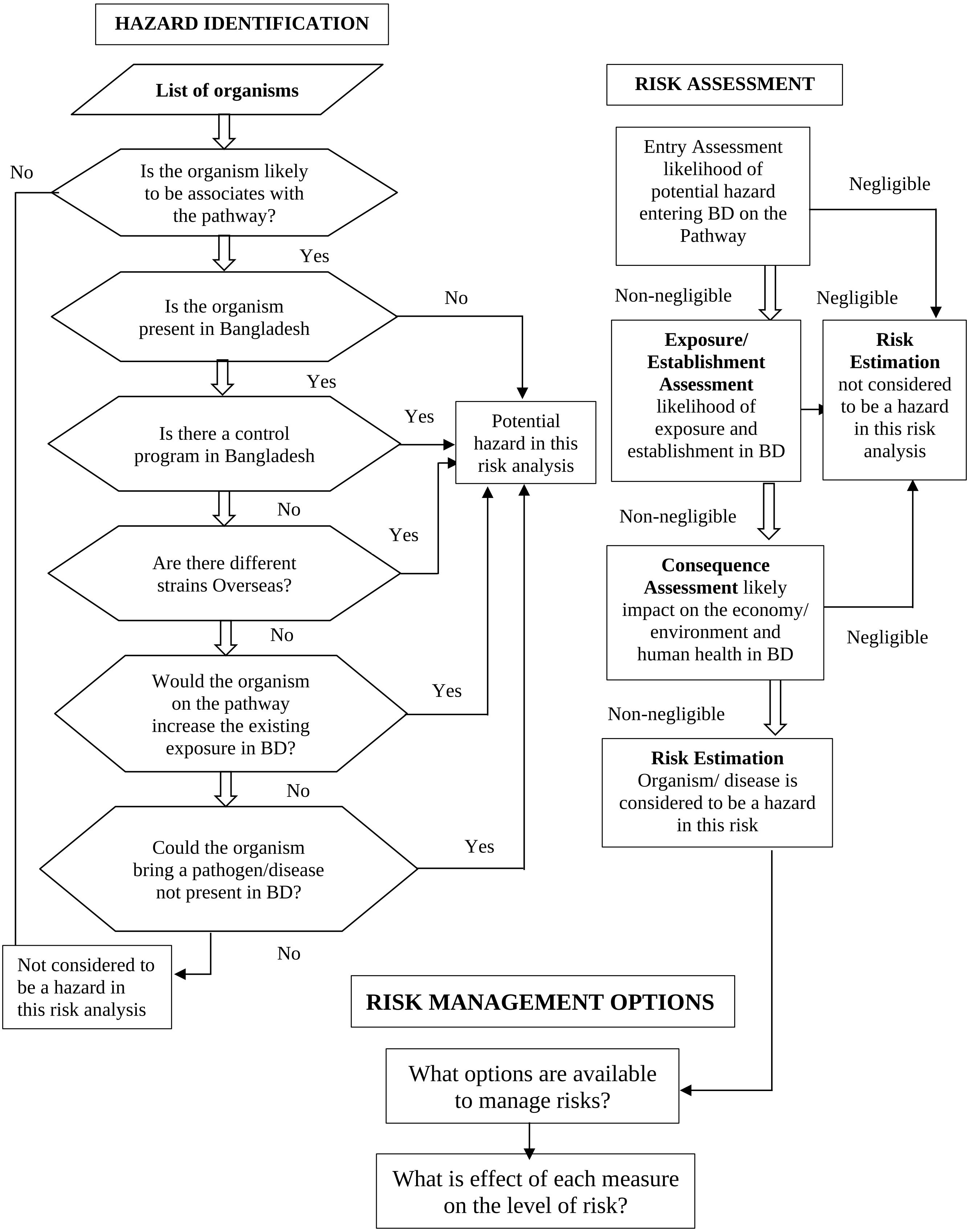
Measures that are expected to be effective against the hazard species are considered. A package of risk management measures is likely to be required to address the risk from all identified hazards. Currently the established pathways are India, Thailand, Pakistan, Australia, the Philippines, etc. for mango and/or its saplings imported into Bangladesh, border interception for these pathways cannot be extrapolated to predict any possible level of slippage or efficacy of treatments. However, border interceptions can be used as evidence of hazard organism association with the commodity. Each new pathway must be regarded as unique, given differing pre- and post-harvest practices and treatment measures. Different pest species are associated with each pathway and measures therefore must be tailored to the individual organisms. So, it consists of

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

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

The result of outlining the risk management options would 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.

Figure-5. Diagram of the Risk Analysis Process that includes hazard identification, risk assessment and risk management



2.9 Review and Consultation

The critique provided by the reviewers where appropriate, was incorporated into the risk analysis to ensure it is based on the most up-to-date and credible information available. 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.

CHAPTER 3
INITIATION

3.1 Introduction

This chapter provides information on the commodity and pathway that is relevant to the analysis of biosecurity risks and common to all organisms or diseases potentially associated with the pathway and commodity—here, the mango. It 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.

3.2 Commodity Description

3.2.1 Mango and its origin

The mango (*Mangifera indica* L.) belongs to the genus *Mangifera* under the flowering plant family Anacardiaceae and cultivated mostly for edible fruit. It is the 'King of Fruits' of Bangladesh which is very important and popular fruit in the world. It is also considered a national fruit of India, Pakistan, and the Philippines. It is believed to have originated in South Asia or the Malayan Archipelago (Salunkhe and Desai, 1984[22]). The mango is native to South and Southeast Asia, from where it has been distributed worldwide to become one of the most cultivated fruits in the tropics. The highest concentration of Mangifera genus is in the Western part of Malesia (Sumatra, Java and Borneo) and in Burma and India (Morton, 1987)[23]. *Mangifera indica*—the "common mango" or "Indian mango"—is the only mango tree commonly cultivated in many tropical and subtropical regions (Kostermans and Bompard, 1993)[24]. It originated in Indian subcontinent and Burma. It is the national fruit of India, Pakistan, and the Philippines, and the national tree of Bangladesh.

3.2.2 Botanical identity

Mango trees grow up to 35–40 m tall, with a crown radius of 10 m. The trees are long-lived, as some specimens still fruit after 300 years. The leaves are evergreen, alternate, simple, 15–35 cm long, and 6–16 cm broad; when the leaves are young, they are orange-pink, rapidly changing to a dark, glossy red, then dark green as they mature. The flowers are produced in terminal panicles 10–40 cm long; each flower is small and white with five petals 5–10 mm long, with a mild, sweet odor suggestive of lily of the valley. Over 400 varieties of mangoes are known, many of which ripen in summer, while some give double crop. The fruit takes three to six months to ripen. The ripe fruit varies in size and color. Cultivars are variously yellow, orange, red, or green, and carry a single flat, oblong pit that can be fibrous or hairy

[22] Salunkhe, D. K., and Desai, B. B. 1984. "Postharvest Biotechnology of Fruits". CRC Press, Inc. Boca Raton, Florida. 1, 168.

[23] Morton, J. 1987. Mango. p. 221–239. (In: Fruits of warm climates. Julia F. Morton, Miami, FL). New Crop Resource Online Program, Purdue University.

[37] Kostermans, A.J.G.H. and Bompard, J.M. 1993. The Mangoes: Their Botany, Nomenclature, Horticulture and Utilization. Academic Press, Waltham.

on the surface, and which does not separate easily from the pulp. Ripe, unpeeled mangoes give off a distinctive resinous, sweet smell. Inside the pit 1–2 mm thick is a thin lining covering a single seed, 4–7 mm long. The seed contains the plant embryo (toptropicals.com). The taxonomic position of mango is given below:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Sapindales
Family: Anacardiaceae
Genus: Mangifera
Species: *Mangifera indica*

EPPO Code: MNGIN (*Mangifera indica*)

3.2.3 Mango variety

Mango, the king of fruits in Bangladesh, is several times ahead among fruits produced in terms of production, trade, and consumer demand. According to the Horticultural Research Center (HRC) of Bangladesh Agricultural Research Institute (BARI), 21 varieties of mangoes are produced in Bangladesh on a commercial basis. Among the 21 varieties, half of these are improved varieties of mango. However, there are hundreds of varieties of mangoes that are grown in Bangladesh. The mango season lasts for a total of 5 months, from May to September, while most mangoes are available from June to July. The mango season in Bangladesh can be divided into three parts, early varieties, mid-season varieties, and late varieties. **Early varieties** of mangoes ripen from the second week of May to mid-June, and among these notable varieties are Gopalbhog, Govindobhog, Brindabani, Gulabkhash, Ranipchanda, Himsagar (Khirshapat), and BARI Aam-1. The mid-season mango varieties start ripening from mid-June, the notable varieties are Langra, Haribhanga, Lakkhanbhog, Khudikhirsha, BARI Aam-2, BARI Aam-3 (Amrapali), Bombay, Surjopuri, etc. Late varieties of mangoes are usually ripen from July to the first week of September. The notable late varieties of mangoes are Fazli, Mohanbhog, Ashwina, Gauramati, BARI Aam-4 (hybrid mango), etc.

3.2.4 Climate

The climate of a place is dependent on its latitudes, altitude, temperature and rainfall. Mangoes are grown commercially within an area roughly 30 degrees north to 30-degree south latitude. Bangladesh is situated between 20.5 degree to 26.5-degree north latitude. The mango is in general a tropical fruit that grows in the sub-tropical zone too and grows up to an altitude of 4600 feet (1400m) provided there is no high humidity, rain or frost during the flowering period. So, the range of latitude and altitude in Bangladesh is basically good for mango. It does well within a temperature range from 24 to 27 degree centigrade. Bangladesh's overall mean annual temperature of 18 to 30 degree centigrade, which is quite good for mango production. The amount of rainfall is not so important factor as its intensity and distribution. It can do well in areas having an average rainfall as low as 25 cm to as high as 250 cm. The period of preceding flowering needs to be dry in order to induce flowering in the absence of chilling temperature.

3.2.5 Soil

Mangoes can be grown on a wide range of soil type, but well drainage deep, fertile loamy soil of high to medium high land is best. pH 5.5-7.5 and water table below 180 cm around the year.

3.2.6 Land preparation

Mango plantation are made on the selected site after cleaning the land of all wild growth, weeds etc. The seedling/sapling are planted generally during the rains in pit made well-leveled areas.

3.2.7 Planting system

Square or rectangular for plain land and contour system for hilly areas. One year old seedling obtained through vegetative propagation that are strong, stout, and free from any diseases should be planted.

3.2.8 Mango production in Bangladesh

Bangladesh is one of the major mango-producing countries along with India, China, Thailand, Indonesia, Pakistan, Mexico, Brazil, Nigeria, the Philippines, etc. (Alexander, 1989)[25]. Mango grows in almost all areas of Bangladesh, but the main growing areas are located in the North-Western districts of the country and dominates the economy in Rajshahi and Chapainawabganj districts. In Bangladesh, mango occupies about an area of 2,86,823 acres with a production of 12,14,597 metric tons during 2020-21 according to (BBS, 2022[26]). Based on the FAO Statistical Database, there are top 15 countries who are leading in the production of mango, among which Bangladesh stands 8th in position in terms of production.

3.2.9 Export-imports of mango in Bangladesh

According to the information given by DAE (2023)**,** Bangladesh exports mango mainly to Middle East, United Kingdom, Canada, Switzerland and European countries. The export volume of mango from Bangladesh is about 1757 tons in the fiscal year 2021-22, whereas it was about 791 tons in the previous fiscal year (DAE, 2022[27]). But if one considers the $1.5 billion global mango trade into perspective, Bangladesh's export growth is still very insignificant when the country holds enormous potential as 8th biggest producer of the juicy edible mango fruit (Amber Pariona, 2018[28]).

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[25] Alexander, D. McE. 1989. The mango in Australia, Common-wealth Scientific and Industrial Research Organization, Australia. pp. 1-28.
[26] BBS. 2022. Yearbook of Agricultural Statistics of Bangladesh, 2021. Bangladesh Bureau of Statistics, Ministry of Planning, Bangladesh. pp. 212-213.
[27] DAE, 2022. Bangladesh's Mango Export. Retrieved on 11 February 2023: https://www.thedailystar.net/business/economy/news/mango-exports-hit-five-year-high-3060026
[28] Amber Pariona, 2018. The Top Mango Producing Countries in the World. The World Atlas Economics: Retrieved on 11 February 2023: https://www.worldatlas.com/articles/the-top-mango-producing-countries-in-

For many years, Bangladesh's potential, however, remained largely untapped as the regulators wasn't mindful of implementing good agricultural practices (GAP), a prerequisite for exporting mango to foreign markets. Bangladesh also imports mangoes from different countries viz. Thailand, India, Australia, Pakistan, the Philippines, etc. (DAE, 2022). The amount of mango imports in Bangladesh is neglectable compared to the total production in Bangladesh and export that is almost near to zero (FAOSTAT, 2018[29]).

The introduction of insect pests, plant diseases and weeds is brought about mainly during the accelerated agricultural development in different countries, when plants and plant materials were brought into, or sent out with little or no concern for the insect pests, diseases and weeds that were transported along with them. There are many instances of accidental introductions of insect pests and diseases from one country to another. Extensive damages, often sudden in nature, have been caused not by indigenous pests, but with exotic ones introduced along with plants, plant parts or seeds in the normal channel of trade or individual interest. But the import of mango from different exporting countries to Bangladesh may lead to introduction of Invasive Alien Species (IAS) of pests during international trading that may cause severe damage to mango, if they establish successfully. So, to safeguard our agriculture from entering IAS by imported commodities as well as maintain and develop our market access by fulfilling the importing countries' requirement conducting PRA is most essential. Considering this situation, the project will conduct PRA on mango and prepare a GAP-guidelines for the farmers. The review and analysis of the fruits has been furnished below:

3.3 Description of the Import Pathway

For the purpose of this risk analysis, mango is presumed to be imported from anywhere in exporting counties particularly Thailand, India, Pakistan, Australia and the Philippines. Hence, the quarantine pests of mango for Bangladesh were identified based on the pests available in Thailand, India, Pakistan, Australia, the Philippines, and any other country of the world from where Bangladesh usually imports mango.

During importation, the quarantine pests associated with mango may enter into Bangladesh that may cause serious damage to mango sector in the country. Considering the possibility of introduction and establishment, the risk analysis of quarantine pests of mango was done to set the proper mitigation and phytosanitary measures against those quarantine pests.

Besides, Bangladesh also exports a good quantity of mangoes in UK, Middle East, Canada, and many of the EU Countries, particularly France, Germany, Switzerland, Netherlands, Austria, Italy, etc. To comply with existing export requirements for mango, the commodity would need to be prepared for export by ensuring certain pests (insect and mite pests, diseases, weeds or other pests) are not associated with the product. Commodity would then be sea or land or air freighted from exporting country where it goes to a holding facility before being distributed to dealers, distributors, markets, sellers and farmers for cultivation of the exported

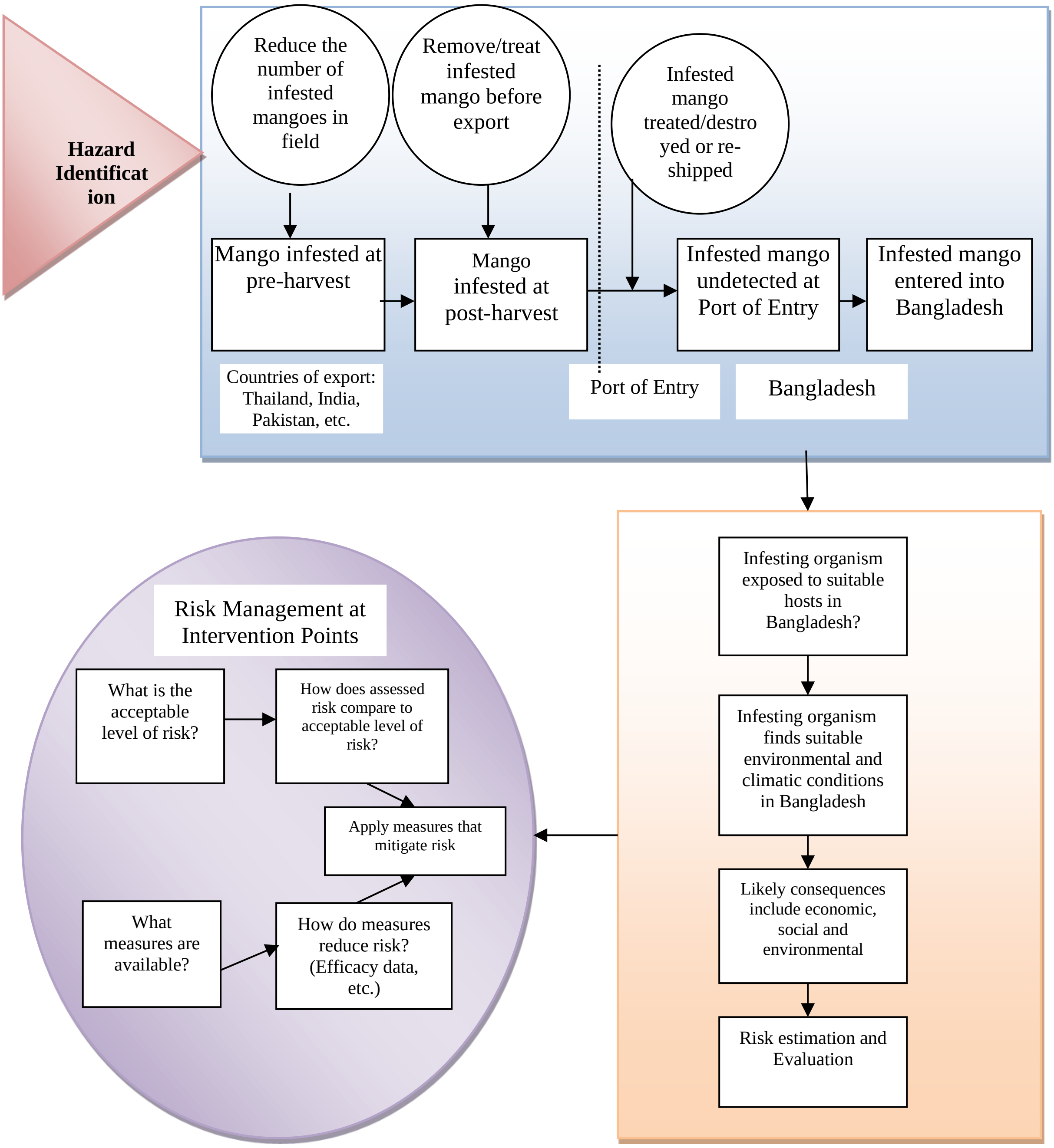
the-world.html#:~:text=Mango%20Producing%20Countries-,India,of%20the%20global%20mango%20supply.

[29] FAOSTAT, 2018. Land use. http://www.fao.org/faostat/en/#country/16 Accessed 4 February 2021

mango. The linear import pathway of mango from any country of export is presented in the following figure:

Synthesis of figures 2 & 3 indicating how the risk analysis process is applied at the pathway level.

Figure-6: Pathway and Likelihood of Entry Assessment



3.4 Geographic Position and General Climate of Importing Countries—Bangladesh

Geographic Position: Bangladesh officially the People's Republic of Bangladesh, is a country in South Asia; and is bordered by India to its west, north and east; Burma to its southeast and separated from Nepal and Bhutan by the Chicken's Neck corridor, while in the south lays the Bay of Bengal.

The latitude of **Bangladesh** is 23°41'39.52" N and the longitude is 90°20'39.67" E. The combination of these two coordinates mean that Bangladesh is located in the northern hemisphere as well as the eastern hemisphere.

General Climate: 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 temperature in different locations of the country ranges from 10.0^{o}C to 15.40^{o}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^{o}C in Mymensingh district to 36.10^{o}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

The Climate of Bangladesh can be divided in different climate zones. The central and southern part can be classified as **Aw**[30] 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**[31] climate; a Temperate, 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

3.5 Geographic Position and General Climate of Exporting Countries

3.5.1 India

Geographic Position: India is situated north of the equator between 8°4' north (the mainland) to 37°6' north latitude and 68°7' east to 97°25' east longitude. It is the seventh-largest country in the world, with a total area of 3,287,263 square kilometers (1,269,219 sq miles). India measures 3,214 km (1,997 mi) from north to south and 2,933 km (1,822 mi) from east to west. It has a land frontier of 15,200 km (9,445 mi) and a coastline of 7,516.6 km (4,671 mi).

[30] *Aw* means Tropical Savanna Climate (*A* = Equatorial, *w* = winter dry)
[31] Cwa means Center Weather Advisory (C = Mild temperate, w = Dry winter, a = Hot summer)

India is situated north of the equator between 8°4' north (the mainland) to 37°6' north latitude and 68°7' east to 97°25' east longitude. The combination of these two coordinates mean that India is located in the northern hemisphere as well as the eastern hemisphere.

General Climate: India's climate can be classified as a hot tropical country. 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, Brahmaputhra 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.

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 Temperate, humid climate with the warmest month above 22°C (Weather Online, 2015a).

3.5.2 Thailand

Geographic Position: It has a total size of 513,120 km^2 (198,120 sq miles) which is the 50th largest in the world. The land border is 4,863 km (3,022 miles) long with Myanmar, Cambodia, Laos and Malaysia. The nation's axial position influenced many aspects of Thailand's society and culture. It controls the only land route from Asia to Malaysia and Singapore.

The GPS coordinates denote that **Thailand** is positioned to the north of the equator. With a latitude of 15.8700° N and a longitude of 100.9925° E, Thailand is surrounded by four other Asian countries.

General Climate: 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[32] climate, a hot, humid climate with all months above 18°C (WeatherOnline, 2015c).

3.5.3 Pakistan

Geographic Position: The **Geography of Pakistan** is a profound blend of landscapes varying from plains to deserts, forests, and plateaus ranging from the coastal areas of the Indian Ocean in the south to the mountains of the Karakoram, Hindukush, Himalayas ranges, in the north. Pakistan is bordered by India to the east, Afghanistan to the northwest and Iran to the west while China borders the country in the northeast.

The latitude of **Pakistan** is 30.3753°N, which denotes Pakistan's positioning in the northern hemisphere. The longitude of the country is 69.3451°E, meaning it is part of the eastern hemisphere. Together, these points indicate that Pakistan is situated to the north of the equator.

General Climate: In case climate, **Pakistan** has recorded one of the highest temperatures (53.5°C) in the world 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 Baluchistan 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°C to 17°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 Baluchistan.

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 Baluchistan, 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.

[32] Af means 'tropical rainforest climate'. These climates usually occur within 10° latitude of the equator.

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

3.5.4 Philippines

Geographic Position: The **Philippines** is an archipelago that comprises 7,641 islands with a total land area of 300,000 square kilometers (115,831 sq miles). It is the world's fifth largest island country. The eleven largest islands contain 95% of the total land area. The largest of these islands is Luzon at about 105,000 square kilometers (40,541 sq miles). The next largest island is Mindanao at about 95,000 square kilometers (36,680 sq mi). The archipelago is around 800 kilometers (500 mi) from the Asian mainland and is located between Taiwan and Borneo.

Philippines is a country in Asia at latitude 11°48′10.80″ North, longitude 122°33′46.80″ East. The combination of these two coordinates mean that Australia is located in the Northern hemisphere as well as the eastern hemisphere.

General Climate: The main variable of the **Philippines climate** is not temperature or air pressure, but rainfall. In general, the climate of the Philippines can be described 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 Philippines 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]

3.5.5 Australia

Geographic Position: The geography of **Australia** encompasses a wide variety of biogeographic regions being the world's smallest continent, while comprising the territory of the sixth-largest country in the world. The population of Australia is concentrated along the eastern and south-eastern coasts. The geography of the continent is extremely diverse, ranging from the snow-capped mountains of the Australian Alps and Tasmania to large deserts, tropical and temperate forests, grasslands, heathlands and woodlands.

The GPS coordinates of Australia are comprised of a latitude of 25.2744° S and a longitude of 133.7751° E. The combination of these two coordinates mean that Australia is located in the southern hemisphere as well as the eastern hemisphere.

General Climate: Due to the huge size of the continent, **Australia** has several 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 harsh 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]

3.6 Pests of Mango in Exporting Countries

The availability of insect and mite pests, diseases, weeds and other pests associated with mango in exporting countries such as India, Thailand, Pakistan, the Philippines and Australia was collected from various secondary sources and critically reviewed. The list of these mango pests has been furnished separately for theses mango exporting countries in the following sub-headings:

3.6.1 India

3.6.1.1 Insect and mite pests of mango

A total of 37 arthropod pests of mango has been reported in India, out of which 36 were insect pests and one was mite pest. The available insect and mite pests of mango as reported in India through the review of secondary documents has been presented in the following Table-3.1 with their common name, scientific name, family, order and reference.

Table-3.1: Insect and mite pests of mango in India

Common name	Scientific name	Family	Order	Reference
Insect Pests				
Mango stone weevil	*Sternochetus mangiferae*	Curculionidae	Coleoptera	Godase *et al.* (2013)
Mango Pulp weevil	*Sternochaetus frigidus*	Curculionidae	Coleoptera	Ahad (2003)
Mango stem borer	*Batocera rubus*	Cerambycidae	Coleoptera	en.wikipedia.org
Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	Naik and More (2019)
Mango leaf cutting weevil	*Deporaus marginatus*	Attelabidae	Coleoptera	Muniappan, R. (2012)
A member of Oriental fruit fly	*Bactrocera caryeae*	*Tephritidae*	Diptera	Jiji *et al.* (2016)
Guava fruit fly	*Bactrocera correcta*	*Tephritidae*	Diptera	Yugendra *et al.* (2020)
Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera	Yugendra *et al.* (2020)

Common name	Scientific name	Family	Order	Reference
Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	Prabhakar (2011)
Mango leaf gall midge	*Procontarinia matteiana*	Cecidomyiidae	Diptera	Prasad and Grover, 1976
Mango Hoppers	*Amritodus atkinsoni, Idioscopus clypealis, I. nagpurensis*	Cicadellidae	Hemiptera	Girish *et al.* (2019)
Coconut scale	*Aspidiotus destructor*	Diaspididae	Hemiptera	Joshi and Sangma (2015)
Mango common scale insect	*Coccus mangiferae (Green)*	Coccidae	Hemiptera	EPPO (2022)
Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	Prakash and Patil (2015)
Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	Verma and Dinabandhoo (2005)
Tapioca scale insect	*Aonidomytilus albus*	Diaspididae	Hemiptera	Sankaran *et al.* (1984)
Shoot gall psyllid	Apsylla cistellata	Aphalaridae	Hemiptera	Akhter *et al.* (2022)
Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Srinivasnaik *et al.* (2016)
Grey pineapple mealybug	*Dysmicoccus neobrevipes*	Pseudococcidae	Hemiptera	García Morales *et al.* (2016)
Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	Josephrajkumar *et al.* (2012)
Fruit tree mealybug	*Rastrococcus invadens*	Pseudococcidae	Hemiptera	Joshi and Sangma (2015)
Cottony cushion scale	*Icerya purchasi*	Monophlebidae	Hemiptera	Kotikal *et al.* (2011)
Peach scale	*Parthenolecanium persicae*	Coccidae	Hemiptera	Shafee *et al.* (1989)
Mango aphid	*Toxoptera odinae*	Aphididae	Hemiptera	UK, CAB International (1991)
Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Munj *et al.* (2017)
Mango defoliator	*Cricula trifenestrata* (Helfer 1837)	Saturnidae	Lepidoptera	Ahad (2003)
Mango fruit borer	*Citripestis eutraphera* Meyrick	Pyralidae	Lepidoptera	Alam & Ahmad (1969)
Mango leaf weber	*Orthaga exvinacea* Hampson	Pyralidae	Lepidoptera	Singh and Verma (2013)
Mango leaf caterpillar	*Euthalia aconthea*	Gracillariidae	Lepidoptera	Wikimediacommons (2015)
Shoot borer of mango	*Penicillaria jocosatrix*	Noctuidae	Lepidoptera	CABI (2000)
Bark eating caterpillar of mango	*Indarbela tetraonis*	Metarbelidae	Lepidoptera	Plantwise Factsheets for Farmers (2013)
Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Chakravarty and Srivastava (2020)
Black tea thrips	*Heliothrips haemorrhoidalis*	Thripidae	Thysanoptera	Bhatti (1990)
Mango/chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Kumar and Rachana (2021)
Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Chinthangkhomba and Varatharajan (2016)
Yellow crazy ant	*Anoplolepis gracilipes*	Formicidae	Hymenoptera	Invasive Species Specialist Group (ISSG) (2011)
Mite pest of mango				
Mango eriophyid mite	*Aceria mangiferae* Sayed	Eriophyidae	Acarina	www.agridr.in

3.6.1.2 Diseases of Mango

A total of 14 diseases of mango has been reported in India, out of which 11 were fungal diseases, one algal, one bacterial and one nemic diseases. The available diseases of mango as reported in India through the review of secondary documents has been presented in the following Table-3.2 with their common name, scientific name, family, order, pest status and reference.

Table-3.2: Diseases of mango in India

Common Name	Scientific name	Family	Order	Pest status	References
Causal organism: Fungi					
Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Minor	Somasekhara (2006)
Mango Anthracnose	*Colletotrichum gloeosporioides*	Glomerellaceae	Glomerellales	Major	EPPO, 2006
Powdery mildew	*Oidium mangiferae*	Erysiphaceae	Erysiphales	Minor	Verma and Sharma, 1999;
Mango malformation	*Fusarium moniliforme*	Nectriaceae	Hypocreales	Minor	Kumar *et al.*, 2011;
Blossom blight/grey mold	*Botrytis cinerea* Pers.1794	Sclerotiniaceae	Helotiales	Minor	Asharafuzzaman, 1991 http://en.wikipedia.org/
Die-back	*Botryosphaeria theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Khanzada et al., 2005;
Leaf and stem blight	*Macrophoma mangiferae* Hing. & Sharma	Botryosphaeriaceae	Botryosphaeriales	Minor	Hingorani, *et al.*, 1960;
Mango scab	*Elsinoë mangiferae*	Elsinoaceae	Myriangiales	Minor	Ashrafuzzaman, 1991
Fruit-end-rot of mango	*Phomopsis mangiferae* S. Ahmad 1954	Diaporthaceae	Diaporthales	Major	Laxinarayana and Reddy, 1975
Twig canker/stem-end rot	*Cytosphaera mangiferae* Died. 1916	Incertae sedis	Incertae sedis	Minor	Farr et al., 2006;
Mango black spot	*Actinodochium jenkinsii* Uppal, Patel & Kama*t*	Incertae sedis	Incertae sedis	Minor	Uppal *et al.*, 1953
Causal Organism: Algae					
Leaf red rust	*Cephaleuros virescens* Kunze 1827	Trentepohliaceae	Trentepohliales	Minor	Ashrafuzzaman, 1991;
Causal organism: Bacteria					
Asiatic canker	*Xanthomonas citri*	Xanthomonadaceae	*Xanthomonadales*	Minor	Savitha *et al.* (2016)
Causal organism: Nematode					
Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	Minor	Patel *et al.* (2021)

3.6.1.3 Weeds of Mango

There were two weeds of mango has been reported in India namely Parthenium and Loranthus/Indian mistletoe that has been presented in the following Table-3.3 with their common name, scientific name, family, order, pest status and reference.

Table-3.3: Weeds of mango in India

Common Name	Scientific name	Family	Order	Pest status	References
Weeds of mango					
Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Minor	Das and Nath (2022)
Loranthus/ Indian Mistletoe	*Dendrophthae falcate*	Loranthaceae	Santalales	Minor	Singh, 2015

3.6.2 Thailand

3.6.2.1 Insect pests of mango

A total of 26 insect pests of mango has been reported in Thailand. The available insect pests of mango as reported in Thailand through the review of secondary documents has been presented in the following Table-3.4 with their common name, scientific name, family, order and reference.

Table-3.4: Insect and mite pests of mango in Thailand

Common Name	Scientific name	Family	Order	References
Mango pulp weevil	*Sternochaetus frigidus*	Curculionidae	Coleoptera	EPPO (2006)
Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	Mitra *et al.* (2016)
Mango leaf cutting weevil	*Deporaus marginatus*	Attelabidae	Coleoptera	Muniappan, R. (2012)
Guava fruit fly	*Bactrocera correcta*	*Tephritidae*	Diptera	Orankanok *et al.* (2013)
Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera	Tigvatananont and Areekul (1984)
Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	NHM (Undated)
Inflorescence midge	*Erosomyia indica*	Cecidomyiidae	Diptera	Waterhouse (1993)
Mango Hoppers	*Amritodus atkinsoni, Idioscopus clypealis, Idioscopus nagpurensis*	Cicadellidae	Hemiptera	Waterhouse (1993)
Coconut scale	*Aspidiotus destructor*	Diaspididae	Hemiptera	Waterhouse (1993)
Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	
Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	UK, CAB International (1969)
Tapioca scale insect	*Aonidomytilus albus*	Diaspididae	Hemiptera	APPPC 1987
Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Williams (2004)
Grey pineapple mealybug	*Dysmicoccus neobrevipes*	Pseudococcidae	Hemiptera	García Morales *et al.* (2016)
Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	CABI and EPPO (2005)
Fruit tree mealybug	*Rastrococcus invadens*	Pseudococcidae	Hemiptera	EPPO (2022)

Common Name	Scientific name	Family	Order	References
Cottony cushion scale	*Icerya purchasi*	Monophlebidae	Hemiptera	Waterhouse (1993)
Mango aphid	*Toxoptera odinae*	Aphididae	Hemiptera	UK, CAB International (1991)
Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Waterhouse (1993)
Shoot borer of mango	*Penicillaria jocosatrix*	Noctuidae	Lepidoptera	CABI (2000)
Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Bhonwong *et al.* (2009)
Black tea thrips	*Heliothrips haemorrhoidalis*	Thripidae	Thysanoptera	Waterhouse (1993)
Mango/chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Toda *et al.* (2014)
Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Kadirvel *et al.* (2013)
Yellow crazy ant	*Anoplolepis gracilipes*	Formicidae	Hymenoptera	Invasive Species Specialist Group (ISSG) (2011)
Rubber termite	*Coptotermes curvignathus*	Rhinotermitidae	Isoptera	Waterhouse (1993)

3.6.2.2 Diseases of Mango

A total of 6 diseases of mango has been reported in Thailand, out of which six (6) were fungal diseases, one algal, one bacterial and one nemic diseases. The available diseases of mango as reported in Thailand through the review of secondary documents has been presented in the following Table-3.5 with their common name, scientific name, family, order, pest status and reference.

Table-3.5: Diseases of mango in Thailand

Common Name	Scientific name	Family	Order	Pest status	References
Causal organism: Fungi					
Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Minor	EPPO (2022)
Powdery mildew	*Oidium mangiferae*	Erysiphaceae	Erysiphales	Minor	Akhter *et al.* (2000)
Alternaria leaf spot	*Alternaria alternate (Fr.)* Keissl.	Pleosporaceae	Pleosporales	Minor	Ashrafuzzaman (1991)
Blossom blight/ grey mould	*Botrytis cinerea* Pers.1794	Sclerotiniaceae	Helotiales	Minor	Asharafuzzaman (1991)
Die back	*Botryosphaeria theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Khanzada *et al.* (2005)
Mango scab	*Elsinoë mangiferae*	Elsinoaceae	Myriangiales	Minor	Ashrafuzzaman (1991)
Causal Organism: Algae					
Leaf red rust	*Cephaleuros virescens* Kunze 1827	Trentepohliaceae	Trentepohliales	Minor	Ashrafuzzaman (1991)
Causal organism: Bacteria					
Asiatic canker	*Xanthomonas citri*	Xanthomonadaceae	*Xanthomonadales*	Minor	EPPO (2022)
Causal organism: Nematode					
Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	Minor	Ruanpanun and Khun-in (2015)

3.6.2.3 Weeds of Mango

There were two weeds of mango has been reported in Thailand namely Parthenium and Loranthus/Indian mistletoe that has been presented in the following Table-3.6 with their common name, scientific name, family, order, pest status and reference.

Table-3.6: Weeds of mango in Thailand

Common Name	Scientific name	Family	Order	Pest status	References
Weeds of mango					
Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Minor	Adkins *et al.* (2019)
Loranthus/ Indian Mistletoe	*Dendrophthae falcate*	Loranthaceae	Santalales	Minor	Singh (2015)

3.6.3 Pakistan

3.6.3.1 Insect and mite pests of mango

A total of 18 arthropod pests of mango has been reported in Pakistan, out of which 17 were insect pests and one was mite pest. The available insect pests of mango as reported in Pakistan through the review of secondary documents has been presented in the following Table-3.7 with their common name, scientific name, family, order and reference.

Table-3.7: Insect and mite pests of mango in Pakistan

Common Name	Scientific name	Family	Order	References
A. Insect pests of mango				
Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	Mitra *et al.* (2016)
Mango leaf cutting weevil	*Deporaus marginatus*	Attelabidae	Coleoptera	Muniappan (2012)
Guava fruit fly	*Bactrocera correcta*	*Tephritidae*	Diptera	Bilal *et al.* (2017)
Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera	Zain *et al.* (2020)
Inflorescence midge	*Erosomyia indica*	Cecidomyiidae	Diptera	CABI (2022)
Mango hopper	*Amritodus atkinsoni, I. clypealis, Idioscopus nagpurensis*	Cicadellidae	Hemiptera	Khatri and Webb (2014)
Coconut scale	*Aspidiotus destructor*	Diaspididae	Hemiptera	CABI (1966)
Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	EPPO (2022)
Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Ben-Dov (1994)
Grey pineapple mealybug	*Dysmicoccus neobrevipes*	Pseudococcidae	Hemiptera	EPPO (2022)
Fruit tree mealybug	*Rastrococcus invadens*	Pseudococcidae	Hemiptera	EPPO (2022)
Cottony cushion scale	*Icerya purchase*	Monophlebidae	Hemiptera	EPPO (2022)
Peach scale	*Parthenolecanium persicae*	Coccidae	Hemiptera	CABI (1979)
Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Khatri and Webb (2014)

Common Name	Scientific name	Family	Order	References
Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Khan *et al.* (2019)
Mango/chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	EPPO (2022)
Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Iftikhar *et al.* (2016)
B. Mite pest of mango				
Mango eriophyid mite	*Aceria mangiferae* Sayed	Eriophyidae	Acarina	www.agridr.in

3.6.3.2 Diseases of Mango

A total of 12 diseases of mango has been reported in Pakistan, out of which nine (9) were fungal diseases, one algal, one bacterial and one nemic diseases. The available diseases of mango as reported in Pakistan through the review of secondary documents has been presented in the following Table-3.8 with their common name, scientific name, family, order, pest status and reference.

Table-3.8: Diseases of mango in Pakistan

Common Name	Scientific name	Family	Order	Pest status	References
Causal organism: Fungi					
Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Minor	Ahmad *et al.* (2022)
Powdery mildew	*Oidium mangiferae*	Erysiphaceae	Erysiphales	Minor	Nelson, 2008;
Mango malformation	*Fusarium moniliforme*	Nectriaceae	Hypocreales	Minor	Kumar *et al.* (2011)
Alternaria leaf spot	*Alternaria alternate (Fr.)* Keissl.	Pleosporaceae	Pleosporales	Minor	Ashrafuzzaman, 1991
Blossom blight/ grey mould	*Botrytis cinerea* Pers.1794	Sclerotiniaceae	Helotiales	Minor	Asharafuzzaman, 1991
Die back	*Botryosphaeria theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Khanzada et al., 2005;
Mango scab	*Elsinoë mangiferae*	Elsinoaceae	Myriangiales	Minor	Ashrafuzzaman, 1991
Fruit-end-rot of mango	*Phomopsis mangiferae* S. Ahmad 1954	Diaporthaceae	Diaporthales	Major	Laxinarayana and Reddy, 1975
Twig canker/stem-end rot	*Cytosphaera mangiferae* Died. 1916	Incertae sedis	Incertae sedis	Minor	Farr et al., 2006;
Causal Organism: Algae					
Leaf red rust	*Cephaleuros virescens* Kunze 1827	Trentepohliaceae	Trentepohliales	Minor	Ashrafuzzaman, 1991;
Causal organism: Bacteria					
Asiatic canker	*Xanthomonas citri*	Xanthomonadaceae	*Xanthomonadales*	Minor	EPPO (2022)
Causal organism: Nematode					
Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	Minor	Hussain *et al.* (2015)

3.6.3.3 Weeds of Mango

Two weeds of mango has been reported in Pakistan namely Parthenium and Loranthus/Indian mistletoe that has been presented in the following Table-3.9 with their common name, scientific name, family, order, pest status and reference.

Table-3.9: Weeds of mango in Pakistan

Common Name	Scientific name	Family	Order	Pest status	References
Weeds of mango					
Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Minor	Iqbal *et al.* (2020)
Loranthus/ Indian Mistletoe	*Dendrophthae falcate*	Loranthaceae	Santalales	Minor	Singh (2015)

3.6.4 The Philippines

3.6.4.1 Insect and mite pests of mango

A total of eight (8) arthropod pests of mango has been reported in the Philippines, out of which seven (7) were insect pests and one was mite pest. The available insect pests of mango as reported in the Philippines through the review of secondary documents has been presented in the following Table-3.10 with their common name, scientific name, family, order and reference.

Table-3.10: Insect and mite pests of mango in the Philippines

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests of mango				
Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	DUFFY (1968)
Mango Hoppers	*Amritodus atkinsoni, Idioscopus clypealis, I. nagpurensis*	Cicadellidae	Hemiptera	Yee and Ocampo (2010)
Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	EPPO (2022)
Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	CABI (1969)
Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	Caasi-Lit *et al.* (2012)
Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Khin Nyunt Yee and Ocampo (2010)
Chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Reyes *et al.* (2020)
B. Mite pest of mango				
Mango eriophyid mite	*Aceria mangiferae* Sayed	Eriophyidae	Acarina	www.agridr.in
Fungus				
Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	EPPO (2022)
Nematode				
Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	CABI and EPPO (2002)

3.6.4.2 Diseases of Mango

Two diseases of mango has been reported in the Philippines, out of which one was fungal disease and one nemic disease. The available diseases of mango as reported in the Philippines through the review of secondary documents has been presented in the following Table-3.11 with their common name, scientific name, family, order, pest status and reference.

Table-3.11: Diseases of mango in the Philippines

Common name	Scientific name	Family name	Order name	Reference
Causal organism: Fungus				
Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	EPPO (2022)
Causal organism: Nematode				
Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	CABI and EPPO (2002)

3.6.4.3 Weeds of Mango

One weed of mango has been reported in the Philippines namely Loranthus/Indian mistletoe that has been presented in the following Table-3.12 with their common name, scientific name, family, order, pest status and reference.

Table-3.12: Weeds of mango in the Philippines

Common Name	Scientific name	Family	Order	Pest status	References
Loranthus/ Indian Mistletoe	*Dendrophthae falcate*	Loranthaceae	Santalales	Minor	Singh (2015)

3.6.5 Australia

3.6.5.1 Insect and mite pests of mango

A total of 15 insect pests of mango has been reported in Australia. The available insect pests of mango as reported in Australia through the review of secondary documents has been presented in the following Table-3.13 with their common name, scientific name, family, order and reference.

Table-3.13: Insect and mite pests of mango in Australia

Common Name	Scientific name	Family	Order	Reference
Mango stone weevil	*Sternochetus mangiferae*	Curculionidae	Coleoptera	Peng and Christian (2007)
Queensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	Cameron *et al.* (2010)
Mango hopper	*Amritodus atkinsoni, Idioscopus clypealis, Idioscopus nagpurensis*	Cicadellidae	Hemiptera	Qureshi *et al.* (2011)
Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	Qin and Gullan (1994)
Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	Seebens *et al.* (2017)
Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Ben-Dov (1994)
Cottony cushion scale	*Icerya purchasi*	Monophlebidae	Hemiptera	Williams and Watson (1990)

Common Name	Scientific name	Family	Order	Reference
Peach scale	*Parthenolecanium persicae*	Coccidae	Hemiptera	Rakimov *et al.* (2013)
Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Qureshi *et al.* (2011)
Mango fruit borer	*Citripestis eutraphera Meyrick*	Pyralidae	Lepidoptera	Alam & Ahmad, 1969
Shoot borer of mango	*Penicillaria jocosatrix*	Noctuidae	Lepidoptera	CABI (2000)
Black tea thrips	*Heliothrips haemorrhoidalis*	Thripidae	Thysanoptera	Seebens *et al.* (2017)
Chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	EPPO (2022)
Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Kay and Herron (2010)
Yellow crazy ant	*Anoplolepis gracilipes*	Formicidae	Hymenoptera	Invasive Species Specialist Group (ISSG) (2011)

3.6.5.2 Diseases of Mango

Only one fungal disease of mango has been reported in Australia namely fruit-end-rot through the review of secondary documents that has been presented in the following Table-3.14 with their common name, scientific name, family, order, pest status and reference.

Table-3.14: Diseases of mango in Australia

Common Name	Scientific name	Family	Order	Pest status	Reference
Causal organism: Fungi					
Fruit-end-rot of mango	*Phomopsis mangiferae* S. Ahmad 1954	Diaporthaceae	Diaporthales	Major	Laxinarayana and Reddy, 1975

3.6.5.3 Weeds of Mango

There was one weed of mango has been reported in Australia namely Parthenium and it is presented in the following Table-3.15 with their common name, scientific name, family, order, pest status and reference.

Table-3.15: Weeds of mango in Australia

Common Name	Scientific name	Family	Order	Pest status	Reference
Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Minor	Seebens *et al.* (2017)

CHAPTER 4
HAZARD IDENTIFICATION

4.1 Introduction

This chapter outlines the potential hazards associated with mango in Bangladesh and mango exporting countries viz. India, Thailand, Pakistan, Australia, Philippines, etc. and considers some of the major risk characteristics of the mango and its hazards.

An initial hazard list was made of all pests and pathogens associated with mango found in Bangladesh, and mango exporting countries of the world from where Bangladesh usually imports mango. The PRA study team at first reviewed a report on "Pest Risk Analysis of Mango in Bangladesh' conducted in the year 2015 sponsored by "Strengthening Phytosanitary Capacity in Bangladesh" Project under Plant Quarantine Wing, Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh. This PRA report had made the list of pests of mango those were available in Bangladesh as well as in the above-mentioned exporting countries from where Bangladesh usually imports mango. These lists of pests of mango were used as basis for the current PRA of Mango in Bangladesh. The list of these mango pests was later refined and finalized after adding and/or excluding the pests based on consideration of association with mango as found available in Bangladesh identified through field survey and secondary sources as well as found in the above-mentioned exporting countries identified through literature review. Some hitch-hiker pests are also included in the pest risk analyses, where entry and establishment of a species into the country would cause potential economic, environment and/or health consequences. These organisms were also assessed and discarded as likely hazards based on biology and lack of association with the commodity—here, the mango (*Mangifera indica*). Then all potential hazards identified through primary data collection survey and literature review were considered for pest risk assessment and recommended necessary management options.

4.2 Potential Hazard Groups

Pests and pathogens identified through primary data collection survey as well as literature review were grouped in two main ways regarding their association with the commodity—here, the Mango (*Mangifera indica*). Under their taxonomic category, i.e., Arthropods, Fungi, Bacteria, Viruses, etc., or within the trophic role, they play in their association, and what structures or part of the plants they attack, e.g., surface feeder, internal borer of plant and/or plant parts, seed feeder. 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. If organisms that are hitch-hikers or vectors this is noted in the individual pest risk assessment. The following categories of potential hazards are used for this study:

A. Arthropod
- Insect pest
- Mite pest

B. Pathogen
- Fungi
- Bacteria
- Algae
- Nematode
- Virus

C. Herb
- Weed
- Parasitic plant

4.3 Interception of Pests on Mango from Existing Pathways

In the past, there was no previous pest risk assessment on mango (*Mangifera indica*) from any of the exporting countries including Thailand, India, Pakistan, Australia, the Philippines, etc. As reported by the Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Bangladesh, during inspection in port of entry of mango in Bangladesh, not a pest had been intercepted yet today on the citrus imported into Bangladesh from any country of mango export.

4.4 Review of earlier PRA

The "Pest Risk Analysis (PRA) of Mango in Bangladesh" previously conducted in the year 2015 sponsored by the "Strengthening Phytosanitary Capacity in Bangladesh (SPCB)" under Plant Quarantine Wing, Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh has been considered and reviewed by the current PRA study team. This PRA report was used as the basis to consider the pest list of mango (*Mangifera indica*) as well as to conduct the current study on "PRA of mango in Bangladesh". As per requirement of the international standard, every three to five years interval to update the pest list, PRA of any commodity need to be updated by the NPPO. Therefore, the present "PRA of Mango in Bangladesh" has been initiated and conducted.

4.5 Other Risk Characteristics of the Commodity

Although many pests dealt with in this risk analysis have adequate information for assessment, the PRA study team can't 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 the use of chemical products in agriculture and further reliance on Integrated Pest Management (IPM) strategies it is assumed that new pests might enter the system at some time in future.

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

4.5.2 Latent micro-organisms

Pests such as microbes and fungi infect mango before transit and may not produce symptoms making them apparent only when they reach a suitable climate to sporulate or reproduce.

Many fungi can infect mango after arrival making it difficult to distinguish the origin of saprobes and pathogens without adequate identification. Consumers tend to throw away molded mango rather than take it to a diagnostic laboratory so there is little data on post entry appearance of "invisible organisms".

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 moderately rated insect and mite pests, diseases and weeds or other pests found in Thailand, India, Pakistan, Australia, the Philippines, etc. and any other mango exporting countries of the world.

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 pests of mango in the importing countries, and preferably, any information on incidence level in pests infested mango 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 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 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.

If a pest species occurs in Bangladesh often its full host range, or behavior in the colonized environment remains patchy. It is difficult to predict how a species have in a new environment, particularly if it has not become established as a pest elsewhere outside its natural range. Therefore, there considerable uncertainty around the likelihood of an organism colonizing new hosts or the consequences of its establishment and spread on the natural environment. Where indigenous plants are discussed as potential hosts this is extrapolated from the host range (at genus and family level) overseas and is not intended as a definitive list.

4.8 Assumption and Uncertainties around the Inspection Procedure

Some uncertainty exists around the efficacy of risk management measures. Interception data is one way of estimating efficacy, as records of live and dead organisms indicate the success of a treatment and the thresholds for growth and development of each individual organism. A sample audit is required to monitor efficacy. Currently this is 600 units of fruit/vegetable product per consignment. The assumption is that this monitoring will adequately record type and number of organisms associated with each commodity. The 600-sample inspection requirement to achieve a 95 percent level of confidence that the maximum pest level will not be exceeded makes assumptions around consignment homogeneity, that samples will be random, and that the inspector has a 100 percent likelihood of detecting pests if they are present in the sample. It is accepted that the sampling system is based on a level (percentage) of contamination rather than a level of surviving individuals, and that because for lines of less than 600 units, 100 percent inspection is required, it is therefore acceptable that the effective level of confidence gained by the sampling method significantly increases as the consignment size moves below 10,000. This is because a sample of around 590 provides 95 percent confidence that a contamination level of 1 in 200 (0.5 percent) will be detected in consignments larger than about 25,000 individuals.

4.9 Assumption around Transit Time of Commodity on the Air Pathway

An assumption is made around the time the fresh mango and/or its saplings take to get from the field in India, Philippines, Thailand, Pakistan, Australia, or any other mango exporting country to Bangladesh ready for wholesale, if it is transported by Land port or Sea or Air 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 mango exporting countries
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 management options for insect and mite pests, diseases and weeds of mango have been collected and systematically reviewed by the experts. Besides the management options for mango pests, the phytosanitary procedures were also reviewed. Finally, the review findings on the management options and phytosanitary measures for mango pests have been incorporated in this chapter as follows:

5.2 Insect pests of mango

5.2.1 Mango weevil

In Australia, *S. mangiferae* control is of utmost importance because adult oviposition activities can downgrade the fruit, resulting in reduction in growers' profit (Smith 1996, Peng and Christian, 2007). In South Africa, *S. mangiferae* has to be controlled in orchards where fruit is grown for export market (Villiers 1987, Joubert 1997). Also, Follett (2002) and Abraham *et al.* (2005) showed the importance of controlling *S. mangiferae* because seed weevil infestation can increase fruit drop during the early fruit developmental stage. In other mango-growing regions, there is little incentive for growers to attempt control because the eating qualities of the fruit are usually unaffected.

(a) Cultural control and sanitary measures: Good orchard sanitation is an effective way to reduce adult populations, and this involves the destruction of all the fallen fruit, stones and fruits with seed weevil damage during and immediately after mango harvest (Peng and Christian 2004).

In nursery beds, more seeds than are required for the projected number of seedlings can be planted to allow for a lower percentage of germination. Alternatively, the seed may be shelled and only sound kernels planted (O'Connor, 1969).

(b) Biological control: The ant *Oecophylla smaragdina* is an effective biocontrol agent of *S. mangiferae* adults (Peng and Christian 2004, 2007). A method of using Oecophylla ants together with orchard sanitation has been developed for controlling *S. mangiferae*, and is promoted by the Horticulture Division of Northern Territory Government, Australia (Peng and Christian 2005).

(c) Host plant resistance: In India, ten cultivars (out of 92 studied) were found to be free from *S. mangiferae* infestation, and these cultivars are Sindhu, Bombay Green, Firangi Ludua, Pulihora, Jahangir, Sabja, Salgadino, Hatizool, Dodamio and Fazri (Godse and Bhole 2003). Larval penetration of the seed of the variety Itamaraca is reported to be impossible (Balock and Kozuma, 1964).

(d) Chemical control: Chemical control has been used with some success and a wide range of insecticides have been recommended (Shukla and Tandon 1985, Villiers 1987). The main strategy is to attack diapausing adults by trunk applications or to use foliar sprays at the time of oviposition.

5.2.2 Stem borer

(a) Biological Control

Successful biological control of this species was achieved in Guam (Nafus 1991). In 1986-87 four species of parasitoids were imported from California and India and released. These were *Trichogramma platneri*, *Aleiodes* sp. nr *circumscriptus*, *Blepharella lateralis* and *Euplectrus* sp. nr *parvulus*. *T. platneri* was obtained from California and the other three species came from India. *B. lateralis* was found several miles from the release point within a few months and became readily established, even though only 45 adult flies were released and many of these had damaged wings. *Euplectrus* sp. also became established. The egg parasitoid *T. platneri*, was not recovered and apparently did not establish. The larval parasitoid, *Aleiodes* sp., was recovered several months after it was released, but no parasitized caterpillars could be found 6 months later, and apparently the population failed to establish permanently. Both *B. lateralis* and *Euplectrus* became common in Guam. Population levels of both parasitoids vary with the season. *B. lateralis* is more common during the rainy months from August to November, averaging about 20% parasitization in the wet season and 2% in the dry season. In contrast, *Euplectrus* sp. parasitized about 68% of larvae during the dry months, but only 20% during the wet months. Together they reduced the caterpillar populations to one quarter of previous levels. The damage caused by the mango shoot caterpillar has decreased from about 55% leaf area consumed to about 15%. As a result, production of mangoes increased 40-fold.

(b) Chemical Control

P. jocosatrix caterpillars are readily controlled by chemicals. Both carbaryl and formulations of *Bacillus thuringiensis* effectively reduced caterpillar numbers (Schreiner 1987, Schreiner and Nafus 1991). However, it is difficult to spray frequently enough to protect all vulnerable young foliage. Major leaf flushes, in the greatest need of protection, are also likely to occur during the heavy rainy season when it is difficult to carry out pesticide application. Except in commercial orchards where mango trees are kept pruned at small sizes, it is also difficult to get adequate coverage of large tall trees with small manual applicators.

5.2.3 Fruit flies

(a) Biological Control: Several non-indigenous species have been released for biological control of this fruit fly in Australia. Of these, only *Fopius arisanus* became established, and although it reduced the number of flies per fruit it had little effect on the percentage of fruits damaged (Waterhouse 1993).

(b) Regulatory Control: Many countries, such as the mainland USA, forbid the import of susceptible fruit without strict post-harvest treatment having been applied by the exporter. This may involve fumigation, heat treatment (hot vapour or hot water), cold treatments, insecticidal dipping, or irradiation (Armstrong and Couey 1989). Recent work on hot water dipping was reported by Waddell *et al.* (2000). Irradiation is not accepted in most countries and many have now banned methyl bromide fumigation. Heat treatment tends to reduce the shelf life of most fruits and so the most effective method of regulatory control is to preferentially restrict imports of a given fruit to areas free of fruit fly attack.

(c) Cultural Control and Sanitary Methods: One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper, a paper bag, or in the case of long/thin fruits, a polythene sleeve. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked. Little information is available on the attack time for most fruits but few *Bactrocera* spp. attack prior to ripening.

(d) Chemical Control

Although cover sprays of entire crops are sometimes used, the use of bait sprays is both more economical and more environmentally acceptable. A bait spray consists of a suitable insecticide (e.g., malathion) mixed with a proteinaceous bait (usually termed 'protein'). Both males and females of fruit flies are attracted to protein sources emanating ammonia, so insecticides can be applied to just a few spots in an orchard and the flies will be attracted to these spots when they get near them during their daily foraging (Bateman *et al.*, 1966 ab; Bateman, 1982). The protein most widely used in Australia was acid-hydrolysed yeast. This was neutralised by sodium hydroxide yielding a concentrate with a salt content of up to 50%. In South Australia an effective concentration was found to be strongly phytotoxic due to its high salt content. Thus from 1983 yeast autolysate was used instead (Madge *et al.* 1997). This product can be made cheaply from brewery waste (Umeh and Garcia 2008). Horticultural mineral oil (HMO) is strongly repellent to female *B. tryoni* and can be used successfully to protect fruit in small crops, including home gardens (Nguyen *et al.* 2007, Meats *et al.* 2012).

(e) Male Suppression/Annihilation Techniques and SIT: The males of most pest species of *Bactrocera* are attracted to either cue lure (4-(p-acetoxyphenyl)-2-butanone) or to methyl eugenol (4-allyl-1,2-dimethoxybenzene). Males of *B. tryoni* are attracted to cue lure, sometimes in very large numbers. Combined with an insecticide it can be impregnated into small caneite blocks or other absorbent material. If these are distributed at sufficient density (~ 30m spacing) most males can be annihilated (Bateman 1982). This has been termed the 'male annihilation technique' (MAT). Bateman *et al.* (1966 a,b) pioneered combined MAT and bait spray in Australian coastal and inland towns and on Easter Island (Bateman *et al.*1973, Bateman 1982). This tactic is now used in are-wide management programs.The sterile insect technique (SIT) has been used for localized outbreaks in quarantined areas (Jessup *et al.* 2007).

(f) Early Warning Systems: Many countries that are free of *Bactrocera* spp., such as the USA (California and Florida) and New Zealand, maintain a grid of methyl eugenol and cue lure traps, at least in high-risk areas (ports and airports) if not around the entire climatically suitable area. The trap used will usually be modelled on the Steiner trap (White and Elson-Harris 1994) or Lynfield (pot) trap.

(g) Field Monitoring: Monitoring is largely carried out by traps set in areas of infestation. However, there is evidence that some fruit flies have different host preferences in different parts of their range and host fruit surveys should also be considered as part of the monitoring process.

(h) IPM: The control of tephritid fruit flies is practiced in two ways. The first is area-wide control that requires quarantine regulations and expensive technology such as SIT in a restricted and defendable area, but may require grower and community participation (Jessup *et al.* 2007). Features include trap arrays for early warning and prompt responses, border inspections, community awareness programs as well as bait-spraying and the male annihilation technique (MAT) (Jessup *et al.* 2007). A good example and case study is given by Lloyd *et al.* (2010).

The second is farmer-operated local or 'crop by crop' control and is generally suited to local economies with local (non-export) distribution and is particularly relevant to areas with naturally high endemic pest populations and to village horticulture in tropical Asia and the South Pacific islands (Allwood & Leblanc 1997, Vijaysegaran 1997), where high infestation rates would damage local economies and cause migration to towns.

5.2.4 Mango leaf gall midge

(a) Cultural Control: In India, Prasad (1971) noted that the standard practice of flooding the root zone of mango trees before flowering inhibits the emergence of *E. mangiferae* adults from the soil. Biological Control Biological control has not been attempted and would require considerable research on the natural enemy complex, especially in India where it is likely to be most diverse.

Collection and proper disposal of infested panicles and twigs, and deep ploughing of orchards to expose pupae and diapausing larvae to sun´s heat and natural enemies are general recommendations for a proper integrated management of mango cecidomyiid pests in India (Reddy *et al.* 2018). In Pakistan, Muhammad *et al.* (2013) evaluated the efficiency of colored sticky traps and plastic sheets in capturing adults of *Procontarinia mangicola*. They found that orange-colored traps attracted the highest numbers of adults compared to all other traps.

(b) Chemical Control: In India, chemical control has been attempted using contact insecticides to kill emerging adults. Timing of applications is critical but some success has been claimed in small-scale trials (Prasad 1971). Soil treatments have also been used to kill carry-over populations of larvae in soil under mango trees.

According to Ahmed *et al.* (2005), midges are commonly controlled by the heavy use of synthetic insecticides, although some less-common techniques to manage populations of these pests have been developed and tested over the last years (Muhammad *et al.*, 2013). In India, spreading chlorpyrifos dust on soil below the tree canopy in April-May, and spraying dimethoate at bud burst stage are recommended (Prakash, 2012; Reddy *et al.*, 2018). In Pakistan, Muhammad *et al.* (2017) found that the insecticides Imidacloprid and Nitenpyram were effective against mango gall midges' larval population, while the trees treated with the insectide Bifenthrin showed least development of galls and concluded that the use of these insecticides can be helpful for controlling mango gall midges.

(c) Biological Control: In India, recommendations for a proper management of cecidomyiid pests in mango include conservation of predators like Formicai sp., Oecophila sp. and Camponotus sp., and parasitoids like Platygaster sp., Systasis sp. and Eupelmus sp., associated with Dasineura sp., Tetrastychus sp., associated with E. indica, and the pteromalid Pirene sp., associated with Procystiphora mangiferae (Felt) (Reddy *et al.*, 2018). In Pakistan, a survey of midges and their natural enemies associated with mango showed that

Procontarinia sp. populations were drastically reduced because of increase in parasitism of Closterocerus pulcherimus and an unidentified parasitoid (CABI, 2009).

5.2.5 Mango hopper

(a) Cultural control: Reddy *et al.* (2018) recommends avoiding dense planting and maintain tree architecture in such a way that adequate light is penetrated. They also suggest regulating the number of flushes mainly by pruning. Significant differences in the hopper incidence among genotypes were recorded indicating the scope of host plant resistance (Nachiappan and Bhaskaran 1983; Devi Thangam *et al.*, 2013).

(b) Biological Control: There have been few attempts at biological control of mango leafhoppers, despite the extensive list of parasitoids. Several fungal pathogens may prove useful for biological control (Kumar *et al.*, 1983). Vyas *et al.* (1993) reported on trials of a 75-minute exposure to an inert dust containing 1 billion spores/g of *Metarhizium anisopliae* var. *anisopliae*, which caused 100% mortality of *A. atkinsoni* after 96 h. Reduced exposure times resulted in reduced mortality. Experiments with spore suspensions in 0.1% Tween 80 demonstrated that greatest mortality (24%) was achieved when *A. atkinsoni*, reared on mango twigs, were sprayed with a suspension of 1 billion spores/ml of *M. anisopliae* var. *anisopliae*.

Mohyuddin and Mahmood (1993) reported the egg parasitoids, Gonatocentrus sp., Miurfens sp. *nr. mangiferae* Viggiani and Hayat, *Centrodora sp. nr. scolypopae* Valentine, *Aprostocetus* sp. and *Quadrastichus* sp., and the adult ectoparasitoid *Epipyrops fuliginosa* Tames in Pakistan. Fasih and Srivastava (1990) reported that *Aprostocetus* sp., *Gonatocerus* sp. and *Polynema* sp. parasitize eggs. Five species of predators, including *Chrysopa lacciperda* (Kimmins), *Mallada boninensis* (Okomote), *Bochartia* sp. and two unindentified species (one each of Mantidae and Lygaeidae) prey on nymphs (Fasih and Srivastava, 1990). In India, Sadana and Kumari (1991) studied the efficacy of the lyssomanid spider, *Lyssomanes sikkimensis* on *Idioscopus clypealis*.

Classical biological control of mango hoppers has not been attempted. Whitwell (1993) described four genera of parasitoids from Dominica, the most common being Aprostocetus sp., followed by *Platygaster* sp., *Synopeas* sp. and *Zatropis* sp. Peng and Christian (2005a, b) reported that the weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae) is an efficient biocontrol agent of *I. nididulus* in northern Australia. The entomopathogens, *Verticillium lecanii* (Zimmerman) Viegas, *Beauveria bassiana* Balsamo (Vuillemin) and *Isaria tax*, infect *I. clypealis* in India (Kumar *et al.*, 1993; Srivastava and Tandon, 1986) while the effectiveness of *Metarhizium anisopliae var. anisopliae* was tested under laboratory conditions against *A. atkinsoni* (Vyas *et al.*, 1993). Reddy *et al.* (2018) recommends the conservation of natural enemies of mango hoppers, especially coccinellids (e.g. *Coccinella septempunctata, C. transversalis* and *Menochilus sexmaculatus*) and spiders. This can be achieved by avoiding spray of broad-spectrum insecticides, and instead entomopathogens like *Metarhizium anisopliae* and botanicals should be used.

(c) Field Monitoring: Murthi *et al.* (1983) investigated 12 mango varieties for population fluctuations of leafhoppers during preflowering and postflowering periods by means of monthly sweeps of trees of uniform age. Progeny production by *Idioscopus niveosparsus* on floral branches was positively associated with the nitrogen content of the branches.

(d) Chemical control: Khanzada and Naqvi (1985) reported that six sprays of fenitrothion/year were effective in Pakistan. Nachiappan and Baskaran (1986) tested eight insecticides: phasalone, endosulfan, carbaryl, penthoate, fenitrothion, monocrotophos, quinalphos and phosphamidom. Endosulfan provided the best control when spraying was done 1 week after flowering and another treatment 14 days later. Jhala *et al.* (1989) considered that sprays of carbaryl during the off-season maintained the hopper population at low-density levels. Godase *et al.* (2004) demonstrated that sprays of 0.05% monocrotophos at the first panicle emergence and a second spray 15 days later are essential to prevent yield loss. Kudagamage *et al.* (2001) found that imidacloprid controlled mango hoppers if applied just after flowering and again 10 days later. Verghese (2000) recommends using botanical insecticides, like azadirachtin, lemmon grass oil, and citronella oil, if leafhopper populations are low (<4/panicle). If leafhopper density is beyond 4/panicle, he recommends spraying imidacloprid at 0.3 ml/l or thiamethoxam at 0.5 g/l or lambda-cyhalothrin at 0.5 ml/l at panicle initiation stage. In both cases, spraying should be avoided when trees are on full bloom to avoid damage to pollinating insects (Verghese and Devi Thangam 2011).

5.2.6 Morgan's scale

(a) Cultural Control and Sanitary Methods: In Spain, Limon *et al.* (1976) recorded that carob trees (*Ceratonia siliqua*) were a major reservoir of infestation of citrus by *Chrysomphalus dictyospermi*, but that this problem was decreasing over time as this tree species was being less widely grown.

(b) Biological Control: Successful biological control of *C. dictyospermi* in the Mediterranean Basin was developed by capitalising on the experience gained in California, USA, in controlling citrus scale insects. Various species of Aphytis that had been used for control of *Aonidiella aurantii* in California were introduced, but only *Aphytis melinus* became widely established and effective against *C. dictyospermi*, often displacing the native *Aphytis chrysomphali* (Argyriou, 1974). In Italy, *A. chrysomphali* was responsible for up to 40% parasitism of young adult female *C. dictyospermi* (Viggiani and Iannoconne, 1972). The background and results of biological control of *C. dictyospermi* in Cyprus and Greece were reviewed by Greathead (1976). The successful campaign in Greece was described by De Bach and Argyriou (1967), and that in Morocco by Benassy and Euverte (1970). Subsequently, *A. melinus* spread, or was deliberately introduced to, other countries in the Mediterranean Basin, where it is also an effective control agent - provided chemical control of other pests does not interfere with the parasitoid. In Sicily, *A. melinus* is preyed upon by the introduced ant, *Iridomyrmex humilis* [*Linepithema humile*], causing biological control of *C. dictyospermi* to be ineffective in ant-infested areas of Sicily (Inserra, 1970). In mainland Italy, biological control by A. melinus was so effective that chemical control was unnecessary except in areas infested by I. humilis [L. humile] ants (Inserra, 1971). *Aphytis citrinus* [*Aphytis aonidiae*] appeared in Turkey in 1966 and spread throughout the country, principally attacking *C. dictyospermi* (Tuncyurek-Soydanbay and Erkin, 1979a). *A. citrinus* [*A. aonidiae*] and *A. melinus* apparently did not compete because each species prefers to attack different developmental stages of the scale insect (nymphs on upper leaf surfaces and adults on lower leaf surfaces, respectively); *C. dictyospermi* ceased to be a problem in unsprayed orchards where both parasitoids were present (Tuncyurek and Oncuer 1974). Chkhaidze and Yasnosh (2001) remarked that in the Republic of Georgia, the natural enemy complex considerably limits the presence of *C. dictyospermi*, but does not appear to be capable of eradicating it, so sometimes the use of additional control measures is necessary. In Cuba, control of *C. dictyospermi* by natural enemies is so effective that the scale is only found in citrus orchards that are treated with insecticides, which reduce the natural enemy populations (Fontenla Rizo *et al.* 1987). Benassy (1977) discussed the mass rearing of *A. melinus* in a laboratory in France.

(c) Chemical Control: *C. dictyospermi* can be successfully treated with white mineral oils (Lodos 1982). Chkhaidze and Yasnosh (2001) remarked that in the Republic of Georgia, the natural enemy complex considerably limits the presence of *C. dictyospermi*, but does not appear to be capable of eradicating it, so sometimes the use of additional control measures is necessary. In the Aegean part of Turkey, Soydanbay (1977) recommended a single application of white oil before July if scale density on leaves exceeded 3 scales/cm^2 at the beginning of summer. The use of pesticides can have an adverse impact on natural enemy populations (Bozan and Yildirim, 1992).

(d) Field Monitoring/Economic Threshold Levels: In the Aegean part of Turkey, biological control of *C. dictyospermi* by hymenopteran parasitoids was mostly effective. However, if scale density on leaves at the beginning of summer exceeded a threshold of 3 scales/cm^2, use of a selective insecticide least harmful to the parasitoids was recommended (Tuncyurek-Soydanbay and Erkin, 1981).

5.2.7 Shoot gall psyllid

Management of the shoot gall maker can be made using various techniques.

(a) Cultural control: Pruning and burning of gall. Removal of egg bearing leaves from infested plants (Ajay, 2004 & 2007). Appropriate use of nitrogenous fertilizer.

(b) Resistant variety: Use of resistant varieties like Makaram, Mulgoa, Delhi etc (Shivankar and Rao 2010).

(c) Chemical control: Application of Dimethoate 0.03% three times at 20 days interval was found most successful for the control of mango shoot gall maker (Ajay, 2007). Application of Phosphamidon 0.05% three times at 15 days interval starting from second fortnight of September (Singh and Monobrullah 1997). Bark pasting with Dimethoate. Bark injection of Dimethoate @ 0.3 ml a.i./cm circumference (Singh and Monobrullah 1997). Spray 2,4-D @ 150mg/l of water. Application Imidacloprid 0.006% (Jha, 2013).

5.2.8 Spiked mealybug

(a) Chemical Control: In Hawaii, the efficacy of a series of methods were evaluated as post-harvest treatments to eliminate *N. nipae*, along with other mealybugs, scale insects and aphids, from tropical cut flowers and foliage before shipment. A series of insecticidal dips were tested and the most effective was found to be a combination dip for at least 5 minutes in an insecticidal soap composed of potassium salts of fatty acids with fluvalinate (Hansen *et al.* 1992a). Vapour heat treatment was found to kill mealybug adults and nymphs after 1 hour at 46.6°C; and nymphs were killed after 2 hours at 45.2°C (Hansen *et al.* 1992b). Hydrogen cyanide fumigation treatment was found to kill *N. nipae* nymphs on palms (Hansen *et al.* 1991). Infestations of *N. nipae* were eliminated in coconut plantations by chemically controlling Azteca ants which maintained and protected the mealybug colonies (Raj 1977).

(b) Biological Control: Bartlett (1978) records successful biological control of *N. nipae* in Hawaii by *Pseudaphycus utilis*. In Puerto Rico some improvement was reported following the introduction of *Cryptolaemus montrouzieri*, but good control was later obtained with the establishment of *P. utilis* (Bartlett 1978).

5.2.9 Mango Aphid

(a) Cultural Control: Sanitary measures are important to prevent the spread of viruses for which aphid is a vector. Virus-infected plant material should be removed after harvest and any volunteer plants or weeds that harbour viruses should also be destroyed (Mayeux, 1984)

(b) Chemical Control: Most major groups of insecticides have been used against this insect pest, including chlorinated hydrocarbons, organophosphates, carbamates and pyrethroids. The persistence and effectiveness of insecticides on the plants is an important factor. Control in groundnuts must be very effective between germination and the 40th day, and therefore systemics with satisfactory persistence through this growth stage are preferred. The high cost of systemics to farmers in the developing world emphasizes the need for early warning and forecast systems (Mayeux, 1984). Systemics will kill aphids effectively, but they may still have time to feed and transmit virus before dying. In such circumstances, it may be more effective to control aphids on wild hosts on which they feed before dispersing to crops.

Pest resistance to pyrethroid insecticides. Other sprays tried on crops include neem (Dimetry and El Hawary, 1995) and petroleum oil (El Sisi and El Hariry, 1991). Formulations of neem (*Azadirachta indica*) have been shown to be effective against *A. craccivora* and can be used as an alternative to chemical insecticides (Chaudhari *et al.*, 2015).

Experimental work is focused on botanical insecticides, e.g. oil of *Parkia roxburghii*, fractions of *Atriplex semibaccata* and crude extracts of *Halocnemon strobilacium*. A mixture of alkaloids of *Sophora alopecuroides* and nicotine showed significant synergistic activity against *A. craccivora* in field trials (Huo *et al.*, 2014).

(c) Biological Control: In Bangladesh, five larvae of the coccinellid *Cheilomenes sexmaculata* caused 73-95% suppression of infesting *A. craccivora* at high densities (490-640) and 86-100% reduction on caged bean plants in 7 days; while the efficacy of 15 larvae of *C. sexmaculata* per bean plant was significantly greater than two insecticide treatments (Bari and Sardar, 1998).

A potential parasitoid for biological control programmes is the braconid *Trioxys indicus*. It was introduced to Australia from India to control *A. craccivora* on lupins and other crops (Sandow, 1986). This parasitoid has a high fecundity and can withstand long periods of hot weather. Third-instar nymphs are most suitable for parasitism. However, the presence of hyperparasitoids such as *Aphidencryptus* spp. may limit its effectiveness in certain areas.

Experimental releases of an introduced aphid parasitoid, *Lysiphlebus testaceipes*, from the USA, were carried out in Shaanxi, China, in 1983 (Zheng and Tang, 1989). In the former USSR, *Lysiphlebus fabarum*, which appears in mid-April, reproduced at a rate paralleling that of the aphid and reached its peak of activity in June, when it parasitized up to 85% of an aphid population. To conserve these valuable natural enemies, insecticides should be used against the aphid only in cases of absolute necessity.

(d) Integrated Pest Management: *A. craccivora* is controlled within IPM systems practised on a numerous crop, including cotton in Russia, cowpea in Nigeria, groundnut in Africa and USA, beans in Syria and citrus in Mediterranean Europe. Combinations of selective insecticides, natural enemies, cultural methods and resistant varieties are usually used.

5.2.10 Mango fruit borer

(a) Cultural control: General control measures recommended for control of mango fruit borer include collection and destruction of affected and fallen fruits, avoid weed plants that serve as alternative hosts, using light traps (1 per ha) to monitor the activity of adults and fruit bagging at 55-65 days after pollination (Peña *et al.*, 2009; Reddy *et al.*, 2018).

(b) Chemical control: Control measures against these pests in mango are still mainly depend on the use of pesticides (Istianto and Soemargono, 2015). According to Golez (1991), mango fruit become susceptible to fruit borers 60 days after flowering, and insecticide applications should start at that time. Additional treatments at 75, 90 and 105 days are often required to fully protect the fruit. In Indonesia, Istianto and Soemargono (2015) found that *Noorda albizonalis* began attacking mango fruits when fruits are at the young phase and the attack can occur until the fruits ripened. Chemicals recommended for control of these pests are deltamethrin and cyfluthrin in the Philippines (Golez, 1991), and fenthion, deltamethrin, indoxacarb and dimethoate in India (Prakash, 2012; Reddy *et al.*, 2018). Plantix recommends sprays with thiacloprid or chloripyriphos on marble fruit sizes, but always within an integrated approach (https://plantix.net/en/library/plant-diseases/600128/mango-fruit-borer). In Indonesia, the application of citronella essential oil reduced the rate of fruit borer attack and the production loss on mango (Istianto and Soemargono, 2015). Repellent, insecticidal, inhibitory, and ovicidal properties of the essential oils of citronella would be behind the effective control of mango fruit borers.

(c) Biological control: According to Waterhouse (1998) no natural enemies of mango fruit borers were detected in Java, Indonesia. However, in the Guimaras Islands of the Philippines, the vespid wasp, *Rychium attrisimum*, preys on the larvae, used to stock the wasps' nests as food for their young, as they exit the fruit to pupate and was suspected to contribute to the high larval disappearance in the field. Moreover, the egg parasitoids *Trichogramma chilonis* Ishii and *Trichogramma chilotreae* attack the pest in Luzon (Golez, 1991), and in India, larval parasitoids, such as *Apanteles* sp., *Angitia trochanterata*, and *Bracon brevicornis*, have been reported (Reddy *et al.*, 2018). In spite of this, no references on biological control of these pests through augmentation releases has been found, just the suggestion to maintain natural populations of mango fruit borer predators and parasitoids as high as possible (https://plantix.net/en/library/plant-diseases/600128/mango-fruit-borer). This app also recommends, as part of the biologicl control approach, apply neem extracts at weekly intervals, starting when mango is flowering and for 2 months.

5.2.11 Mango caterpillar

(a) Cultural Control: Cultural manipulations of the crop or cropping system and land management have been tried as tactics to manage *H. armigera* populations. Trap cropping and planting diversionary hosts have been widely applied and recommended in the past, although with limited success (Stadelbacher, 1982).

(b) Biological Control: While IPM strategies are generally geared to provide a regime in which maximum feasible advantage is taken of local biological control agents, their unassisted suppression of *H. armigera* populations to below an economic threshold without the use of insecticides would be a major advantage, both in ecological and economic terms, particularly if this was sustainable. To this end, substantial efforts have been made either to introduce exotic natural enemies or to augment existing populations of parasitoids and predators to achieve satisfactory levels of control. Because of the need to produce very large numbers of parasitoids or predators simultaneously and economically, emphasis has been placed on *Trichogramma* spp. which are most amenable to mass rearing. Although these and a number of other parasitic species have been field evaluated against *H. armigera*, results have not so far been encouraging, especially in agroecosystems where insecticide applications against *H. armigera* or other pests are consistently necessary.

There have been attempts to enhance mortality due to natural enemies by the introduction of species that might complement existing natural enemies or be superior to them (Waterhouse, 1993). Attempted introductions have included parasitoids of *Heliothis virescens* and *Helicoverpa zea* from the Americas as well as species from other parts of the range of *H. armigera*. Few of these have been successful. *Trichogramma pretiosum* and *T. perkinsi* from the USA are reported to have become established in Indonesia and South Africa, respectively. Other successful establishments are: India *(Chelonus blackburni*, *Eucelatoria bryani*, both from the USA, and *Bracon kirkpatricki from* Kenya); Fiji (*Cotesia marginiventris*, also from the USA); New Zealand (*Glabrobracon croceipes* from the USA); Western Australia (*Cotesia kazak* from Europe). However, the introduction of *Cotesia kazak* from Greece into New Zealand, where there were no native parasitoids of this pest, resulted in substantial parasitism but because of the low tolerance for insect damage in tomato crops, insecticides are still needed.

The relative specificity, potential activity, environmental safety and immunity to insecticides have made microbial pesticides a favoured component of IPM strategies, and considerable efforts have been made to develop the most promising agents, *Bacillus thuringiensis* and *Helicoverpa armigera* nuclear polyhedrosis virus (HaNPV) into commercially viable products.

(c) Chemical Control: Most insecticide applications are targeted at the larval stages, but as these are only really effective when larvae are small, the need to scout for eggs and spray soon afterward is paramount. Young larvae are difficult to find, and older larvae soon burrow into the floral organs where they become less accessible to contact insecticides, require higher doses to kill and cause direct economic loss. Moreover, resistant larvae were still susceptible while less than 4 days old, so that targeting of neonates is essential in areas where resistant populations are present (Daly, 1988).

The considerable selection pressure which *H. armigera* has experienced, particularly to the synthetic pyrethroids which were used predominantly in the early 1980s, has resulted in the development of resistance to the major classes of insecticides in many of the areas where these have been used.

Pyrethroid resistance in *H. armigera* may be conferred through three separate mechanisms: detoxification by mixed-function oxidases (metabolic resistance), nerve insensitivity, and delayed penetration. Metabolic resistance may be inhibited by piperonyl butoxide and other synergists, providing a (costly) means whereby the use of pyrethroids might be prolonged in populations where this is the principal mechanism.

(d) IPM Programs: In view of the need to make use of and exploit the existing spectra of natural enemies and to reduce excessive dependence on chemical control, particularly where there is resistance to insecticides, various IPM programmes have been developed in which different control tactics are combined to suppress pest numbers below a threshold. These vary from the judicious use of insecticides, based on economic thresholds and regular scouting to ascertain pest population levels, to sophisticated systems, almost exclusively for cotton, using computerized crop and population models to assess the need, optimum timing and product for pesticide application. The SIRATAC system, developed in Australia during the 1980s, and its subsequent derivatives fall into this category (Room, 1983). A major constraint to the development of IPM for *H. armigera*, particularly on cotton, has been the need to deal with a complex of pests where control needs may be irreconcilable, as for example in the characteristics of the cotton plant which can either be unfavourable to *H. armigera* or to jassid pests in terms of leaf hairiness, and in the withholding of early season applications to encourage the build-up of natural enemies against the need to control sucking pests which can be severe on young plants.

5.2.12 Thrips

Franklinothrips megalops is a common predator of *S. dorsalis* on castor (*Ricinus communis*) plants, each larva consuming 4-5 thrips a day. *Erythrothrips asiaticus* [*Aduncothrips asiaticus*], a highly seasonal species, is also a predator on *S. dorsalis*, along with *Mymarothrips garuda* (Ananthakrishnan, 1984). The predaceous species, *Scolothrips indicus*, feeds on the larvae of *S. dorsalis* (Raizada, 1965). *Geocoris ochropterus* is also reported as a potential predator of *S. dorsalis* (Sannigrahi and Mukhopadhyay, 1992). In Japan, parasitism of larval *S. dorsalis* at rates of up to 52% by the trichogrammatid, *Megaphragma* sp. have been recorded on grapes (Shibao *et al.*, 2000).

Banker plants, such as ornamental capsicums, have been demonstrated to support populations of *Amblyseius swirski*, a predatory phytoseiid mite, from which they can disperse to provide control of *S. dorsalis* infesting greenhouse-grown crops (Xiao *et al.*, 2012). Commercially available entomopathogenic fungi (e.g. *Beauveria bassiana*, *Metarhizium brunneum* and *Isaria fumosorosea*) have been evaluated for efficacy against *S. dorsalis* infesting pepper (*Capsicum annuum*) plants (Arthurs *et al.*, 2013).

5.2.13 Termite

(a) Cultural Control and Sanitary Methods: Ensuring good tree health is likely to reduce the risk of attack by *C. curvignathus*. Trees that are nutrient deficient, water-stressed or grown in waterlogged areas may be more prone to attack (Thapa and Shim 1971, Tho and Kirton 1992 & 1998). Thinning should be conducted at suitable periods to ensure trees are not grown in crowded, light-deprived situations. Mechanical injury to trees from machines or weeding exercises should be minimized. Where pruning is conducted, the wounds need to be properly dressed to reduce the likelihood of these becoming routes of entry into the tree for the termite (Kirton *et al.* 1999b). The control of bark and stem borers is also important because wounds from borers can predispose trees to attack by *C. curvignathus* as well (Kalshoven, 1961, Kirton *et al.* 1999b). Although it has often been suggested that wood debris on the planting site provides food sources and breeding sites for the termite and, thus, it has been strongly advocated that all wood debris be cleared and burnt before planting, recent evidence shows otherwise (Kirton *et al.* 1999a). In reality, the termite is seldom found on wood residues in plantations but attacks trees more frequently. Host susceptibility and residual populations of *C. curvignathus* in the original planting site are the factors that have the largest impact on subsequent attack on plantation trees. The removal of wood debris has limited value, and may only serve to reduce suitable sites for colony establishment in plantations of tree species in which the termite is unable to nest in the trunks.

(b) Tree Species-Site Matching: Wherever possible, trees should be matched with sites on the basis of their relative resistance to attack and the risk posed by the planting site (Kirton 1998). Planting sites originating from land cleared of peat swamps pose a high risk of attack. Planting sites derived from logged over lowland dipterocarp forest pose a moderate risk, whereas sites derived from secondary vegetation dominated by bushes and small trees or grassland pose a lesser threat. Tree species that are particularly susceptible, such as pines, are best planted on sites that pose a low risk, whereas sites that pose a high risk are best planted with resistant tree species.

(c) Biological Control: The use of entomophagous nematodes and entomopathogenic fungi to control species of *Coptotermes* has been largely experimental and laboratory-based, and most of the work has focused on *C. formosanus*. The histopathology of infection by entomopathogenic fungus *Metarhizium anisopliae* in *C. curvignathus* has been investigated in the laboratory (Sajap and Kaur 1990), while field-derived cultures of *Conidiobolus coronatus* have been demonstrated to be highly pathogenic to *C. curvignathus* (Sajap *et al.* 1997).

(d) Chemical Control: Chemical control is the most commonly practiced method of control for *C. curvignathus*. Three general methods exist, that is the use of termiticides, chitin synthesis inhibitors and fumigants.

Termiticides: Termiticides are insecticides formulated for use against termites. Among the insecticides used for this purpose are chlorpyrifos, cypermethrin, alpha-cypermethrin and new generation insecticides such as fipronil and imidacloprid. The use of organochlorine insecticides has been discontinued because of the persistent nature of these insecticides in the environment and their harmful long-term effects on wildlife. Termiticides are usually applied to the soil to form a chemical barrier that protects the tree against termite attack. These chemicals last for several months to a few years depending on the characteristics of the chemical, the concentration used and the site conditions. Chlorpyrifos, for example, has been shown to give at least 4 years protection to *Gmelina arborea* grown in Sabah (Chey 1996b). The chemicals may be applied as a granular formulation or in liquid form, diluted in water. Prophylactic treatment can be used for highly susceptible tree species grown in medium- to high-risk sites, but is not cost effective when the termite hazard is low. Prophylactic treatment involves the application of the termiticides (usually in granular form for ease of application) into the planting hole, mixed with the soil, at the time seedlings are transplanted from the nursery into the field (Tho and Kirton 1992). Remedial treatment is carried out when trees are attacked by termites, and is usually done by drenching the soil surrounding the tree using a water-soluble insecticide formulation. A furrow or drain is dug around the tree to contain the chemical as it seeps into the ground (Tho and Kirton 1992) but better results can probably be obtained if the soil surrounding the tree trunk is shallowly excavated and the chemical is applied to the trunk and allowed to seep into the ground close to the tree.

Chitin Synthesis Inhibitors: These hormones or insect growth regulators are used in a baiting technique that allows the chemical to be taken back to the nest by foraging workers, thereby causing the gradual collapse of the colony from the death of the queen and nymphs. The chemical interferes with the normal moulting process of the termites and the production of eggs by the queen. Hexaflumuron and triflumuron are examples of such chitin synthesis inhibitors; however, they are largely used in the public health pest control industry, and the cost of using them in plantation situations may be prohibitive for the time being. Hexaflumuron has been demonstrated to be effective in eliminating field colonies of *C. curvignathus* (Sajap *et al.* 2000).

Fumigants: These are used primarily to disinfest cargo on board ships prior to export. Sulfuryl fluoride should be used instead of methyl bromide, which is now banned, as it does not damage the Earth's ozone layer. Fumigants are applied to cargo in enclosed situations or after enclosing them with plastic sheets.

(e) Monitoring and Decision Making: Monitoring can be carried out by looking for signs of soil on the surface of tree trunks. In large plantations where close inspection of all trees may be impractical, attack may initially be suspected when wilting or yellowing can be seen from a distance. Closer inspection can then be carried out to determine if the observed symptoms are due to attack by *C. curvignathus*. The distribution of the termite in plantations is usually patchy (Tho and Kirton 1992) and large numbers of foraging workers can attack a number of trees in a localised area near to the nest. Thus, when one tree is attacked, adjacent and nearby trees are likely to be attacked either simultaneously or subsequently. Monitoring and treatment efforts can, therefore, be targeted towards trees in the vicinity of visible attack. The cost of treatment has to be weighed against the potential economic losses when considering whether to embark on treatment. Labour costs and the need to transport large amounts of water to the site can make treatment costs higher than potential economic losses. If the plantation is scheduled to be thinned, the possibility of thinning out trees that are attacked should be considered as an alternative to chemical control.

(f) IPM: The practice of prophylactic soil treatment with insecticides should generally be avoided in favour of pest management practices that reduce the severity of the pest problem. UNEP hosts a website that outlines many alternatives to pesticides for the management of termites, including *C. curvignathus*: http://www.chem.unep.ch/pops/termites/termite_toc.htm.

Tree species-site matching should be considered at an early stage in the planning of the plantation and silvicultural and agricultural practices that minimize tree stress and injury should be employed as a means of reducing the susceptibility of trees to attack.

(g) Phytosanitary Measures: Logs being exported from countries where *C. curvignathus* occurs should be debarked to reduce the risk of transporting alates that could found new colonies. Fumigation of logs or wood material at the port of origin will also reduce the risk of transporting nests, colony fragments or alates.

5.3 Management options for mite pests of mango

(a) Cultural control: Dusty conditions often lead to mite outbreaks. Apply water to pathways and other dusty areas at regular intervals. Water-stressed trees and plants are less tolerant of spider mite damage. Be sure to provide adequate irrigation. Mid-season washing of trees and vines with water to remove dust may help prevent serious late-season mite infestations.

In gardens and on small fruit trees, regular, forceful spraying of plants with water often will reduce mite numbers adequately. Be sure to get good coverage, especially on the undersides of leaves. If more control is required, use an insecticidal soap or oil in your spray, but test the product on one or two plants to be sure it isn't damaging to them (Dreistadt *et al.*, 2004).

(b) Biological control: Mites have many natural enemies, which limit their numbers in many landscapes and gardens, especially when undisturbed by pesticide sprays. Some of the most important are the predatory mites, including the western predatory mite, *Galendromus* (formerly *Metaseiulus*) *occidentalis*, and Phytoseiulus mite species. Predatory mites are about the same size as plant-feeding mites but have longer legs and are more active.

Various other insects are also important predators—six spotted thrips (*Scolothrips sexmaculatus*), the larvae and adults of the mite destroyer lady bird beetle (*Stethorus picipes*), the larvae of certain flies including the cecidomyid *Feltiella acarivora*, and various general predators such as minute pirate bugs, bigeyed bugs, and lace-wing larvae. Western flower thrips, *Frankliniella occidentalis*, can be an important predator on mite eggs and larvae, but this species will also inflict severe damage to plants if mites aren't present on which to feed.

In a heavily infested orchard or garden that has few predators, use a soap spray or selective miticide to bring pest mites to a lower level and then release predatory mites. A good guideline is that one predator is needed for every 10 mites to provide control. More than one application of predatory mites may be required to reduce pest populations rapidly. Concentrate releases in hot spots where mite numbers are highest. Once established on perennials, predatory mites may reproduce and provide biological control indefinitely without further augmentation unless nonselective insecticides are applied that kill the predators (Dreistadt *et al.*, 2004).

(c) Chemical control: Mites frequently become a problem after applying insecticides. Such outbreaks are commonly a result of the insecticide killing off the mites' natural enemies but also occur when certain insecticides stimulate mite reproduction. Mites exposed to carbaryl (Sevin) in the laboratory have been shown to reproduce faster than untreated populations. Carbaryl, some organophosphates, and some pyrethroids apparently also favor spider mites by increasing the level of nitrogen in leaves. Insecticides applied during hot weather usually appear to have the greatest effect, causing dramatic spider mite outbreaks within a few days.

If a treatment for mites is necessary, preferably insecticidal soap or insecticidal oil need to be used. Both petroleum-based horticultural oils and plant-based oils such as neem, canola, or cottonseed oils are acceptable. There are also a number of plant extracts formulated as acaricides (a pesticide that kills mites) that exert an effect on spider mites. These include garlic extract, clove oil, mint oils, rosemary oil, cinnamon oil and others. Sulfur sprays can be used on some vegetables, fruit trees, and ornamentals (Dreistadt *et al.*, 2004).

5.4 Management options for diseases of mango

5.4.1 Ceratocystis blight

(a) Cultural control: Sanitation is also effective for disease control. Disinfecting machetes and pruning tools between plants may help control the disease in Platanus and Prunus (Teviotdale and Harper, 1991). Heat treatment of Ipomoea roots used in propagation has been suggested (Daines *et al.*, 1962).

(b) Chemical control: Fungicides are used with some success to treat tapping panels of *Hevea* and in *Ipomoea* fields or as post-harvest dips of *Ipomoea* roots (Yang *et al.*, 2000). Fungicides injected into the stems of Platanus species may provide some protection (Minervini *et al.*, 2001). Fungicides are also used to control the disease in Ficus (Hirota *et al.*, 1984).

5.4.2 Anthracnose

(a) Cultural control: post-harvest diseases can be reduced by various pre-harvest control measures, including the use of tolerant cultivars, orchard hygiene, manipulation of flowering and integrated management using chemical, physical and biological controls (Akem, 2006). Since the development of mango anthracnose is dependent on high humidity, mango orchards should ideally be established in areas with a well-defined dry season, to allow for fruit development under conditions unfavorable for disease development (Prusky *et al.*, 2009). In the tropics, mango flowering usually occurs during the dry seasons, and the incidence and severity of mango anthracnose can be close to zero in fruits that develop completely in the dry season, without the need of any additional control measures (Arauz, 2000). However, anthracnose incidence of > 90% is common in fruits that develop during the rainy season (Arauz, 1999). Thus, modifying flowering time to a less sensitive period could be an appropriate option. Flowering can be advanced by several weeks by applying potassium nitrate sprays to mature foliage (Núñez-Elisea, 1985). The growth retardant paclobutrazol, alone or followed by potassium nitrate sprays, can also be used to advance flowering (Núñez-Elisea *et al.*, 1993) although its use is not allowed in some countries. Sanitation of the tree in the field is a difficult practice since elimination of dry panicles and mummified fruits is time consuming. Bagging can result in reduced anthracnose severity, but it also reduces the red color of the fruit of some varieties, which could reduce consumer appeal in some markets (Hofman *et al.*, 1997). Although all commercial mango cultivars are susceptible to anthracnose, some varieties are less susceptible than others. Thus, 'Tommy Atkins' and 'Keitt' seem to be less susceptible than 'Irwin', 'Kent', 'Haden' and 'Edward' (Campbell, 1992). Consequently, cultivar selection should be taken into account in areas with high incidence of the disease. Regarding stem-end rot, Johnson *et al.* (1992) demonstrated that infection of mango fruits before harvest occurred through endophytic colonization of the pedicel tissues by Botryosphaeria spp. present from previous growth flushes. The possibility of pruning to promote new growth flush was tested as a means to reduce inoculum in the stem tissue from which new season inflorescences emerged. Cooke *et al.* (1998) reported that the levels of endophytic organisms such as Botryosphaeria spp. were reduced significantly when a pruning program was implemented in mango orchards as a preharvest control measure. Korsten (2006) found that prevention of water stress during fruit development and maturation, and avoidance of placing fruits on the ground suppressed disease development. He also suggested that fruits should be cooled to 13°C immediately after harvest and stored in a well-ventilated place.

Growing public demand for chemical residue-free fruits has encouraged the development of alternative technologies, such as irradiation, heat treatment and cold-temperature storage. Cold storage of mango fruit (10–12°C) is one of the best ways of delaying fruit ripening and, thus, decreasing post-harvest decay (Sivankalyani *et al.*, 2016). Shortwave infrared radiation treatments reduce anthracnose damage in mango and this approach can also be considered for the organic market. Heat treatment is known to reduce post-harvest diseases. Different approaches have been used, such as hot-water dipping and rinsing, and hot water vapour and dry-air treatments (Schirra *et al.*, 2000). There are many benefits to heat treatments, such as reduction in post-harvest decay, killing of pests, colour and flavour preservation and shelf-life improvement, among others (Lurie, 1998; Schirra *et al.*, 2000; Fallik, 2004). Hot-water brushing at 50–60°C for 20 seconds after harvesting reduces decay development via both surface cleansing and induction of fruit resistance against pathogens (Prusky *et al.*, 1996; Fallik, 2004); this method is applied in Israel. Hot-water dipping for 3–7 minutes has been recommended and is moderately efficient at delaying post-harvest rot (Johnson, 1994). Hot-water dips, or spray can control fungal infections such as anthracnose and alternaria rot better than stem-end-rot (Johnson, 1994). Trials using gamma irradiation to control mango anthracnose have concluded that incorporation of hot fungicide dip is necessary to improve disease control afforded by irradiation (Chadha, 1989). Regarding stem-end rot, for high-value fruit, especially those destined for export, various post-harvest treatments have been beneficial (Ploetz, 2018). Alvindia and Acda (2015) reported a 48–61% reduction in stem-end rot of 'Carabao' fruits after 20 min in 53°C water. Terao *et al.* (2015) indicated that a low dose (< 3 kJ m^{-2}) of UV-C irradiation helped manage post-harvest diseases of mango caused by *B. dothidea*, *L. theobromae*, *A. alternata* and *C. gloeosporioides*, even though a direct impact on the pathogens was not evident.

(b) Fruit sanitizers: The purpose of fruit sanitizers is to wash and kill the microorganisms on the fruit surface. Traditionally, the sanitizers consisted of water with or without chemicals. One of the most extensively used and studied sanitizers is chlorine (water pH 6.5–7.5; chlorine concentration 100–150 ppm). In addition to chlorine, sulphur dioxide has also been used as fungal disinfectant (Tefera *et al.*, 2007). Different forms of chlorine, such as sodium hypochlorite, calcium hypochlorite and chlorine gas, control a wide range of post-harvest pathogens. In the past, elevated chlorine dosages were frequently used due to the misconception that chlorine leaves no residues on the fruit. Common alternatives to chlorine are ozone (O_3), oxidized water and hydrogen peroxide. Ozone and ozonated water were recognized in 1997 by the FDA as safe food disinfectants and were proven to control post-harvest rots of mango (Monaco *et al.*, 2016). Recently, ozonated water has been reported as a sanitizer for mango cv. Palmer as it increases antioxidant activity (Monaco *et al.*, 2016). Electrolyzed water has also been suggested as a sanitizer for the industry (Colangelo *et al.*, 2015). Electrolyzed water is produced by adding sodium chloride to tap water and passing an electrical current through an anode or cathode to produce oxidizing (acidic) and reducing water (alkaline), respectively. The high electrolyzed water potential works against both bacteria (Pinto *et al.*, 2015) and fungi (Guentzel *et al.*, 2010). Hydrogen peroxide has also been recommended as an effective disinfectant against several fungi (Boyette, 1995).

(c) Biological control: *Bacillus licheniformis*, on its own or alternated with copper oxychloride (allowed in organic farming management), has been evaluated as a preharvest spray treatment to control mango fruit diseases (Prusky *et al.*, 2009). Preharvest applications of B. licheniformis at 3-week intervals from flowering until harvest controlled moderate levels of anthracnose and of soft rot caused by Botryosphaeria, which suggests a potential treatment for commercial preharvest applications (Silimela and Korsten, 2007).

Post-harvest biological control agents have been the focus of considerable research (Droby *et al.* 2016). A number of microorganisms with in vitro or in vivo activity against *C. gloeosporioides* have been isolated (Jeffries and Koomen, 1992), but few examples have been used commercially in the field until Korsten (2004) isolated Bacillus licheniformis from leaf and fruit surfaces, and effectively controlled anthracnose of mango. This product was used either alone or in combination with hot water treatments for 5 minutes at 45°C and with low doses of prochloraz or sodium hypochlorite, although only when used alone could be considered in organic agriculture (Govender *et al.*, 2005). The yeasts *Rhodotorula minuta* (Patino-Vera *et al.*, 2005) and *Debaryomyces nepalensis* (Luo *et al.*, 2015) have also been suggested as potential biocontrol agents of anthracnose, but they have not been widely applied commercially (Droby *et al.*, 2016). Other approaches to anthracnose control using biological methods included the use of a nonpathogenic strain of *Colletotrichum magna* that colonizes the fruit endophytically and prevents infection by *C. gloeosporioides* (Prusky *et al.*, 1993), and the expression of an antifungal peptide in the yeast Saccharomyces, which controlled postharvest diseases caused by *C. coccodes* (Jones and Prusky, 2001). Recently, Luo *et al.* (2015) found that the yeast *Debaryomices nepalensis* decreased the decay incidence to anthracnose while maintained storage quality of mango fruits. In Thailand, Rungjindamai

(2016) found that two isolates of epiphytic bacteria, identified as *Bacillus* sp. MB61 and *Bacillus* sp. LB72, reduced the size of the lesions caused by *C. gloeosporioides*.

(d) Chemical control: Although resistance to anthracnose is variable depending on the mango cultivar, even the most tolerant cultivars must be protected by fungicides in humid environments (Lim and Khoo, 1985; Jefferies *et al.*, 1990). In situations where mango fruits develop entirely under disease-favouring conditions, seasonal applications of up to 25 sprays of protective and systemic fungicides have been used (Dodd *et al.*, 1997). However, fungicide use is constrained by the limited number of efficient available products, and by regulations that exist in the producing and/or destination countries (Ploetz, 2018). In general, copper fungicides are the most popular, but their efficacy is often low (Arauz, 2000), and they are usually applied with other fungicides. For example, monthly applications of copper oxychloride combined with mancozeb has been shown as effective for most post-harvest diseases in South Africa (Lonsdale and Kotze, 1993), although the registration of dithiocarbamate fungicides, such as mancozeb, varies among production areas. Preventive treatments with fungicides based on copper or triazoles are the most common decisions of mango growers in Brazil to control anthacnose (Pinto *et al.*, 2004). Another contact fungicide, chlorothalonil, is effective but phytotoxic to fruit larger than a golf ball and, as a result, it should not be used after early fruit set (Ploetz, 2018).

With regard to systemic fungicides, only few are available. The benzimidazoles, primarily benomyl and carbendazim, provided excellent anthracnose control before resistance to them developed (Akem, 2006). Two imidazoles, prochloraz and imazalil, are used in some countries for pre- and post-harvest anthracnose, respectively, since they are moderately effective against this disease, but they are ineffective against stem-end rot (Ploetz, 2018). The stobilurins are effective against anthracnose and several other post-harvest diseases, but to avoid the development of fungicide resistance, no more than three stobilurin applications should be made per season, preferably alternating or combining with fungicides that have a different mode of action (Brent and Hollomon, 2007). Some pre-harvest spray programs used in the control of anthracnose in mango fruits are shown below. Those of Australia, Malaysia and the Philippines are included in Uddin *et al.* (2018), while that proposed for Honduras is described in Huete & Arias (2007).

Anthracnose forecasting models have been developed to schedule, and reduce, fungicide applications (Fitzell *et al.*, 1984; Dodd *et al.*, 1991). Akem (2006) noted differences between the time prediction of each model; he suggested to use caution when a model was used in an area other than where it was developed. Forecasting would be most useful in seasonally dry situations (where infection occurs only after significant rainfall) (Arauz, 2000). Calendar-based application schedules are needed wherever regular rainfall occurs (Ploetz, 2018). Fungicide applications usually focus on reducing damage to fruit, but foliar disease control is indicated in some situations and on inflorescences in most situations (Ploetz, 2018). Since infected foliage and branch terminals are important reservoirs of inoculum, fruit set and anthracnose control on fruit are enhanced if applications are made prior to flowering (Jefferies *et al.*, 1990). Off-season control measures are especially beneficial in production environments that receive significant rainfall (Ploetz, 2018). Although pre-harvest sprays and especially fruit sanitation techniques can eliminate all pathogens on the fruit surface, most of them may have already penetrated the fruit, and, therefore, further treatments to control post-harvest diseases are needed.

Several fungicides have been tested as dip treatments. Benomyl was found effective against quiescent infections of anthracnose of mango in hot water (Peak, 1986), but the application of benomyl after harvest has been banned (Alkan *et al.*, 2018). Post-harvest application of prochloraz in hot and cold dips effectively controls *C. gloeosporioides* and *A. alternata* during storage at low temperature and ripening at 20°C for the cultivars Tommy Atkins, Keitt, Lilly and Haden (Prusky *et al.*, 1999), but it does not provide good control for stem-end-rot (SER). Prochloraz is a well-recognized fungicide that is used commercially to control postharvest diseases of mango fruit. In Australia, prochloraz at 250 ppm is applied and in Israel it is applied at 300 ppm by overhead spray (Alkan *et al.*, 2018). Other fungicides have been also used successfully for certain mango varieties including thiophanate-methyl and hot imazalil (Secretariat Commonwealth, 1987; Dodd *et al.*, 1991b) The main disadvantage of imidazoles (i.e. prochloraz and imazalil) is that they are less effective at controlling SER pathogens than benzimidazoles (i.e. benomyl and thiabendazole) (Estrada *et al.*, 1996).

With the appearance of various fungicide-resistant isolates, no single fungicide can provide complete protection against anthracnose, alternaria rot and SER, and, consequently, a combination of treatments must be applied to cope with post-harvest pathogens (Alkan *et al.*, 2018). One combination used in Australia is hot water treatment with benomyl followed by a prochloraz spray, which provides effective control of anthracnose, SER and alternaria rot during long storage (Johnson *et al.*, 1990). Another combination applied in Israel includes chlorine sanitation, hot-water brushing (15–20 s) and then a spray of 50-mM hydrochloric acid (HCl), alone or in combination with prochloraz. This combination improved the control of anthracnose and alternaria rot (Prusky *et al.*, 2006). Trials using gamma irradiation to control mango anthracnose have concluded that incorporation of hot fungicide dip is necessary to improve disease control afforded by irradiation (Chadha, 1989). Appropriate post-harvest treatments have to be selected for individual mango cultivars and possibly even for the same cultivar in different environments (Uddin *et al.*, 2018).

5.4.3 Powdery mildew

(a) Cultural control: Reduction of inoculum potential of the pathogen at early stages is likely to decrease disease incidence (Joubert, 1991). Regular inspection of mango orchards and removal/pruning of infected leaves and malformed panicles reduce the load of primary inoculum and improve fungicidal control (Prakash and Misra, 1992, 1993a; 1993b; Prakash and Raoof, 1994). Mango cultivars vary in their resistance to powdery mildew (Palti *et al.*, 1974). 'Zill', 'Kent', 'Alphonso', 'Seddek' and 'Nam Doc Mai' are very susceptible; 'Haden', 'Glenn', 'Carrie', 'Zebda', 'Hindi be Sennara', 'Ewaise' and 'Keitt' are moderately susceptible; and 'Sensation', 'Tommy Atkins' and 'Kensington' are slightly susceptible (Ploetz *et al.*, 1994; Nofal and Haggag, 2006). In India, Tiwari *et al.* (2006) reported that 'Baigan Phalli', 'Barbalia', 'Dabari', 'Dilpasand', 'Khirama', 'Nagarideeh', 'Oloor' and 'Totapari' were highly resistant and 'Amrapali' was most susceptible.

(b) Biological control: Sztejnberg *et al.* (1989) reported that an isolate of *Ampelomyces quisqualis* parasitized powdery mildew of mango and reduced the disease in field trials. He also found that A. quisqualis was tolerant to many fungicides currently used to control powdery mildew. Nofal and Haggag (2006) reported that in vitro application of biocontrol agents as *Verticillium lecanii, Bacillus subtilis* and *Tilletiopsis minorto* leaf disks before inoculation with *O. mangiferae* markedly decreased conidial germination and leaf infection. In field trials, the application of those agents at 15 days intervals effectively controlled *O. mangiferae* on blossom clusters and fruit set on naturally powdery mildew infected cultivars Alphonso and Seddek. Mixing kaolin and monopotassium phospate with biocontrol agents increased their efficacy. In Egypt, Azmy (2014) found that spraying with the bio-fungicide AQ10 (*Ampelomyces quisqualis*) at the rate of 0.005% after harvesting the crop showed good reduction of powdery mildew severity on mango trees with an increase of fruit yield. Kaur *et al.* (2018) found that among six biocontrol agents evaluated by giving three sprays (starting from two weeks after the panicle emergence) at 15 days intervals against powdery in mango, two antagonists, namely *Bacillus subtilis* and *Ampelomyces quisqualis,* exhibited high degree of disease control, when tested over two different locations. The mechanisms implicated in biological control of powdery mildew fungus include mycoparasitism, antibiosis, competition, and induced resistance.

(c) Chemical control: A large number of fungicides have been used against this disease in different mango growing countries. Apart from dormant sprays, several applications of suitable fungicides at 15-20 dayintervals are required to effectively control the disease. Initially, inorganic copper or sulfurbased chemicals were used and then a broad range of organic and systemic fungicides, which acted as eradicants, protectants or both, were introduced (Nasir *et al.* 2014). These authors reviewed the main groups of chemicals used against the powdery mildew of mango: copperbased fungicides, sulphur fungicides, chlorothalonil, nitro compounds, and systemic fungicides (benzimidazols, imidazole, morpholines, organophosphorus, oxathiins, piperazine, pyridimines, strobilurins and triazoles).

Sulfur fungicides, as dusts or sprays, are widely used and provide reasonable protectant control of powdery mildews (Palti *et al.*, 1974; Gupta and Yadav, 1984; Prakash and Misra, 1986; Kawate, 1993; Prakash and Raoof, 1994; Desai, 1998; Chavan *et al.*, 2009), although they can burn flowers and young fruits during warm, sunny conditions (Johnson, 1994a). Systemic fungicides in general are very effective in reducing the disease (Ihsan *et al.*, 1999). In addition, some fungicides, such as dinocap, fenbuconazole and hexaconazole, can reduce pollen germination (Dag *et al.*, 2001), and, consequently, their use should be limited during the flowering season. Application of phosphate solutions is a new and safer approach in the control strategies of powdery mildews in several vegetables and fruit trees (Nasir *et al.*, 2014). In mango, foliar sprays of K2HPO4 and KH2PO4, especially in alternation with systemic fungicides, were effective against powdery mildew (Nofal and Haggag, 2006; Reuveni *et al.*, 1998).

5.4.4 Alternaria leaf spot

(a) Chemical control: Preharvest treatments with dithiocarbamate fungicides inhibit the development of latent infection. Three sprays with the protectant fungicide maneb, starting 2 weeks after initial fruit set, seem to be most effective (Prusky *et al.*, 1983). However, since quiescent infections do not develop until after harvest and ripening, the application of a postharvest treatment by spraying the fruits on the packing line with prochloraz is simpler and more efficient than the preharvest fungicide treatment (Prusky *et al.*, 2009).

Control of alternaria rot is significantly improved by a combination of physical and chemical treatments. The physical treatment includes a 15–20 seconds hot water spraying and brushing (HWB) treatment at temperatures between 50 and 55°C (Prusky *et al.*, 1999). This approach improved fruit quality and, at the same time, reduced disease incidence. If a prochloraz spray follows this physical treatment it can further improve disease control. Prusky *et al.* (1999) concluded that the type and strength of the postharvest treatment should be optimized according to the level of quiescent infection of *A. alternata* at harvest time. Although prochloraz is very effective for postharvest disease control, a milder postharvest treatment, such as chlorine, can be applied to fruits in which a low incidence of quiescent infections is found at harvest (Prusky *et al.*, 2002). This postharvest physical-chemical treatment has been further improved in light of the finding that *A. alternata* pathogenicity may modulate the pH of the host environment to promote colonization (Eshel *et al.*, 2002; Prusky and Yakoby, 2003; Prusky and Lichter, 2007). Application of a combination of HWB for 15–20 s, followed by spraying with 50 mM hydrochloric acid (HCl), effectively controlled alternaria rot in stored mango fruit. Similar HWB treatments followed by spraying with reduced concentrations of prochloraz at 45 µg/ml in 50 mM HCl inhibited alternaria rot development better than treatment with HCl alone (Prusky *et al.*, 2006). This technology provides a simple treatment for the control of diseases that alkalinize the host environment, including both alternaria rot and anthracnose (Prusky *et al.*, 2009).

Postharvest control of Botryosphaeria spp. was achieved by postharvest dipping, spraying or ultra-low-volume application of benomyl (where possible). Prochloraz or sodium hypochlorite also effectively suppressed postharvest rot of mango (Plan *et al.*, 2002; Korsten, 2006). A combined treatment of wax and hot water (55ºC) provide very effective control of most postharvest pathogens (Sangchote, 1998), but in some cases partial-vacuum infiltration improved disease control, which suggests that control efficiency may have been reduced because the fungicide did not reach the pathogen (Plan *et al.*, 2002).

5.4.5 Grey mould

(a) Cultural control: Not planting cultivars that have an upright or dense growth habit can reduce disease as the limit air flow and are favorable for the pathogen. Spacing of plants so they are not touching will increase airflow allowing the area to dry out and reduce the spread of disease. Pruning or purposeful removal of diseased, dead, or overgrown limbs on a regular schedule can also help to improve air movement (UC IPM, 2017).

Sanitation by removing dead or dying plant tissue in the fall will decrease inoculum levels as there is no debris for the sclerotium or mycelia to overwinter. Removing debris in the spring will remove inoculum from the site. Disposal of berries during harvest that have signs and symptoms of gray mold will reduce inoculum for the following year.

Biochar, a form of charcoal, can be applied as a soil amendment to strawberry plants to reduce the severity of the fungal disease by stimulating defense pathways within the plant (Harel *et al.*, 2012).

(b) Chemical control: Gray mold can be chemically controlled with well-timed fungicide applications starting during the first bloom. Timing can reduce the chance of resistance and will save on costs.

(c) Biological control: Biological controls or microbial antagonists used for disease suppression, have been successfully used in Europe and Brazil in the form of fungi-like *Trichoderma harzianum* Rifai and *Clonostachys rosea* f. *rosea* Bainier (syn. *Gliocladium roseum*). *Trichoderma* species especially, have been shown to control gray mold (Harel *et al.*, 2012).

5.4.6 Die-back

- Avoid mechanical injuries to the plants.
- Prevent termites and longicorn beetles causing damage to the plants.
- Reduce plant stress, including stress caused by drought and nutritional deficiencies.
- Reduce sunburn of the trunk and branches when severely pruning the trees.
- Prune dying branches by cutting the branch back to below the edge of the dead or symptomatic areas. Disinfect the pruning tool after each plant. Remove the symptomatic pruned branches from the orchard.
- Avoid pruning mango trees when the canopy is wet or during rainfall.
- Follow the 'come clean go clean' practices, and make sure to clean and disinfect any tree pruning machinery when moving it between farms.
- Although mango mulch is an important source of nutrients, removal of under tree mango mulch/litter in orchards with high disease load may be beneficial as it is a potential source of inoculum.

5.4.7 Mango scab

(a) Cultural control: Remove or destroy infected plant material that can survive in soil material to prevent infection. It is helpful to prune away old infected stems to reduce the levels of infection (Terry 2014).

(b) Chemical control: Copper fungicide-based sprays (oxychloride, hydroxide or oxide) needs to be applied as soon as the flowers start to emerge and continue to spray until the fruit has set until half size. Usually, two-to-three weeks interval till fruit is half size and weekly sprays after in order to protect that fruit from infection (Terry 2014).

Wet climate conditions increase the risk of developing and spreading a fungus infection. More frequent applications of the fungicide are needed when these conditions occur since rain can decrease the effectiveness of the treatment.

5.4.8 Leaf red rust

Cephaleuros virescens is not damaging enough to the host plant's vigor or crop yield and therefore generally does not warrant management. If however the crop is highly susceptible, a form of integrated pest management can be used to prevent the spread and infection of the disease. This includes sanitation and pruning of infected plant parts. Since lower branches are usually infected, make sure to remove them as well as any debris that has littered the ground below the infected plant. Reducing humidity or increasing air flow can also help, as the pathogen is most successful in moist, humid environments. Keep the plant or crop in a sunny, aerated, well-drained area. Selecting for a tolerant variety of plant, and if needed, intercropping, can reduce the rate of infection. If needed copper fungicides may assist but would need to be applied every two weeks if the environment remains wet (Janet and Joey, 2017).

5.4.9 Bacteria Canker

(a) Cultural control: The use of canker-free nursery plants is the first essential step in the management of citrus canker. Windbreaks established around citrus groves reduce the disease. Pruning of angular shoots which hold canker lesions removes over-seasoning inoculum (Goto, 1992). The disease has attracted widespread attention because of the serious efforts that have been made for eradication; these include destruction of citrus trees on a large scale and the implementation of strict international plant quarantine regulations against the pathogen (Goto, 1992).

(b) Mechanical control: Photodynamic inactivation of *X. citri* pv. *citri* has the potential to be applied in the control of citrus canker in field conditions (Ndemueda *et al.*, 2020).

(c) Host resistance: Several cases of resistance or immunity against citrus canker are reported in the literature while the commercial value and cultivability of these lines/hybrids have yet to be examined. Most of the lemon cultivars exhibited a high level of resistance against different strains of *X. citri* pv. *citri.* Two hybrids from acid lime × Nepali round lemon were reported to be free from disease. In Brazil, 582 accessions (319 varieties of sweet orange), including varieties with a potential commercial use were evaluated and approximately 13% of all accessions were resistant to citrus canker. The mandarin cultivar 'Okitsu' shows substantial resistance to *X. citri* pv. *citri* (Favaro *et al.*, 2020). Of the primary hosts listed, yuzu is highly resistant (Goto, 1992) and calamondins, *Cleopatra mandarin* and sunki mandarin are immune. *Fortunella japonica* is highly resistant against *X. citri pv. citri* (Goto, 1992). According to de Carvalho *et al.* (2015) after a 6-year study in Brazil, no genotype was immune to citrus canker. Among five satsuma cultivars evaluated by de Souza *et al.* (2021), Brown's Select and Miho consistently showed less disease severity with delayed incidence. Additionally, both Brown's Select and Miho exhibited significantly smaller lesion size, which could lower canker inoculum production for secondary infections. A thicker cuticle covering the epidermal surface and guard cells in young leaves was associated with a smaller stomatal aperture and reduced cuticle permeability. Faster development of epicuticular waxes in leaves plays a central role in resistance to *X. citri* pv. *citri* (Favaro *et al.*, 2020). By the beginning of the genome editing era, Jia *et al.* (2022) developed canker-resistant 'Duncan' grapefruit using biallelic genome editing of the LOB1 promoter via CRISPR/Cas9.

(b) Biological control: Different biocontrol agents such as antagonistic bacteria (*Pseudomonas* spp. and *Bacillus* spp.) and bacteriophages have been reported against *X. citri* pv. *citri.* Poveda *et al.* (2021) summarized all the microbiological control strategies reported against bacterial diseases that affect citrus, highlighting those fields of study where there is great potential yet to be discovered. Interactions between *X. citri* pv. *citri* and antagonistic bacteria including *Bacillus subtilis, Pantoea agglomerans, Pseudomonas syringae* and *Pseudomonas fluorescens* have been reported in vitro and in vivo. However, the practical usefulness of these bacteria in controlling the pathogen has not been proved. Rhizobacteria can modulate citrus immunity resulting in a systemic defence response against *X. citri* pv. *citri*. Islam *et al.* (2019) reported biocontrol of citrus canker disease caused by *X. citri* pv. *citri* using Bacillus thuringiensis. *Pseudomonas geniculata* root-treated plants contained higher reactive oxygen species levels in aerial tissues than control plants 8 days post-treatment application (Riera *et al.*, 2018). Oliveira *et al.* (2011) demonstrated antibiotic activity of metabolites produced by the *Pseudomonas* sp. strain LV. Antarctic fungal strains Pseudogymnoascus, Penicillium, Cadophora, Paraconiothyrium and Toxicocladosporium isolated from terrestrial and marine sediments were able to produce secondary metabolites with antimicrobial activity against *X. citri* pv. *citri* (Vieira *et al.*, 2018). An agglutinin was purified from citrus leaves against extracellular polysaccharides (EPS) of *X. citri* pv. *citri*.

(c) Chemical control: Citrus canker disease cannot be controlled by chemicals after it has reached epidemic proportions. Therefore, prevention of primary infection on spring shoots is emphasized which is achieved by spraying copper compounds 10-14 days after the first shoots emerge in the spring. Asiatic citrus canker lesions on shoots produce fewer bacteria compared to leaf and fruit lesions. Minimizing early fruit infection will reduce the risk of inoculum dispersal; lesions on fruit have low risk for dispersing canker (Luo *et al.*, 2020). Reduction of disease on spring shoots reduces inoculum for subsequent developing shoots. The minimum threshold deposition of copper is 1.5 µg $Cu^{2}+/cm^{2}$ leaf area. The lowest spray volume and copper rate necessary to achieve this deposition are 35 ml/m3 and 30 mg/m3 (Behlau *et al.*, 2020). Lesion size affected survival - small lesions (<10 mm^2) declined in activity rapidly compared to larger lesions. Mechanical wounds caused by cultural practices are entry points for the causal bacterium, and exacerbate the disease. Wounds need to be protected with copper sprays if rain is forecast within 7 days of a wounding event. If no rain is expected, there is no need to protect the trees with copper (Machado *et al.*, 2021). Copper sprayed before wounding and/or inoculation showed the greatest reduction (>90%) in the incidence of citrus canker. The reduction in canker associated with wounds ranged from 91.8 to 96.1% for copper sprays applied from 24 h before, to 0.5 h after, wounding and inoculation, and was 67.8% when copper was applied up to 8 h after wounding and inoculation (Machado *et al.*, 2021).

(d) IPM: The relative contribution of three control measures, i.e. windbreak with *Casuarina cunninghamiana* trees, copper sprays and leafminer control were assessed by Behlau *et al.*

(2021). Individually, copper sprays showed the highest contribution to canker control, followed by windbreak. Windbreak + copper sprays showed the highest efficiency for control of the disease and reduced the incidence of diseased trees by 60%, and the incidence of diseased leaves and fruit by ≥ 90% and increased the yield by 2.0 to 2.6-fold in comparison with the unmanaged plots. *Xanthomonas citri* pv. *citri* does not survive for long periods in soil or in association with non-host plants. Hence, an integrated programme for management of the pathogen was implemented to prevent the occurrence of the disease in new plantings and to eradicate the disease locally.

5.4.10 Bacterial black spot

(a) Cultural control: Resistance to Bacterial Black Spot varies greatly among mango cultivars, and resistant cultivars should be used where disease pressure is high (Manicom and Pruvost, 1994). Pathogen-free planting material should be utilized when new orchards are established. The pathogen moves only short distances in wind-blown aerosols (usually within orchards) (Gagnevin and Pruvost, 2001), and long-distance dissemination occurs almost entirely via infected propagation material and less frequently in surface-contaminated seeds (Manicom and Pruvost, 1994). Windbreaks should be used to reduce wounding and infected twigs should be removed from the canopy.

(b) Biological control: Biological control measures against Bacterial Black Spot have not been widely studied (Prusky *et al.*, 2009). In India, Kishun (1994) indicated that a strain of *Bacillus coagulans* from the phylloplane of mango was effective against strains of the pathogen, although control of bacterial black spot in the field was not reported.

(c) Chemical control: Bacterial Black Spot can be difficult to control on susceptible cultivars, as the available chemicals are marginally effective (Pruvost *et al.*, 1989). During rainy weather, applications of copperbased bactericides are recommended. Their application should focus on protecting fruit and should vary according to the lenght of the time during which the fruits are exposed to wet conditions (Manicom and Pruvost, 1994). Agricultural antibiotics, such as streptomycin sulphate or nitrate, have been effective (Misra and Prakash, 1992; Viljoen and Kotze, 1972), but their long-term effectiveness is reduced by resistance that develops after continued use.

5.4.11 Root-knot nematode

A considerable amount of work has been devoted to the biological control of root-knot nematodes in general and M. incognita in particular (Kerry, 1987). Most research has concentrated on the endoparasitic microorganism *Pasteuria penetrans* and the egg-parasitic fungus *Purpureocillium lilacinum* (*Paecilomyces lilanicus*). Experimental work has been encouraging, *P. penetrans* in the control of *M. incognita* on tomatoes and *P. lilanicinum* in the control of *M. incognita* on potatoes. The development of *P. lilanicinum* has reached the stage of multi-local field trial. However, there are considerable problems in the preparation and incorporation of inocula of putative biocontrol agents and the practical application of such technology remains to be developed (Kerry, 1987).

Methods for the control of *M. incognita* vary with the production system used and the value of the crop. Chemical control may be used on high-value crops, and a wide range of chemicals are available. More recently, seed treatments have become widely utilized to minimize the amount on active ingredient applied or for the application of biological control agents. Often these tactics are reserved for the most important row crops like soyabean, maize and cotton (Monfort *et al.*, 2006). Strategies of cultural control are less well developed and crop rotations are difficult to design because of the wide host range of *M. incognita*. Groundnuts or maize, which are both poor or non-hosts to *M. incognita*, have been evaluated for use in cropping systems designed to manage this nematode. Systems of integrating cropping sequences and chemical control have been evaluated in the USA. Resistance to M. incognita exists in a number of commercial crop varieties, principally vegetables. These have generally been developed in the USA, but have been evaluated in other parts of the world.

5.5 Management options for weeds of mango

5.5.1 Parthenium weed

(a) Eradication: In Kenya, the Suppression of Noxious Weeds Act of 2010 (CAP 325) obliges land owners to remove the species from their properties (Rubaba *et al.*, 2017). The species is regulated as a quarantine pest in Europe under the EU IAS Regulation introduced in 2014 (EPPO, 2018), restricting its sale and movement, and requiring government agencies to undertake eradication programs.

(b) Mechanical control: Kaur *et al.* (2014) recommends the manual uprooting of the plants before flowering and seed set, followed by sowing desirable crops or pasture species. In some African countries with light infestations where labour is not too expensive, the use of machetes, hand pulling and burning of the species are a common practice (Rubaba *et al.*, 2017). Physical removal by hand-pulling poses health risks and has not been recommended in Australia. Mechanical treatments, such as grading, mowing, slashing and ploughing are also considered inappropriate since they may promote seed dispersal as well as rapid regeneration from lateral shoots close to the ground. Fire has been used to control the first flush of emergent weeds at the beginning of the rains in Australia but is only considered to be a short-term control measure. A study by Vogler *et al.* (2002) showed that fire created open niches in the landscape, into which larger number of parthenium seeds were able to germinate in the absence of vegetation. Therefore, management of *P. hysterophorus* in pastures through burning is not considered to be an option.

(c) Biological control: The leaf-feeding beetle *Zygogramma bicolorata*, the stem-galling moth *Epiblema strenuana*, the stem-boring beetle *Listronotus setosipennis*, and the seed-feeding weevil *Smicronyx lutulentus*, are proving to be the most successful when climatic factors are favourable. Some control of *P. hysterophorus* has also been achieved in India with *Z. bicolorata*, although there has been controversy concerning its taxonomy and host specificity. Shabbir *et al.* (2016) reported that Z. bicolorata was most effective when applied in higher densities and at early growth stages of the weed.

(d) Chemical control: Some of the newer herbicides, such as imazapyr, oxadiazon, oxyfluorfen, pendimethalin and thiobencarb, have also been reported to be highly effective against parthenium weed. Imazethapyr is particularly effective as a pre-emergence treatment in green gram. Bromoxynil + MCPA was the most effective of a range of post-emergence treatments. Glyphosate, glufosinate, chlorimuron and trifloxysulfuron applied at the rosette stage provided greater than 93% control, while halosulfuron, MSMA, bromoxynil, 2,4-D, and flumioxazin gave 58-90% control (Reddy *et al.*, 2007), and norflurazon and clomazone were also highly effective.

(e) IPM: In many locations parthenium weed is able to survive individually-applied management measures, and a more effective integrated approach is therefore required in these locations. A holistic IPM approach is propounded in India to achieve sustainable management of parthenium weed, and implemented in Australia through improved extension strategies. Nav-Bahr and Bahar (2000) proposed ploughing before flower set and burning when the plants are dry and mature, application of atrazine or other herbicides like 2,4-D, paraquat, glyphosate diuron and dalapon, using Cassia sericea to displace parthenium weed, and biocontrol using *Zygograma bicolorata*.

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CHAPTER 6
IDENTIFICATION OF PESTS

6.1 Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding the mango imported from any exporting countries like Thailand, India, Pakistan, Australia and the Philippines into Bangladesh.

6.2 Pests of mango recorded in Bangladesh

The study for "Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh" was done in 15 major mango 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 insect and mite pests, diseases, weed pests and other pests associated with mango have been presented below:

6.3 Insect and mite pests of mango in Bangladesh

A total number of thirty-five (35) arthropod pests, of which thirty-four (34) insect pests and one (1) mite pest of mango were recorded in Bangladesh as reported by the mango growers and relevant experts as well as literature reviewed. The incidence and damage potential of reported mango insect and mite pests have been presented below:

6.3.1 Insect pests recorded

There were two ways considered to record the insect and mites of mango available in Bangladesh. The ways were field level survey and literature review. The insect and mite pests of mango identified through those ways are illustrated below:

(a) Field survey-based findings: The study team made a list of insect and mite pests of mango identified through face-to-face interviews of mango growers in the pre-selected PRA areas as well as gathered information by means of focus group discussion with mango growers and from field level officials of Department of Agriculture Extension (DAE) and other experts by means of key informant interviews. As per field survey-based data, it was revealed that the incidence of 16 insect pests of mango were identified in Bangladesh through field survey. Amon these insect pests, four (4) were major insect pests of mango as recorded and those were mango hopper (*Amritodus atkinsoni*, *Idioscopus clypealis*, *I. nagpurensis*), oriental fruit fly (*Bactrocera dorsalis* (Hendel)), mango leaf-cutting weevil (*Deporaus marginatus*) and mango mealybug (*Drosicha mangiferae*) in field condition.

While the other 12 insect pests were designated as minor insect pests of mango identified through field survey in Bangladesh and those were mango pulp weevil (*Sternochaetus frigidus*), mango stem borer (*Batocera rubus*) caused infestation in the field condition of mango. Other minor insect pests of mango as recorded were mango stone/seed weevil (*Sternochetus mangiferae* (Fabricius)), mango leaf gall midge (*Procontarinia matteiana*), mango white scale (*Aulacaspis tubercularis*), mango/chili thrips (*Scirtothrips dorsalis*), mango shoot gall psyllid (*Apsylla cistellata* (Cockerell, 1893)), mango leaf miner

(*Acrocercops syngramma* Meyrick), mango defoliator (*Cricula trifenestrata* (Helfer 1837)), mango fruit borer (*Citripestis eutraphera* Meyrick*),* mango leaf weber *(Orthaga exvinacea* Hampson), mango leaf caterpillar (*Euthalia aconthea*), (Table-6.1).

(b) Literature review-based findings: Besides, field level survey-based findings, the study team also made a list of insect pests of mango by means of review of secondary documents collected from different sources. As per literature review, it was revealed that a total of eighteen (18) insect pests of mango were recorded for Bangladesh and these were apple stem borer (*Trirachys holosericeus*), cucurbit fruit fly (*Bactrocera (Zeugodacus) cucurbitae*), mango fruit fly (*Bactrocera tau* (Walker, 1849)), guava fruit fly (*Bactrocera correcta*), peach fruit fly (*Bactrocera zonata* (Saunders)), mango inflorescence midge (*Erosomyia indica*), mango common scale (*Coccus mangiferae* (Green)), coconut scale (*Aspidiotus destructor*), cottony cushion scale (*Icerya purchasi*), pineapple mealybug (*Dysmicoccus brevipes*), fruit tree mealybug (*Rastrococcus invadens*), mango aphid (*Toxoptera odinae*), mango leafhopper (*Idioscopus nitidulus*), bark eating caterpillar (*Indarbela tetraonis*), cotton bollworm (*Helicoverpa armigera*), pink gypsy moth (*Lymantria mathura* Moore 1865), black tea thrips (*Heliothrips haemorrhoidalis*) and melon thrips (*Thrips palmi*) (Table-6.2).

But the incidence of Mediterranean fruit fly (*Ceratitis capitata*), Queensland fruit fly (*Bacterocera troyni*), and Tapioca scale insect (*Aonidomytilus albus* (Cockerell, 1893)) were not recorded in the field of mango growing areas of Bangladesh neither through field survey nor through literature review. Likewise, mango mealybug (*Droshicha mangiferae* Green) was recorded in the restricted areas of mango field in Bangladesh.

6.3.2 Mite pests recorded

It was revealed that only one mite pest of mango had been identified through field survey in the PRA areas of Bangladesh and it the mango eriophyid mite (*Aceria mangiferae*). This mite pest caused damage on both mango leaves and young fruits.

6.3.3 Damage potential of insect and mite pests

Among these insect pests, mango hopper, oriental fruit fly and mango leaf-cutting weevil were more damaging pests than others. The adults and nymphs of mango hopper caused damage mango from its flowering stage on inflorescence and fruits at pea size stage with medium to high infestation severity, if not controlled properly. Usually, Bangladesh's farmers always used chemical insecticides at field condition of mango and suppressed the infestation of mango hopper in every season; while both adults and grubs of mango leaf-cutting weevil caused damage on newly flashed leaf at seedling stage of mango by feeding the epidermal surfaces of the leaves as well as cutting new leaves at night with low to medium infestation severity. Besides, the oriental fruit fly (*Bactrocera dorsalis*) caused damage mango at fruiting stage by feeding the internal pulp by maggots with medium to high infestation severity. Other minor insect pests damage mango with low infestation intensity. On the other hand, mango eriophyid mite caused damage on mango leaves and fruit with medium level infestation intensity, where on fruit the mite starting damage on young fruits at marble stage and the damage symptoms are shown as straw color on full grown mango that reduces the market value of mangoes.

Table-6.1. List of insect and mite pests of mango, their identity, status and infestation severity as recorded in Bangladesh through field survey

SN	Common Name	Scientific name	Plant parts affected	Pest status	Infestation severity	District-wise farmer's response of pest incidence (%)*	
						Maximum	Minimum
A	**Insect pests of mango**						
1	Mango stone weevil	*Sternochetus mangiferae* Family: Curculionidae Order: Coleoptera	Fruit	Minor	Low	Bandarban (37.8%)	Chuadanga, Meherpur, and Rangpur (1.7%)
2	Mango pulp weevil	*Sternochaetus frigidus* Family: Curculionidae Order: Coleoptera	Fruit	Minor	Low		
3	Mango stem borer	*Batocera rubus* (Linnaeus) Family: Cerambycidae Order: Coleoptera	Tree trunk, stem	Minor	Low	Bandarban (48.9%)	Rangamati (1.1%)
4	Mango leaf-cutting weevil	*Deporaus marginatus* Family: Attelabidae Order: Coleoptera	Young leaf	Major	Low to medium	Rangpur (17.5%)	Chapainawabganj, Khagrachhari, Meherpur, and Thakurgaon (1.0%)
5	Oriental fruit fly	*Bactrocera dorsalis* (Hendel) Family: Tephritidae Order: Diptera	Fruit	Major	Medium to high	Dinajpur (68.3%)	Chapainawabganj (0.7%)
6	Mango leaf gall midge	*Procontarinia matteiana* Family: Cecidomyiidae Order: Diptera	Leaf	Minor	Low	Jashore (33.3%)	Khagrachhari and Chuadanga (1.7%)
7	Mango hopper	*Amritodus atkinsoni*, *Idioscopus clypealis* *Idioscopus nagpurensis* Family: Cicadellidae Order: Hemiptera	Inflorescence, leaf	Major	High	Rangpur (97.5%)	Chapainawabganj and Chuadanga (1.0%)

SN	Common Name	Scientific name	Plant parts affected	Pest status	Infestation severity	District-wise farmer's response of pest incidence (%)*	
						Maximum	Minimum
8	Shoot gall psyllid	*Apsylla cistellata* Family: Aphalaridae Order: Hemiptera	Stem	Minor	Low	Jashore (26.7%)	Chapainawabganj, Khagrachhari, and Chuadanga (1.0%)
9	Mango mealybug	*Drosicha mangiferae* Family: Margarodidae Order: Hemiptera	Fruit, leaf, stem, Inflorescence	Major	Low to medium	Jashore (23.3%)	Khagrachhari, Satkhira, and Thakurgaon (1.7%)
10	Mango white scale	*Aulacaspis tubercularis* Family: Diaspididae Order: Hemiptera	Leaf, fruit	Minor	Low	Meherpur (26.7%)	Naogaon (1.0%)
11	Mango/chilli thrips	*Scirtothrips dorsalis* Family: Thripidae Order: Thysanoptera	Leaf, inflorescence	Minor	Low	Kustia (36.7%)	Naogaon (1.0%)
12	Mango leaf miner	*Acrocercops syngramma* Family: Gracillariidae Order: Lepidoptera	Leaf, twig	Minor	Low	Bandarban (20.6%)	Thakurgaon, and Dinajpur (1.7%)
13	Mango defoliator	*Cricula trifenestrata* (Helfer) Family: Saturniidae Order: Lepidoptera	Leaf, twig	Minor	Low	Jashore (36.7%)	Chapainawabganj, Dinajpur, and Naogaon (1.0%)
14	Mango fruit borer	*Citripestis eutraphera* Family: Pyralidae Order: Lepidoptera	Fruit	Minor	Low	Rangpur (27.5%)	Khagrachhari, Satkhira, and Thakurgaon (1.7%)
15	Mango leaf weber	*Orthaga exvinacea* Hampson Family: Pyralidae Order: Lepidoptera	Leaf, twig	Minor	Low	Jashore (26.7%)	Khagrachhari, Rangamati, and Thakurgaon (1.7%)

SN	Common Name	Scientific name	Plant parts affected	Pest status	Infestation severity	District-wise farmer's response of pest incidence (%)*	
						Maximum	Minimum
16	Mango leaf caterpillar	*Euthalia aconthea* Family: Nymphalidae Order: Lepidoptera	Leaf, twig	Minor	Low	Jashore (36.7%)	Khagrachhari, Rangamati, Dinajpur, and Thakurgaon (1.7%)
B	**Mite pest of mango**						
17	Mango eriophyid mite	*Aceria mangiferae* Sayed Family: Eriophyidae Order: Acarina	Leaf, fruit	Major	Medium	Naogaon (11.3%)	Khagrachhari (1.7%)

* **N.B.:** The numerical values in the parenthesis of a column indicate the percent response of mango growers on whether the respective pest incidence occurred or not on mango plant/plant parts during data collection through face-to-face interview at field level

Table-6.2. List of insect and mite pests of mango and their identity present in Bangladesh as recorded through literature review

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity	Reference
A	**Insect Pests**							
1	Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	Stem	Minor	Low	Gahan (1906)
2	Cucurbit fruit fly	*Bactrocera (Zeugodacus) cucurbitae*	Tephritidae	Diptera	Fruit	Minor	Low	DAE (2019)
3	Guava fruit fly	*Bactrocera correcta*	Tephritidae	Diptera	Fruit	Minor	Low	Leblanc *et al.* (2014)
4	Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera	Fruit	Minor	Low	EPPO (2022)
5	Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	Fruit	Minor	Low	Akhtaruzzaman *et al.* (1999)
6	Inflorescence midge	*Erosomyia indica*	Cecidomyiidae	Diptera	Shoot, inflorescence, fruit	Minor	Low	CABI (2019)

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity	Reference
7	Mango common scale insect	*Coccus mangiferae* (Green)	Coccidae	Hemiptera	Fruit, shoot, inflorescence	Minor	Low	DAE (2015)
8	Coconut scale	*Aspidiotus destructor*	Diaspididae	Hemiptera	Fruit, shoot, inflorescence	Minor	Low	APPPC (1987)
9	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Fruit, Leaf, Inflorescence	Minor	Low	Williams (2004)
10	Fruit tree mealybug	*Rastrococcus invadens*	Pseudococcidae	Hemiptera	Leaf, Stem, Inflorescence	Minor	Low	EPPO (2022)
11	Cottony cushion scale	*Icerya purchase*	Monophlebidae	Hemiptera	Tender shoot, young fruit, leaf	Minor	Low	NHM (1980)
12	Mango aphid	*Toxoptera odinae*	Aphididae	Hemiptera	Leaf, Inflorescence, fruit	Minor	Low	CABI (1991)
13	Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Leaf, Inflorescence	Minor	Low	International Barcode of Life Consortium (2016)
14	Bark eating caterpillar	*Indarbela tetraonis*	Metarbelidae	Lepidoptera	Stem	Minor	Low	DAE (2019)
15	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Fruit	Minor	Low	Hossain *et al.* (2009)
16	Pink gypsy moth	*Lymantria mathura*	Erebidae	Lepidoptera	Leaf, flower	Minor	Low	EPPO (2022)
17	Black tea thrips	*Heliothrips haemorrhoidalis*	Thripidae	Thysanoptera	Leaf, flower	Minor	Low	DAE (2019)
18	Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Leaf, inflorescence	Minor	Low	Rashid *et al.* (2008)

6.3.4 Identification of fruit fly and its diversity

The fruit flies available in the mango orchards under the survey areas covering 15 sampled districts were captured using two types of pheromone traps such as Bactro-D and Cue-Lure. The collected fruit flies were identified with the help of Stereo Microscope in the Department of Entomology, Sher-e-Bangla Agricultural University following the Taxonomic Key. Ten adult fruit flies for each of Bactro-D and Cue-Lure were studied for each of 15 sampled districts. The identification results evident that irrespective of sample districts, all of the studied adult fruit flies captured through Bactro-D were found oriental fruit fly, *Bactrocera dorsalis*, belonging to the Family: Tephritidae under the Order: Diptera; while the adult fruit flies captured through Cue-Lure were identified as cucurbit fruit fly, *Bactrocera cucurbitae*, belonging to the Family: Tephritidae and Order: Diptera.

By this study, the number of fruit flies were counted daily using two types of pheromone lures such as Bactro-D and Cue-Lure from the mango orchards under 15 selected mango growing districts. Irrespective of sample districts, the population of fruit flies captured through these two types of pheromone lures revealed that the incidence of oriental fruit fly (*Bactrocera dorsalis*) was much higher than that of cucurbit fruit fly (*Bactrocera cucurbitae*). Variation analysis of both fruit fly species among 15 sample districts revealed that the highest population was recorded in Satkhira and Chauadanga districts followed by Natore and Rangamati districts. That was also followed by Rangpur and Thakurgaon districts. Conversely, the lowest population of both fruit fly species was recorded in Bandarban, Khagrachari, Dinajpur and Kushtia districts followed by Rajshahi, Meherpur and Chapainawabganj districts. That was followed by Naogaon and Jashore districts.

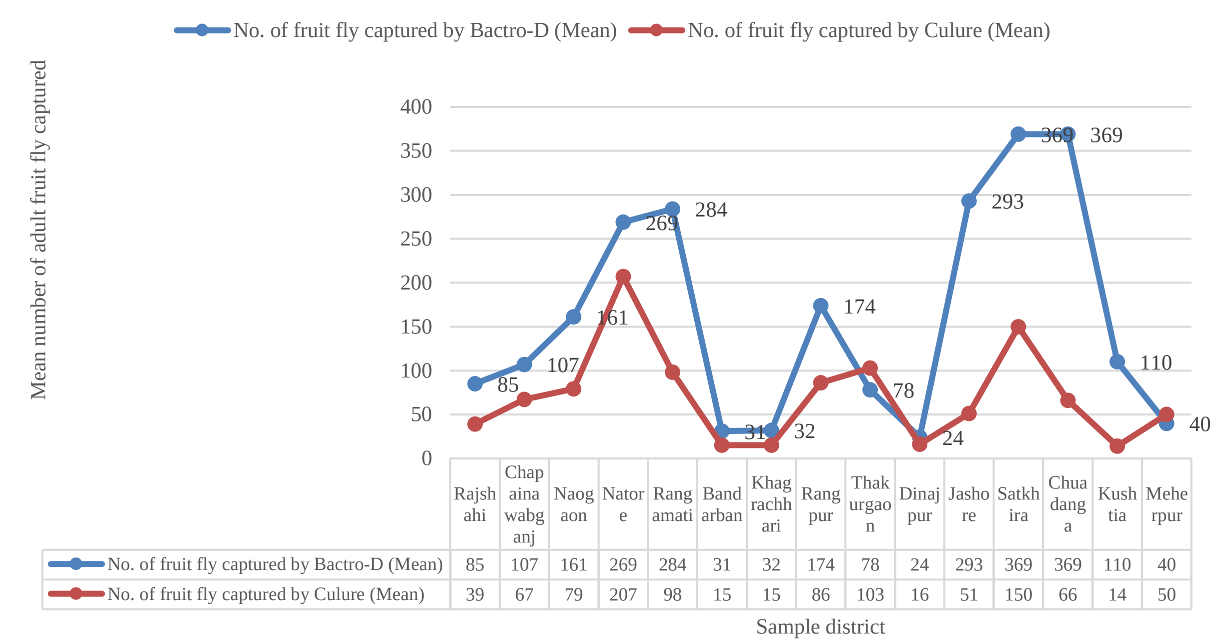


Figure-6.1: Distriction-wise comparative mean population of oriental fruit fly and cucurbit fruit fly captured daily through Bactro-D and Cuelure pheromone, respectively

6.3.5 Comparison of recorded arthropod pests identified through present PRA study (2023) with the previous PRA report (2015)

There was a study on "Pest Risk Analysis (PRA) of Mango in Bangladesh" conducted in the year of 2015 sponsored by the "Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under the Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh". The findings of the 'present PRA study on Mango conducted in 2023' were compared with the findings of 'previous PRA study on Mango conducted in 2015'. In case of pest listing, the present PRA study identified a total of 35 arthropod pests of mango by means of both field survey and literature review, out of which sixteen (16) were insect pests and one (1) mite pest were identified through field survey those were shown in the Table-6.1. Besides field survey, the present PRA study also identified additional 18 insect pests of mango through literature review as shown in the Table-6.2. Whereas the previous PRA study conducted in 2015 identified a total of 19 arthropod pests for mango in Bangladesh, of which 18 insect pests and one mite pest.

Conversely, a number (4) of insect pests of mango those were reported in the previous PRA study, which were not identified through field survey of present PRA study, but reported in the present PRA study identified through literature review. These insect pests were cucurbit fruit fly (*Bactrocera (Zeugodacus) cucurbitae*), mango fruit fly (*Bactrocera tau*), mango common scale insect (*Coccus mangiferae* (Green)) and pink gypsy moth (*Lymantria mathura*). On the other hand, in the present PRA study, there were two (2) additional insect pests also identified for mango as reported through field survey, but not reported in the previous PRA study conducted in 2015. The newly enlisted insect pests of mango were mango white scale insect (*Aulacaspis tubercularis*) and mango/chilli thrips (*Scirtothrips dorsalis*) as shown in the Table-6.1.

Simultaneously, the study team also compared the arthropod pests of mango as reported in the present PRA study identified through literature review with the findings of previous PRA study. There were 18 insect pests of mango were reported in the present PRA study identified through literature, of which only five (5) insect pests were reported in the previous PRA study. But the rest 13 insect pests were not identified through previous PRA study. These additional insect pests of mango were apple stem borer (*Trirachys holosericeus*), guava fruit fly (*Bactrocera correcta*), mango inflorescence midge (*Erosomyia indica*), coconut scale (*Aspidiotus destructor*), cottony cushion scale (*Icerya purchasi*), pineapple mealybug (*Dysmicoccus brevipes*), fruit tree mealybug (*Rastrococcus invadens*), mango aphid (*Toxoptera odinae*), mango leafhopper (*Idioscopus nitidulus*), bark eating caterpillar (*Indarbela tetraonis*), cotton bollworm (*Helicoverpa armigera*), black tea thrips (*Heliothrips haemorrhoidalis*) and melon thrips (*Thrips palmi*) (Table-6.2).

6.3.6 Pictorial presentation of insect and mite pests of mango

During field observation, the PRA study team captured photographs of insect and mite pests associated with the mango and its plants as well as plant parts. Simultaneously, study team also collected relevant photographs from secondary sources. These pictures have been presented as follows:

(a) Adult male fruit fly

(b) Adult female fruit fly ovipositing eggs

(c) Presence of gummy exudations on the surface of infested fruit

(d) Damaged mango by oriental fruit fly

(e) Severely damaged fruit by laying eggs and decaying by larval

(f) Fruit fly eggs

(g) Fruit fly maggots inside the ripen mango

(h) Internally damaged mango by fruit fly

Plate-1: Oriental fruit fly (*Bactrocera dorsalis*, Family: Tephritidae, Order: Diptera) and its damages

(a) Adult pulp weevil ovipositing eggs on the surface of young mango

(b) Internally damaged pulp of matured mango showing excreta

(c) Showing hole after emergence of adult pulp weevil from infested mango

(d) Damaged ripen mango and adult weevil on the surface of peeled-out mango

Plate-2: Mango pulp weevil (*Sternochaetus frigidus*, Family: Cucurlionidae, Order: Coleoptera) and its damages

(a) Adult mango stone/nut/seed weevil

(b) Eggs of stone/nut weevil on the surface of young mango

(c) Longitudinal section of mango showing stone weevil affected mango seed/nut

(d) Grub of mango stone weevil on the severely damaged mango seed

Plate-3: Mango stone weevil (*Sternochaetus mangiferae*, Family: Cucurlionidae, Order: Coleoptera) and its damages

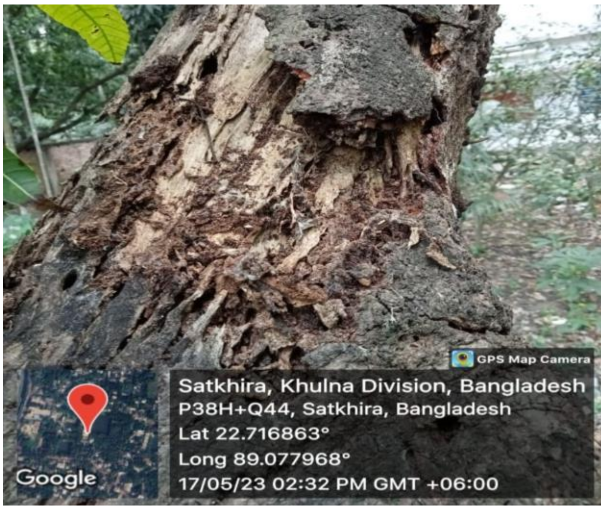
(a) Adult mango stem borer on the surface of mango tree trunk

(b) Saw dust exuded from mango tree trunk afftected by mango stem borer

(c) Grub of mango stem borer

(d) Cross-section of mango tree trunk showing the grub of mango stem borer

(e) Showing holes and damaged mango tree trunk affected by mango stem borer



(f) Severely damaged mango tree by mango stem borer

Plate-4: Mango stem borer (*Batocera rubus*, Family: Cerambycidae, Order: Coleoptera) and its damages

(a) Adult of mango leaf cutting weevil

(b) Severely damaged young leaves of mango cut by mango leaf cutting weevil

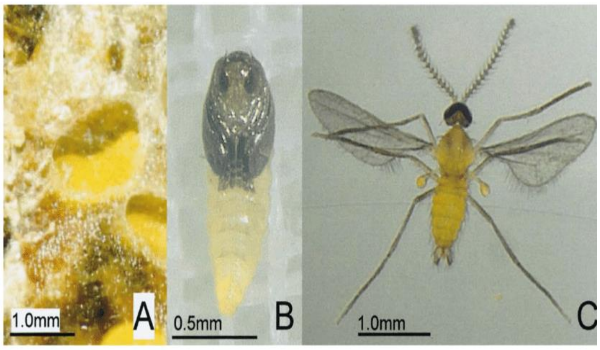
(c) Drop-off of mango leaves cut by mango leaf-cutting weevil

(d) Pile of cut leaves of mango

(e) Scrapped mango leaves by adult weevil

(f) Severely damaged young leaves of mango after scrapping by leaf-cutting weevil

Plate-5: Mango leaf cutting weevil (*Deporaus marginatus*, Family: Attelabidae, Order: Coleoptera) and its damages



(a) Mango leaf gall midge (A: Larvae inside the gall, B: Pupa & C: Adult male) Source: ResearchGate.net

(b) Severely damaged mango leaves by leaf gall midge

Plate-6: Mango leaf gall midge (*Procontarinia matteiana*, Family: Cecidomyiidae, Order: Diptera) and its damages

(a) Adult mango hoppers sucking cell-sap from mango twig

(b) Hopper infested inflorescence and honey dew secreted on the leaves by hoppers

(c) Black layer of shooty mould fungus formed on the surface of mango leaves due to honew dews secreted by mango hopper

(d) Severely damaged mango inflorescence by hoppers where none of fruit set

Plate-7: Mango hopper (*Amritodus atkinsoni*, *Idioscopus clypealis,* Family: Cecadellidae, Order: Homoptera) and its damages

(a) Mango leaf showing severely infested by mango white scale

(b) Mango white scales on mango leaf with high magnification

(c) Severely infested mango leaves in a twig

(d) Mango white scale infestation on the surface of mango fruit

Plate-8: Mango white scale insect (*Aulacaspis tubercularis*, Family: Diaspididae, Order: Homoptera) and its damages

(a) Gall formation at the apex of mango twig after oviposition by mango shoot gall psyllid

(b) Severely damaged mango twig by mango shoot gall psyllid

Plate-9: Mango leaf shoot gall psyllid (*Apsylla cistellata*, Family: Aphalaridae, Order: Homoptera) and its damages

(a) Giant mealybug infestation on mango twig

(a) Giant mealybug infestation on stem

(c) Giant mealybug infestation on stalk of mango inflorescence

(d) Severely damaged mango inflorescence by giant mealybug leaving only the rachis

(e) Giant mealybug infestation at fruit setting stage of mango

(f) Giant mealybug infestation on fruit stalk of mango

Plate-10: Mango giant mealybug (*Drosicha mangiferae*, Family: Margarodidae, Order: Homoptera) and its damages

(a) Mango aphid infestation on the rachis of mango inflorescence

(a) Aphid infestation on the surface of mango fruit

Plate-11: Mango aphid (*Toxoptera odinae*, Family: Aphididae, Order: Homoptera) and its damages

(a) Leaf miner adult on mango leaf

(b) Mango leaf showing mining on the surface of leaf lanina caused by leaf miner

(c) Mango leaves showing damaged areas caused by leaf miner

(d) Severely damaged mango leaves caused by leaf miner

Plate-12: Mango leaf miner (*Acrocercops syngramma*, Family: Gracillariidae, Order: Lepidoptera) and its damages

(a) Mango defoliator (caterpillar) infestation on a mango twig

(b) Severely damaged mango leaves in a twig leaving only the mid-ribs by mango defoliator

Plate-13: Mango defoliator (*Cricula trifenestrata*, Family: Saturniididae, Order: Lepidoptera) and its damages

(a) Young fruit damaged by mango fruit borer

(b) Severely damaged young fruit showing larvae of mango fruit borer

(c) Mango fruit borer damaged mango showing exil hole of caterpillar

(d) Larva of mango fruit borer also known as red-banded caterpillar

Plate-14: Mango fruit borer/Red-banded caterpillar (*Citripestis eutraphera,* Family: Pyralidae, Order: Lepidoptera) and its damages

(a) Adult thrips

(b) Thrips causing damage on newly developed mango leaves

(c) Young leaves turned yellowish color due to severe infestation caused by thrips

(c) Thrips feeding spots on mango leaf lamina turn white colour due to sucked out green chlorophyll below the surface

(c) Thrips causing damages on fruit surface at pea size stage of mango by scrapping green contents

(d) Thrips causing damages on young mango fruits by scrapping green contents

(d) Straw color symptom on mango due to Thrips feeding by scrapping green contents

(d) Thrips casuing severe damage on surfaces of full grown mango

Plate-15: Mango Thrips (*Aceria mangiferae*, Eriphyidae: Acarina) and its damages

(a) Symptom of Eriophyid mite infestation on mango leaves

(b) Leaf coating symptom of Eriophyid mite infestation on older leaves of mango

Plate-16: Mango Eriophyid mite (*Aceria mangiferae*, Family: Eriphyidae, Order: Acarina) and its damages

6.4 Diseases of mango in Bangladesh

A total number of twenty (20) diseases of mango, of which fifteen (14) fungal, one (1) algal, four (4) bacterial and one (1) nemic diseases were reported for field and storage condition of mango in Bangladesh as reported by different stakeholders such as mango growers, field level DAE officials and other experts. These diseases were identified for mango by means of face-to-face interview and focus group discussion with mango growers, key informant interview with DAE officials and other experts as well as by means of literature review. The incidences and damage potential of reported mango diseases have been presented below:

6.4.1 Incidence of diseases as recorded

There were two ways considered to record the diseases of mango available in Bangladesh. The ways were field level survey and literature review. The diseases of mango identified through those ways are illustrated below:

(a) Field survey-based findings: The study team made a list of diseases of mango identified through face-to-face interviews of mango growers in the pre-selected PRA areas as well as gathered information by means of focus group discussion with mango growers and from field level officials of Department of Agriculture Extension (DAE) and other experts by means of key informant interviews. As per field survey-based data, it was revealed that incidence of 16 diseases of mango were identified in Bangladesh through field survey. Amon these diseases, eleven (11) were fungal, four (4) bacterial and one algal diseases of mango were identified through field survey and those diseases were anthracnose (*Colletotrichum gloeosporioides*) of mango fruits and leaves, fruit end rot (*Phomopsis mangiferae*), charcoal/Diplodia rot (*Diplodia natalensis*), mango sooty mold (*Meliola mangiferae*), those were designated as major diseases of mango in Bangladesh. Other diseases identified through field survey were Cladosporium rot of mango (*Cladosporium cladosporioides*), powdery mildew (*Oidium mangiferae*), mango malformation (*Fusarium moniliforme*), die-back (*Botryosphaeria theobromae*), mango scab (*Elsinoë mangiferae*), mango tear stain (*Colletotrichum gloeosporioides*), mango gummosis (*Lasiodiplodia theobromae*) caused by fungi those were identified as minor diseases. Among algal disease, leaf red rust of mango (*Cephaleuros virescens* Kunze 1827) was reported as minor disease in the field condition. Among bacterial diseases of mango, Asiatic canker (*Xanthomonas citri*), bacterial leaf blight (*Pseudomonas syringae* pv. *syringae*) and Crown gall of mango *(Agrobacterium tumefaciens)*, bacterial leaf blight (*Xanthomonas campestris* pv. *mangiferae-indicae*) those were identified as minor diseases of mango in Bangladesh.

(b) Literature review-based findings: Besides, field level survey-based findings, the study team also made a list of diseases of mango by means of review of secondary documents collected from different sources. As per literature review, it was revealed that a total of four (4) diseases of mango were recorded for Bangladesh and these were Alternaria leaf spot of mango (*Alternaria alternate* (Fr.) Keissl. (1912)), blossom blight/grey mould (*Botryosphaeria theobromae*), Ceratocystis blight (*Ceratocystis fimbriata*) caused by fungi those were designated as minor diseases of mango. The furth disease as identified through literature review was root-knot nematode of mango (*Meloidogyne incognita*), which was also designated as minor disease of mango (Table-6.4).

6.4.2 Damage potential of diseases

Among these diseases, the anthracnose diseases on leaves and fruits were more damaging than others. The anthracnose disease caused damage to mango at vegetative and fruiting stage as well as in storage condition with high infection intensity, but the damage severity was controlled by the farmers through routine application of fungicides in the orchard. While sooty mold and charcoal rot were also reported as major diseases for mango and caused damage with medium to high intensity (Table-6.3 & 6.4). But the mango leaf red rust disease caused damage mango leaves at vegetative stage with high infection intensity in the hilly areas such as Khagrachari, Rangamati and Bandarban districts. Other diseases caused damage mango with low infection intensity. But all these diseases of mango were being regularly controlled by the application of chemical pesticides in the field. Therefore, the severity of these diseases stayed behind, otherwise they could become severe.

Table-6.3. Diseases of mango in Bangladesh, their categorical identity, status and infection severity recorded through field survey

SN.	Common name	Scientific name	Plant parts affected	Pest status	Infection severity	District wise farmer response	
						Maximum	Minimum
Causal organism: Fungi							
1	Mango anthracnose	*Colletotrichum gloeosporioides* Family: Glomerellaceae Order: Glomerellales	Panicles, leaves, branch terminals, fruit	Major	High	Rangpur (95.0%)	Chapainawabganj (1.0%)
2	Powdery mildew	*Oidium mangiferae* Family: Erysiphaceae Order: Erysiphales	Leaves, inflorescences, fruits	Minor	Low	Jashore (60.0%)	Chapainawabganj, Chuadanga, Dinajpur, Kushtia, and Meherpur (1.0%)
3	Mango malformation	*Fusarium moniliforme* Family: Nectriaceae Order: Hypocreales	Inflorescences, twig, saplings	Minor	Low	Jashore (46.7%)	Chuadanga (1.0%)
4	Die-back	*Botryosphaeria theobromae* Family: Botryosphaeriaceae Order: Botryosphaeriales	Shoots, leaves, twigs	Minor	Low	Jashore (40.0%)	Chapainawabganj, Chuadanga, Dinajpur, and Meherpur (1.0%)
5	Fruit end rot	*Phomopsis mangiferae* Family: Diaporthaceae Order: Diaporthales	Fruit	Major	Low to medium	Rangpur (50.0%)	Chuadanga (1.0%)
6	Diplidia/Charcoal rot/Stem-end-rot	*Diplodia natalensis* Family: Botryosphaeriaceae Order: Botryosphaeriales	Fruit	Major	Medium	Rajshahi (7.3%)	Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)
7	Cladosporium rot of mango	*Cladosporium cladosporioides* Family: Cladosporiaceae Order: Capnodiales	Fruit	Minor	Low to medium	Rajshahi (5.3%)	Chapainawabganj, Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)
8	Mango Scab	*Elsinoë mangiferae* Family: Elsinoaceae Order: Myriangiales	Fruit, Stem, Flower and fruit stalk	Minor	Low	Bandarban (30.0%)	Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)
9	Mango sooty mold	*Meliola mangiferae* Family: Meliolaceae Order: Meliolales	Leaf, inflorescence, fruit	Major	Medium to high	Rangpur (45.0%)	Chapainawabganj (1.0%)
10	Mango tear stain	*Colletotrichum gloeosporioides* Family: Glomerellaceae Order: Glomerellales	Fruit	Minor	Low to medium	Rajshahi (7.3%)	Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)
11	Mango gummosis	*Lasiodiplodia theobromae* Family: Botryosphaeriaceae Order: Botryosphaeriales	Stem	Minor	Low	Meherpur (5.3%)	Chapainawabganj, Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)

Causal Organism: Algae							
12	Leaf red rust	*Cephaleuros virescens* Family: Trentepohliaceae Order: Trentepohliales	Leaves, petioles, twigs	Minor	Low	Bandarban (30.0%)	Chapainawabganj, Chuadanga, Dinajpur, and Jashore (1.0%)
Causal Organism: Bacteria							
13	Asiatic canker	*Xanthomonas citri* Family: Xanthomonadaceae Order: Xanthomonadales	Leaf, fruit	Minor	Low	Rangamati (5.3%)	Satkhira (1.0%)
14	Bacterial leaf blight	*Pseudomonas syringae* pv. *syringae* Family: Pseudomonaceae Order: Pseudomonadales	Leaf	Minor	Low	Bandarban (30.0%)	Chapainawabganj and Satkhira(1.0%)
15	Crown gall of mango	*Agrobacterium tumefaciens* Family: Rhizobiaceae Order: Hyphomicrobiales	Stem	Minor	Low	Rangamati (7.3%)	Chuadanga, Dinajpur, Jashore, and Satkhira (1.0%)
16	Bacterial leaf blight	*Xanthomonas campestris* pv. *mangiferae-indicae* Family: Xanthomonadaceae Order: Xanthomondales	Leaf	Minor	Low	Rangamati, Khagrachari, Chapainawabganj (3%)	Other districts (0%)

* N.B.: The numerical values in the parenthesis of a column indicate the percent response of mango growers on whether the respective pest incidence occurred or not on mango plant/plant parts during data collection through face-to-face interview at field level

Table-6.4. Diseases of mango in Bangladesh, their categorical identity, status and infection severity recorded through literature review

SN.	Common name	Scientific name	Family	Order	Plant parts affected	Pest status	Infection severity	Reference
Causal organism: Fungi								
1	Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Leaf	Minor	Low	DAE (2019)
2	Alternaria leaf spot	*Alternaria alternate (Fr.)* Keissl.	Pleosporaceae	Pleosporales	Leaf	Minor	Low	DAE (2015)
3	Blossom blight/ grey mould	*Botrytis cinerea* Pers.1794	Sclerotiniaceae	Helotiales	Flowers and fruits	Minor	Low	DAE (2019)
Causal organism: Nematode								
4	Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	Root	Minor	Low	CABI and EPPO (2002)

6.4.3 Comparison of recorded diseases of mango identified through present PRA study (2023) with the previous PRA study report (2015)

The findings of the 'present PRA study on Mango conducted in 2023' were compared with the findings of 'previous PRA study on Mango conducted in 2015'. In case of listing of mango diseases in Bangladesh, the present PRA study identified a total of 20 diseases of mango by means of both field survey and literature review, out of which sixteen (16) diseases were identified through field survey those were shown in the Table-6.3. Besides field survey, the present PRA study also identified additional four (4) diseases of mango through literature review as shown in the Table-6.4. Whereas the previous PRA study identified a total of eight (8) diseases for mango in Bangladesh, of which seven (7) fungal and one (1) was algal disease.

Conversely, there were two (2) diseases of mango those were reported in the previous PRA study, which were not identified through field survey of present PRA study, but reported in the present PRA study identified through literature review. These diseases were Alternaria leaf spot of mango (*Alternaria alternate* (Fr.) Keissl. (1912)) and blossom blight/grey mould (*Botryosphaeria theobromae*). On the other hand, in the present PRA study, ten (10) additional diseases were also identified for mango through field survey, but not reported in the previous PRA study conducted in 2015. The newly enlisted diseases of mango were fruit end rot (*Phomopsis mangiferae*), charcoal/Diplodia rot (*Diplodia natalensis*), mango sooty mold (*Meliola mangiferae*), Cladosporium rot of mango (*Cladosporium cladosporioides*), mango tear stain (*Colletotrichum gloeosporioides*), mango gummosis (*Lasiodiplodia theobromae*), Asiatic canker (*Xanthomonas citri*), bacterial leaf blight (*Pseudomonas syringae* pv. *syringae*) and Crown gall of mango *(Agrobacterium tumefaciens)*, bacterial leaf blight (*Xanthomonas campestris* pv. *mangiferae-indicae*) as shown in Table-6.3.

Simultaneously, the study team also compared the mango diseases identified through literature review reported in the present PRA study with the findings of previous PRA study. A total of four (4) diseases of mango identified through literature were reported in the present PRA study, of which two (2) diseases were reported in the previous PRA study. While the rest two (2) diseases were not identified through previous PRA study. These additional diseases of mango were Alternaria leaf spot of mango (*Alternaria alternate* (Fr.) Keissl. (1912)), blossom blight/grey mould (*Botryosphaeria theobromae*) (Table-6.3).

6.4.4 Pictorial presentation of diseases of mango

During field observation, the PRA study team captured photographs of diseases associated with mango and its plants as well as plant parts. Simultaneously, study team also collected relevant photographs from secondary sources. These pictures have been presented as follows:

(a) Anthracnose disease infected mango leaf

(b) Anthracnose disease infected mango leaves on a standing tree

(c) Anthracnose disease infected mango twigs

(d) Anthracnose disease infected mango inflorescences

(e) Anthracnose disease infected mango

(f) Anthracnose disease infected mangoes in a busket

Plate-17: Antracnose disease of mango (*Colletotrichum gloeosporioides*, Family: Glomerellaceae, Order: Glomerellales) and its damages

(a) Severely infected mango inflorescence by powdery mildew disease

(b) Powdery mildew disease infected mango mango inflorescence

(c) Powdery mildew disease infected mango leaves in a twig

(d) *Oidium mangiferae* leaf spots and leaf curling on mango leaves

Plate-18: Powdery mildew (*Oidium mangiferae,* Family: Erysiphaceae, Order: Erysiphales) and its damages

(a) Mango malformation on mango twigs

(b) Mango malformation on mango inflorescence

(c) Mango malformation on mango stem

Plate-19. Mango malformation (*Fusarium moniliforme*, Family: Nectriaceae, Order: Hypocreales) and its damages

(a) Wilted branches later die, leading to death of whole trees

(b) Dropped off leaves from the wilted plant due to attack of die-back disease

(c) Die-back disease affected leaves turns brown and dry up

(d) Die-back disease causing to dry up of mango tree

Plate-20. Mango die-back disease (*Botryosphaeria theobromae*, Family: Botryosphaeriaceae, Order: Botryosphaeriales) and its damages

(a) Mango fruit-end-rot (b) Fruit-end-rot of mango at standing tree

Plate-21: Fruit-end-rot of mango (*Phomopsis mangiferae,* Family: Diaporthaceae, Order: Diaporthales) and its damages

(a) Stem-end-rot starting at the base of mango (b) Severely affected mango by stem-end-rot

Plate-22: Stem-end-rot/Diplodia/Charcoal rot of mango (*Diplodia natalensis*, Family: Botryosphaeriaceae, Order: Botryosphaeriales) and its damages

(a) Black spots on mango caused by Cladosporium fungus infection

Plate-23: Cladosporium rot of mango (*Cladosporium cladosporioides*, Family: Cladosporiaceae, Order: Capnodiales) and its damages

(a) Raised brown lessions on the surface of mango due to mango scab infection

(b) Brown lessions on the surface of mango due to mango scab infection

Plate-24: Mango scab (*Elsinoe mangiferae*, Family: Elsinoaceae, Order: Myriangiales) and its damages

(a) Black layer on a mango covered by the shooty mold fungus

(b) Severely affected mango leaves on a tree by shooty mold fungus

Plate-25: Mango shooty mold (*Meliola mangiferae*, Family: *Meliolaceae*, Order: *Meliolales*) and its damages

(a) Exudations of tear stain from the mangoes affected by *C. gloeosporioides* fungus

Plate-26: Mango tear stain (*Colletotrichum gloeosporioides*, Family: Glomerellaceae, Order: Glomerellales) and its damages

(a) Amber coloured gum exudes from the gummosis affected bark of the mango stem (left) and tree trunks (mid and right)

Plate-27: Mango gummosis (*Lasiodiplodia theobromae*, Family: Botryosphaeriaceae, Order: Botryosphaeriales) and its damages

(a) Red spots on mango leaf caused by red rust disease

(b) Early greyish spots on mango leaf affected by ***Cephaleuros virescens* algae**

(c) Severely affected mango plant caused by red rust disease

(d) Severely affected mango plant showing greyish spots on leaves caused by red rust disease

Plate-28: Leaf red rust (algae) of mango (*Cephaleuros virescens*, Family: Trentepohliaceae, Order: Trentepohliales) and its damages

(a) Crown gall produced on a mango tree at junction of branches

(b) Severely damaged mango tree by producing grown galls of mango

Plate-29: Crown gall of mango caused by bacterium (*Agrobacterium tumefaciens,* Family: Rhizobiaceae, Order: Hyphomicrobiales) and its damages

(a) Bacterial leaf blight affected mango plant at field level

(b) Bacterial leaf blight affected mango leaves

Plate-30: Bacterial leaf blight of mango caused by bacterium (*Xanthomonas campestris* pv. *mangierae-indicae,* Family: Xanthomondaceae, Order: Xanthomonadales) and its damages

Plate-31: Cracked mango fruits because of boron deficiency

6.5 Weeds of mango in Bangladesh

A total number of five weeds were reported by the stakeholders those were found in the field of mango. The incidences and damage potential of reported mango weeds have been presented below:

6.5.1 Incidence of weeds as recorded

The incidences of weeds of mango found in the study were Loranthus/Indian mistletoe (*Dendrophthae falcate*), Dodder plant (*Cuscuta* spp.), Pathenium weed (*Parthenium hysterophorus* L.), Staghorn fern (*Platycerium* sp.) and Parasitic orchid (*Cleisostoma* sp.) in the field of mango and both of the weeds had minor importance. The incidence of loranthus and dodder were as the parasitic plants on mango trees, but parthenium grows on the lands of mango orchards (Table-6.5). The parthenium weed (*Parthenium hysterophorus*) was found only some restricted areas such as Rajshahi, Natore, Pabna, Kustia, Jessore districts among 19 sampled districts of Bangladesh. The stakeholders also reported that the parthenium weed might be entered into Bangladesh through cross boundary from India by the transportation system of border trading.

6.5.2 Damage potentiality of weeds

Among these diseases, the Parthenium was more damaging than other and caused damage in the whole season with low infestation intensity. As a newly introduced weed, though parthenium caused damage with low infestation intensity, but it could cause severe damage and spread to other areas, if not controlled properly. The loranthus caused damage mango plants throughout the year with low infestation intensity, where it was severely found on the very much older mango plants with high infestation intensity.

Table-6.5. Weeds of mango in Bangladesh, their identity, status and infestation severity recorded through field survey

Weed	Weed identity	Pest status	Stage of plant affected	Infestation severity	Reference
Loranthus/ Indian Mistletoe	*Dendrophthae falcate* Order: Santalales Family: Loranthaceae	Minor	Stem, twigs, tree	Low	Field survey
Dodder plant	*Cuscuta* spp. Order: Solanales Family: Convolvulaceae	Minor	Stem, twigs, tree	Low	Field survey
Parthenium weed	*Parthenium hysterophorus* Order: Asterales Family: Asteraceae	Minor (limited areas)	Annual herb aggressively disturbed sites	Low	Field survey & Hossain & Zuberi (2013)
Staghorn fern	*Platycerium sp.* Order: Polypodiaceae Family: Polypodiales	Minor	Stem	Low	Field survey
Parasitic orchid	*Cleisostoma sp.* Order: Asparagales Family: Orchidaceae	Minor	Trunk of older mango plants	Low	Field survey

6.5.3 Pictorial presentation of weeds of mango

During field observation, the PRA study team captured photographs of weeds associated with mango. Simultaneously, study team also collected relevant photographs from secondary sources. These pictures have been presented as follows:

Plate-31: Staghorn fern (*Platycerium* sp., Family: Polypodiaceae, Order: Polypodiales) and its incidence on mango tree

Plate-32: Parasitic orchid (*Cleisostoma* sp., Family: Orchidaceae, Order: Asparagales and its incidence on mango tree


Plate-33: Loranthus/Mistletoe (*Dendrophthae* sp., Family: Loranthaceae, Order: Santalales) and its incidence on mango tree

Plate-34: Parasitic dodder on mango tree (*Cascuta* sp., Family: Convolvulaceae, Order: Solanales) and its incidence on mango tree

Plate-35: Parthenium weed (*Parthenium hysterophorus,* Order: Asterales, Family: Asteraceae) and its incidence

6.6 Endangered areas of serious pests of mango

The fruit flies of mango reported in all over the sampled districts, but severe in Satkhira, Chuadanga, Natore, Rangamati, Rangpur, Thakurgaon districts of Bangladesh. The parthenium weed (*Parthenium hysterophorus*) also found in Rajshahi, Natore, Pabna, Kustia, Jessore districts among 15 sampled districts of Bangladesh. The stakeholders also reported that the parthenium weed might be entered into Bangladesh through cross boundary from India by the transportation system of border trading. Therefore, the restriction should be taken to prevent the dissemination of these quarantine disease and weed to other areas as well as to take management against these noxious pests.

6.7 Management options for mango pests

6.7.1 Management options for insect pests

According to the responses by the stakeholders, the most effective and commonly practiced management options against the insect pests of mango were spraying insecticides on the mango tree in the orchard followed by removal of unnecessary branches of the trees after harvesting of the fruits. Other important management options are the use of balanced fertilizer, use of pheromone traps for capturing and killing of fruit fly adults, bagging of fruits to protect mango from fruit fly infestation, removal of weeds from mango orchards, application of insecticides with irrigation to kill pupae of fruit fly and other soil dwelling insects, application of granular insecticides at the base of the mango trees, application of IPM, fumigation under the mango tree, leaving the birds from the orchards to protect the ripen fruits from infestation.

6.7.2 Management options for diseases

The most effective and commonly practiced management options against the diseases of mango were spraying of fungicide on the mango trees in the orchards, bagging of fruits to reduce the anthracnose and diplodia rot, pruning of the diseased branches from the trees followed by removal of unnecessary branches of the trees after harvesting of the fruits. Other important management options for controlling mango diseases were the removal of weeds from the mango orchards, application of pesticides at the base of the mango trees, use of tolerant variety, application of IPM, fumigation under the mango tree.

6.7.3 Management options for weeds

According to the responses by the stakeholders, the most effective and commonly practiced management options against the weeds of mango were weeding from the orchards particularly for parthenium, spraying herbicide.

6.8 Possible ways of entry of quarantine pests into Bangladesh

Bangladesh usually imports most of the fresh mangoes mainly from India through land ports and Thailand, Pakistan, Australia and the Philippiines through Air ports. But no pests of mango had yet been intercepted in any of the consignment of mangoes imported as reported by the PQW-DAE. Besides, there is a possibility to enter mango pests through the fresh mango fruits consignment, if imported without considering the standard phytosanitary system of International Standard Phytosanitary Measures (ISPM).

6.9 Effective ways to prevent the entry of quarantine pests of mango into Bangladesh

The entry of quarantine pests of potato can be prevented by the following of phytosanitary measures as prescribed by the ISPM. Following steps can be followed as reported by the stakeholders participated in the study:

- Assurance of phytosanitary certificate during importation of fresh mango fruits,

- In case of high-risk rating pests, pre-inspection of crop in the exporting countries should be ensured,
- Existing legislation method should be implemented by following quarantine rules and regulations,
- Standard phytosanitary activities should be followed during customs clearance of the products,
- Strengthening the laboratory capacity with modern equipment to inspect the imported product properly considering standard phytosanitary system,
- Strengthening the activities and monitoring system of quarantine centers under PQW, DAE in Bangladesh.
- Illegal entry of seed and ware fresh mango fruits and mango seedlings from neighboring countries especially India should be restricted applying legislation and awareness buildup of the respective stakeholders,
- Intensify the co-operation with quarantine sectors of other countries.
- Action oriented training should be provided for skill development of the quarantine personnel of quarantine wing.

6.10 Options to prevent the spread of quarantine pests of mango within Bangladesh

The quarantine pests of mango, if already entered into Bangladesh, can be prevented their spread within the country considering the following steps as reported by the stakeholders participated in the study:

- Proper identification of the quarantine pests
- Awareness builds up among the growers/farmers and other stakeholders about quarantine pests including their management,
- Restriction should be applied for the dissemination of infested mangoes from pest infested areas to pest free areas,
- Production of pest free mangoes by the application of proper management for pests,
- Intensive and frequent inspection of mango orchards by the experts,
- Follow the quarantine rules and regulation,
- Proper training of the quarantine personnel particularly on quarantine pests of respective crops along with their management options and phytosanitary measures.

6.11 Measures need to be taken by the exporters to export mangoes

- Pest free mango should be produced,
- Pre-and post-harvest phytosanitary technique should be followed,
- Pest infested/infected mangoes should be discarded from the lots,
- Proper grading for the quality mango fruits should be ensured,
- Proper packing should be followed,
- Graded and packed mango fruits should be preserved in cold storage,
- Phytosanitary certificate must be ensured before importing the mangoes.

CHAPTER 7
POTENTIAL HAZARD ORGANISM: RISK ASSESSMENT

7.1 Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding the mango imported from any exporting countries of India, Thailand, Pakistan, Australia, the Philippines and others into Bangladesh.

7.2 Pest Categorization: Identification of Quarantine Pests Likely to Follow the Pathway

7.2.1 Pests of mango in the world

The pests associated with fresh fruits and planting materials of mango in the world have been categorized and listed below based on their scientific name, taxonomic position, common name, plant parts affected, geographical distribution and their quarantine status for Bangladesh.

Seventy-four (74) species of pests were recorded for mango in the world of which 46 species were insect pests and 1 specie were mite pests; the species of disease-causing fungi were 18, bacteria 3, nematode 1, and algae was 1. On the other hand, 4 species of weeds for mango were recorded in the world.

Among Table 7.1 depicted the lists of pests associated with the mango that also occur in India, Thailand, Pakistan and Australia and the absence or presence of these pests in Bangladesh. Based on Table 7.1, any pest that meets all above criteria selected for further risk assessment (Table 7.2).

7.2.2 Quarantine pests of mango for Bangladesh

Sixteen (16) species of quarantine pests of mango for Bangladesh were identified those were present in India, Thailand, Pakistan, Australia, and Myanmar, but not in Bangladesh. Among these 16 species of quarantine pests, 12 were insect pests and 4 fungus (Table 7.2).

The quarantine insect pests are Queensland fruit fly (*Bactrocera tryoni*), Mexican fruit fly (*Anastrepha ludens*), A member of Oriental fruit (*Bactrocera caryeae*), Marula fruit fly (*Ceratitis cosyra*), Stellate scale (*Ceroplastes stellifer*), Morgan's scale (*Chrysomphalus dictyospermi*), Tapioca scale insect (*Aonidomytilus albus*), Spiked mealybug (*Nipaecoccus nipae*), Grey pineapple mealybug (*Dysmicoccus neobrevipes*), Peach scale (*Parthenolecanium persicae*), Shoot borer of mango (*Penicillaria jocosatrix*), and Rubber termite (*Coptotermes curvignathus*) (Table 7.2).

On the other hand, three (4) disease causing pathogens have been identified as quarantine pests of mango for Bangladesh. All the disease-causing pathogens are Fungus and these are: Leaf and stem blight (*Macrophoma mangiferae*), Twig canker/stem-end rot (*Cytosphaera mangiferae*), Soft brown rot (*Hendersonia creberrima*) and Mango black spot (*Actinodochium jenkinsii*).

Table 7.1. Pests associated with mango in the world and identification of quarantine organisms

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
Arthropod pests									
A. Insect pests									
1	Mango stone weevil	*Sternochetus mangiferae*	Curculionidae	Coleoptera	Minor	Yes	No	Bangladesh	Amin *et al.* (2015)
								Bhutan	EPPO (2022)
								China	Seebens *et al.* (2017)
								India	Godase *et al.* (2013)
								Indonesia	EPPO (2022)
								Malaysia	Abdullah and Shamsulaman (2008)
								Myanmar	EPPO (2022)
								Nepal	CABI and EPPO (2015)
								Sri Lanka	EPPO (2022)
								Australia	Peng and Christian (2007)
2	Mango Pulp weevil	*Sternochaetus frigidus*	Curculionidae	Coleoptera	Minor	Yes	No	Bangladesh	DAE (2019)
								Myanmar	CABI (2006)
								Thailand	EPPO (2006)
								India	Ahad, (2003)
3	Mango stem borer	*Batocera rubus* (Linnaeus, 1758)	Cerambycidae	Coleoptera	Minor	Yes	No	Bangladesh	DAE (2019)
								India	en.wikipedia.org
								China	
								Malaysia	
4	Apple stem borer	*Trirachys holosericeus*	Cerambycidae	Coleoptera	Minor	Yes	No	Bangladesh	Gahan (1906)
								China	Kariyanna *et al.* (2018)
								India	Naik and More (2019)
								Myanmar	Khan and Maiti (1983)
								Pakistan	Mitra *et al.* (2016)
								Philippines	DUFFY (1968)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Sri Lanka	Mitra *et al.* (2016)
								Thailand	Mitra *et al.* (2016)
5	Mango leaf cutting weevil	*Deporaus marginatus*	Attelabidae	Coleoptera	Major	Yes	No	Pakistan, India, Bangladesh, Myanmar, Thailand, Malaysia and Singapore	Muniappan, R. (2012)
6	Queensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	Minor	No	Yes	Singapore, Netherlands, United States, Australia, New Zealand, Chile	EPPO (2022), Cameron *et al.* (2010), Bateman (1982)
7	Mexican fruit fly	*Anastrepha ludens*	Tephritidae	Diptera	Minor	No	Yes	Netherlands	EPPO (2022)
								Costa Rica	Scally *et al.* (2016)
								Mexico	Vanoye-Eligio *et al.* (2017)
								United States	NAPPO (2018)
								New Zealand	EPPO (2022)
								Argentina	EPPO (2022)
8	A member of Oriental fruit fly	*Bactrocera caryeae*	*Tephritidae*	Diptera	Minor	No	Yes	India	Jiji *et al.* (2016)
								Oman	EPPO (2022)
					Minor	Yes	No	Bangladesh	Leblanc *et al.* (2014)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
9	Guava fruit fly	*Bactrocera correcta*	*Tephritidae*	Diptera				Bhutan	Drew *et al.* (2007)
								China	Liu XiaoFei *et al.* (2019)
								India	Yugendra *et al.* (2020)
								Japan	Satoh *et al.* (1985)
								Malaysia	EPPO (2022)
								Myanmar	Qin YuJia *et al.* (2016)
								Nepal	White and Elson-Harris (1992)
								Pakistan	Bilal *et al.* (2017)
								Sri Lanka	CABI and EPPO (2003)
								Thailand	Orankanok *et al.* (2013)
10	Oriental fruit fly	*Bactrocera dorsalis* (Hendel)	*Tephritidae*	Diptera	Major	Yes	No	Bangladesh	DAE (2019)
11	Cucurbit fruit fly	*Bactrocera (Zeugodacus) cucurbitae*	*Tephritidae*	Diptera	Minor	Yes	No	Bangladesh	DAE (2019)
12	Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								India	Yugendra *et al.* (2020)
								Indonesia	EPPO (2022)
								Myanmar	CABI and EPPO (2013)
								Nepal	EPPO (2022)
								Oman	White (2006)
								Pakistan	Zain *et al.* (2020)
								Saudi Arabia	White (2006)

S N	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Sri Lanka	Tsuruta *et al.* (1997)
								Thailand	Tigvatananont and Areekul (1984)
								Sudan	EPPO (2022)
13	Marula fruit fly	*Ceratitis cosyra*	Tephritidae	Diptera	Minor	No	Yes	Benin	Vayssières *et al.* (2015)
								Nigeria	Meyer *et al.* (2002)
								Sierra Leone	Meyer *et al.* (2002)
								South Africa	Villiers *et al.* (2013)
								Sudan	Fadlelmula and Ali (2014)
								New Zealand	EPPO (2022)
14	Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	Minor	Yes	No	Bangladesh	Akhtaruzzaman *et al.* (1999)
								India	Prabhakar (2011)
								Sri Lanka	Drew and Romig (2013)
								Thailand	NHM (Undated)
15	Inflorescence midge	*Erosomyia indica*	Cecidomyiidae	Diptera	Minor	Yes	No	Bangladesh	CABI
								India	Prasad and Grover, 1976
								Pakistan	CABI
								Thailand	Waterhouse (1993)
								Brazil	CABI
16	Mango leaf gall midge	*Procontarinia matteiana*	Cecidomyiidae	Diptera	Minor	Yes	No	Bangladesh	DAE (2015)
								India	
								Kenya	
17	Mango Hoppers	*Amritodus atkinsoni*, *Idioscopus*	Cicadellidae	Hemiptera	Major	Yes	No	Bangladesh	The International Barcode of Life Consortium (2016)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
		clypealis, Idioscopus nagpurensis						China	Zizhong and Jichun (2021)
								India	Girish *et al.* (2019)
								Indonesia	Waterhouse (1993)
								Malaysia	NHM (2022)
								Myanmar	Waterhouse (1993)
								Pakistan	Khatri and Webb (2014)
								Philippines	Yee and Ocampo (2010)
								Sri Lanka	Gnaneswaran *et al.* (2007)
								Thailand	Waterhouse (1993)
								Vietnam	
								Australia	Qureshi *et al.* (2011)
18	Coconut scale	*Aspidiotus destructor*	Diaspididae	Hemiptera	Minor	Yes	No	Bangladesh	APPPC (1987)
								Bhutan	NHM (1985)
								China	Tao (1999)
								India	Joshi and Sangma (2015)
								Japan	Danzig and Pellizzari (1998)
								Malaysia	UK, CAB International (1966)
								Myanmar	
								Vietnam	
								Sri Lanka	
								Pakistan	
								Nepal	NHM (1967)
								Thailand	Waterhouse (1993)
19			Coccidae		Minor	Yes	No	Bangladesh	DAE (2015)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
	Mango common scale insect	*Coccus mangiferae (Green)*		Hemiptera				India	
								China	
20	Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	Minor	No	Yes	China	Seebens *et al.* (2017)
								India	Prakash and Patil (2015)
								Myanmar	EPPO (2022)
								Pakistan	
								Philippines	
								Sri Lanka	
								Thailand	
								Australia	Qin and Gullan (1994)
21	Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	Minor	No	Yes	China	UK, CAB International (1969)
								India	Verma and Dinabandhoo (2005)
								Japan	Kawai (1987)
								Malaysia	UK, CAB International (1969)
								Myanmar	
								Philippines	
								Sri Lanka	
								Thailand	
								Australia	Seebens *et al.* (2017)
22	Tapioca scale insect	*Aonidomytilus albus*	Diaspididae	Hemiptera	Minor	No	Yes	China,	Tao, 1999
								India	Sankaran *et al.* 1984
								Sir Lanka	Williams and Williams 1988
								Thailand	APPPC 1987
23	White scale	*Aulacaspis tubercularis*	Diaspididae	Hemiptera	Minor	Yes	No	Bangladesh	Field visit

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
24	Shoot gall psyllid	*Apsylla cistellata*	Aphalaridae	Hemiptera	Minor	Yes	No	Bangladesh	DAE (2019)
								India	Kumar *et al.* (2007)
25	Mango mealy bug	*Drosicha mangiferae*	Margarodidae	Hemiptera	Major	Yes	No	Bangladesh	Akhter *et al.* (2022)
								India	
								South Asia	
26	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Minor	Yes	No	Bangladesh	Williams (2004)
								China	Palma-Jiménez and Blanco-Meneses (2017)
								India	Srinivasnaik *et al.* (2016)
								Pakistan	Ben-Dov (1994)
								Thailand	Williams (2004)
								Vietnam	Vu *et al.* (2006)
								Australia	Ben-Dov (1994)
27	Grey pineapple mealybug	*Dysmicoccus neobrevipes*	Pseudococcidae	Hemiptera	Minor	No	Yes	China	Seebens *et al.* (2017)
								India	García Morales *et al.* (2016)
								Japan	
								Malaysia	
								Pakistan	
								Sri Lanka	Sirisena *et al.* (2013)
								Thailand	García Morales *et al.* (2016)
28	Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	Minor	No	Yes	China	CABI and EPPO (2005)
								India	Josephrajkumar *et al.* (2012)
								Indonesia	CABI and EPPO (2005)
								Thailand	
								Philippines	Caasi-Lit *et al.* (2012)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
29	Fruit tree mealybug	*Rastrococcus invadens*	Pseudococcidae	Hemiptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								China	Wu (2016)
								India	Joshi and Sangma (2015)
								Indonesia	EPPO (2022)
								Malaysia	EPPO (2022)
								Pakistan	EPPO (2022)
								Sri Lanka	Sirisena *et al.* (2013)
								Thailand	EPPO (2022)
30	Cottony cushion scale	*Icerya purchase*	Monophlebidae	Hemiptera	Minor	Yes	No	Bangladesh	NHM (1980)
								China	Seebens *et al.* (2017)
								India	Kotikal *et al.* (2011)
								Japan	Seebens *et al.* (2017)
								Malaysia	Waterhouse (1993)
								Pakistan Sri Lanka	EPPO (2022)
								Thailand	Waterhouse (1993)
								Australia	Williams and Watson (1990)
31	Peach scale	*Parthenolecanium persicae*	Coccidae	Hemiptera	Minor	No	Yes	China	Xie (1998)
								India	Shafee *et al.* (1989)
								Japan	Kawai (1980)
								Pakistan	UK, CAB International (1979)
								Sri Lanka	Ben-Dov *et al.* (2001)
								Australia	Rakimov *et al.* (2013)
32	Mango aphid	*Toxoptera odinae*	Aphididae	Hemiptera	Minor	Yes	No	Bangladesh China India Japan	UK, CAB International (1991)

S N	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Malaysia	
								Nepal	
								Sri Lanka	
								Thailand	
33	Mango leafhopper	*Idioscopus nitidulus*	Cicadellidae	Hemiptera	Minor	Yes	No	Bangladesh	The International Barcode of Life Consortium (2016)
								China	Li Zizhong and Xing Jichun (2021)
								India	Munj *et al.* (2017)
								Pakistan	Khatri and Webb (2014)
								Philippines	Khin Nyunt Yee and Ocampo (2010)
								Sri Lanka	Gnaneswaran *et al.* (2007)
								Thailand	Waterhouse (1993)
								Vietnam	Waterhouse (1993)
								Australia	Qureshi *et al.* (2011)
34	Mango leaf minor	*Acrocercops syngramma*	Gracillariidae	Lepidopter	Minor	Yes	No	Banglaesh	Field visit
35	Mango defoliator	*Cricula trifenestrata* (Helfer 1837)	Saturnidae	Lepidoptera	Minor	Yes	No	Bangladesh	DAE (2019)
								India	Ahad (2003)
36	Mango fruit borer	*Citripestis eutraphera* Meyrick	Pyralidae	Lepidoptera	Minor	Yes	No	Bangladesh India Indonesia Australia	Alam & Ahmad, 1969; planthealthaustralia.com.au; en.wikipedia.org;
37	Mango leaf weber	*Orthaga exvinacea* Hampson	Pyralidae	Lepidoptera	Minor	Yes	No	Bangladesh, India	Singh and Verma (2013); Singh *et al.* (2006)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
38	Mango leaf caterpilla	*Euthalia aconthea*	Gracillariidae	Lepidoptera	Minor	Yes	No	Bangladesh, India	Wikimediacommons (2015)
39	Shoot borer of mango	*Penicillaria jocosatrix*	Noctuidae	Lepidoptera	Minor	No	Yes	Myanmar	CABI (2000)
								Sri Lanka	
								India	
								China	
								United States of America	
								Malaysia	
								Australia	
								Nepal	
								Thailand	
40	Bark eating caterpillar of mango	*Indarbela tetraonis*	Metarbelidae	Lepidoptera	Minor	Yes	No	Bangladesh	DAE (2019)
								India	Plantwise Factsheets for Farmers (2013)
41	Cotton bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh	Hossain *et al.* (2009)
								China	Yang YiHua *et al.* (2013)
								India	Chakravarty and Srivastava (2020)
								Indonesia	EPPO (2022)
								Japan	Jallow *et al.* (2001)
								Mayanmar	EPPO (2022)
								Nepal	EPPO (2022)
								Pakistan	Khan *et al.* (2019)
								Sri Lanka	EPPO (2022)
								Thailand	Bhonwong *et al.* (2009)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
42	Pink gypsy moth	*Lymantria mathura*	Erebidae	Lepidoptera	Minor	Yes	No	Bangladesh	EPPO (2022)
43	Black tea thrips	*Heliothrips haemorrhoidalis*	Thripidae	Thysanoptera	Minor	Yes	No	Bangladesh	DAE (2019)
								China	Zhang and Tong (1993)
								India	Bhatti (1990)
								Japan	UK, CAB International (1961)
								Sri Lanka	
								Thailand	Waterhouse (1993)
								Australia	Seebens *et al.* (2017)
								China	Mohn (2001)
								India	EPPO (2022)
								Japan	EPPO (2022)
								Nepal	EPPO (2022)
44	Chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								China	Mirab-Balou *et al.* (2014)
								India	Kumar and Rachana (2021)
								Japan	Toda *et al.* (2014)
								Malaysia	Aliakbarpour and Rawi (2011)
								Pakistan	EPPO (2022)
								Philippines	Reyes *et al.* (2020)
								Sri Lanka	EPPO (2022)
								Thailand	Toda *et al.* (2014)
								Australia	EPPO (2022)
45	Melon thrips	*Thrips palmi*	Thripidae		Minor	Yes	No	Bangladesh	Rashid *et al.* (2008)
								China	Sun *et al.* (2016)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
				Thysanoptera				India	Chinthangkhomba and Varatharajan (2016)
								Japan	Seebens *et al.* (2017)
								Pakistan	Iftikhar *et al.* (2016)
								Sri Lanka	CABI (1998)
								Thailand	Kadirvel *et al.* (2013)
								Australia	Kay and Herron (2010)
46	Rubber termite	*Coptotermes curvignathus*	Rhinotermitidae	Isoptera	Minor	No	Yes	Indonesia	Waterhouse (1993)
								Malaysia	Waterhouse (1993)
								Singapore	Snyder (1949)
								Thailand	Waterhouse (1993)
								Vietnam	Duong NguyenHai *et al.* (1998)
47	Mango eriophyid mite	*Aceria mangiferae* Sayed	Eriophyidae	Acarina	Major	Yes	No	Bangladesh	DAE (2019)
								India	www.agridr.in
								Philippines	
								Pakistan	
								Malaysia	
Diseases									
Causal organism: Fungi									
48	Ceratocystis blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Minor	Yes	No	Bangladesh	DAE, (2019)
								China	Zhang Yu *et al.* (2022)
								India	Somasekhara (2006)
								Pakistan	Ahmad *et al.* (2022)
								Myanmar	EPPO (2022)
								Philippines	
								Thailand	
								Vietnam	
49		*Colletotrichum gloeosporioides*	Glomerellaceae		Major	Yes	No	Bangladesh	DAE (2015)
								India	EPPO, 2006

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
	Mango Anthracnose			Glomerellales				China	Kong *et al.* (2020)
50	Powdery mildew	*Oidium mangiferae*	Erysiphaceae	Erysiphales	Minor	Yes	No	Bangladesh	DAE (2015)
								India Pakistan Thailand	CABI, 2012; Akhter *et al.*, 2000; Nelson, 2008; Verma and Sharma, 1999; Rawal, 1997
51	Mango malformation	*Fusarium moniliforme*	Nectriaceae	Hypocreales	Minor	Yes	No	Bangladesh	DAE (2019)
								India, Pakistan, Myanmar	Kumar *et al.*, 2011; Khan and Khan, 1960; Meah and Khan, 1992
52	Alternaria leaf spot	*Alternaria alternate (Fr.)* Keissl.	Pleosporaceae	Pleosporales	Minor	Yes	No	Bangladesh	DAE (2015)
								India, Pakistan, Thailand	Ashrafuzzaman, 1991;http://en.wikipedia.org/
53	Blossom blight/ grey mould	*Botrytis cinerea* Pers.1794	Sclerotiniaceae	Helotiales	Minor	Yes	No	Bangladesh	DAE (2019)
								India, Pakistan, Thailand	EPPO, 2006; Asharafuzzaman, 1991 http://en.wikipedia.org/
54	Mango Sooty Mold	*Meliola mangiferae*	Meliolaceae	Meliolales	Minor	Yes	No	Bangladesh	Field visit
55	Die back	*Botryosphaeria theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Yes	No	Bangladesh	DAE (2015)
								India, Pakistan, Thailand	Ashrafuzzaman, 1991; Khanzada et al., 2005; ttp://en.wikipedia.org/
56	Leaf and stem blight	*Macrophoma mangiferae*	Botryosphaeriaceae	Botryospha	Minor	No	Yes	India	Hingorani, *et al.*, 1960;
								Nigeria	Farr *et al.*, 2006

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
		Hing. & Sharma		eriales					
57	Mango scab	*Elsinoë mangiferae*	Elsinoaceae	Myriangiales	Minor	Yes	No	Bangladesh	DAE (2015)
								India, Pakistan, Thailand	CABI, 2012; Ashrafuzzaman, 1991
58	Tear stain	*Colletotrichum gloeosporioides*	Glomerellaceae	Incertae sedis	Minor	Yes	No	Bangladesh	Field visit
59	Diplodia rot/Charcoal rot	*Diplodia natalensis*	Botryosphaeriaceae	Botryosphaeriales	Major	Yes	No	Bangladesh	Field visit
60	Cladosporium rot of mango	*Cladosporium cladosporioides*	Cladosporiaceae	Capnodiales	Minor	Yes	No	Bangladesh	Field visit
61	Mango Gummosis	*Lasiodiplodia theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Yes	No	Bangladesh	Field visit
62	Fruit-end-rot of mango	*Phomopsis mangiferae* S. Ahmad 1954	Diaporthaceae	Diaporthales	Major	Yes	No	Bangladesh	Field visit
								India, Pakistan, Australia	ARS, 2001; Laxinarayana and Reddy, 1975
63	Twig canker/stem-end rot	*Cytosphaera mangiferae* Died. 1916	Incertae sedis	Incertae sedis	Minor	No	Yes	India, Pakistan, Malaysia,	Farr et al., 2006; http://eol.org/pages/295159/names
64	Soft brown rot	*Hendersonia creberrima* (Syd. & P.	Incertaesedis	Pleosporales	Minor	No	Yes	India, Pakistan, Thailand	Farr *et al.*, 2006; Cline, 2006

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
		Syd. & E.J. Butler)							
65	Mango black spot	*Actinodochium jenkinsii* Uppal, Patel & Kama*t*	Incertae sedis	Incertae sedis	Minor	No	Yes	India	Uppal *et al.*, 1953
Causal Organism: Algae									
66	Leaf red rust	*Cephaleuros virescens* Kunze 1827	Trentepohliaceae	Trentepohliales	Minor	Yes	No	Bangladesh	DAE (2015)
								India, Pakistan, Thailand	Ashrafuzzaman, 1991; http://en.wikipedia.org/ ;
Causal organism: Bacteria									
67	Asiatic canker	*Xanthomonas citri*	Xanthomonadaceae	*Xanthomonadales*	Minor	Yes	No	Bangladesh	Vernière *et al.* (2013)
								China	Ye *et al.* (2013)
								India	Savitha *et al.* (2016)
								Indonesia	Ngoc *et al.* (2010)
								Japan	Ngoc *et al.* (2010)
								Malaysia	Arshadi *et al.* (2013)
								Myanmar	EPPO (2022)
								Nepal	EPPO (2022)
								Pakistan	EPPO (2022)
								Sri Lanka	Li *et al.* (2007)
								Thailand	EPPO (2022)
68	Bacterial bight	*Pseudomonas syringae* pv. *syrigae*	Pseudomonadaceae	Pseudomonadales	Minor	Yes	No	Bangladesh	Dastogeer *et al.*, (2013)
69	Crown gall of mango	*Agrobacterium tumefaciens*	Rhizobiaceae	Hyphomicrobiales	Minor	Yes	No	Bangladesh	Field visit

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
Causal organism: Nematode									
70	Root-knot nematode	*Meloidogyne incognita*	Meloidogynidae	Tylenchida	Minor	Yes	No	Bangladesh	CABI and EPPO (2002)
								China	Chang *et al.* (2022)
								India	Patel *et al.* (2021)
								Indonesia	CABI and EPPO (2002)
								Japan	
								Myanmar	
								Nepal	
								Philippines	
								Pakistan	Hussain *et al.* (2015)
								Thailand	Ruanpanun and Khun-in (2015)
Weed									
71	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Minor	Yes	No	Bangladesh	Hossain and Zuberi (2013)
								China	PIER (2018)
								India	Das and Nath (2022)
								Japan	PIER (2018)
								Nepal	India Biodiversity Portal (2018)
								Pakistan	Iqbal *et al.* (2020)
								Saudi Arabia	Thomas *et al.* (2015)
								Sri Lanka	EPPO (2022)
								Thailand	Adkins *et al.* (2019)
								Vietnam	EPPO (2022)
								Australia	Seebens *et al.* (2017)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
72	Loranthus/ Indian Mistletoe	*Dendrophthae falcate*	Loranthaceae	Santalales	Minor	Yes	No	Bangladesh	DAE (2015)
								India, Pakistan, Thailand	Singh, 2015
73	Cuscuta	*Cuscuta* sp.	Convolvulaceae	Solanales	Minor	Yes	No	Bangladesh	Field visit
74	Staghorn fern	*Platycerium* sp.	Polypodiaceae	Polypodiales	Minor	Yes	No	Bangladesh	Field visit
75	Parasitic orchid	*Cleisostoma sp.*	Orchidaceae	Asparagales	Minor	Yes	No	Bangladesh	Field visit

Table 7.2: **Quarantine pests for Bangladesh likely to be associated with mango imported from exporting countries**

Sl. No.	Common name	Scientific name	Distribution to mango exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect pests					
1	Queensland fruit fly	*Bactrocera tryoni*	Australia	Fruit	Dominiak and Barchia (2005), Maelzer *et al.* (2004), Foote *et al.*, 1993, Baker and Cowley (1991)
2	Mexican fruit fly	*Anastrepha ludens*	Netherlands, Australia	Fruit	EPPO (1990)
3	A member of Oriental fruit fly	*Bactrocera caryeae*	India	Fruit, Adult flight	Qin *et al.*, 2018
4	Marula fruit fly	*Ceratitis cosyra*	Australia	Fruit	EPPO (2022)
5	Stellate scale	*Ceroplastes stellifer*	India, Pakistan, Thailand	Ornamental plants,	Peronti and Kondo (2022)

Sl. No.	Common name	Scientific name	Distribution to mango exporting countries	Plant parts likely to carry the pest	References
				Propagation materials	
6	Morgan's scale	*Chrysomphalus dictyospermi*	India, Thailand	Plant material	EPPO (2022)
7	Tapioca scale insect	*Aonidomytilus albus*	India, Thailand	Plant material	Sankaran *et al.* 1984
8	Spiked mealybug	*Nipaecoccus nipae*	India, Thailand	Plant material	Josephrajkumar *et al.* (2012)
9	Grey pineapple mealybug	*Dysmicoccus neobrevipes*	India, Singapore, Italy, Netherlands	Plant material	Rohrbach *et al.* (1988)
10	Peach scale	*Parthenolecanium persicae*	India, Italy, Netherlands, Sweden, Switzerland, United Kingdom	Plant material	(Danzig (1980 a, b)
11	Shoot borer of mango	*Penicillaria jocosatrix*	India, Thailand, Australia	Fruit, Plant	CABI (2000)
12	Rubber termite	*Coptotermes curvignathus*	Thailand	Ship	Kirton and Brown (2003)
Disease causing organisms					
Fungi					
13	Leaf and stem blight	*Macrophoma mangiferae* Hing. & Sharma	India	Leaves, stems, fruits	Hingorani, *et al.*, 1960;
14	Twig canker/stem-end rot	*Cytosphaera mangiferae* Died. 1916	India, Pakistan	Stem, leaf, twig, fruit	Farr *et al.*, 2006; http://eol.org/pages/295159/names
15	Soft brown rot	*Hendersonia creberrima*	India, Australia	Fruit	Farr *et al.*, 2006; Cline, 2006
16	Mango black spot	*Actinodochium jenkinsii* Uppal, Patel & Kamat	India	Fruits	Uppal *et al.*, 1953

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7.4 Risk assessment

The pest risk assessment of quarantine pests and regulated non-quarantine pest was divided into three interrelated steps: 1) pest categorization; 2) assessment of the probability of introduction and spread; and 3) assessment of potential economic consequences (including environmental impacts). The risk assessment of quarantine pests and regulated non-quarantine pests of mango was done in accordance with International Plant Protection Convention (IPPC) and the International Standards for Phytosanitary Measures (ISPM 2, ISPM 11 and ISPM No. 21). The risk analysis of quarantine pests of mango identified for Bangladesh has been analyzed details as follows:

7.4.1 A. Arthropod: Insect and mites pests

7.4.1.1 A. Queensland fruit fly, *Bactrocera tryoni*

7.4.1.1.1 Hazard identification

Preferred Common names: Queensland fruit fly
Scientific name: *Bactrocera tryoni* (Froggatt)

Synonyms: *Chaetodacus tryoni* (Froggatt)
Dacus ferrugineus tryoni (Froggatt)
Dacus tryoni (Froggatt)
Strumeta tryoni (Froggatt)
Tephritis tryoni Froggatt

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Tephritidae
Genus: Bactrocera
Species: *Bactrocera tryoni*

EPPO Code: DACUTR. This pest has been included in EPPO A1 list: No. 235

Bangladesh status: Not present in Bangladesh [CABI, 2023; EPPO, 2022]

7.4.1.1.2 Biology

The general life cycle is similar to those of other *Bactrocera* species infesting fruits: eggs are deposited inside fruits by the female puncturing the fruit skin. Three larval stages develop inside the fruit, feeding on the plant tissue. Once mature the third instar larva will leave the fruit, dig down into the soil and turn into a pupa enclosed in a puparium. The adult fly will emerge from the puparium. During summer larvae mature in 7-10 days, while the pupal stage lasts about 10 days. The full life cycle can be completed in 2.5 weeks during summer but will take considerably longer in cooler conditions. A detailed overview of developmental rates and population dynamic models in relation to different weather conditions in Australia, is given in Yonow *et al.* (2004). Models predict 12-15 generations in the tropical parts of Australia, to 3-4 generations in Southern New South Wales (Clarke, 2019). Adults usually live around 80 days but can survive 7 to 8 months when overwintering (Clarke, 2019). The ability of *B. tryoni* to survive repeated frosts has been studied by Meats & Fitt (1987). In their review of overwintering of *B. tryoni*, Clarke *et al.* (2019) state that available data show the fly to overwinter almost exclusively as an adult.

7.4.1.1.3 Hosts

Bactrocera tryoni has a wide range of hosts. In Australia, it has been reported from 234 plant species, belonging to 49 different families, according to the catalogue compiled by Hancock *et al. (2000).* Leblanc *et al.* (2012) gives a list of host plant records for the adventive populations in Pacific Islands. In total, it is reported from more than 250 different hosts. Fitt (1986) states that adults of *B. tryoni* exhibit no particular preference in the species of fruits on which they will lay eggs, but Clarke *et al.* (2011) argue that data on relative susceptibility are largely missing. The main hosts of interest are fruit trees: *Annona, Averrhoa carambola*, avocados *(Persea americana), Citrus, Fortunella*, guavas *(Psidium guajava), Malus,* **mangoes *(Mangifera indica)***, passion fruits *(Passiflora edulis),* pawpaws *(Carica papaya),* peaches *(Prunus persica),* plums *(Prunus domestica)* and *Pyrus*. However, vegetables such as tomatoes *(Lycopersicon esculentum)* are also infested. Many tree fruit crops of the EPPO region are potential hosts.

7.4.1.1.4 Distribution

This species is found in Eastern Australia, from the Northern Territory, and Queensland southwards to New South Wales and the eastern part of Victoria. It is also reported from the Torres Strait Islands. See Dominiak & Mapson (2017) for a review of the distribution in Eastern Australia. It was introduced and became established in French Polynesia, New Caledonia, and Pitcairn Island (Leblanc *et al.*, 2012). It has been introduced in other areas but eradicated.

EPPO region: Absent.

North America: USA (absent, formerly present, (EPPO, 2022)).

South America: Chile (absent, but eradicated; (EPPO, 2022)).

Oceania: Australia (New South Wales, Northern Territory, Queensland, Victoria), French Polynesia, New Caledonia, Pitcairn (EPPO, 2022)

EU: Absent.

7.4.1.1.5 Hazard identification conclusion

Considering the facts that *B. tryoni* -

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: *Averrhoa carambola*, avocados (*Persea americana*), *Citrus*, guavas (*Psidium guajava*), mangoes (*Mangifera indica*), and pawpaws (*Carica papaya*). However, vegetables such as tomatoes (*Lycopersicon esculentum*) are also infested.
- It is a serious pest of Australia from where a large number of fruits are imported to Bangladesh.
- *Bactrocera tryoni* is a known pest of several fruit and vegetable crops in the area where it is present. It can be moved in trade with infested fruit. However, taken into consideration that the species co-occurred with *Ceratitis capitata* and displaced the latter in eastern Australia

(Dominiak & Mapson, 2017), it is considered likely that *B. tryoni* could survive in parts of the EPPO region where *C. capitata* currently occurs. Transient populations could have impacts on the export of host fruit from the EPPO region. The EFSA Panel on Plant Health, in their Pest Categorization of non-EU Tephritidae (EFSA, 2020) placed *B. tryoni* on the list of fruit flies that satisfy the criteria to be regarded as a potential Union quarantine pest for the EU.

- The major risk is from the importation of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail. For example, in New Zealand Baker and Cowley (1991) recorded 7-33 interceptions of fruit flies per year in cargo and 10-28 per year in passenger baggage. Private individuals who successfully smuggle fruit are likely to discard it when they discover that it is rotten.
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable cultivated crops and fruits.
- *B. tryoni* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.1.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.1.1 – 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 • This pest has been established in many Oceania countries including Australia, New Zealand [EPPO, 2022]. A huge amount of mango was imported from Thailand, **Australia,** India, Pakistan, Philippine, etc (DAE, 2022). In Australia, *B. tryoni* is very common pest. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • The adult females of *B. tryoni* lay eggs below the skin of the host fruit. These hatch within 1-3 days and the larvae feed for 10-31 days (Christenson & Foote, 1960). This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. • On the other hand, the adults are best able to survive low temperatures. *Bactrocera* spp. generally having a normal torpor threshold of 7°C, dropping as low as 2°C in winter. The ability of *B. tryoni* to survive repeated frosts has been studied by Meats & Fitt (1987). Sutherst & Maywald (1991) have used the CLIMEX model to describe the potential for population growth of *B. tryoni* in Australia, together with the climatic factors which limit its geographical distribution and abundance. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,**	**Yes and High**

• Adult flight and the transport of infested fruits are the main means of movement and dispersal to previously uninfested areas. Many *Bactrocera* spp. can fly 50-100 km (Fletcher, 1989). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *B. tryoni* is the most serious insect pest of fruit and vegetable crops in Australia, and it infests all commercial fruit crops, other than pineapple (Drew, 1982). Most of the data given here are from the host catalogue of Hancock et al. (2000), much of which derives from host data gathered in a major survey in the Cairns area. That revised list recorded *B. tryoni* from 49 families of plants, represented by 234 species. In addition to the hosts listed, *Garcinia dulcis, Diplocyclos palmatus, Flaacourtia inermis, Sandoricum indicum, Artocarpus odoratissima, Casimiroa tetrameria, Murraya exotica* and *Solanum muricatum* are economically important hosts of *B. tryoni*. Other major wild hosts are *Annona atemoya, Terminalia aridicola, T. muelleri, T. platyphylla, T. sericocarpa, T. subacroptera, Syzgium suborbiculare, S. tierneyanum and Nauclea orientalis*. is highly polyphagous, • It is an important pest of many cultivated plants including most characteristically fruits: avocados (*Persea americana*), **Citrus**, Fortunella, **guavas** (*Psidium guajava*), Malus, **mangoes** (*Mangifera indica*), passion fruits (*Passiflora edulis*), **pawpaws** (*Carica papaya*), peaches (*Prunus persica*), plums (*Prunus domestica*) and Pyrus. However, vegetables such as **tomatoes** (*Lycopersicon esculentum*) are also infested; but seldom cucurbits. • *B. tryoni* would be unable to survive the winter in the EPPO region, except in the south. The adults are best able to survive low temperatures, *Bactrocera* spp. generally having a normal torpor threshold of 7°C, dropping as low as 2°C in winter. The ability of *B. tryoni* to survive repeated frosts has been studied by Meats & Fitt (1987). Sutherst & Maywald (1991) have used the CLIMEX model to describe the potential for population growth of *B. tryoni* in Australia, together with the climatic factors which limit its geographical distribution and abundance. • The climate of Bangladesh is similar to places it is established.	
• 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.1.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.1.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many cultivated plants including most characteristically fruits: Annona, Averrhoa carambola, avocados (*Persea americana*), **Citrus**, Fortunella, **guavas** (*Psidium guajava*), Malus, **mangoes** (*Mangifera indica*), passion fruits (*Passiflora edulis*), **pawpaws** (*Carica papaya*), peaches (*Prunus persica*), plums (*Prunus domestica*) and Pyrus. However, vegetables such as **tomatoes** (*Lycopersicon esculentum*) are also infested. Therefore, it is a high risk, if fruits and plant material are imported from Australia there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • In Australia, *B. tryoni* is a serious pest of a wide variety of unrelated fruit and vegetable crops (Dominiak, 2012). Sutherst *et al*. (2000) estimated the annual cost in Australia to be between 25.7 and 49.9 million AUD. • There are about 4,500 species of tephritid flies (Diptera: Tephritidae). Approximately one third are frugivorous and around 250 are considered economic pests, with 23 of these known to be serious pests in Australia, Oceania and tropical Asia (White and Elson-Harris, 1994; Vijaysegaran, 1997). Adults of frugivorous Tephritidae lay their eggs beneath the skin of sound ripening fruit; the larvae feed within the fruit and cause direct damage and induce decay and premature fruit drop (Allwood and Leblanc, 1997). • The percentage of produce lost has been estimated to be 10-50% in tropical Asia and Oceania and higher levels can occur in other parts of the world if control measures are not in place (Allwood and Leblanc, 1997). • *B. tryoni* has a permanent presence in the eastern Australian states as well as the Northern Territory and the north of Western Australia (Meats *et al.*, 2008; Cameron et al., 2010). Various statutory authorities have estimated economic losses in Australia due to *B. tryoni* to be between $28.5 million and $100 million per annum (Sutherst *et al.,* 2000). **c. Environmental Impact** • **Impact on Natural Habitats:** Impacts on natural habitats are unlikely because *B. tryoni* is a generalist and is mainly abundant in crops, villages and towns, and in natural habitats it would be only one of several fruit fly species present (Drew *et al.,* 1984; Raghu *et al.,* 2000). • **Impact on Biodiversity:** Impacts on biodiversity are also unlikely for the same reasons as for impacts on natural habitats. However, as far as fruit flies are concerned an unequivocal answer to the question - whether there is an impact of a pest species on other species in a district - should be assessed only by experiment or by incubating field-sampled fruit individually in order to rear out and identify surviving adult insects (Gibbs, 1967; Fitt, 1986). Conversely, frugivorous birds and rodents can destroy a large percentage of wild fruit in some places that would be otherwise available to fruit flies or have fruit fly larvae already in them (Drew, 1987).	**Yes and High**

• **Impact on human health:** Adult fruit fly can be controlled with methyl eugenol traps (Lakshmanan *et al.* 1973), bait sprays, pheromone mating disruption, and pesticide applications to fruit (Abbas *et al.*, 2000). Larvae inside mango fruit can be killed by gamma irradiation (Heather *et al.*, 1991). The residual toxicity of the applied chemical insecticides on fruits and irradiated fruits would have a high-risk potential for **environment and human health**.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.1.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table-7.1.3 – Calculating 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

7.4.1.1.9 Risk Management Measures

Consignments of fruits from countries or regions where *B. tryoni* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *B. tryoni* does not occur, or from a place of production found free from the pest by regular inspection for 3 months before harvest. Cold treatment and irradiation are described in the USDA treatment manual (USDA, 2021). Annex 16 to 18 of ISPM 28 Phytosanitary treatments for regulated pests (FAO, 2015) describe a cold treatment for *B. tryoni* on *Citrus sinensis*, *Citrus reticulata x C. sinensis* and *Citrus limon*, respectively. Annex 5 of ISPM 28 Phytosanitary treatments for regulated pests (FAO, 2009) describes an irradiation treatment for *Bactrocera tryoni*.

Plants of host species transported with roots from countries where *B. tryoni* occurs should be free from soil, or the soil should be treated against puparia. The plants should not carry fruits.

7.4.1.1.10 References

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7.4.1.2 A. Mexican fruit fly, *Anastrepha ludens* (Loew)

7.4.1.2.1 Hazard identification

Preferred Common names: Mexican fruit fly
Scientific name: *Anastrepha ludens* (Loew)

Synonyms: *Acrotoxa ludens* (Loew)
Anastrepha lathana Stone
Trypeta ludens Loew

Taxonomic tree
- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Diptera
            - Family: Tephritidae
              - Genus: Anastrepha
                - Species: *Anastrepha ludens*

EPPO Code: CERTCO. This pest has been included in EPPO A1 list: No. 230

Bangladesh status: Not present in Bangladesh [CABI, 2020; EPPO, 2021]

7.4.1.2.2 Biology

As in *Anastrepha* species generally, eggs are laid in the host fruit, in the case of *A. ludens* these are laid singly or in clutches of up to 40 eggs, with clutch size related to fruit size (Aluja *et al.*, 1999). Development time for eggs has been reported as 3 days to as long as 6-12 days; larvae pass through three instars, with development time varying from 8–30 days depending on the host fruit and temperature and other environmental conditions (Birke *et al.*, 2013). Larvae feed in the albedo or pulp of commercial fruits but can feed on the seeds of native Casimiroa hosts (Aluja *et al.* 1999). Mature larvae exit the fruit and pupariate in the soil. Adults emerge after 12 to 32 days, depending upon temperature (Birke *et al.*, 2013). Adults can be long lived, up to a year under certain conditions, and occur throughout the year (Christenson & Foote, 1960, Aluja, 1994). Adult males produce a pheromone and lek to attract females for mating. Calling occurs in late afternoon, with mating at dusk (Aluja, 1994; Birke *et al.*, 2013).

7.4.1.2.3 Hosts

Mango (*Mangifera indica*) and various species of Citrus, especially grapefruit and oranges, are the most important commercial hosts (Hernandez-Ortiz, 1992) of *A. ludens*. Peach (Prunus persica) and various other fruit crops are attacked less frequently, but more than 40 plant species are reported as at least occasional field hosts of this polyphagous pest (Norrbom, 2004). Thomas (2004) provides an example of *A. ludens* adaptive capability to infest new host plants, describing the discovery of the introduced manzano pepper (Capsicum pubescens) as an unexpected new host in Mexico. Nearly all of the commercial hosts of *A. ludens* are exotic. Baker *et al.* (1944) considered *Casimiroa greggii* (Rutaceae) to be the only native wild host, although three other *Casimiroa* spp. (Jirón *et al.,* 1988) and several other wild native plants could also have been original hosts.

Host list: *Anacardium occidentale* (cashew nut), *Carica papaya* (pawpaw), *Citrus aurantiifolia* (lime), *Citrus medica* (citron), *Citrus reticulata* (mandarin), *Citrus sinensis* (sweet orange), *Coffea arabica* (arabica coffee), *Mangifera indica* (mango), *Prunus persica* (peach) and *Psidium guajava* (guava).

7.4.1.2.4 Distribution

A. ludens occurs from Northeastern Mexico south to Panama. In Mexico there are fly free areas in Baja California and Northwestern Mexico (Ramírez y Ramírez *et al.,* 2020). Frequent incursions are detected in the Rio Grande Valley of Texas in the USA and are subjected to eradication. Outbreaks have also occurred in California and less commonly in Arizona but have been eradicated (McCombs *et al.,* 2010). *A. ludens* is occasionally trapped in other states of the USA (e.g., Florida) and in other countries, but it is not established there. The record of this species from Colombia (Núñez Bueno, 1981) was based on misidentification of *Anastrepha manizaliensis* (Norrbom *et al.*, 2005). There are no valid reports of *A. ludens* from Colombia.

Baker *et al.* (1944) considered this species to be native only to northeastern Mexico, but Jirón *et al.* (1988) and Ruiz-Arce *et al.* (2015) did not support that hypothesis, the latter finding higher genetic diversity in populations in southern Mexico and Central America. Dupuis *et al.* (2019) identified four populations (Western Mexico, Eastern Mexico, Guatemala/Belize/Honduras, and Costa Rica/Panama) but found significant intergradation and could not identify an ancestral range. *A. ludens* was rare in Costa Rica and was not a pest of citrus prior to the mid-1990s, when it suddenly became common in the central highlands and was found attacking orange and grapefruit, including at a research station where Jirón *et al.* (1988) had worked extensively and had not found it attacking these fruits. It has subsequently been detected in western and central Panama, where it is invasive. This suggests that there was an introduction of a northern population into Costa Rica leading to the spread of this species into Panama.

North America: Mexico, United States of America (California, Texas)

Central America and Caribbean: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama

7.4.1.2.5 Hazard identification conclusion

Considering the facts that *Anastrepha ludens*-

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- potentially economic important to Bangladesh because *A. ludens* has a broad host range and is a major pest, especially of citrus and mango (*Mangifera indica*) in most parts of its range. This species and *Anastrepha obliqua* are the most important pest species of *Anastrepha* in Central America and Mexico. It occurs in subtropical areas as far north as southern Texas, thus it may be more of a threat of introduction to other subtropical areas of the world than other species of Anastrepha..

- It is invasive at least in Panama and has been trapped in California, USA. It is considered an A1 quarantine pest by EPPO.
- *A. ludens* has a broad range of hosts and is a major pest throughout its range. It occurs in higher, more temperate areas of Central America and Mexico than most other Anastrepha species, thus it may pose a higher risk of establishment in other subtropical areas of the world than other species of *Anastrepha*. It is invasive at least in Panama and has been trapped in California and other states in the USA.
- *A. ludens* poses a phytosanitary risk to other countries with a suitable sub-tropical climate and suitable hosts crops, particularly mango (*Mangifera indica*).
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable fruits.
- *A. ludens* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.2.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.2.1 – 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? - No • *Ceratitis cosyra* has a distribution in Mexico, USA, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama. But it is not present in those countries from where we import mango, citrus, papaya or guava. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • In international trade, the major means of fruit fly dispersal to previously uninfested areas is via transport of fruit containing live eggs or larvae. • As in many *Anastrepha* spp., generally, the eggs are laid below the skin of the host fruit in clutches of 1-23 eggs. They hatch within 6-12 days and the larvae feed for another 15-32 days at 25°C. • This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • *Anastrepha* adults are capable of long-distance dispersal, and adult *A. ludens* have been reported to fly as far as 135 km (Aluja, 1994). Natural movement is therefore an important means of spread. • In international trade, the major means of fruit fly dispersal to previously uninfested areas is via transport of fruit containing live eggs or larvae. For the EPPO region, the most important imported fruits liable to carry *A.*	**Yes and Moderate**

ludens are *Citrus* and *Mangifera indica*, and to a lesser extent various minor hosts. There is also a risk of the transport of fruit fly puparia in soil or packaging. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • Baker *et al.* (1944) considered *Casimiroa greggii* (Rutaceae) to be the only native wild host of A. *ludens*, although *Casimiroa edulis* may also have been an original native host (Jirón *et al.*, 1988). Citrus spp. and mango (*Mangifera indica*) are the most important introduced hosts (Hernandez-Ortiz, 1992). Myrtaceae (e.g. guavas, *Psidium guajava*), Rosaceae (e.g. peaches, Prunus persica) and a variety of other fruits are occasional hosts (Norrbom, 2004a). • The climate of Bangladesh is similar to places it is established.	
• 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.2.7 Determine the Consequence establishment of this pest in Bangladesh-

Table-7.2.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many fruits including: *Anacardium occidentale* (cashew nut), *Carica papaya* (pawpaw), *Citrus aurantiifolia* (lime), *Citrus medica* (citron), *Citrus reticulata* (mandarin), *Citrus sinensis* (sweet orange), *Mangifera indica* (mango) and *Psidium guajava* (guava). Therefore, it is a high risk, if fruits and plant material are imported from north and central America there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *Anastrepha* species are the most serious fruit fly pests in the tropical Americas (Norrbom & Foote, 1989), along with the introduced Ceratitis capitata and *Bactrocera carambolae*. *A. ludens* is considered the most important fruit fly pest in Mexico and Central America, especially on Citrus spp. and mango (Enkerlin *et al.*, 1989). • *A. ludens* has a major effect on México's economy because it attacks fruits as citrus and mangoes. In 2008 the exports of these two fruits only to the U.S. had a value of 121.8 million US dollars (Gutiérrez, 2010). **c. Environmental Impact** • Disruption of Native Ecosystems: The introduction and establishment of *Anastrepha ludens* in non-native regions can disrupt native ecosystems. The	**Yes and High**

fruit fly can affect native plant species, their pollinators, and seed dispersers, leading to changes in plant diversity and community composition (Aluja, M., & Norrbom, A. L. 2019). • Impact on Biodiversity: Infestations of *Anastrepha ludens* can negatively impact biodiversity by affecting native fruiting plants and their associated wildlife. The decline of native plant species can disrupt ecological interactions and lead to changes in species composition within ecosystems. • Pesticide Use and Non-Target Effects: Controlling *Anastrepha ludens* populations often involves the use of insecticides. Widespread pesticide applications can have unintended consequences on non-target organisms, including beneficial insects, birds, and other wildlife. It can also lead to soil and water contamination, potentially affecting aquatic ecosystems and non-target plant species (Vargas, R. I., & Carey, J. R. 2013). • Economic Impacts on Agriculture: The economic impacts of Anastrepha ludens in agriculture have indirect environmental implications. The pest can significantly reduce fruit yields and quality, leading to economic losses for farmers. This can result in land-use changes, such as the abandonment of orchards or the conversion to alternative crops, which can impact land management practices and potentially lead to changes in habitats and ecosystems.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.2.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table-7.2.3 – Calculating 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

7.4.1.2.9 Risk Management Measures

Consignments of fruits of Annona, Citrus, Malus, Mangifera indica, *Prunus domestica*, *Prunus persica* and *Psidium guajava* from countries where this pest occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Such fruits should come from an area where *A. ludens* does not occur or from a place of production found free from the pest by regular inspection for 3 months before harvest. Fruits may also be treated in transit by cold treatment (e.g., 18, 20 or 22 days at 0.5, 1 or 1.5°C, respectively) or, for certain types of fruits, by hot water treatment (for mango, 46°C for 65 to 110 minutes depending on fruit size) or by vapour heat (e.g., keeping at 43°C for 4-6 h) (USDA, 2020), or forced hot-air treatment (Mangan & Ingle, 1994).

Ethylene dibromide was previously widely used as a fumigant but is now generally withdrawn because of its carcinogenicity. Methyl bromide is approved on a very limited basis; e.g., 1 treatment schedule (T101-j-2-1; 40 g/m^3 for 2 h at 21-29.5°C) is currently approved by USDA (2020) to treat oranges, tangerines and grapefruit from Mexico under pre-clearance. Irradiation at 70 gy is considered effective treatment for immature stages of *A. ludens* (USDA, 2020).

Plants of host species transported with roots from countries where *A. ludens* occurs should be free from soil, or the soil should not contain fruits or seeds or be treated to kill any puparia.

7.4.1.2.10 References

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7.4.1.3 A. A member of Oriental fruit fly, *Bactrocera caryeae* (Kapoor)

7.4.1.3.1 Hazard identification

Preferred Common names: A member of Oriental fruit fly
Scientific name: *Bactrocera caryeae* (Loew)

Synonyms: *Dacus caryae* Kapoor, 1971

Taxonomic tree

- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Diptera
            - Family: Tephritidae
              - Genus: Bactrocera
                - Species: *Bactrocera caryeae*

EPPO Code: BCTRCR. This pest has been included in EPPO A1 list: No. 233

Bangladesh status: Not present in Bangladesh [CABI, 2020; EPPO, 2021]

7.4.1.3.2 Biology

Eggs of related species are laid below the skin of the host fruit. These hatch within a day (although delayed up to 20 days in cool conditions) and the larvae feed for another 6-35 days, depending on season. Pupariation is in the soil under the host plant for 10-12 days but may be delayed for up to 90 days under cool conditions. Adults occur throughout the year and begin mating after about 8-12 days, and may live 1-3 months depending on temperature (up to 12 months in cool conditions) (Christenson and Foote, 1960). Adult flight and the transport of infected fruit are the major means of movement and dispersal to previously uninfested areas.

7.4.1.3.3 Hosts

This pest species is known from a limited but varied range of hosts, including several commercial crops. However, because of possible confusion with *B. dorsalis*, several older records need confirmation.

Host list: *Aegle marmelos* (golden apple), *Artocarpus integer*, *Careya arborea*, *Casimiroa edulis*, *Citrus maxima (pummelo)*, *Citrus tangerina*, *Citrus*, *Malpighia emarginata*, ***Mangifera indica*** **(Mango),** *Persea americana*, *Pouteria sapota* (mammey sapote), *Psidium guajava* (guava), *Syzygium jambos.*

7.4.1.3.4 Distribution

B. caryae is found in southern India, particularly at higher altituudes (*B. dorsalis* being more abundant at lower altitudes) (I.M. White personal observation, 1992). This species is restricted to southern part of the Indian Subcontinent. Although some sources indicate that the species is present in Sri Lanka, Drew & Romig (2013) state explicitly that the earlier recorded presence in Sri Lanka is erroneous.

Asia: India (EPPO, 2022), Sri Lanka (EPPO, 2022)

7.4.1.3.5 Hazard identification conclusion

Considering the facts that *Bactrocera caryeae*-

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- potentially economic important to Bangladesh because *B. caryeae* has a broad host range and is a major pest, especially of mango (*Mangifera indica*), citrus and guava in most parts of its range.
- The EFSA Panel on Plant Health, in their Pest Categorization of non-EU Tephritidae (EFSA, 2020) placed *B. caryeae* on the list of fruit flies that satisfy the criteria to be regarded as a potential Union quarantine pest for the EU.
- *B. caryeae* poses a phytosanitary risk to other countries with a suitable sub-tropical climate and suitable hosts crops, particularly mango (*Mangifera indica*), citurs and guava.
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable fruits.
- *B. caryeae* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.3.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-7.3.1 – 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 • *B. caryae* is found in southern India, particularly at higher altituudes (*B. dorsalis* being more abundant at lower altitudes). The record from Sri Lanka (Drew and Hancock, 1994) was not confirmed by the extensive survey carried out by Tsuruta *et al*. (1997) and I.M. White (personal communication) examined one of the two reported specimens and noted that it was badly discoloured and possibly a misidentification of *B. kandiensis*. A record of the pest in Oman (Drew and Hancock, 1994) was possibly a quarantine interception. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • In international trade, the major means of fruit fly dispersal to previously uninfested areas is via transport of fruit containing live eggs or larvae. • Eggs of related species are laid below the skin of the host fruit. These hatch within a day (although delayed up to 20 days in cool conditions) and the larvae feed for another 6-35 days, depending on season. • This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process.	**Yes and High**

c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes, • Transport of infested fruits is the main means of movement and dispersal to previously uninfested areas. Adult flight can also result in dispersal but previous citations of long (50-100 km) dispersal movements for *Bactrocera spp*. are unsubstantiated according to a recent review by Hicks *et al*. (2019). Dispersal up to 2 km is considered more typical. • The major risk is from the import of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail. For example, in New Zealand Baker and Cowley (1991) recorded 7-33 interceptions of fruit flies per year in cargo and 10-28 per year in passenger baggage. Individuals who successfully smuggle fruit are likely to discard it when they discover that it is rotten. This method of introduction probably accounts for the discovery of at least one fly in a methyl eugenol trap in California every year (Foote *et al.*, 1993), although immediate implementation of eradication action plans has ensured that the fly has never been able to establish a proper breeding population. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *Aegle marmelos* (golden apple), *Artocarpus integer*, *Careya arborea*, *Casimiroa edulis*, *Citrus maxima* (pummelo), *Citrus tangerina*, Citrus, *Malpighia emarginata*, *Mangifera indica* (Mango), *Persea americana*, *Pouteria sapota* (mammey sapote), *Psidium guajava* (guava), *Syzygium jambos* are the major host of *B. caryeae*. • The climate of Bangladesh is similar to places it is established.	
• 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.3.7 Determine the Consequence establishment of this pest in Bangladesh-

Table-7.3.2 – Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many fruits including: *Mangifera indica (*Mango*)*, *Pouteria sapota (*mammey sapote*)*, *Psidium guajava (*guava*)*, *Syzygium jambos*. Therefore, it is a high risk, if fruits and plant material are imported from southern part of Indian subcontinent there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh.	**Yes and High**

b. Economic Impact and Yield Loss • Ramani *et al.* (2008) mention mango and guava as the main commercial hosts. • *B. caryeae* occurs in very large numbers in many fruit growing areas of southern India and is probably responsible for much of the damage generally attributed to *B. dorsalis.* **c. Environmental Impact** • The pest can significantly reduce fruit yields and quality, leading to economic losses for farmers. This can result in land-use changes, such as the abandonment of orchards or the conversion to alternative crops, which can impact land management practices and potentially lead to changes in habitats and ecosystems.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.3.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table-7.3.3 – Calculating 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

7.4.1.3.9 Risk Management Measures

Consignments of fruits from countries or regions where *B. caryeae* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *B. caryeae* does not occur, or from a place of production found free from the pest by regular inspection in the 3 months before harvest. Plants transported with roots from countries or regions where *B. caryeae* occurs should be free from soil, or the soil should be treated against puparia. The plants should not carry fruits.

7.4.1.3.10 References

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7.4.1.4 A. Marula fruit fly, *Ceratitis cosyra* (Walker)

7.4.1.4.1 Hazard identification

Preferred Common names: Marula fruit fly
Scientific name: *Ceratitis cosyra* (Walker)

Synonyms: *Ceratitis giffardi* Bezzi
Pardalaspis cosyra (Walker)
Pardalaspis giffardi (Bezzi)
Pardalaspis giffardi var. sarcocephali Bezzi
Pardalaspis parinarii Hering
Trypeta cosyra Walker

Taxonomic tree
- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Diptera
            - Family: Tephritidae
              - Genus: Ceratitis
                - Species: *Ceratitis cosyra*

EPPO Code: CERTCO.

Bangladesh status: Not present in Bangladesh [CABI, 2020; EPPO, 2022]

7.4.1.4.2 Biology

Mature females of *Ceratitis* oviposit into fruit, usually at the start of ripening (this may vary with fly or host species); there are three larval instars and depending on temperatures they develop over a period ranging from 6 to 33 days (temperatures ranging from 14 to 30°C) (Grout and

Stoltz, 2007); final instar larvae of *Ceratitis* drop to the ground, find a crack to drop into and then form a puparium (hardened larvae skin) within which pupation takes place; the pupal stage lasts between 10 and 33 days (at temperatures varying between 14 and 30°C) (Grout and Stoltz, 2007); adults are long lived (2-3 months) (Manrakhan and Lux, 2006; Malod *et al.*, 2020) and so several generations must be completed in each year.

7.4.1.4.3 Hosts

The principal host of *Ceratitis cosyra* is maroola plum (*Sclerocarya birrea*) but it will also heavily attack mango (*Mangifera indica*); guava (*Psidium guajava*); avocado (*Persea americana*) (White and Elson-Harris 1992; De Meyer 1998)

7.4.1.4.4 Distribution

Ceratitis cosyra is recorded from a limited range of plants, but it is an important pest of mangoes (*Mangifera indica*) in Kenya (Malio, 1979), Zambia (Javaid, 1986), Zimbabwe (Rendell et al., 1995) and some areas of South Africa (Labuschagne et al., 1996). Outcompetition of C. cosyra by the introduced Bactrocera dorsalis has been clearly demonstrated in laboratory and field studies (Ekesi et al., 2009). In Cote d'Ivoire, C. cosyra was the major pest of guava (Psidium guajava) (N'Guetta, 1994).

EPPO region: Absent.

Africa: Benin (Vayssières *et al.* 2009), Cameroon (Steck *et al.* 1986), Ethiopia (EPPO, 2022), Ghana (Badii *et al.* 2015), Kenya, Madagascar, Mali, Nigeria, Senegal, South Africa, Zimbabwe (De Meyer 1998).

Oceania: Absent.

EU: Belgium (Absent, intercepted only) (EPPO, 2022)

7.4.1.4.5 Hazard identification conclusion

Considering the facts that *Ceratitis cosyra*-

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- potentially economic important to Bangladesh because *Ceratitis cosyra* is recorded from a limited range of plants, but it is an important pest of mangoes (*Mangifera indica*) in Kenya (Malio, 1979), Zambia (Javaid, 1986), Zimbabwe (Rendell *et al.*, 1995) and some areas of South Africa (Labuschagne *et al.*, 1996). In Cote d'Ivoire, *C. cosyra* was the major pest of guava (*Psidium guajava*) (N'Guetta, 1994).
- It is a serious pest of sub-Saharan Africa from where a large number of fruits are imported to Bangladesh.
- *Ceratitis cosyra* poses a phytosanitary risk to other countries with a suitable tropical climate and suitable hosts crops, particularly mango (*Mangifera indica*).
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable fruits.
- *C. cosyra* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.4.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-7.4.1 – 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? - No • *Ceratitis cosyra* has a widespread distribution in sub-Saharan Africa (de Meyer, 2001). In South Africa and Namibia, the species is limited to the northern parts of the country (de Meyer, 2001; de Villiers *et al.*, 2013). Outside of the African continent, *C. cosyra* is known to occur only in Madagascar, Indian Ocean region (de Meyer, 1998). But it is not present in those countries from where we import mango or guava. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Mature females of *Ceratitis* oviposit into fruit, usually at the start of ripening (this may vary with fly or host species); there are three larval instars and depending on temperatures they develop over a period ranging from 6 to 33 days (temperatures ranging from 14 to 30°C) (Grout and Stoltz, 2007); final instar larvae of *Ceratitis* drop to the ground, find a crack to drop into and then form a puparium (hardened larvae skin) within which pupation takes place; the pupal stage lasts between 10 and 33 days (at temperatures varying between 14 and 30°C) (Grout and Stoltz, 2007). This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Adult flight and the transport of infested fruits are the main means of movement and dispersal to previously uninfested areas. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • The fly's impact is growing along with the more widespread commercialization of mango. Late maturing varieties of mango suffer most in Zambia (Javaid 1986). In Ivory Coast, *Ceratitis cosyra* and *Ceratitis anonae* Graham are the main pests in guava (N'Guetta 1993). *Ceratitis cosyra*, as larvae in infested mangoes from Africa, is one of the most commonly intercepted fruit flies in Europe (I. M. White, The Natural History Museum, London, personal communication). • The climate of Bangladesh is not similar to places it is established.	**Yes and Moderate**
• 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	

7.4.1.4.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.4.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many fruits including: (*Mangifera indica*) mango; (*Sclerocarya birrea*) marula plum; (*Persea americana*) avocado; (*Psidium guajava*) guava. Therefore, it is a high risk, if fruits and plant material are imported from Africa there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • Due to lack of information, we cannot predict about the economic impact of this pest. **c. Environmental Impact** • **Due to lack of information, we cannot predict about the economic impact of this pest.**	**Yes and Low**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.4.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table-7.4.3 – Calculating 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

7.4.1.4.9 Risk Management Measures

Grové *et al.* (1998) found that *C. cosyra* larvae were more heat tolerant than those of *C. capitata* or *C. rosa* but 98.7% mortality followed 70 min hydro-heating at 46.1-46.7°C. Steyn and Grove (1999) experimented with cold storage and found that 3 weeks storage at 7.5°C or less killed all larvae.

Visual inspection alone is not considered to be an appropriate risk management option in view of the level of risk identified and because clear visual signs of infestation (particularly in recently infested fruit) may not be present. If infested fruit was not detected at inspection, fruit flies may enter, establish and spread. Other measures that might be applied to mitigate risks associated with fruit flies are either the use of disinfestations treatments or by sourcing fruit from pest free areas.

The PQW-DAE of Bangladesh therefore can propose the following phytosanitary risk management options to mitigate the risk posed by fruit flies of quarantine concern associated with mangoes: (1a) vapour heat treatment (VHT) or (1b) hot water treatment (HWT).

7.4.1.4.10 References

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7.4.1.5 A. Stellate scale, *Ceroplastes stellifer* (Westwood, 1871)

7.4.1.5.1 Hazard identification

Preferred Common names: Stellate scale
Scientific name: *Ceroplastes stellifer* (Westwood, 1871)
Synonyms: *Coccus stellifer* (Westwood, 1871)
Vinsonia pulchella (Signoret, 1869)
Vinsonia stellifera (Westwood, 1871)

Taxonomic tree

- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Hemiptera
            - Family: Cccidae
              - Genus: *Ceroplastes*
                - Species: *Ceroplastes stellifer*

EPPO Code: VINSST.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.4.1.5.2 Biology

When alive, covering wax hard, semi-translucent, white, or pinkish; becoming first pale green and darkening with age to purplish red. In dried specimens, wax tint fades to reddish brown. Wax-covered body is horizontally flattened, with six or seven marginal rays that give it a star-like appearance; each ray tipped by a fairly long conical process of opaque white wax. The median anterior ray carries a supplementary white point on each side of terminal process; the following two rays on each side have a well-defined median ridge; the following two rays on each side are associated with the two pairs of stigmata, while the two remaining rays proceed from the abdominal lobes. At the extremity of each ray, below the base of the terminal process, is a fringe of minute glassy points - the remains of the earliest larval fringe. Diameter across rays: 3.0-4.5 mm. Eyespots dorsal. Antennae 120-160 µm long; with six segments, I: 25 µm, II: 25-27.5 µm, III: 32.5-55 µm, IV: 7.5 µm; V: 10-12.5 µm, VI: 27.5 µm. There are ten or more long interantennary setae; 15-19 (Peronti 2004). Legs 200-220 µm long; claw digits, without denticles, equal with dilated tips: 25 µm; tibia and tarsus fused, without sclerosis (García Morales *et al.* 2016).

Body of mounted specimens (presumably without wax), 0.8-2.0 mm long by 0.6-1.45 mm wide; globose to oval, but with anterior margin of head forming a pronounced prominence in mature specimens; convex in cross section, brown, and with a short, dark brown caudal process. Without an ovisac, but after oviposition the hemispherical body forms a cavity due to median area shrinking for the reception of the eggs. Margin colourless during life; yellowish in dried examples. From below, the median area corresponds with the cephalic lobe; ventral derm of cephalic prominence heavily sclerotized on old specimens. On dorsal surface: membranous dermis; with eight clear areas, one in the cephalic region, one mid-dorsal and three lateral pairs; setae sparse, conical and short, about 2 µm long (García Morales *et al.* 2016).

Area around anal region sclerotized, forming protuberance or causal process, extending dorsoposteriorly. A pair of small white waxy processes project from the posterior margin immediately behind the anal aperture. Anal plates rounded, without distinct angle, with three dorsal setae and one ventral setae (Miller *et al.* 2014), each anal plate with two or three apical setae and one subdiscal seta; without subapical setae. Anal fold with five or six fringe setae, normally six; anal ring with six arrows. Preopercular pores inconspicuous, restricted to area anterior of anal plates. A pair of prevulvar setae are often obscured by anal plates. Stigmatic clefts obscure, shallow; there are 7-10 conical setae at the apex of the stigmatic canals, of these, four or five are longer and have obtuse apexes. There are 6-15 spiracular setae in each cleft, arranged in two or three rows, intergrading from short to long. Pores of the stigmatic canals with five loculi; cruciform pores concentrated in the submarginal area. Multilocular pores present in vulvar area only; genital multiloculars normally with ten or more loculi; multilocular pores anterior of anterior spiracle predominantly with five loculi, about same size as pores laterad of anterior spiracle. Tubular ducts absent, without submarginal tubercles.

First instar

Body 290-510 long x 170-330 µm wide. Dorsal region lacking clear areas, simple pores not detected; one pair of trilocular pores, each 2 µm in diameter; a pair of sharply conical setae, each 3 µm long (Rosa *et al.* 2016).

Second instar

Body 500-680 long x 340-500 µm wide. Dorsal region lacks clear areas, simple pores not detected. Interantennal setae: two pairs, longer pair each 25-33 µm long, shorter 20-23 µm long (Rosa *et al.* 2016).

Third instar

Size not reported; dorsal microducts not detected. Interantennal setae: 8-10, longer setae 30-50 µm long (Rosa *et al.* 2016).

7.4.1.5.3 Hosts

There are over 100 species reported as hosts of *C. stellifer* in more than 30 plant families. Some important hosts are cultivated species and ornamentals, for example orchids, ferns, palms, *Citrus* spp., *Coffea* sp., *Garcinia* spp., ***Mangifera indica***, *Musa* sp., *Oryza sativa*, *Persea americana* and *Syzigium* spp. (Suh *et al.* 2013, Miller *et al.* 2014, García Morales *et al.* 2016, CDFA 2022).

7.4.1.5.4 Distribution

While *C. stellifer* is widespread in tropical and subtropical areas, its native range is uncertain (Peronti and Kondo 2022). According to CDFA (2022), early records are from the Caribbean, but it was first described from Thailand (Suh *et al.* 2013).

Although *C. stellifer* is listed for USA as present in Florida, Alabama and Georgia, it is also reported as a commonly intercepted species in ports of entry (Miller *et al.* 2014, CDFA 2022). The species is listed only as intercepted in Europe (Fetykó and Kozár 2012, Mazzeo *et al.* 2014).

Africa: Kenya, Tanzania (Hodgson and Peronti 2012).

Asia: China, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand (Prakash and Patil 2015, Seebens *et al.* 2017, EPPO 2022).

North America: USA (Seebens *et al.* 2017).

South America: Brazil (Culik *et al.* 2011).
Oceania: Australia (New South Wales, Northern Territory) (EPPO 2022).
Europe: Germany, Netherlands, United Kingdom (Hodgson and Peronti 2012, EPPO 2022).

7.4.1.5.5 Hazard identification conclusion

Considering the facts that *C. stellifer* -

- is not known to be present in Bangladesh (CABI 2023, EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: avocados (*Persea americana*), *Citrus*, guavas (*Psidium guajava*), mangoes (*Mangifera indica*), banana (*Musa* sp.), guava (*Psidium* sp.) and coconut (*Cocos nucifera*). However, forest trees like banyan tree (*Ficus benghalensis*), orchids, agricultural crops like rice (*Oryza sativa*), spices such as zinger (*Zingiber* sp.) are also infested.
- It is a serious pest of Australia, China, Brazil, USA, Thailand, Pakistan, India from where a large number of fruits are imported to Bangladesh.
- *C. stellifer* is a known pest of several fruit and agricultural crops in the area where it is present. It can be moved in trade with infested fruit.
- The major risk is from the importation of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail.
- *Ceroplastes stellifer*'s native distribution is uncertain and is highly likely to spread into tropical and subtropical areas through the commercial trade of crops and ornamentals (CDFA 2022, Peroni and Kondo 2022).
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable cultivated crops and fruits.
- *C. stellifer* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.5.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.5.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
c. Has this pest been established in several new countries in recent years? - Yes • It was first reported in Taiwan by 1929 on *Mangifera indica*, and in China by 2013 on *Schefflera octophylla* and *M. indica* (Wu and Wang, 2019). • Neither is *C. stellifer* likely to get established in the Palaearctic, where it is reported as intercepted in various countries (Malumphy 2010, Miller *et al.* 2014, EPPO 2022). It is listed as a quarantine pest in Argentina, Mexico, China, Japan, Republic of South Korea and United Kingdom (Malumphy 2010, CDFA 2022, EPPO 2022, SINAVIMO 2022).	**Yes and High**

d. Possibility of survival of this pest during transport, storage and transfer? – Yes • Biological characteristics that enable scale insect pests to establish and spread include their small size and cryptic habitats, their protective wax body coverings, their plant feeding nature and predisposition to polyphagous behaviours, their ability to reproduce parthenogenetically as well as sexually, and their capacity for active and passive dispersal, most commonly by the 'crawler' life stage. • Normark *et al.* (2019) stated that *C. stellifer* is extraordinarily invasive, in part because they are very small, cryptic, and nearly ubiquitous associates of woody plants. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • The first instars (crawlers) of *C. stellifer* can walk short distances within the canopy or connected canopies. They can also be passively transported by wind (Peronti 2004, Peronti and Kondo 2022). • The crawlers can hitchhike on animals (CDFA 2022, Peronti and Kondo 2022). • *C. stellifer* can be transported with the commercial trade of plants or less frequently with fruits and flowers. The species is also reported as moved on equipment but without further details (CDFA 2022, Peronti and Kondo 2022). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *C. stellifer* is highly polyphagous. It infested the ten most common host families, in descending order, are Fabaceae, Poaceae, Rosaceae, Myrtaceae, Orchidaceae, Asteraceae, Euphorbiaceae, Pinaceae, Arecaceae, and Fagaceae. • There are over 100 species reported as hosts of *C. stellifer* in more than 30 plant families. Some important hosts are cultivated species and ornamentals, for example orchids, ferns, palms, *Citrus* spp., *Coffea* sp., *Garcinia* spp., *Mangifera indica*, *Musa* sp., *Oryza sativa*, *Persea americana* and *Syzigium* spp. (Suh *et al.* 2013, Miller *et al.* 2014, García Morales *et al.* 2016, CDFA 2022, EPPO 2022). • *C. stellifer* (Kozár 1990) is reported from all the zoogeographical regions of Europe, Asia, North America, South America, Africa and Australasia (Miller *et al.* 2014). It occur in climatic conditions of tropics, subtropics and temperate regions (Kozár 1990; Kozár and Ben-Dov 1997) and thus display capacity to reproduce in a wide range of terrestrial environments. • The climate of Bangladesh is similar to places it is established.	
• 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.5.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.5.2 – Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many cultivated plants including most characteristically fruits: Avocados (*Persea americana*), **Citrus**, **guava** (*Psidium guajava*), **mangoes** (*Mangifera indica*), papaya (*Carica papaya*). However, agricultural crops such as **rice** (*Oryza sativa*), Zinger (*Zingiber* sp.) are also infested. Therefore, it is a high risk, if fruits and plant material are imported from Australia, China, Brazil, Pakistan, Thailand there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • Although *C. stellifer* is not reported as reducing crop yields, it can lower the value of nursery stocks and traded ornamentals. Its presence can cause an increase in production costs in crops, nurseries and orchards. It could also trigger the loss of markets (CDFA 2022). **c. Environmental Impact** • *C. stellifer* is not expected to affect the biodiversity and disrupt natural habitats. Neither is it reported as affecting any threatened or endangered species (CDFA 2022). • *C. stellifer* negatively impacts urban gardens but mainly by the presence of the sooty mould (Hodgson and Peronti 2012, CDFA 2022). The species is not expected to cause changes in cultural practices, nor act as a vector of other organisms, injure animals, or disrupt water supplies (CDFA 2022).	**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

7.4.1.5.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.5.3 – Calculating 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

7.4.1.5.9 Risk Management Measures

Consignments of fruits from countries or regions where *C. stellifer* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *C. stellifer* does not occur, or from a place of production found free from the pest by regular inspection for 3 months before harvest. The infected branches and leaves should be pruned and destroyed (Peronti and Kondo 2022). Three parasitic wasps are reported as affecting *C. stellifer* (Peronti and Kondo 2022). The waxy tests of large nymphs and adults protect them from pesticide sprays. Horticultural mineral oil sprays are effective on early nymph stages (Peronti and Kondo 2022).

7.4.1.5.10 References

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7.4.1.6 A. Morgan's scale, *Chrysomphalus dictyospermi* (Morgan, 1889)

7.4.1.6.1 Hazard identification

Preferred Common Name: Dictyospermum Scale, Morgan’s scale
Scientific Name: *Chrysomphalus dictyospermi* (Morgan, 1889)
Synonyms:

Aspidiotus (Chrysomphalus) dictyospermi (Morgan) Cockerell, 1897
Aspidiotus agrumicula De Gregorio, 1915
Aspidiotus arecae (Newstead) Cockerell, 1894
Aspidiotus dictyospermi Morgan, 1889
Aspidiotus dictyospermi jamaicensis Cockerell, 1894
Aspidiotus dictyospermi var. arecae Newstead, 1893
Aspidiotus jamaicensis (Cockerell) Ferris, 1941
Aspidiotus mangiferae Cockerell, 1893
Chrisomphalus dictyospermi Yasnosh, 1995
Chrysomphalus arecae (Newstead) Malenotti, 1916
Chrysomphalus castigatus Mamet, 1936
Chrysomphalus dictyospermatis Lindinger, 1949

Common names: Dictyosperm scale; Morgan's scale; palm scale;

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Suborder: Sternorrhyncha

Superfamily: Coccoidea
Family: Diaspididae
Genus: Chrysomphalus
Species: *Chrysomphalus dictyospermi*

EPPO Code: CHRYDI
Bangladesh status: Not present in Bangladesh [CABI,2021]

7.4.1.6.2 Biology

Reproduction is sexual in most *C. dictyospermi* populations. The adult male flies to locate the sessile adult female, and the long genitalia are used to mate with the female beneath her scale cover. It is likely that the male locates an unmated female by smell, although details of the pheromone secretion mechanism are not known. However, both uniparental (parthenogenetic) and biparental (sexual) populations of this species have been recorded in the USA (Brown, 1965). Each female lays 1 to 200 eggs beneath her scale cover, where they are sheltered until they hatch and the first-instar crawlers disperse. *C. dictyospermi* requires warm temperatures and does not multiply much in cold weather. In Egypt, optimal conditions for *C. dictyospermi* were found to be 22 to 25°C, and mean relative humidity of 50 to 58% (Salama, 1970).

7.4.1.6.3 Hosts

C. dictyospermi is a highly polyphagous species; Borchsenius (1966) recorded it from hosts belonging to 73 plant families, but its host range is probably wider than this. Favoured hosts are citrus and other trees such as olives (Olea europaea subsp. europaea) and palms. Ebeling (1950) noted that it preferred feeding on leaves.

a) Major hosts: *Albizia julibrissin* (silk tree), Citrus, *Cocos nucifera* (coconut), *Mangifera indica* (mango), Musa (banana), *Persea americana* (avocado), Rosa (roses), *Zingiber* (ginger), *Solanum melongena* (aubergine)

b) Minor hosts:*Vitis vinifera* (grapevine), Pyrus (pears), *Psidium guajava* (guava), *Phoenix* (date palm), *Elaeis guineensis* (African oil palm)

7.4.1.6.4 Distribution

C. dictyospermi is probably native to southern China (Longo *et al.*, 1995); it is widespread in tropical and subtropical regions, and occurs under glass in temperate areas (Davidson and Miller, 1990; Gill, 1997). It is distributed predominantly in Mediterranean countries such as Turkey and Syria, and in Middle Eastern countries such as Iran (Lodos, 1982). In Turkey, it is more common in the Aegean region than in the Black Sea and Mediterranean regions (Alkan, 1953). It has a wide distribution in the South Pacific area, and plant quarantine interceptions from the region suggest that it has an even wider distribution there than has been documented (Williams and Watson, 1988). In spite of the record published in Danzig and Pellizzari (1998), *C. dictyospermi* has not been recorded in the UK in recent years and is regarded as absent (CP Malumphy, Central Science Laboratory, UK, personal communication, 2002).

- **Asia:** China (CIE, 1969); India (CIE, 1969), Japan, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and Turkey (CIE, 1969; Wong, 1999)
- **Africa:** Cameroon, Kenya, Nigeria, Sudan (CIE, 1969; Matile-Ferrero & Oromí, 2001; Amparo Blay Colcoechea, 1993)
- **North America:** Mexico (Schotman, 1989; Miller, 1996; Myartseva & Ruíz-Cancino, 2000; CIE, 1969), USA (Restricted distribution) (CIE,1996)
- **Central America:** Cuba, Costa Rica, Panama (CIE, 1969)

- **South America:** Argentina (Claps & Terán, 2001; CIE, 1969; Claps *et al.*, 2001; Crouzel, 1973), Brazil, Chile (CIE, 1969; Claps *et al.*, 2001)
- **Europe:** France, Italy, Poland, Spain (Longo *et al.*, 1995; CIE, 1969; Danzig & Pellizzari, 1998)
- **Oceania:** Australia, Fiji (Veitch & Greenwood, 1921; Greenwood, 1929; Williams & Watson, 1988; CIE, 1969; Simmonds, 1925; Lever, 1945)

7.4.1.6.5 Hazard Identification Conclusion

Considering the facts that *C. dictyospermi* -

- is not known to be present in Bangladesh [CABI,2021];
- will be potentially economic important to Bangladesh because it is a major pest of several crops, fruits and ornamental plants like avocados, bananas, citrus, coconuts, mangoes, ginger and eggplant etc. which are also important crops in our country.
- It is a serious pest of Asia including China, India, Thailand from where a large number of fruits is imported to Bangladesh.
- *C. dictyospermi* is mentioned on quarantine lists (Burger and Ulenberg, 1990). It could become a serious pest of palms in greenhouses in the USA (Westcott, 1973).
- *C. dictyospermi* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.6.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.6.1 – 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- No • *C. dictyospermi* is probably native to southern China (Longo *et al.*, 1995); it is widespread in tropical and subtropical regions, and occurs under glass in temperate areas (Davidson and Miller, 1990; Gill, 1997). It is distributed predominantly in Mediterranean countries such as Turkey and Syria, and in Middle Eastern countries such as Iran (Lodos, 1982). In Turkey, it is more common in the Aegean region than in the Black Sea and Mediterranean regions (Alkan, 1953). It has a wide distribution in the South Pacific area, and plant quarantine interceptions from the region suggest that it has an even wider distribution there than has been documented (Williams and Watson, 1988). Moreover, this pest is already established in many Asain countries from where we imported many fruits. **b. Possibility of survival during transport, storage and transfer? Yes** • *C. dictyospermi* requires warm temperatures and does not multiply much in cold weather. In Egypt, optimal conditions for *C. dictyospermi* were found to be 22 to 25°C, and mean relative humidity of 50 to 58% (Salama, 1970). So, the storage condition is favourable for its growth, reproduction and survival. Besides this, the transport duration of fruits from exporting countries is about 20 days, which is favourble for their survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Pest or symptoms not visible to the naked eye but usually visible under light microscope. So, it is very difficult to detect them during inspection.	**YES and HIGH**

Moreover, the adults, eggs, nymphs and pupae may enter into imported countries through fruits, seedlings, barks, leaves, flowers. • Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high in this stage. • Dispersal of sessile adults and eggs occurs through human transport of infested plant material. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *C. dictyospermi* is a highly polyphagous species; Borchsenius (1966) recorded it from hosts belonging to 73 plant families, but its host range is probably wider than this. Favoured hosts are citrus and other trees such as olives (*Olea europaea* subsp. europaea) and palms. Ebeling (1950) noted that it preferred feeding on leaves. Besides this Citrus, mango, *Cocos nucifera* (coconut), Musa (banana), Rosa (roses), Zingiber (ginger), etc are its major hosts. So, the pests can easily estabilished in our country. The climatic condition of exporting countries and our countries is more or less same.	
• NOT AS ABOVE OR BELOW	Moderate
• **This pest has not established in new countries in recent years** • **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

7.4.1.6.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.6.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • Citrus, mango, *Cocos nucifera* (coconut), Musa (banana), Rosa (roses), Zingiber (ginger), etc are its major hosts. So, the pest can easily estabilished in our country. The pest became a serious pest where they established and the insect established in those countries from where we imported coconut seedlings. So, if the pests enter into our country become a serious pest. **b. Economic impact and yield loss** • *C. dictyospermi* is known mainly as a serious pest of Citrus (Zahradník, 1990). In Spain, Melia (1976) recorded it as one of the arthropods responsible for rejection of 22% of citrus fruits in the sorting and packing house; wastage was highest for Navel oranges (23%) and lowest for blood oranges (9%). Danzig and Pellizzari (1998) referred to *C. dictyospermi* as a dangerous pest in the Palaearctic region. Miller and Gimpel (2004) mentioned it being a most serious pest of citrus in the western Mediterranean Basin, Greece and Iran. Crouzel (1973) recorded *C. dictyospermi* causing damage of economic importance to citrus in Argentina, and Squire (1972) recorded the scale as a pest of citrus and other plants in Bolivia. In the Republic of Georgia, it is the main scale insect pest of citrus (Chkhaidze and Yasnosh, 2001). In Russia, *C. dictyospermi* is a pest of tea (Dzhashi, 1970). It is also known as a minor	**Yes and High**

pest in Mexico and South America (Rosen and DeBach, 1978). Foldi (2001) listed it as an economically important pest in France. • In Turkey, *C. dictyospermi* was most active in citrus plantations in the Aegean region in the past, and even now is often found on citrus trees in gardens, where damage is generally caused by the larvae and is not economically serious; however, never less than 25% of tangerine fruit are heavily infested (Tuncyurek and Oncuer, 1974; Soydanbay, 1977). Infestation decreases plant growth and development and disfigures the fruit, reducing their market value. *C. dictyospermi* is a pest in citrus plantations in the Black Sea region of Russia (Wyniger, 1962) and is the most important scale insect in Greece (De Bach and Argryiou, 1967). In Egypt, it attacks ornamental plants under glass (Nada, 1987). • In the western Mediterranean region and Florida, USA, *C. dictyospermi* is a serious pest of Citrus; it is a minor pest of Citrus, palms and young avocado trees in Mexico and South America (Chua and Wood, 1990; Gill, 1997). The species is of economic importance on several hosts in Brazil, and is regarded as a pest in Argentina, where it occurs on both cultivated and native plants; in Chile it is a primary pest on Citrus and is common on ornamental plants (Claps et al., 2001). *C. dictyospermi* is a pest of olive in Italy, Spain and Turkey (Argyriou, 1990). The species has been reported as a significant pest of Citrus in a number of countries in the South Pacific region; it is also very destructive to rose trees (Williams and Watson, 1988). FAO (1976) recorded *C. dictyospermi* attacking Pinus caribaea and Pinus caribaea var. hondurensis in Fiji. **c. Environmental Impact** • The estabilishment of the insect creats a serious problem in many countries. Farmers use different types of pesticides to control this insect. The excessive use of harmful pesticides cause different type of hazards like development of resistence, resurgence and secondary pest outbread.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.6.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.6.3 – 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 – High

7.4.1.6.9 Risk Management Measures

- Avoid importation of mango fruit and seedlings from countries, where this pest is available.
- In countries where *C. dictyospermi* is not already present, the enforcement of strict phytosanitary regulations as required for *C. dictyospermi*, may help to reduce the risk of this red scale 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 *C. dictyospermi* are present.

7.4.1.6.10 References

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7.4.1.7 A. Tapioca scale, *Aonidomytilus albus* (Cockerell, 1893)

7.4.1.7.1 Hazard identification

Preferred Common names: Tapioca scale
Scientific name: *Aonidomytilus albus* (Cockerell, 1893)

Synonyms: *Coccomytilus dispar (Vayssière)* Takahashi, 1935
Lepidosaphes alba (Cockerell) Fernald, 1903
Lepidosaphes cockerelliana Kirkaldy, 1904
Lepidosaphes dispar
Mytilaspis (Coccomytilus) dispar Vayssière, 1914

Mytilaspis albus Cockerell, 1893

Mytilococcus dispar (Vayssière) Lindinger, 1943

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Suborder: Sternorrhyncha
Superfamily: Coccoidea
Family: Diaspididae
Genus: Aonidomytilus
Species: *Aonidomytilus albus*

EPPO Code: AONMAL.

Bangladesh status: Not present in Bangladesh [CABI, 2019; EPPO, 2020]

7.4.1.7.2 Biology

Adult female *A. albus* feed throughout their lives and, once adult, live for several months. The adult male lacks mouthparts, so cannot feed and lives only a few days. The eggs hatch in 3-4 days; in 20-25 days the immature stages are fully grown (Lal and Pillai, 1981). The first-instar crawlers are the primary dispersal stage and walk to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high in this stage. There are two immature instars in the female and four in the male (including non-feeding pre-pupal and pupal stages).

Reproduction is sexual. The sessile female's mate with winged males, and begin to lay eggs approximately 2 days after reaching maturity (Anantanarayanan *et al.*, 1957).

Dry conditions may make plants more susceptible to attack, and favour dispersal of the crawlers, which are vulnerable to drowning and being swept off the host in heavy rain and high winds.

7.4.1.7.3 Hosts

The preferred hosts of *A. albus* are species of Manihot, but this insect has been recorded feeding on a variety of hosts, including several species of Solanum. The main hosts of interest are: *Atriplex, Carica papaya, Chrysanthemum, Flourensia, Harrisia, Malvaceae, Malvastrum,* ***Mangifera indica****, Manihot esculenta, Manihot spp., Mimosa, Sechium, Solanum, Suaeda and Ziziphus.*

Affected plant stages: vegetative growing, flowering, fruiting and post-harvest stages

7.4.1.7.4 Distribution

A. albus is a tropical species of New World origin. It has not been recorded from Australia or the Pacific islands.

Africa: Angola (NHM, 1978); Ghana (NHM, 1937), Nigeria (UK, CAB International, 1978),

Asia: China (Tao, 1999). India (Sankaran *et al.* 1984), Indonesia (Nakahara, 1982), Malaysia (Takahashi 1942), Sri Lanka (Williams and Williams 1988), Thailand (APPPC 1987).

North America: Cuba (Ballou 1923), Mexico (Cockerell 1899), United States (Williams and Williams 1988)

South America: Argentina (UK, CAB International 1978), Brazil (Nakahara 1982)

EU: Absent.

7.4.1.7.5 Hazard identification conclusion

Considering the facts that *A. albus*-

- is not known to be present in Bangladesh [CABI, 2019; EPPO, 2020]
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: *Carica papaya*, *Mangifera indica*, *Mimosa*, *Sechium*, *Solanum*, *Suaeda and Ziziphus*.
- It is a serious pest of Asia including China, India, Indonesia, Malaysia, Thailand, Sri Lanka, Taiwan (EPPO, 2014; Tao, 1999) from where a large number of fruits are imported to Bangladesh.
- The first-instar crawlers are the dispersal stage and move across quite short distances to new parts of the host-plant or to adjacent plants. Dispersal over longer distances is only possible with the assistance of wind or animals/humans (CABI, 2019). Dispersal of the sessile adults and immature stages between countries occurs through human transport of infested plant material, mainly on planting sticks rather than on stored tubers (CABI, 2019). Because this pest has high dispersal potential for long distance, the risk rating for establishment potential is high.
- *A. albus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.7.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.7.6 – 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 • This pest has been established in many Asian countries including Bahrain, China, India, Indonesia, Malaysia, Thailand, Sri Lanka, Taiwan (EPPO, 2020; Tao, 1999). • *A. albus* is a tropical species of New World origin. There is no mention in the literature of the history of its spread, but it has undoubtedly reached countries outside the New World as a result of human transport of infested planting sticks of cassava. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Adult female *A. albus* feed throughout their lives and, once adult, live for several months. The eggs hatch in 3-4 days; in 20-25 days the immature stages are fully grown (Lal and Pillai, 1981). This period of time taken for	**Yes and High**

shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. • The first-instar crawlers are the dispersal stage and move across quite short distances to new parts of the host-plant or to adjacent plants. Dispersal over longer distances is only possible with the assistance of wind or animals/humans. Mortality due to abiotic factors is high during dispersal. Dispersal of the sessile adults and immature stages between countries occurs through human transport of infested plant material, mainly on planting sticks rather than on stored tubers. So, the pests could survive during transporting process. Therefore, this pest is rated with High-risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Internationally, *A. albus* is liable to be carried on any plants for planting or on cut flowers and foliages, and nursery stocks, which are the main means of dispersal of this pest (EPPO, 2016). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • The preferred hosts of *A. albus* are species of Manihot esculenta (cassava), but this insect has been recorded feeding on a variety of hosts such as *Chrysanthemum* (daisy), *Rosa chinensis* (roses), Salvia sp. (sage), *Croton bonp*landianus, *Jatropha gossypiifolia* (bellyache bush), *Malvastrum americanum* (spiked malvastrum (Australia)), *Mangifera indica* (mango), *Solanum* (nightshade), *Turnera ulmifolia* (west Indian holly), *Carica papaya* (papaw), (CABI, 2019), among which mostly common in Bangladesh. • These climatic requirements for growth and development of A. albus are 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.7.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.7.2. – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *A. albus* is a more or less serious pest of cassava in East and West Africa, Argentina, Brazil, Colombia, India, Madagascar, Mexico, Taiwan, Thailand,	

West Indies and USA (Florida) (Simmonds, 1960; Subramaniam *et al.*, 1977; Anon., 1978; Vargas *et al.*, 1978; Lal and Pillai, 1981; Wongkobrat, 1988). In Brazil, this species is a pest on Manihot and Solanum spp. (Foldi, 1988), and was regarded with potential pest status on Manihot spp. (source of Ceara rubber) by Bastos *et al.* (1979). It can cause serious damage locally in Kenya (Bruijn and Guthrie, 1982). Severe attacks on cassava cuttings kept for planting can lead to losses (Lal and Pillai, 1981; Chua and Wood, 1990); it is a field pest less often (Lal and Pillai, 1981). **b. Economic Impact and Yield Loss** • *A. albus* is only an occasional problem in the field; most often, it is a pest of cassava stems stored for later planting. Infested cuttings often do not root, and use of infested cuttings at planting can result in rooting failure of up to 80% (Lal and Pillai, 1981). Heavy infestation causes desiccation of the stems; in the field, this causes them to become thin and weak, and to break in the wind; death of the plant may result. Breakage of stems leads to profuse branching, and infested plants often appear bushy. The severity of attack becomes worse in drought conditions, aggravating drought stress (Lal and Pillai, 1981). • The socio-economic impact of this can be considerable, as cassava is an important staple crop during drought, e.g. in Africa.A. albus is a more or less serious pest of cassava in East and West Africa, Argentina, Brazil, Colombia, India, Madagascar, Mexico, Taiwan, Thailand, West Indies and USA (Florida) (Simmonds, 1960; Subramaniam et al., 1977; Anon., 1978; Vargas et al., 1978; Lal and Pillai, 1981; Wongkobrat, 1988). In Brazil, this species is a pest on Manihot and Solanum spp. (Foldi, 1988), and was regarded with potential pest status on Manihot spp. (source of Ceara rubber) by Bastos et al. (1979). It can cause serious damage locally in Kenya (Bruijn and Guthrie, 1982). Severe attacks on cassava cuttings kept for planting can lead to losses (Lal and Pillai, 1981; Chua and Wood, 1990); it is a field pest less often (Lal and Pillai, 1981). **c. Environmental Impact** • ***A. albus* represents a potential threat to many crops. The establishment of it could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment.**	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.7.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.7.3 – Calculating 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

7.4.1.7.9 Risk Management Measures

- Avoid importation of fruits from countries, where this pest is available.
- For planting material, EPPO recommends (OEPP/EPPO, 1990) absence of the pests from the place of production during the last 3 months, or treatment of the consignment. For cut flowers, pre-export inspection is considered sufficient.
- Planting sticks of cassava, and stored cassava, should be thoroughly inspected for A. albus scales before export, as there is a risk of their dissemination on such material (Lozano *et al.*, 1977). Imported planting material of cassava should also be thoroughly inspected before planting and treated, if necessary, to kill any scale insects present.

7.4.1.7.10 References

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7.4.1.8 A. Spiked mealybug, *Nipaecoccus nipae* (Maskell, 1893)

7.4.1.8.1 Hazard identification

Preferred Common names: Spiked mealybug, coconut mealybug,
Scientific name: *Nipaecoccus nipae* (Maskell, 1893)

Synonyms: *Ceroputo nipae (Maskell), Lindinger, 1904*
Dactylopius dubia Maxwell-Lefroy, 1903
Dactylopius nipae Maskell, 1893

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 [CABI, 2021; EPPO, 2020]

7.4.1.8.2 Biology

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

7.4.1.8.3 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.

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)

7.4.1.8.4 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)

7.4.1.8.5 Hazard identification conclusion

Considering the facts that *N. nipae*-

- is not known to be present in Bangladesh [CABI, 2021; EPPO, 2020]
- 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.
- It is a serious pest of Asia including China, India, Indonesia, Korea, Turkey from where a large number of fruits is imported to Bangladesh.
- The degree of polyphagy of *N. nipae* 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.
- *N. nipae* is a quarantine pest for Bangladesh and considered to be a potential hazard organism in this risk analysis.

7.4.1.8.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.8.1 – 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? - 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 of this pest 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 establish? - 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 established 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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.8.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.8.2 – 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 (Ben-Dov, 1994). 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

7.4.1.8.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.8.3 – Calculating 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

7.4.1.8.9 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.

7.4.1.8.10 References

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7.4.1.9 A. Grey pineapple mealybug, *Dysmicoccus neobrevipes* Beardsley

7.4.1.9.1 Hazard identification

Preferred Common names: Grey pineapple mealybug
Scientific name: *Bactrocera tryoni* (Froggatt)

Taxonomic tree

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

Order: Hemiptera
Suborder: Sternorrhncha
Superfamily: Coccoidea
Family: Pseudococcidae
Genus: Dysmicoccus
Species: *Dysmicoccus neobrevipes*

EPPO Code: DYSMNE.

Bangladesh status: Not present in Bangladesh [CABI, 2023]

7.4.1.9.2 Biology

D. neobrevipes males and females reproduces sexually. Unmated females will not produce young (Beardsley, 1960). *D. neobrevipes* is ovoviviparous, with each female giving birth to approximately 350 live young in a lifetime, although it can be as many as 1000 (Kessing and Mau, 1992). Females go through 3 larval instars which last for 11 to 23 days, 6 to 20 days and 7 to 28 days, respectively. The total larval period is 35 days on average but can range from 26 to 52 days.

Males go through 4 larval instars before becoming winged adults. These instars last for 11 to 19 days, 7 to 19 days, 2 to 7 days and 2 to 8 days, respectively. The total larval period ranges from 22 to 53 days (Kessing and Mau, 1992). Adult females can live for 48 to 72 days, whereas the winged males live for 2 to 7 days (Kessing and Mau, 1992). Qin *et al.* (2011) found that the longevity of *D. neobrevipes* can vary depending on the mealybug's host; the longevity of *D. neobrevipes* on most hosts tested was 51.0 days, but they recorded a longevity of 62.5 days for female mealybugs on *Ananas comosus* Baili.

7.4.1.9.3 Hosts

As the common name suggests, the grey pineapple mealybug is primarily a pest of pineapple, although it does not depend on that single host plant to complete its life cycle. Due to its polyphagous nature, the grey pineapple mealybug has been reported on more than 100 plant genera in 53 families (Ben-Dov). This insect is a minor pest on other bromeliads and a wide range of other plants including, but not limited to, Annona, avocado, banana, carrot, celery, Citrus, cocoa, coconut, coffee, cotton, Euphorbia, ginger, Gliricidia, Hibiscus, mulberry, orchid pineapple, taro, pumpkin, and many perennial grasses (CABI 2014).
Major host: *Ananas comosus* (pineapple); *Alpinia purpurata* (red ginger); *Arachis hypogaea* (groundnut); *Artocarpus heterophyllus* (jackfruit); *Cajanus cajan* (pigeon pea); *Citrus aurantiifolia* (lime); *Citrus reticulata* (mandarin); *Citrus sinensis* (sweet orange); *Cocos nucifera* (coconut); *Coffea* (coffee); *Cucurbita maxima* (giant pumpkin); *Gossypium* (cotton); *Mangifera indica* (mango); *Musa* (banana); *Polianthes tuberosa* (tuberose); *Psidium guajava* (guava); *Punica granatum* (pomegranate); *Solanum lycopersicum* (tomato); *Solanum melongena* (aubergine); *Vigna unguiculata* (cowpea).

7.4.1.9.4 Distribution

D. neobrevipes is thought to be native to tropical America, but now has a pantropical distribution, with a small number of records from subtropical or Mediterranean localities (Kessing and Mau, 1992). It has been found in all zoogeographic regions on a wide diversity of hosts, but has a smaller geographical range than the related pink form, *D. brevipes* (Jahn *et al.*, 2003). *D. neobrevipes* is known to have been introduced to China, Japan, Sri Lanka and Lithuania.

Africa: Uganda;

Asia: China; India; Indonesia; Japan; Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam. (Seebens *et al.* (2017); García Morales *et al.* (2016))

Europe: Italy, Netherlands. Seebens *et al.* (2017)

North America: Jamaica, Mexico, United States (United States Department of Agriculture (1979))

South America: Brazil (García Morales *et al.* (2016)).

7.4.1.9.5 Hazard identification conclusion

Considering the facts that *D. neobrevipes*-

- is not known to be present in Bangladesh [CABI, 2023]
- potentially economic important to Bangladesh because it is an important major pest of many cultivated plants including most characteristically fruits: pineapple; groundnut; jackfruit; pigeon pea; lime; mandarin; sweet orange; coconut; coffee; giant pumpkin; cotton; banana; tuberose; guava; pomegranate; tomato; aubergine and cowpea.
- *D. neobrevipes* has the potential to cause harm to its hosts in areas where it is introduced that lack natural enemies, or where it is protected from natural enemies by caretaker ants, most commonly species of Pheidole and Solenopsis (Jahn *et al.*, 2003). *D. neobrevipes* is under quarantine restrictions in the USA, where it has been intercepted many times, particularly on samples from the Philippines (Ben-Dov, 2001). Qin *et al.* (2010) conducted an investigation into the risk of invasion by *D. neobrevipes* into China. Their results suggested that *D. neobrevipes* is a dangerous alien species with a high risk of invasion.
- The main damage that pineapple mealybugs such as *D. neobrevipes* cause is as a result of their role as a vector of pineapple wilt. *D. neobrevipes* also causes green spot disease of pineapple, which is characterized by galls on leaves caused by a reaction between the plant and a secretion from the mealybugs.
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable cultivated crops and fruits.
- *D. neobrevipes* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.9.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.9.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
e. Has this pest been established in several new countries in recent years? - Yes • *D. neobrevipes* is thought to be native to tropical America, but now has a pantropical distribution and it has been found in all zoogeographic regions on a wide diversity of hosts. *D. neobrevipes* is known to have been	

introduced to China, India, Japan, Pakistan, Thailand, etc. from where huge amount of mango imported in our country. **f. Possibility of survival of this pest during transport, storage and transfer? – Yes** • The total larval period is 35 days on average but can range from 26 to 52 days. Adult females can live for 48 to 72 days, whereas the winged males live for 2 to 7 days (Kessing and Mau, 1992). Qin *et al.* (2011) found that the longevity of *D. neobrevipes* can vary depending on the mealybug's host; the longevity of *D. neobrevipes* on most hosts tested was 51.0 days, but they recorded a longevity of 62.5 days for female mealybugs on *Ananas comosus* Baili. This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • The pathway appears 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. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *B. tryoni* is the most serious insect pest of fruit and vegetable crops pineapple; groundnut; jackfruit; pigeon pea; lime; mandarin; sweet orange; coconut; coffee; giant pumpkin; cotton; banana; tuberose; guava; pomegranate; tomato; aubergine and cowpea. • The climate of Bangladesh is similar to places it is established.	**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 appear good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.9.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.9.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Due to its polyphagous nature, the grey pineapple mealybug has been reported on more than 100 plant genera in 53 families (Ben-Dov). It is an	

important pest of many cultivated plants including most characteristically fruits and vegetables: *Ananas comosus* (pineapple); *Alpinia purpurata* (red ginger); *Arachis hypogaea* (groundnut); *Artocarpus heterophyllus* (jackfruit); *Cajanus cajan* (pigeon pea); *Citrus aurantiifolia* (lime); *Citrus reticulata* (mandarin); *Citrus sinensis* (sweet orange); *Cocos nucifera* (coconut); *Coffea* (coffee); *Cucurbita maxima* (giant pumpkin); *Gossypium* (cotton); ***Mangifera indica* (mango);** *Musa* (banana); *Polianthes tuberosa* (tuberose); *Psidium guajava* (guava); *Punica granatum* (pomegranate); *Solanum lycopersicum* (tomato); *Solanum melongena* (aubergine); *Vigna unguiculata* (cowpea).. Therefore, it is a high risk, if fruits and plant material are imported from India, Thailand, Japan, Pakistan, there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *D. neobrevipes* is a pest of many economically important crops, particularly pineapple and banana. In addition to the direct damage, it causes, it also causes green spot disease and transmits pineapple wilt which is caused by Pineapple mealybug wilt associated virus-2 (PMWaV-2). Sether and Hu (2002) showed that pineapple wilt can cause yield loss of 35% in pineapple, representing significant losses to producers. **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 has a negative impact to our environment, natural life, wild life, even aquatic life and disrupting the natural control system in the field.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.9.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.9.3 – Calculating 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

7.4.1.9.9 Risk Management Measures

- Avoid importation of infested material from countries, where this pest is available.
- In countries where *D. neobrevipes* not already present, the enforcement of strict phytosanitary regulations as required for *D. neobrevipes* 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 *D. neobrevipes* present.

7.4.1.9.10 References

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7.4.1.10 Peach scale, Parthenolecanium persicae (Fabricius)

7.4.1.10.1 Hazard identification

Preferred Common names: Peach scale
Scientific name: *Parthenolecanium persicae* (Fabricius)

Synonyms: *Eulecanium cecconi* Leonardi
Lecanium (Eulecanium) berberidis Shrank
Lecanium (Eulecanium) magnoliarum Cockerell
Lecanium (Eulecanium) spinosum Brittin
Lecanium (Palaeolecanium) persicae (Fabricius)
Lecanium (Parthenolecanium) berberidis Shrank

Lecanium (Parthenolecanium) magnoliarum Cockerell
Lecanium genistae Signoret
Lecanium mori Signoret
Lecanium sarothamni Douglas
Parthenolecanium thymi Danzig

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Family: Coccidae
Genus: *Parthenolecanium*
Species: *Parthenolecanium persicae*

EPPO Code: LECAPE.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.4.1.10.2 Biology

Adult female (Hodgson 1994)

-Unmounted material: highly variable; not strongly convex, elongate oval with a medial longitudinal ridge. Young adult females usually yellowish with brown markings or mottling, becoming uniformly brown with age.

- Mounted material: elongate oval, with distinct stigmatic clefts; up to 5 mm long and 3 mm wide.

- Dorsum: derm membranous when young, becoming mildly sclerotised when old. Dorsal setae of two sizes: rather large, stout, blunt spines: present in a more or less double line medially anterior to anal plates extending as far forward as mouthparts; much smaller, rather blunt, spines: rather sparse throughout rest of dorsum. Dorsal pores of two types, present throughout. Preopercular pores circular, moderately large, with a rough surface: present in a small loose group of about 20 to 26 pores just anterior to the anal plates. Dorsal tubular ducts absent. Dorsal tubercles normal, large and convex; total of 24 to 42 around submargin. Pocket-like sclerotisations probably present (Gill 1988). Ano-genital fold with two pairs of long setae along anterior margin and two pairs of shorter setae laterally. Anal ring with eight setae present.

- Margin: marginal setae long, slender, curved and pointed, in a single band; with about 8 to 12 setae on each side between stigmatic areas. Stigmatic clefts distinct, each with three stigmatic spines, all sharply spinose and about as long as the marginal setae; each median spine slightly longer than laterals and generally slightly curved.

- Venter: pregenital disc-pores each with mainly ten loculi; fairly abundant around genital opening, becoming progressively less frequent across preceding abdominal segments; with large groups also present mesad to each coxa. Ventral microducts abundant in a submarginal band and near labium, much less frequent medially, particularly on abdomen. Ventral tubular ducts of three types: small duct: present in small submarginal groups between antennae; a slightly larger duct, with outer ductule rather longer than the first type, with a large terminal gland: rather sparse, intermixed with the third type; and large duct, with an inner ductule as wide as or wider than outer ductule: present in a broad submarginal band extending from anterior to each antenna to near anal cleft. Ventral setae: submarginal setae in a double row. Antennae eight- or nine-segmented (rarely six- or seven-segmented). Legs normally developed; each with a tibio-tarsal articulatory sclerosis; claws rather long and narrow with a distinct denticle; claw digitules broad and similar.

Note: despite its taxonomic history (i.e. large number of synonyms), this species is quite distinctive, and can be separated from all other known Parthenolecanium species by the presence of large numbers of dorsal tubercles around the submargin and the ventral submarginal band of tubular ducts, each with a broad inner ductule. For a key to separate the most common species of this genus, see 'Similarities to other species'. The immature stages of Parthenolecanium species are not particularly well known and few have been described to modern standards of description. However, those of *P. persicae* were described and illustrated very accurately by Boratynski (1970), Brittin (1940a). Schmutterer (1954), Dziedzicka (1968) and Gonzalez (1989) have described the immature stages of some of the other species (*Parthenolecanium corni*). As on the adult female, the third-instar nymphs have ventral tubular ducts with the inner ductule as broad as the outer ductule (*P. persicae*), whereas the second-instar nymphs have four pairs of dorsal tubercles submarginally (dorsal tubercles are rare on second-instar nymphs); whether these characters would separate these nymphs from other Parthenolecanium species is uncertain. [The various nymphal stages can be identified by the number of antennal segments (Brittin 1940a, Boratynski 1970). First-instar: six-segmented, with apical segment longer than third segment; second-instar: six segmented, with third segment longer than apical segment; third-instar: seven-segmented and adult female: eight-segmented].

7.4.1.10.3 Hosts

Some important hosts are cultivated species and ornamentals, for example pineapple pigeon pea (*Cajanus cajan*), citrus, coconut (*Cocos nucifera*), date plum tree (*Diospyros lotus*), walnut (*Juglans regia*), ***Mangifera indica***, guava (*Psidium persica*), peach (*Prunus persica*), pomegranate (*Pumica granatum*) *etc.* (Rakimov *et al.* 2013, Hoffmann 2006).

7.4.1.10.4 Distribution

Egypt is referred to as *Parthenolecanium persicae* (*Coccus elongatus*) (El-Minshawy and Moursi 1976). These are two different insect species (Ben-Dov 1977). It seems likely that these records, and perhaps some of the others from Egypt, actually refer to *C. elongatus* (the long brown scale, now known as *Coccus longulus*) rather than *P. persicae*. Because of the complexity of the taxonomy of what was originally the genus *Lecanium*, many of the early records in the distribution table of this datasheet need confirmation. The distribution of *P. persicae* appears to be restricted mainly to the vine-growing areas of the world, although not always of economic importance in many of the areas.

Africa: Egypt, Morocco, Zimbabwe (Badr 2014, Ben-Dov *et al.* 2001, Hall 1935).

Asia: Afghanistan, China, India, Japan, Pakistan, Sri Lanka, Turkey (UK, CAB International 1979).

North America: Canada, USA (Ben-Dov *et al.* 2001).

South America: Argentina, Brazil (Soria and Conte 2000).

Oceania: Australia, New Zealand (Hodgson and Henderson (2000)).

Europe: France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, United Kingdom (Hodgson and Peronti 2012, EPPO 2022).

7.4.1.10.5 Hazard identification conclusion

Considering the facts that *P. persicae*-

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: pineapple pigeon pea (*Cajanus cajan*), citrus, coconut (*Cocos nucifera*), date plum tree (*Diospyros lotus*), walnut (*Juglans regia*), ***Mangifera indica***, guava (*Psidium persica*), peach (*Prunus persica*), pomegranate (*Pumica granatum*) *etc.* (Rakimov *et al.* 2013, Hoffmann 2006). are also infested.
- It is a serious pest of Australia, Pakistan and India from where a large number of fruits are imported to Bangladesh.
- *P. persicae* is a known pest of several fruit and agricultural crops in the area where it is present. It can be moved in trade with infested fruit.
- The most likely method of introduction would be on plants, particularly vine cuttings and small vine plants. It is not a high phytosanitary risk.
- Wind dispersal of first-instar nymphs is the main 'natural' method of dispersal.
- Moving cuttings or plants between fields or farms (i.e. of vines) might disperse it.
- *P. persicae* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.10.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.10.1 – 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 **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Biological characteristics that enable scale insect pests to establish and spread include their small size and cryptic habitats, their protective wax body coverings, their plant feeding nature and predisposition to polyphagous behaviours, their ability to reproduce parthenogenetically as well as sexually, and their capacity for active and passive dispersal, most commonly by the 'crawler' life stage. • *P. persicae* is extraordinarily invasive, in part because they are very small, cryptic and nearly ubiquitous associates of woody plants (Normark *et al.* 2019). **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,**	**Yes and Moderate**

• The first instars (crawlers) of *P. persicae* can walk short distances within the canopy or connected canopies. They can also be passively transported by wind (Peronti 2004, Peronti and Kondo 2022). • The crawlers can hitchhike on animals (CDFA 2022, Peronti and Kondo 2022). • *P. persicae* can be transported with the commercial trade of plants or less frequently with fruits and flowers. The species is also reported as moved on equipment but without further details (CDFA 2022, Peronti and Kondo 2022). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *P. persicae* is highly polyphagous. It infested the ten most common host families, in descending order, are Fabaceae, Poaceae, Rosaceae, Myrtaceae, Orchidaceae, Asteraceae, Euphorbiaceae, Pinaceae, Arecaceae, and Fagaceae. • *P. persicae* is reported from all the zoogeographical regions of Europe, Asia, North America, South America, Africa and Australasia (Miller *et al.* 2014). It occurs in climatic conditions of tropics, subtropics and temperate regions (Kozár 1990, Kozár and Ben-Dov 1997) and thus display capacity to reproduce in a wide range of terrestrial environments. • The climate of Bangladesh is similar to places it is established.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.10.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.10.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many cultivated plants including most characteristically fruits: pineapple pigeon pea (*Cajanus cajan*), citrus, coconut (*Cocos nucifera*), date plum tree (*Diospyros lotus*), walnut (*Juglans regia*), ***Mangifera indica***, guava (*Psidium persica*), peach (*Prunus persica*), pomegranate (*Pumica granatum*) etc. Therefore, it is a high risk, if fruits and plant material are imported from Australia, China, Brazil, Pakistan. There is possibility to established the pest in Bangladesh. • If the pest establishes in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *P. persicae* is mainly a minor pest, but it has occasionally been important on vines and deciduous fruit trees. Outbreaks have been recorded in	**Yes and Moderate**

Australia (Froggatt 1915), Egypt (Hosny 1943), and Chile and Peru (Gonzalez 1983, Foldi and Soria 1989) where it is considered to be a key pest in vineyards. It is common in vineyards in France, Hungary, Italy, Portugal, Spain and Switzerland, and also in the Caucasus, although rarely of economic importance (Pellizari 1997). **c. Environmental Impact** • *P. persicae* is not expected to affect the biodiversity and disrupt natural habitats. Neither is it reported as affecting any threatened or endangered species (CDFA 2022).	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.1.10.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.10.3 – Calculating 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

7.4.1.10.9 Risk Management Measures

Consignments of fruits from countries or regions where *P. persicae* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *P. persicae* does not occur, or from a place of production found free from the pest by regular inspection for 3 months before harvest. The infected branches and leaves should be pruned and destroyed (Peronti and Kondo 2022). Parasites and predators usually keep *P. persicae* near or below the economic threshold. When there is a heavy infestation, light mineral oil treatments or organophosphate products can be applied at the end of the winter against the overwintering nymphs (Pellizari 1997). The control of ants in infested vineyards aids in preventing outbreaks (Gonzalez 1983). Control measures are rarely necessary except in vineyards. In a field experiment, fenitrothion, trichlorfon, imidacloprid and thiamethoxam controlled *P. persicae* efficiently in vineyards in Rio Grande do Sul, Brazil (Afonso *et al.* 2004).

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7.4.1.11 A. Mango shoot borer, *Penicillaria jocosatrix* (Guenée, 1852)

7.4.1.11.1 Hazard identification

Preferred Common names: Mango shoot borer
Scientific name: *Penicillaria jocosatrix* (Guenée, 1852)

Synonyms: *Bombotelia jocosatrix*

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Euteliidae
Genus: *Penicillaria*
Species: *Penicillaria jocosatrix*

EPPO Code: BOMTJO.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.4.1.11.2 Biology

The wingspan is about 20–30 mm. It is dark purplish red brown. Forewings with traces of sub-basal line, an indistinct antemedial line angled on median nervure and a postmedial line angled beyond cell with chocolate below the angle. It joint by a chocolate patch from costa inside the indistinct sub-marginal angled white line. There is a pale streak and slight fold from centre of cell to outer margin. Hindwings white, with dark cell spot. Outer are purplish brown. Underside with prominent black cell spot (Hampson 1894).

Eggs are pale blue green. Larva green with sub-lateral dark stria. Somites with small purple spots and a sub-dorsal series of larger spots. There are few hairs arise from spiracles. Larva completes five instars to become a pupa. Pupa dark brown, much round with no distinguishing lumps or lobes (Hampson 1894).

7.4.1.11.3 Hosts

The larvae feed on *Mangifera indica*, *Anacardium occidentale*, *Schinus molle*, *Terminalia belerica* and *Terminalia carolinensis*. The larvae are translucent mauve, with greenish sides and tail, and are covered sparsely in red dots. It has a light brown head. It is considered an agricultural pest (Herbison-Evans 2018).

7.4.1.11.4 Distribution

Asia: China, India, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand, Vietnam (EPPO 2022).

North America: USA (EPPO 2022).

Oceania: Australia (EPPO 2022).

7.4.1.11.5 Hazard identification conclusion

Considering the facts that *P. jocosatrix* -

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: cashew nut (*Anacardium occidentale*), mangoes (*Mangifera indica*), pepper tree (*Schinus* sp.), Otaheite apple (*Spondias dulcis*).
- It is a serious pest of Australia, China, USA, Thailand, India from where a large number of fruits are imported to Bangladesh.

- *P. jocosatrix* is a known pest of several fruit and agricultural crops in the area where it is present. It can be moved in trade with infested fruit.
- The major risk is from the importation of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail.
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable cultivated crops and fruits.
- *P. jocosatrix* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.11.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.11.1 – 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 **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • *P. jocosatrix* can survive at the time of transport, especially eggs are easily transferred with fruits, plants parts etc. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • The importance and success of *P. jocosatrix* is in large measure due to its well-developed survival strategies, diapause and dispersal, which enable it to exploit food sources separated both by unfavourable times and by distance, and thereby also to escape its natural enemies. *P. jocosatrix* is effectively a facultative migrant, not displaying typical migratory behaviour, but responding largely to local environmental cues and undertaking either short or longer distance flight in directions largely governed by prevailing weather systems (Fitt, 1989). Innately, the disposition to disperse is governed by reproductive maturity, so that in more transient habitats where dispersal has greater survival value, the length of the pre-reproduction period is greater than in less extreme habitats (Colvin, 1990); in these habitats, such as in India, the tendency to fly was moderated chiefly by feeding which reduced the pre-maturation period. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *P. jocosatrix* is not highly polyphagous. It infested cashew nut (*Anacardium occidentale*), mangoes (*Mangifera indica*), pepper tree (*Schinus* sp.), Otaheite apple (*Spondias dulcis*). • *P. jocosatrix* is reported from tropical and sub-tropical region of Asia, North America, and Australasia (EPPO 2022). • The climate of Bangladesh is similar to places it is established.	**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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.4.1.11.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.11.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest for **mangoes** (*Mangifera indica*). Therefore, it is a high risk, if fruits and plant material are imported from Australia, China, USA, Thailand there is possibility to established the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • The mango shoot caterpillar is generally considered a minor pest in Asia (Hill 1983). • This is also the case in Hawaii even though it is a recent accidental introduction to those islands where it might be expected to become a major pest in the absence of its usual natural enemy complex. The fact that it is a minor pest in Hawaii may indicate the presence of indigenous natural enemies attacking the invader. • In Fiji it is also considered to be a minor pest (Robinson *et al.* 1994). • CSIRO (1970) lists *P. jocosatrix* as a serious pest of mango in Australia, but then goes on to describe the damage as boring of the shoots causing wilting. **c. Environmental Impact** • *P. jocosatrix* is not expected to affect the biodiversity and disrupt natural habitats. Neither is it reported as affecting any threatened or endangered species (CDFA 2022).	**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

7.4.1.11.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.11.3 – Calculating 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

7.4.1.11.9 Risk Management Measures

Consignments of fruits from countries or regions where *P. jocosatrix* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *P. jocosatrix* does not occur, or from a place of production found free from the pest by regular inspection for 3 months before harvest. Successful biological control of this species was achieved in Guam. In 1986-87 four species of parasitoids were imported from California and India and released. These were *Trichogramma platneri*, *Aleiodes* sp. nr *circumscriptus*, *Blepharella lateralis* and *Euplectrus* sp. nr *parvulus*. *T. platneri* was obtained from California and the other three species came from India. B. lateralis was found several miles from the release point within a few months and became readily established, even though only 45 adult flies were released and many of these had damaged wings. Euplectrus sp. also became established. The egg parasitoid *T. platneri*, was not recovered and apparently did not establish. The larval parasitoid, *Aleiodes* sp., was recovered several months after it was released, but no parasitized caterpillars could be found 6 months later, and apparently the population failed to establish permanently. Both *B. lateralis* and *Euplectrus* became common in Guam. Population levels of both parasitoids vary with the season. *B. lateralis* is more common during the rainy months from August to November, averaging about 20% parasitization in the wet season and 2% in the dry season. In contrast, *Euplectrus* sp. parasitized about 68% of larvae during the dry months, but only 20% during the wet months. Together they reduced the caterpillar populations to one quarter of previous levels. The damage caused by the mango shoot caterpillar has decreased from about 55% leaf area consumed to about 15%. As a result, production of mangoes increased 40-fold. *P. jocosatrix* caterpillars are readily controlled by chemicals. Both carbaryl and formulations of Bacillus thuringiensis effectively reduced caterpillar numbers (Schreiner and Nafus 1991). However, it is difficult to spray frequently enough to protect all vulnerable young foliage. Major leaf flushes, in the greatest need of protection, are also likely to occur during the heavy rainy season when it is difficult to carry out pesticide application. Except in commercial orchards where mango trees are kept pruned at small sizes, it is also difficult to get adequate coverage of large tall trees with small manual applicators.

7.4.1.11.10 References

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7.4.1.12 A. Rubber termite, *Coptotermes curvignathus* Holmgren

7.4.1.12.1 Hazard identification

Preferred Common names: Rubber termite
Scientific name: *Coptotermes curvignathus* Holmgren
Synonyms: *Coptotermes flavicephalus* Oshima
Coptotermes robustus Holmgren

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Isoptera
Family: Rhinotermitidae
Genus: *Coptotermes*
Species: *Coptotermes curvignathus*

EPPO Code: COPTCU.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.4.1.12.2 Biology

The morphology of *C. curvignathus* is described in detail by Tho (1992). It is the largest species of *Coptotermes* in Asia. Species of the genus *Coptotermes* are recognized by the large frontal opening on the head of the soldier, from which they are able to exude a white, sticky latex used in defence. The latex is stored in a gland in the abdomen, and gives the abdomen a conspicuous white colour.

The alates of *C. curvignathus* are distinguished from other species of *Coptotermes* by their large size. Eggs are small, round and white. The nymphs are also white. The workers are difficult to differentiate from other species of *Coptotermes* except on the basis of size. They are differentiated from the soldier caste in having paler head capsules and abdomens that are not as white. The soldiers have yellow head capsules. When viewed dorsally, the margins of the head capsule can be seen to curve in strongly towards the mandibles. The mandibles of the soldier are also very strongly in-curved compared to other species of *Coptotermes* (Tho 1992).

7.4.1.12.3 Hosts

C. curvignathus generally attacks plants with woody stems. It does not affect grasses, shrubs or herbaceous plants. Often, large- to medium-sized trees are attacked, but seedlings with very small woody stems are also attacked in plantations. A very large number of tree species has been reported to be attacked by *C. curvignathus*, including conifers, monocotyledonous and dicotyledonous plants (Tho and Kirton 1992). Some tree species appear resistant, whereas others appear particularly susceptible. Among the most susceptible tree species are coniferous species such as *Pinus* spp., *Araucaria* spp. and *Agathis* spp. (Tho 1974, Tho and Kirton 1992).

7.4.1.12.4 Distribution

C. curvignathus has a general distribution from Thailand and Indochina to Sulawesi. Though there are no published records of the species occurring on some Indonesian islands, it is likely that it occurs through most of the Indonesian archipelago. It does not occur in Burma [Myanmar] and India. References to it occurring in these countries are most likely to have been due to confusion between *C. gestroi* and *C. curvignathus* before the latter was described as a species distinct from the former.

Asia: Indonesia, Malaysia, Singapore, Thailand, Vietnam (Waterhouse 1993).

7.4.1.12.5 Hazard identification conclusion

Considering the facts that *C. curvignathus* -

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: white siris (*Albizia procera*), coconut (*Cocos nucifera*), rubber plant (*Ficus elastica*), mangoes (*Mangifera indica*), cassava (*Manihot esculenta*) etc.
- It is a serious pest of Thailand, Malaysia, Singapore from where a large number of fruits are imported to Bangladesh.
- *C. curvignathus* is a known pest of woody trees and fruit in the area where it is present. It can be moved in trade with infested fruit.
- The major risk is from the importation of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail.
- It can establish in Bangladesh through imports of the fruits. It has capability to cause direct and indirect economic and ecological damage to many valuable cultivated crops and fruits.
- *C. curvignathus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.1.12.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.12.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
g. Has this pest been established in several new countries in recent years? - No • The risk of introduction of *C. curvignathus* is not as high as for drywood termites (e.g., *Cryptotermes* and *Incisitermes*) or some species of *Coptotermes* that more readily initiate nests in isolated pieces of timber (e.g., *C. formosanus* and *C. gestroi*). However, *C. curvignathus* could be accidentally introduced to new areas through importation of infested logs, whether or not these are debarked. The termite itself, however, is not a species that is traded internationally or locally. *C. curvignathus* is listed as a pest of quarantine concern in China, New Zealand and Australia. (EPPO 2022). **h. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Whether or not survival on board sailing vessels is possible in *C. curvignathus* specifically has not been verified. The most likely route of dispersal of *C. curvignathus* to new geographical areas is through trade in logs, as it is able to nest in the heart of tree trunks, even when the trees are living. The alates or flying forms may also be carried under the loose bark of logs or on wood packaging material transported from one country to another. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • It is believed that one of their routes of dispersal could be by rafting across seas in pieces of timber. Some species of *Coptotermes* have wide distributions across archipelagos that suggest an ability to disperse naturally; however, the risk of natural introductions of this sort over a small geological timescale is very low. Dispersal in Components of Sea Vessels. Some species of *Coptotermes* are known to be able to nest in damp wooden components of ships and sailing vessels (Kirton and Brown 2003). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *C. curvignathus* infested white siris (*Albizia procera*), coconut (*Cocos nucifera*), rubber plant (*Ficus elastica*), mangoes (*Mangifera indica*), cassava (*Manihot esculenta*) etc. • *C. curvignathus* is reported from Asia and North America. It occurs in climatic conditions of tropics and subtropics regions and thus display capacity to reproduce in a wide range of terrestrial environments. • The climate of Bangladesh is similar to places it is established.	**Yes and Moderate**
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and	Low

• The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	

7.4.1.12.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.12.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? – No. • It is not serious pest for Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *C. curvignathus* affects the agricultural, silvicultural and horticultural sectors. In agriculture, it is a serious pest of oil palm (*Elaeis guineensis*) grown on peat soils in Malaysia and coconut grown on peat soils in Indonesia. It is also reported to be a serious pest of rubber (*Hevea brasiliensis*), although on land that has been long planted and replanted with rubber, the incidence of attack appears to lower. Among forest plantation trees, species of pines are known to be very susceptible, with complete losses having been reported in some plantations (Tho 1974). **c. Environmental Impact** • In natural habitats in which *C. curvignathus* occurs, it fulfils a useful role in the removal of weak and injured trees, forest gap formation and nutrient recycling. In plantations, the extensive use of organochlorine pesticides to control this pest in the past has left a current environmental hazard (Tho and Kirton 1992), as these chemicals are extremely persistent in the environment and pose a threat to many forms of wildlife.	**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

7.4.1.12.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.12.3 – Calculating 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

7.4.1.12.9 Risk Management Measures

Consignments of fruits from countries or regions where *C. curvignathus* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. Possible measures include that such fruits should come from an area where *C. curvignathus* does not occur, or from a place of production found free from the pest by regular inspection for 3 months before harvest. Logs being exported from countries where *C. curvignathus* occurs should be debarked to reduce the risk of transporting alates that could found new colonies. Fumigation of logs or wood material at the port of origin will also reduce the risk of transporting nests, colony fragments or alates. Ensuring good tree health is likely to reduce the risk of attack by *C. curvignathus*. Trees that are nutrient deficient, water-stressed or grown in waterlogged areas may be more prone to attack (Tho and Kirton 1992). Thinning should be conducted at suitable periods to ensure trees are not grown in crowded, light-deprived situations. Mechanical injury to trees from machines or weeding exercises should be minimised. Where pruning is conducted, the wounds need to be properly dressed to reduce the likelihood of these becoming routes of entry into the tree for the termite (Kirton *et al.* 1999b). The control of bark and stem borers is also important because wounds from borers can predispose trees to attack by C. curvignathus as well (Kirton *et al.* 1999b). Although it has often been suggested that wood debris on the planting site provides food sources and breeding sites for the termite and, thus, it has been strongly advocated that all wood debris be cleared and burnt before planting, recent evidence shows otherwise (Kirton *et al.* 1999a). In reality, the termite is seldom found on wood residues in plantations but attacks trees more frequently. Host susceptibility and residual populations of *C. curvignathus* in the original planting site are the factors that have the largest impact on subsequent attack on plantation trees. The removal of wood debris has limited value, and may only serve to reduce suitable sites for colony establishment in plantations of tree species in which the termite is unable to nest in the trunks. Although *C. curvignathus* attacks a wide range of hosts, some tree species are noticeably less susceptible to attack. Among the more resistant is teak (*Tectona grandis*). *Acacia mangium* is equally susceptible to attack as species of conifers (Pinus, Araucaria, etc.) but is less prone to mortality from attack (Kirton *et al.*, 1999a). Species-site matching should take into consideration the susceptibility of the tree species to *C. curvignathus* and the likelihood of attack in the planting site, based on a knowledge of the habitat and site history. Wherever possible, trees should be matched with sites on the basis of their relative resistance to attack and the risk posed by the planting site. Planting sites originating from land cleared of peat swamps pose a high risk of attack. Planting sites derived from logged over lowland dipterocarp forest pose a moderate risk, whereas sites derived from secondary vegetation dominated by bushes and small trees or grassland pose a lesser threat. Tree species that are particularly susceptible, such as pines, are best planted on sites that pose a low risk, whereas sites that pose a high risk are best planted with resistant tree species. The use of entomophagous nematodes and entomopathogenic fungi to control species of *Coptotermes* has been largely experimental and laboratory-based, and most of the work has focussed on C. formosanus. The histopathology of infection by entomopathogenic fungus Metarhizium anisopliae in C. curvignathus has been investigated in the laboratory (Sajap and Kaur 1990), while field-derived cultures of Conidiobolus coronatus have been demonstrated to be highly pathogenic to C. curvignathus (Sajap *et al.* 1997). Termiticides are insecticides formulated for use against termites. Among the insecticides used for this purpose are chlorpyrifos, cypermethrin, alpha-cypermethrin and new generation insecticides such as fipronil and imidacloprid. The use of organochlorine insecticides has been discontinued because of the persistent nature of these insecticides in the environment and their harmful long-term effects on wildlife. Termiticides are usually applied to the soil to form a chemical barrier that protects the tree against termite attack. These chemicals last for several months to a few years depending on the characteristics of the chemical, the concentration used and the site conditions. Chlorpyrifos, for example, has been shown to give at least 4 years protection to Gmelina arborea grown in Sabah (Chey 1996b). The chemicals may be applied as a granular formulation or in liquid form, diluted in water. Prophylactic treatment can be used for highly susceptible tree species grown in medium- to high-risk sites, but is not cost effective when the termite hazard is low. Prophylactic treatment involves the application of the termiticides into the planting hole, mixed with the soil, at the time seedlings are transplanted from the nursery into the field (Tho and Kirton 1992). Remedial treatment is carried out when trees are attacked by termites, and is usually done by drenching the soil surrounding the tree using a water-soluble insecticide formulation. A furrow or drain is dug around the tree to contain the chemical as it seeps into the ground (Tho and Kirton 1992) but better results can probably be obtained if the soil surrounding the tree trunk is shallowly excavated and the chemical is applied to the trunk and allowed to seep into the ground close to the tree. These hormones or insect growth regulators are used in a baiting technique that allows the chemical to be taken back to the nest by foraging workers, thereby causing the gradual collapse of the colony from the death of the queen and nymphs. The chemical interferes with the normal moulting process of the termites and the production of eggs by the queen. Hexaflumuron and triflumuron are examples of such chitin synthesis inhibitors; however, they are largely used in the public health pest control industry, and the cost of using them in plantation situations may be prohibitive for the time being. Hexaflumuron has been demonstrated to be effective in eliminating field colonies of *C. curvignathus* (Sajap *et al.* 2000). These are used primarily to disinfest cargo on board ships prior to export. Sulfuryl fluoride should be used instead of methyl bromide, which is now banned, as it does not damage the Earth's ozone layer. Fumigants are applied to cargo in enclosed situations or after enclosing them with plastic sheets. The practice of prophylactic soil treatment with insecticides should generally be avoided in favour of pest management practices that reduce the severity of the pest problem. UNEP hosts a website that outlines many alternatives to pesticides for the management of termites, including *C. curvignathus*: http://www.chem.unep.ch/pops/termites/termite_toc.htm.

7.4.1.12.10 References

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7.4.2 B. Disease Causing Pathogen: Fungi

7.4.2.1 B. Twig Canker: Cytosphaera mangiferae (Died 1916)

7.4.2.1.1 Hazard Identification

Scientific Name: *Cytosphaera mangiferae* Died (1916)

Common names: Twig Canker

Taxonomic tree

- Kingdom: Fungi
  - Phylum: Ascomycota
    - Sub-phylum: Pezizomycotina
      - Genus: *Cytosphaera*
        - Species: *Cytosphaera mangiferae*

EPPO Code: CYSHMN (*Cytosphaera mangiferae*)

Bangladesh status: Not present in Bangladesh [CABI, 1993]

7.4.2.1.2 Biology

Colonies on potato dextrose agar pellicular, with crenate margins, whitish grey to buff, conidiomata produced in concentric bands above dark flecks. Mycelium on mango fruit initially immersed in host tissue, later forming a white stromatal collar at the stem end; on leaves forming a brown zonate leaf spot with conidiomata on the upper surface. Conidiomata on mango fruit scattered, initially immersed, but becoming strongly erumpent, eustromatic, tan, discrete or less commonly aggregated, 400–900 µm diam., locules 300–400 µm diam. and walls 50–140 µm thick; walls comprised of an outer layer (45–65 µm wide) of texture intricate, a middle layer (45–95 µm wide) of texture porrecta and an inner layer (28–46 µm wide) of flattened cells. Conidiomata on leaves scattered, eustromatic, immersed, becoming erumpent, discrete, opening by irregular cracking of the host epidermis. Conidiophores 1–2-septate, hyaline, smooth, formed from the cells at the base of the locule. Conidiogenous cells simple, cylindric, aseptate, hyaline, smooth, phialidic. Conidia 16–26 × 10–13 µm, hyaline, oblong to ovate, unicellular, basally truncate, very thick-walled (1·5–2·5 µm thick), cytoplasm granular, sometimes weakly constricted at the centre, sometimes basally papillate (Johnson and Hyde, 1992).

7.4.2.1.3 Hosts

The major host of this pathogen is mango. Other hosts are *Aquilaria agallocha*, *Artocarpus frengenifolia*, *Macadamia integrifolia*, and *Sabal palmetto* (Johnson and Hyde, 1992).

7.4.2.1.4 Distribution

C. mangiferae is not well distributed to the world. It is found in only Asian subcontinent like India, Pakistan and Thailand. This pathogen is also present in Australia, Malaysia and Papua New Guinea (Johnson and Hyde, 1992).

7.4.2.1.5 Hazard Identification Conclusion

Considering the facts that *C. mangiferae* -

- is not known to be present in Bangladesh.
- is potentially economic important to Bangladesh because it is an important fungal disease of neighboring countries like India, and also found in Pakistan and Thailand from which mangoes are imported to Bangladesh.
- *C. mengiferae* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.2.1.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.13.1. – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. This pest has established in several new countries in recent years?-No • Due to lack of information regarding the distribution of the pathogen, we cannot predict about its establishment in new countries in recent years. **b. Possibility of survival during transport, storage and transfer?-Yes** • The mycelium and conidia present into the fruit and twig of mango and causes canker on leaves and fruits (Agrios, 1978). Mycelium can present into the fruit without showing any symptoms. • Therefore, it evidenced that the fungus can survive during transport, storage and transfer of mango from exporting countries to Bangladesh **c. Does the pathway appear good for this pest to enter Bangladesh and establish? Yes** • The plants and parts of plants including fruits infected with *C. mangiferae* is known to good pathways for this pest to enter into Bangladesh and establish it. • It is possible that other perennials are sources of primary inoculum also. (Staub and Peterson, 1986). **c. Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established – Yes** • The preferred host of *C. mangiferae* is mango which is available in Bangladesh (Agrios, 1978). • Weather conditions have a direct effect on the disease. Environmental conditions which favor the mycelium and conidia growth. • The host of *C. mangiferae* is common in Bangladesh and climatic condition of Bangladesh also favorable for this disease as well.	**YES and Moderate**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and	High

• The pathway appears good for this pest to enter Bangladesh and establish, and • Its host is common in Bangladesh and climate is similar to places it is established.	

7.4.2.1.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.13.2 – Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? Yes • This pathogen found in India, Pakistan and Thailand and causes significant damage in mango production. • This is a fairly serious pest of mango for Bangladesh. **b. Economic Impact and Yield Loss** • Mycelium on mango fruit initially immersed in host tissue, later forming a white stromatal collar at the stem end; on leaves forming a brown zonate leaf spot with conidiomata on the upper surface. Conidiomata on mango fruit scattered, initially immersed, but becoming strongly erumpent, eustromatic, tan, discrete or less commonly aggregated. Conidiomata on leaves scattered, eustromatic, immersed, becoming erumpent, discrete, opening by irregular cracking of the host epidermis (Johnson and Hyde, 1992). **c. Environmental Impact** • As the pathogen is new to our country and difficult to control using chemical pesticides. Thus, the introduction of this pathogen would stimulate the use of insecticides in the mango orchard. Therefore, the establishment of this pest could trigger chemical control programs by using different chemical pesticides that are toxic and harmful to the soil and environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.2.1.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.13.3 – 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**

7.4.2.1.9 Possible Management Options

- Only good-quality clean mango should be imported.
- Twig canker can be avoided only in fruit from healthy plants by storing it in a clean, fumigated warehouse (Agrios, 1978).
- Twig canker of mango is controlled mostly by fungicides. However, recommended fungicides are often toxic to pollinators and should not be applied during pollination. (Staub and Peterson, 1986).

7.4.2.1.10 References

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7.4.2.2 B. Soft brown rot: *Hendersonia creberrima* (Syd. & P. Syd. & E.J. Butler)

7.4.2.2.1 Hazard Identification

Scientific Name: *Hendersonia creberrima* Syd. & P. Syd. & E.J. Butler

Common names: Soft brown rot

Taxonomic tree

Kingdom: Fungi
Phylum: Ascomycota
Class: Dothideomycetes
Order: pleosporales
Family: Incertaesedis
Genus: *Hendersonia*
Species: *Hendersonia creberrima*

Bangladesh status: Not present in Bangladesh [CABI, 1993]

7.4.2.2.2 Biology

In culture on PCA, the mycelium is woolly, spreading, reaching a diameter of up to 40 mm in one week, hyaline at first, soon darkening to olivaceous-brown to black. Hyphae branching, hyaline to olivaceous brown, septate, 2-5 µ in diameter. Pycnidial initials appearing after 2-3 week; pycnidia single, separate, occasionally clustered, immersed in agar or superficial, naked or partly covered with a loose weft of greyish or fuscous mycelium, dark brown to black, mostly subglobose, or ovoid, 250-600 µ in diameter, uniloculate, ostiolate with neck short, conical to long-conical almost cylindrical, single or multiple, 90-1000×180-300 µ, exuding white to yellowish tendrils of conidia or masses of glistening, hyaline to fuscous conidia in droplets of clear liquid. Pycnidial wall consisting of an outer layer 20-30 µ thick of dark, yellow-brown, plectenchymatous cells and an inner, pseudoparenchymatous layer, 40-60 µ thick of hyaline, large, thin-walled cells on which the conidiophorous cells, which line the pycnidial cavity, are borne. Conidiophores hyaline, simple aseptate 5-15×2-3 µ, mostly 8-10 µ; conidia hyaline at first, long ellipsoidal to almost fusiform, rounded at the apex, base narrowly truncate, thin-walled, aseptate, and 12.5-21.5×5.0-6.5 µ at this stage, later with one prominent, dark-brown, transverse septum with simultaneous darkening of the conidial wall, finally with two prominent, thick, dark-brown, transverse septa, occasionally 3, the central cell dark-brown, with end cells paler, later concolourous, and size increased to 18.0-22.0×6.5-7.5 µ; paraphyses hyaline, thin-walled, delicate with occasional simple septa, 40-100×1.0-1.5 µ, arising between the conidiophores (Brodrick and Westhuizen, 1976).

7.4.2.2.3 Hosts

The only one host of soft brown rot is mango.

7.4.2.2.4 Distribution

H. creberrima is well distributed to the world. It is found in Africa, Asia, North, Central and South America, Australasia and Europe (Punithalingam & Waterston, 1970 b). The fungus, *Hendersonia creberrima*, causes a ripe fruit rot of mango, with large, irregular, black spots developing all over the fruit's surface and not exclusively at the stem end (Sydow, *et al.*, 1916). It is reported only from India in mango producing areas (Farr *et al.*, 2006; Cline, 2006).

7.4.2.2.5 Hazard Identification Conclusion

Considering the facts that *H. creberrima* -

- is not known to be present in Bangladesh.
- is potentially economic important to Bangladesh because it is an important fungal disease of importing countries from which mangoes are imported to Bangladesh.
- *H. creberrima* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.4.2.2.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.14.1. – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. This pest has established in several new countries in recent years?—Yes • It is reported only from India in mango producing areas (Farr *et al.*, 2006; Cline, 2006). **b. Possibility of survival during transport, storage and transfer?—Yes** • The mycelium and conidia present into the fruit and stem of mango and causes soft brown rot on leaves and fruits. Mycelium can present into the fruit without showing any symptoms (Sutton and Dyko, 1989). • A soft brown rot of mangoes is severe in export fruit in cold storage for prolong periods. At present mangoes can be exported at 11°C for approximately 21 days, which is most favorable condition for this pathogen (Brodrick and Westhuizen, 1976). • Therefore, it evidenced that the fungus can survive during transport, storage and transfer of mango from exporting countries to Bangladesh **c. Does the pathway appear good for this pest to enter Bangladesh and establish? Yes**	**YES and HIGH**

• The plants and parts of plants including fruits infected with *H. creberrima* is known to good pathways for this pest to enter into Bangladesh and establish it. • It is possible that other perennials are sources of primary inoculum also. (Staub and Peterson, 1986). **d. Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established – Yes** • The preferred host of *H. creberrima* is mango which is available in Bangladesh (Agrios, 1978). • Weather conditions have a direct effect on the disease. Environmental conditions which favor the mycelium and conidia growth. • The host of *H. creberrima* is common in Bangladesh and climatic condition of Bangladesh also favorable for this disease as well.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway appears good for this pest to enter Bangladesh and establish, and • Its host is common in Bangladesh and climate is similar to places it is established.	High

7.4.2.2.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.14.2 – Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? Yes • This pathogen found in all over the world specially present in India, which is our neighboring country and causes significant damage in mango production. • This is a fairly serious pest of mango for Bangladesh. **b. Economic Impact and Yield Loss** • Soft brown rot causes more than 80% losses were recorded in two large consignments of mangoes to England at the time of export (Brodrick and Westhuizen, 1976). • Serious spoilage of mangoes in India by this pest (Brodrick and Westhuizen, 1976). **c. Environmental Impact** • As the pathogen is new to our country and difficult to control using chemical pesticides. Thus, the introduction of this pathogen would stimulate the use of insecticides in the mango orchard. Therefore, the establishment of this pest could trigger chemical control programs by using different chemical pesticides that are toxic and harmful to the soil and environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.4.2.2.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.14.3 – 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**

7.4.2.2.9 Possible Management Options

- Only good-quality clean mango should be imported.
- Soft brown rot can be avoided only in fruit from healthy plants by storing it in a clean, fumigated warehouse (Agrios, 1978).
- Soft brown rot controlled mostly by hot water treatment and Gama ray treatment (Brodrick and Westhuizen, 1976).

7.4.2.2.10 References

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7.5 C. 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 International (2007) and EPPO (European and Mediterranean Plant Protection Organization) (1997).

From the quantitatively risk analysts of quarantine pests likely to be associated and follow the mango pathway to Bangladesh from India, Pakistan, Thailand, Myanmar, Australia and other exporting countries, out 16 potential hazard organisms, 8 hazard organisms were identified with high-risk potential, 5 moderate and 1 low were identified with low-risk potential. Besides, 2 hazard organisms were identified as uncertainly due to lack of information.

The overall pest risk potential ratings of 16 quarantine pests of coconut for Bangladesh have been included in the following Table 7.3:

Table 7.3: The Overall Pest Risk Potential Rating

Sl. No	Potential Hazard Organism	Scientific name	Family	Order	Pest Risk Potential
Insect pests					
1	Queensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	High
2	Mexican fruit fly	*Anastrepha ludens*	Tephritidae	Diptera	High
3	A member of Oriental fruit fly	*Bactrocera caryeae*	*Tephritidae*	Diptera	High
4	Marula fruit fly	*Ceratitis cosyra*	Tephritidae	Diptera	Low
5	Stellate scale	*Ceroplastes stellifer*	Coccidae	Hemiptera	Moderate
6	Morgan's scale	*Chrysomphalus dictyospermi*	Diaspididae	Hemiptera	High
7	Tapioca scale insect	*Aonidomytilus albus*	Diaspididae	Hemiptera	High
8	Spiked mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	Moderate
9	Grey pineapple mealybug	*Dysmicoccus neobrevipes*	Pseudococcidae	Hemiptera	High
10	Peach scale	*Parthenolecanium persicae*	Coccidae	Hemiptera	Moderate
11	Shoot borer of mango	*Penicillaria jocosatrix*	Noctuidae	Lepidoptera	Moderate
12	Rubber termite	*Coptotermes curvignathus*	Rhinotermitidae	Isoptera	Moderate
Fungi					
13	Leaf and stem blight	*Macrophoma mangiferae* Hing. & Sharma	Botryosphaeria ceae	Botryosphae riales	-
14	Twig canker	*Cytosphaera mangiferae Died. 1916*	Incertae sedis	Incertae sedis	High
15	Soft brown rot	*Hendersonia creberrima*	Incertaesedis	pleosporales	High
16	Mango black spot	*Actinodochium jenkinsii Uppal, Patel & Kamat*	Incertae sedis	Incertae sedis	-

7.6 Uncertainty

The quarantine pest species those remain uncertainty as potential hazards due to lack of their detail information. Such uncertain species were Leaf and stem blight (*Macrophoma mangiferae*) and Mango black spot (*Actinodochium jenkinsii*). The taxonomic identity of this uncertain species is given in the table 7.4.

Table 7.4: Quarantine pest 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.	Leaf and stem blight	*Macrophoma mangiferae* Hing. & Sharma	Botryosphaeriaceae	Botryosphaeriales
02.	Mango black spot	*Actinodochium jenkinsii Uppal, Patel & Kamat*	Incertae sedis	Incertae sedis

7.7 Risk Analysis of Regulated Non-quarantine pest

The risk assessment of regulated non-quarantine pests plays a critical role in safeguarding agricultural industries and ecosystems against potential threats. In the context of mango cultivation, the focus of this assessment lies on three significant pests: the Mango Pulp Weevil, Mango Seed Weevil, and Mango Anthracnose. These pests, while not native to the region, have the potential to cause substantial harm to mango production and overall plant health if not managed effectively.

The risk assessment follows the guidelines outlined in ISPM 21 (International Standards for Phytosanitary Measures), which provides a structured approach to evaluate the risks posed by regulated non-quarantine pests. By adhering to this international standard, we aim to ensure a comprehensive and scientifically sound assessment of the potential impacts of these pests on mango crops and the wider agricultural ecosystem.

The objective of this risk assessment is to identify the pathways of introduction, potential establishment, and spread of these pests in the affected area. By evaluating their biology, ecology, and behavior, as well as considering environmental and climatic factors, we aim to gain a comprehensive understanding of their potential threat levels. Additionally, this assessment will explore effective management strategies and mitigation measures to prevent or reduce the risks posed by these regulated non-quarantine pests. The risk assessment of regulated non-quarantine pests concerning Bangladesh is presented below.

7.7.1 Mango seed weevil, *Sternochetus mangiferae* (Fabricius, 1775)

7.7.1.1 Hazard identification

Preferred Common names: Mango seed weevil
Scientific name: *Sternochetus mangiferae* (Fabricius, 1775)

Synonyms: *Acryptorhynchus mangiferae (Fabricius)*
Cryptorhynchus mangiferae (Fabricius)
Curculio mangiferae
Sternochetus ineffectus (Walker)

Taxonomic tree

- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Coleoptera
            - Family: Curculionidae
              - Genus: Sternochetus
                - Species: *Sternochetus mangiferae*

EPPO Code: CRYPMA.

Bangladesh status: Present in Bangladesh [Alam,1962]

7.7.1.2 Biology

Shukla and Tandon (1985) found that females began oviposition 3-4 days after mating. This occurred about mid-March and reached a peak during the first week of April in India. However, the oviposition occurred from mid-August to early October in Australia (Peng and Christian, 2004). The oviposition period varies from 3 weeks (Subramanyam, 1926), 4 weeks (Hansen et al., 1989), about 5 weeks (Shukla and Tandon, 1985) to 6 weeks (Peng and Christian, 2004). Incubation requires 5-7 days, depending on the season and temperature (Balock and Kozuma, 1964). After hatching, the larva burrows through the flesh of the fruit and into the seed. In Hawaii, the larval period ranged from 22 days to 10 weeks (Balock and Kozuma, 1964; Hansen *et al.*, 1989). In the Northern Territory of Australia, larvae developed in mango orchards from late August to early October, taking about 40 days to develop (Peng and Christian, 2004). Often only one adult will mature in each seed, but as many as six have been recorded (Balock and Kozuma, 1964; Follett, 2002). They cut their way out of the naked seed, usually via a small circular hole made in the concave edge of the endocarp, generally 4-8 weeks after the fruit falls and decays. In the Northern Territory, adults were found to be in seeds for 15-40 days from October to mid-November (Peng and Christian, 2004).

7.7.1.3 Hosts

Complete development of *S. mangiferae* is only achieved on mangoes. Oviposition was obtained in the laboratory on potatoes, peaches, Litchi chinensis, plums, Phaseolus vulgaris and several cultivars of apples, but none of the resulting larvae reached maturity (Woodruff, 1970).

7.7.1.4 Distribution

This beetle is found in almost all major mango producing areas of the world: Australasia (but not Western Australia) (personal communication, Szito 2006) and Oceania, Asia, Africa, North America (Hawaii), Caribbean (Barbados, Dominica, French Guiana, Guadeloupe, Martinique, St. Lucia, Trinidad and Tobago, British Virgin Islands, Grenada, Montserrat, St. Vincent and the Grenadines), and South America.

The complete distribution of this pest in the Caribbean is not currently known. USDA-PPQ officers at various ports of entry have commonly intercepted it in mangoes brought by air passengers from Caribbean countries.

Africa: Ghana; Kenya; Nigeria; South Africa; Tanzania (EPPO, 2022)

Asia: Bangladesh (Alam, 1962); China; India; Indonesia; Malaysia; Myanmar; Nepal; Pakistan; Sri Lanka; Thailand; United Arab Emirates; Vietnam (EPPO, 2022)

Europe: Sweden (Seebens *et al.* 2017)

North America: United States (Follett and Gabbard, 2000)

South America: Brazil, Chile (CABI and EPPO, 2015)

Oceania: Australia (New South Wales, Northern Territory, Queensland, Victoria), Fiji, French Polynesia, New Caledonia, Pitcairn (EPPO, 2022)

7.7.1.5 Hazard identification conclusion

Considering the facts that *S. mangiferae* -

- is present in Bangladesh [Alam, 1962]
- The fruit and seeds of mangoes containing larvae, pupae or adults present the main risk of introducing *S. mangiferae,* although mango plants with diapausing adults could also be a danger, and such material from countries where the pest occurs may be prohibited by mango-growing countries or states. It represents a risk to mango-growing regions of North, Central and South America and the Caribbean, Africa, Asia and parts of Australia where it has not been reported or is not widespread.
- *S. mangiferae* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.7.1.6 Determine likelihood of pest establishing in importing countries via this pathway

Table 7.5.1.1 – Which of these descriptions best fit of this pest?

Description	Establishment Potential
i. Has this pest been established in several new countries in recent years? - Yes • *S. mangiferae* is a monophagous pest on mangoes. It is one of the most important mango pests and widespread in most mango-growing countries. It represents a risk to mango-growing regions of North, Central and South America and the Caribbean, Africa, Asia and parts of Australia where it has not been reported or is not widespread. **j. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Incubation requires 5-7 days, depending on the season and temperature (Balock and Kozuma, 1964). After hatching, the larva burrows through the flesh of the fruit and into the seed. In Hawaii, the larval period ranged from 22 days to 10 weeks (Balock and Kozuma, 1964; Hansen *et al.,* 1989). • This period of time taken for shipment through transportation pathways from Bangladesh to importing countries is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. **c. Does the pathway appear good for this pest to enter importing countries and establish? - Yes,** • Long-range dispersal occurs largely through the transport of fruit and seeds containing larvae, pupae or adults. *S. mangiferae* has been intercepted in mango fruits and seeds in international trade (USDA, 1988; SPC, 1989). Mango plants may harbour diapausing adults. **d. Are the host(s) of this fairly common in the importing countries and the climate is similar to places it is established? – Yes**	**Yes and High**

• *S. mangiferae* is the most serious insect pest of mango (*Mangifera indica*) and another alternative host of this pest is not recorded (Silva and Ricalde 2017). • *S. mangiferae* preferred tropical and subtropical climate most for its growth and survival. But it can tolerate temperate climate also. So all climatic conditions were suitable to establish the pest.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.7.1.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.5.1.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of importing countries? - Yes. • It is an important pest of **mango** (*Mangifera indica*). Therefore, it is a high risk, if fruits and plant materials are imported from Bangladesh, there will be possibility to establish the pest in the importing countries. • If the pest establishes in the importing countries, it will be a fairly serious pest of mango in that country/ies. **b. Economic Impact and Yield Loss** • Mango seed weevil infestation can also increase fruit drop during early fruit development (Verghese *et al.* 2005), and may reduce the germination capacity of seeds. • In Hawaii, germination rates for infested seeds were equal to those of uninfested control seeds in a polyembryonic cultivar (Common), whereas germination was reduced for infested seeds of a monoembryonic cultivar (Haden) compared with uninfested control seeds, but germination of infested seeds was still >70% (Follett and Gabbard, 2000). • In South Africa, emerging adults cause post-harvest damage to the fruit flesh of late-maturing cultivars (Kok, 1979). The adults tunnel through the fruit, leaving scars on the outside which serve as sites for secondary fungal infection. **c. Environmental Impact** • Wide range of insecticides were used against *S. mangiferae*. So, indiscriminate uses of these insecticide plays negative impact on the environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.7.1.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.5.1.3 – Calculating 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

7.7.1.9 Risk Management Measures

Consignments of fruits to importing countries or regions should be inspected for symptoms of infestation and those suspected should be cut open in order to look for maggot. Good orchard sanitation is an effective way to reduce adult populations, and this involves the destruction of all the fallen fruit, stones and fruits with seed weevil damage during and immediately after mango harvest (Peng and Christian, 2004). The ant *Oecophylla smaragdina* is an effective biocontrol agent of *S. mangiferae* adults (Peng and Christian, 2004, 2007). Chemical control has been used with some success and a wide range of insecticides have been recommended (Villiers, 1987).

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7.7.2 Mango pulp weevil, *Sternochetus frigidus* (Fabricius)

7.7.2.1 Hazard identification

Preferred Common names: Mango pulp weevil
Scientific name: *Sternochetus frigidus* (Fabricius)

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Order: Coleoptera
Family: Curculionidae

Genus: *Sternochetus*
Species: *Sternochetus frigidus*

EPPO Code: CRYPGR.

Bangladesh status: Present in Bangladesh [Basio *et al.* 1994]

7.7.2.2 Biology

The mango pulp weevil undergoes five larval instars observed in 20.3 days (De Jesus et al., 2004). Older larvae create feeding canals or tunnels as they move from one area to another in order to feed. Before pupation, the mature larvae specifically the 5th larval instar prepares a pupal cell and confines itself to this pupal cell until it becomes an adult. Development from larva to prepupa to pupa to adult takes place inside the fruit. The pupa is exarate and active. Total development of *S. frigidus* from egg to adult stage is 32 d. The adult remains inside the fruit for another 37 d. It was found out that 70% of the adults exit the fruit by boring a hole directly underneath the pupal chamber.

The adult of MPW is a small hard-bodied insect (Altoveros *et al.*, 2004). It is black with brown patches in the elytra and legs. Its female adult lays single eggs on a mango fruit when it is about the size of a chicken egg. Eggs are opaque and turn light yellow with the developing cranium becoming noticeable. The female later covers the eggs with black sticky exudate, which later turns into brown, dry and hardened egg plug. This egg plug serves as protection by holding the eggs in place. Eggs are 0.4 mm long and 0.5 mm wide and hatch in 9.3 d. Eventually the neonate larvae enter the young mango fruits by boring through the soft skin, preferring the area closer to the seed causing the darkening of the affected tissues.

7.7.2.3 Hosts

Complete development of *S. frigidus* is only achieved on mangoes. Oviposition was obtained in the laboratory on potatoes, peaches, Litchi chinensis, plums, Phaseolus vulgaris and several cultivars of apples, but none of the resulting larvae reached maturity (Woodruff, 1970).

7.7.2.4 Distribution

This beetle is found in almost all major mango producing areas of the world: Asia (Bangladesh, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Singapore and Thailand) and Oceania (Papua New Guinea).

The complete distribution of this pest in the Caribbean is not currently known. USDA-PPQ officers at various ports of entry have commonly intercepted it in mangoes brought by air passengers from Caribbean countries.

Asia: Bangladesh; India; Indonesia; Malaysia; Myanmar; Pakistan; Philippines; Thailand (EPPO, 2022)

Oceania: Papua New Guinea (EPPO, 2022)

7.7.2.5 Hazard identification conclusion

Considering the facts that *S. frigidus* -

- is present in Bangladesh [EPPO, 2022]
- The fruit of mangoes containing maggots or adults present the main risk of introducing *S. frigidus,* although mango plants with diapausing adults could also be a danger, and such

material from countries where the pest occurs may be prohibited by mango-growing countries or states. It represents a risk to mango-growing regions of North, Central and South America and the Caribbean, Africa, Asia and parts of Australia where it has not been reported or is not widespread.

- *S. frigidus* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.7.2.6 Determine likelihood of pest establishing in importing countries via this pathway

Table 7.5.2.1 – 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? - No **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • The period of time taken for shipment through transportation pathways from Bangladesh to importing countries is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. **c. Does the pathway appear good for this pest to enter importing countries and establish? - Yes,** • Long-range dispersal occurs largely through the transport of fruit containing maggots or adults. *S. frigidus* has been intercepted in mango fruits and seeds in international trade (USDA, 1988; SPC, 1989). Mango plants may harbour diapausing adults. **d. Are the host(s) of this fairly common in the importing countries and the climate is similar to places it is established? – Yes** • *S. frigidus* is the most serious insect pest of mango (*Mangifera indica*) and another alternative host of this pest is not recorded (Silva and Ricalde 2017). • *S. frigidus* preferred tropical and subtropical climate most for its growth and survival. But it can tolerate temperate climate also. So all climatic conditions were suitable to establish the pest.	**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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.7.2.7 Determine the Consequence establishment of this pest in Bangladesh

Table 7.5.2.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of importing countries? - Yes. • It is an important pest of **mango** (*Mangifera indica*). Therefore, it is a high risk, if fruits and plant materials are imported from Bangladesh, there will be possibility to establish the pest in the importing countries. • If the pest establishes in the importing countries, it will be a fairly serious pest of mango in that country/ies. **b. Economic Impact and Yield Loss** • The damage caused by MPW is not apparent in infested fruits (Velasco and Medina, 2001). By the time, the fruits are harvested the tiny wound created by the young larvae as their point of entry in the skin of mango fruits is not anymore recognizable and had completely gone. • In the absence of mango fruits, MPW adults have been found feeding on mango flowers or panicles during full bloom stage with peak activity observed at 0600-1000h (De Jesus, et al., 2004). During the fruiting season, the adults also feed on the developing fruits by making very small punctures on the peel. However, the larvae are the most destructive because they feed and develop on the pulp. The weevils feed exclusively on mango regardless of the variety (De Jesus and Gabo, 2004). **c. Environmental Impact** • Wide range of insecticides were used against *S. mangiferae.* So, indiscriminate uses of these insecticide play negative impact on the environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.7.2.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.5.2.3 – Calculating 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

7.7.2.9 Risk Management Measures

Consignments of fruits to importing countries or regions should be inspected for symptoms of infestation and those suspected should be cut open in order to look for maggot. One way of preventing the insects from touching the mango fruit is to bag it or cover the whole fruit. The fruits can be bagged when the fruits are the size of a chicken egg or about 55 to 60 d before spraying. Doing so effectively protects the fruits from pest and diseases. Durable papers such as imported newsprints are the recommended bagging materials, newspapers or the yellow pages of phone directories can also be used. Fruit bagging can reduce the use of pesticide by 23% and it reduces fruit rejects from 60% to 15% of the total harvest. It was found out that the cost of chemical control with bagging was P 818.00 a tree, while non-adopters spent P 1,050 a tree (http://www.globalpinoy.com). Pruning is also advisable as it removes unproductive and overlapping branches as well as those damaged by insects and diseases, resulting in good light penetration and air circulation (http://www.globalpinoy.com). Sanitation is another way of control. Infected mango fruits that dropped on the ground should be properly disposed by burying them half meter below the ground to prevent the insect from completing its life cycle (http://www.min.pcarrd.dost.gov.ph.).

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7.7.3 Mango anthracnose, Colletotrichum gloeosporioides

7.7.3.1 Hazard identification

Preferred Common names: Mango anthracnose
Scientific name: *Colletotrichum gloeosporioides*

Taxonomic tree

Kingdom: Fungi
Phylum: Ascomycota

Subphylum: Pezizomycetes
Class: Sordariomycetes
Order: Glomerellales
Family: Glomerellaceae
Genus: *Colletotrichum*
Species: *Colletotrichum gloeosporides*

EPPO Code: COLLGL.

Bangladesh status: Present in Bangladesh [DAE (2015)]

7.7.3.2 Biology

Colletotrichum gloeosporioides Penz. a facultative parasite belongs to the order *Melanconiales.* The fungus produces hyaline, one- celled, ovoid to oblong, slightly curved or dumbbell shaped conidia, 10-15 µm in length and 5-7 µm in width. Masses of conidia appear pink or salmon colored. The waxy acervuli, that are produced in infected tissue, are subepidermal, typically with setae, and simple, short, erect conidiophores.

Isolations from the two different lesion types result in isolates of *C. gloeosporioides* indistinguishable culturally from one another. Each isolate is capable of producing the two different lesion types. The factors involved in influencing a single isolate to produce these different lesion types are not known.

The petioles of papayas support abundant development of *C. gloeosporioides* and its perfect stage, *Glomerella cingulata.* However, the petiole isolates, when used to inoculate fruits, do not cause typical anthracnose, chocolate spot, nor the gray-depressed lesions. Also, they do not produce the masses of pinkish-orange conidia on V-8 juice agar that are characteristic of the fruit isolates.

The pathogen initially infects intact, non-wounded immature green fruit in the field. Spores germinate and form appressoria on the fruit surface. The fungus, using its appressorium, enzymatically penetrates the cuticle and then remains as sub-cuticular hyphae until the post climacteric stage of fruit growth is attained. At this point, for reasons that are not understood, the fungus resumes growth and causes the characteristic symptoms. Thus, papaya anthracnose has a latent stage in its development that is similar to many other anthracnose diseases of tropical fruits.

Environmental conditions favoring the pathogen are high temperatures, 28℃ being optimal, and high humidity. Spores must have free water to germinate; germination is negligible below 97% relative humidity. Spores are only released from acervuli when there is an abundance of moisture. Splashing from rain is a common means of spread. Severity of disease is related to weather and the fungus is relatively inactive in dry weather. Sunlight, low humidity and temperature extremes (below 18℃ or greater than 25℃) rapidly inactivate spores (Dickman 1993).

7.7.3.3 Hosts

Colletotrichum spp. are broad-range pathogens; many species can infect a single host, and single species can infect diverse hosts (Freeman *et al.*, 1998). Examples of single hosts affected by numerous *Colletotrichum* species include strawberry infected by three *Colletotrichum* species, namely *C. acutatum*, *C. fragariae*, and *C. gloeosporioides*; avocado and mango infected by both *C. acutatum* and *C. gloeosporioides*; almond and other deciduous fruits infected by *C. acutatum* or *C. gloeosporioides*; citrus is affected by four different *Colletotrichum* diseases, namely, postbloom fruit drop and key lime anthracnose incited by *C. acutatum* and shoot dieback and leafspot incited by *C. gloeosporioides* (Freeman *et al.*, 1998). Additional hosts affected by multiple *Colletotrichum* species include coffee, cucurbits, pepper, tomato, and others (Bailey and Jeger, 1992).

In contrast, single species of *Colletotrichum* commonly infect multiple hosts. Examples include *C. acutatum*, which infects many fruit and ornamental crops including apple, avocado, almond, anemone, blueberry, citrus, grape, lupin, peach, strawberry, and tamarillo; and *C. gloeosporioides*, which is found on a wide range of fruit crops including almond, avocado, apple, and strawberry (Afanador-Kafuri et al., 2003; Freeman et al., 1998). Examples of other species with multiple host ranges include *Colletotrichum coccodes*, *Colletotrichum capsici*, and *Colletotrichum dematium* (Bailey and Jeger, 1992).

7.7.3.4 Distribution

Colletotrichum *gloeosporioides distributed in Bangladesh, Australia, China, Italy, Japan, Netherlands, India, United States and Thailand (Talhinhas and Baroncelli, 2021).*

7.7.3.5 Hazard identification conclusion

Considering the facts that *C. gloeosporioides*-

- is present in Bangladesh [DAE, 2015]
- Various species, often in the *C. gloeosporioides* complex, infect leaves, crowns, stems, twigs, and petioles as well. Symptoms do not always appear when plants are colonized by *Colletotrichum* spp. For example, *C. acutatum* has been detected germinating and sporulating on symptomless strawberry and blueberry leaves (Yoshida et al. 2007). Quiescent infections on immature fruit are also common. It is a common disease of mango growing regions like Thailand, India, Australia, China etc.
- *C. gloeosporioides* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.7.3.6 Determine likelihood of pest establishing in importing countries via this pathway

Table 7.5.3.1 – 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? - No **b. Possibility of survival of this pest during transport, storage and transfer? – Yes**	

• Although *C. gloeosporioides* has been shown to survive in the soil, on plant debris, and in fumigated field soil, the main source of inoculum is assumed to originate on infected strawberry plant material from the nursery (Eastburn and Gubler, 1990). However, the pathogen may be introduced in contaminated soil, on field equipment, or may be splash-dispersed or blown in from surrounding vegetation that may carry the fungus without visible symptoms (Strand, 1994). **c. Does the pathway appear good for this pest to enter importing countries and establish? - Yes,** • *Colletotrichum gloeosporioides*, which infects many crops including strawberry, has the potential to affect other plant species and survive asymptomatically on alternative hosts. **d. Are the host(s) of this fairly common in the importing countries and the climate is similar to places it is established? – Yes** • *C. gloeosporioides* is the most serious insect pest of mango (*Mangifera indica*) and another alternative host of this pest is not recorded (Silva and Ricalde 2017). • *C. gloeosporioides* preferred tropical and subtropical climate most for its growth and survival. But it can tolerate temperate climate also. So all climatic conditions were suitable to establish the pest *(Talhinhas and Baroncelli, 2021)*.	**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 host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.7.3.7 Determine the Consequence establishment of this pest in Bangladesh-

Table 7.5.3.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of importing countries? - Yes. • It is an important pest of **mango** (*Mangifera indica*), citrus, strawberry, avocado etc. Therefore, it is a high risk, if fruits and plant materials are imported from Bangladesh, there will be possibility to establish the pest in the importing countries. • If the pest establishes in the importing countries, it will be a fairly serious pest of mango in that country/ies. **b. Economic Impact and Yield Loss** • On apple, 75% of an orchard may be defoliated before harvest due to infections by fungi in the *C. gloeosporioides* complex (González et al. 2006).	**Yes and High**

c. Environmental Impact • Wide range of insecticides were used against *C. gloeosporioides.* So, indiscriminate uses of these insecticides play negative impact on the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.7.3.8 Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.5.3.3 – Calculating 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

7.7.3.9 Risk Management Measures

Consignments of fruits to importing countries or regions should be inspected for symptoms of infestation and those suspected should be cut open in order to look for maggot. Good orchard sanitation is an effective way to reduce this disease. Hot water dips at 48°C for 20 min is an effective treatment for reducing anthracnose incidence. Although hot water dips do not completely eliminate anthracnose the reduction in disease is economically significant. Orchard sprays applied at 14-28 day intervals, depending on rainfall, with an appropriate protective fungicide is commonly recommended. Although no known cultivars of papaya offer complete resistance to anthracnose the Hawaiian cultivar Sunrise Solo is more resistant than Kapoho Solo. Postharvest fungicides, applied as a spray or dip, with a food-grade wax have also shown to be effective in reducing anthracnose. This is a common practice especially for fruits shipped to overseas markets (Dickman, 1993).

7.7.3.10 References

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8 CHAPTER 8
RISK MANAGEMENT

8.1 Risk Management Options and Phytosanitary Procedures

Pest risk management evaluates and selects options for measurement to reduce the risk of entry, establishment or spread of quarantine pests of the commodity—here, it is mango, to pose an unacceptable level of risk to Bangladesh via the importation of commercially produced mango from India, Thailand, Pakistan, Australia, the Philippines or any other countries of mango export (i.e., produced under standard cultivation, harvesting and packing activities). Plant Quarantine Wing (PQW) of Department of Agricultural Extension (DAE) of Bangladesh will consider the risk management measures proposed below is commensurate with the identified risks:

The following assessment of pre- and post-harvest practices reflects the current systems approach for risk management employed for commercially produced mangoes. It is proposed that these practices combined with specific post-harvest treatment such as vapor heat treatment (VHT) or irradiation, and other requirements, e.g., phytosanitary inspection need to be used to manage the risks to importing countries posed by regulated organisms associated with the importation of mangoes from exporting countries.

8.1.1 Pre-harvest Management Options

The in-field, pest management practices for the production of mangoes are in brief:

- Annual flooding of orchards to kill fruit fly pupae;
- Pre-flowering pesticide treatments for arthropods, fungi and other pathogenic micro-organisms above threshold levels;
- Post-flowering and fruit pesticide treatments above threshold levels for specific pests such as mango hopper, mealy bug, stem borer, fruit and nut weevil, eriophyid mite and anthracnose, leaf red rust, powdery mildew, dieback, Diplodia rot, fruit-end-rot, etc.;
- Specific pheromone trap and fruit bagging to reduce fruit fly infestation as well as Diplodia rot and anthracnose disease infection;
- Specific fruit fly trapping program to forecast pest prevalence;
- Orchard hygiene which involves removal of fallen fruit under a Good Agricultural Practice (GAP) scheme administered by Department of Agriculture Extension (DAE);
- Designated pest free places of production or production sites selection for the management of *Sternochetus frigidus* (mango pulp weevil) and *S. mangiferae* (mango seed weevil).
- Pre-harvest inspection with the involvement of relevant officers and inspectors from the importing country and need to verify the cleaning and disinfecting of equipment and storage used in mango production. Laboratory testing the equipment and produces periodically. Quarantine restrictions may be used to limit spread of diseases detected.

8.1.2 Post-Harvest Procedures

Mangoes are routinely graded and washed. The procedure is as follows:

1. De-sapping (quality step) of mangoes just after harvest;
2. Washing of harvested mangoes with clean water and drying (likely to remove external arthropods);
3. Sorting and grading to remove damaged, overripe, infested, or infected fruit from the harvested mango lot. The grading process is likely to remove fruit showing obvious signs of fungal and bacterial disease;
4. Fruits are packed for disinfestation by vapour heat treatment (into perforated trays) or for irradiation in export cartons.

8.1.3 Visual Inspection

Visual inspection of fruit occurs at several points during the routine production and post-harvest pathway for mangoes. These include:

- In-field monitoring during the growing season
- Harvesting
- Post-washing, sorting and grading
- Packaging of fruit for treatment
- Packaging of fruit for export (if above differs from packaging for treatment)
- Visual phytosanitary inspection

A visual inspection at multiple points of the pathway provides opportunities to remove infested and/or infected fruit and is considered an appropriate risk management option for regulated organisms such as mealybugs and scale insects as they are easily detected on the surface of mango fruit (DAFF, 2004)[33].

8.1.4 Treatment for arthropods

The current pre- and post-harvest procedures are aimed at reducing regulated organism load rather than removing all risk arthropods associated with mangoes from exporting countries. Therefore, a treatment like vapour heat treatment (VHT) or hot water treatment (HWT) or irradiation is necessary to mitigate residual risk, especially from internally feeding arthropods such as fruit fly. The VHT at fruit pulp temperature ≥ 46.5ºC, held for ≥ 30 minutes and irradiation at 400 Gy absorbed energy against arthropod groups has been found effective for mangoes in India. Vietnam exports vapor heat treated dragon fruit to Japan (Vietnam Net/VNA, 2009) and irradiated dragon fruit to the USA and therefore has the process and quality systems established for these treatment types. Before packaging and exporting, the dragon fruit fruits must undergo vapour heat treatment (VHT) for 40 minutes at 46.5 degrees celsius at a minimum of 90% humidity at a processing facility approved by Vietnam's Plant Protection Department

[33] DAFF. 2004. Australian Food Statistics, 2004. Australian Agriculture, Fisheries and Forestry. Australian Government, Canberra ACT 2601.

(VPPD, 2021)[34]. Irradiation is used to control regulatory insects in exported fresh commodities. Insects vary in their tolerance to ionizing radiation. Treatment with 150 Gy prevents adult fruit fly emergence from pupae (99.99% efficacy) from the fruit fly infested mango (FAO, 2009). Generic radiation treatments of 150 Gy for fruit flies and 400 Gy for other insects are approved for all fresh horticultural commodities in the United States (Follett and Griffin, 2007)[35]. Therefore, expert has indicated a treatment preference for vapor heat treatment (VHT) or irradiation.

- Pre-export vapour heat treatment (VHT) (fruit pulp temperature ≥ 46.5ºC, at a minimum of 90% humidity, held for ≥ 30 minutes) or hot water treatment (HWT) must be applied to mitigate the risk of internally feeding arthropods especially for the management of fruit fly species.

8.1.5 Phytosanitary Inspection and Certification

Importing country requires a phytosanitary certificate issued by respective authority of exporting country to accompany mangoes exported from exporting country to importing country. Before a phytosanitary certificate is issued, the respective authority of exporting country must conduct phytosanitary inspection to ensure that the number of packaged fruits is consistent with the number of disinfested fruits, traceability labelling is complete (including an official seal on the sides of packages), packaging is insect-proof and that all other importing country requirements have been met.

Where phytosanitary inspection occurs post-treatment (i.e., vapor heat treatment) the disinfestation facility is suspended from export, if live arthropods are detected on inspection, pending the results of an investigation.

8.1.6 Post-inspection Product Security

The importing country requires methods to be implemented to ensure post-inspection product security include segregation of product, insect-proof packaging, insect screening of storage facilities, at least yearly pre-season insecticide treatment of storage facility, and secure loading and transport of fruit.

8.1.7 Verification inspection on arrival in importing country

- The respective authority of importing country may inspect a sample taken from each lot on arrival in importing country to verify risk management actions undertaken were effective. The sampling procedure must be in accordance with design followed by the PQW-DAE of Bangladesh.
- If a treatment has failed, or regulated organisms, extraneous plant material or trash are intercepted, one or more of the following actions must be undertaken:
    - re-sorting of the consignment, treatment where an efficacious treatment is available,

[34] VPPD. 2021. Global GAP: Dragon Fruit. Vietnam's Plant Protection Department, Vietnam. Retrieved on 19 June, 2023. https://dragonfruit.net.vn/dragon-fruit/197-fresh-dragon-fruits-treated-by-vapour-heat-treatment.html

[35] Follett, P. and Griffin, R.L. 2007. In book: Food Irradiation Research and Technology. United States Department of Agriculture. USA. pp 143-168.

- re-shipment or destruction of the consignment and/or the temporary suspension of the pathway on the detection of regulated organisms for which pre-export phytosanitary measures are required.
- The suspension must continue until the cause of the non-compliance has been identified and corrective actions have been implemented and approved by respective authority of importing country.

8.1.8 Biosecurity clearance

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

8.1.9 Audit and review of Policy

(a) Auditing: The Quarantine Department of the importing country must monitor interceptions of hitch-hikers and the appropriateness/effectiveness of phytosanitary measures on the commencement of trade.

(b) Review of Policy: The importing country reserves the right to review the adopted policy at any time after significant trade has occurred or where there is reason to believe that the phytosanitary status of the exporting country has changed.

8.1.10 Feedback on non-compliance

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

8.2 Risk Management Conclusions

All the pests 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.

8.3 Recommendation

- Visual inspection at ports-of-entry for high-risk potential pests is insufficient to safeguard the mango industry in Bangladesh and thus the specific phytosanitary measures are strongly recommended.
- While for moderate risk potential pests, specific phytosanitary measures may be necessary to reduce pest risk.
- PRA for potential crops should be continued and updated with regular interval to maintain and develop the market access of Bangladesh by fulfilling the requirement of importing countries in the world.

Appendixes

Appendix 1: Questionnaire for Interview of mango producer

Appendix-1: Face-to-face survey questionnaires for mango farmers

Government of the People's Republic of Bangladesh

Department of Agricultural Extension

Exportable Mango Production Project,

Khamarbari, Farmgate, Dhaka, Phone: 9103774

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh

Prepared by:

DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD. (DTCL)

Niketan, Gulshan-1, Dhaka-1212

E-mail: info@dtcltd.com, Website: www.dtcltd.com

Set-1: Face-to-face survey questionnaires for mango farmers

Code					Mobile No.											

A.0 Personal information of the mango farmer

A.1 Name of the respondent: ---

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

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

A.6 Educational Qualification: ------- A.7 Age: ----------------------------------

A.8 Occupation: [Code: 1= Big farmer, 2= Medium farmer, 3= Small farmer, 4= Marginal farmer] A.9 Sex: [Code: 1=Male, 2=Female]

B.0 Mango production and PRA related information

B.1 Type/Nature of the land used for mango production

Type of land used for mango production	Land size (decimal)
1. Please mention the amount of land used for mango production in this year?	
2. State the approximate percentage (%) of land devoted to mango production this year as compared to other crops	
3. How many years have you been involving in mango production?	

B.2 What varieties of mango do you grow, Please mention the

Name of the cultivated mango variety [N.B. Please use the code from the variety list]	Land size (decimal)	Production (t/ha)
1.		
2.		
3.		
4.		
5.		
6.		

7.		

[Code: 1= BARI Aam-1 (Mahananda), 2= BARI Aam-2 (Neelum), 3= BARI Aam-3 (Amropali), 4= BARI Aam-4 (Hybird Aam), 5= Fazli, 6= Lengra, 7= Khrisapat, 8= Gopalbhog, 9= Lakkhanbhog, 10= Himsagor, 11= Mohanbhog, 12= Ashawina, 13= Kalapahari, 14= Chausa Aam, 15= Bombai, 16= Haribhanga, 17= Guti Aam, 18= Others (if any)--------]

B.3 What is the susceptibility of different mango varieties to pests, diseases and weeds?			
Sl. No.	Name of the mango varieties	Susceptibility (Code: 1= Harmful insect, 2= Disease, 3= Weed, 4= Parasitic weed, 5= Insect and disease, 6= Weed and disease, 7= None of these). Please mention the code in the gap	
1.	BARI Aam-1 (Mahananda)		
2.	BARI Aam-2 (Neelum)		
3.	BARI Aam-3 (Amropali)		
4.	BARI Aam-4 (Hybird Aam)		
5.	Fazli		
6.	Lengra		
7.	Khrisapat		
8.	Gopalbhog		
9.	Lakkhanbhog		
10.	Himsagor		
11.	Mohanbhog		
12.	Ashawina		
13.	Kalapahari		
14.	Chausa Aam		
15.	Bombai		
16.	Haribhanga		
17.	Guti Aam		
18.	Others (if any)...........		

B.4 For mango production generally: from which source do you collect/purchase mango seedlings?

[Code: 1=own grafted seedlings, 2=from neighboring farmers, 3=from BADC nursery, 4=from any local nursery, 5=imported seedlings from neighboring countries, 6=various research institutes, 7=NGO, 8=Other (if any)----------]

B.5 What is the presence and type/status of infestation of mango pests in the field? (Please mention the number in the blank space)

Sl. No.	Name of the harmful insects	Infestation status of the insect: [Code: Major (More damaging) insect=1, Minor (Not economically harmful) insect=2, No infestation of this pest=3]

1.	Mango hopper		
2.	Mango fruit fly		
3.	Mango fruit weevil		
4.	Mango stem borer		
5.	Mango defoliator		
6.	Mango fruit borer		
7.	Mango leaf cutting weevil		
8.	Mango shoot gall		
9.	Mango leaf gall		
10.	Mango mealy bug		
11.	Mango leaf webber		
12.	Mango flower webber		
13.	Mango leaf miner		
14.	Mango leaf caterpillar		
15.	Eriophyid mite		
16.	Others (if any).....		

B.6 What is the status of vertebrate infestation in your area? (Please enter the code in the blank space)

Sl. No.	Name of the Vertebrate		
01.	Bird		
02.	Squirrel		
03.	Rat		
04.	Others (If any)		

B.7 What stages and parts of mango trees are affected by harmful insects in the field and how severe is the attack? (Enter number in blank)

Sl. No.	Name of the insects	Stages of vulnerability of mangoes to harmful insects [Code: 1=seedling, 2=growing plant, 3=growth stage of mango flower, 4=growth/ripening stage of mango fruit].	Plant parts infested by pests [Code: 1=mango leaf, 2=stem, 3=inflorescence, 4= green mango, 5=ripe mango 4=root].	Infestation intensity (Code: 1=High, 2=Medium, 3=Low)
1.	Mango hopper			
2.	Mango fruit fly			
3.	Mango fruit weevil			
4.	Mango stem borer			
5.	Mango defoliator			
6.	Mango fruit borer			

7.	Mango leaf cutting weevil			
8.	Mango shoot gall			
9.	Mango leaf gall			
10.	Mango mealy bug			
11.	Mango leaf webber			
12.	Mango flower webber			
13.	Mango leaf miner			
14.	Mango leaf caterpillar			
15.	Eriophyid mite			
16.	Others (if any)			

B.08.a a. Are mango mealy bugs present on mango trees in your area? [Code: 1=Yes, 2=No]

b. If the answer is yes, how many years do you think this insect has been present?

[Code: 1= For 1 year, 2= For last five years, 3= For last 10 years, 4= For last 15 years, 5= For more than last 15 years, 6= Not known]

c. What stage of the plant does this insect attack?

[Code: 1=seedling, 2=growing plant, 3=growth stage of mango flower, 4=growth/ripening stage of mango fruit].

d. What part of the plant does this insect attack?

(Code: 1=mango leaf, 2=stem, 3=inflorescence, 4=green mango, 5=mango bud, 6=ripe mango, 4=root).

e. Infestation intensity of the insect? [Code: 1=High, 2=Medium, 3=Low]

B.08.b a. Are fruit fly present on mango trees in your area? [Code: 1=Yes, 2=No]

b. If the answer is yes, how many years do you think this insect has been present?

[Code: 1= For 1 year, 2= For last five years, 3= For last 10 years, 4= For last 15 years, 5= For more than last 15 years, 6= Not known]

c. What stage of the plant does this insect attack?

[Code: 1=seedling, 2=growing plant, 3=growth stage of mango flower, 4=growth/ripening stage of mango fruit].

d. What part of the plant does this insect attack?

(Code: 1=mango leaf, 2=stem, 3=inflorescence, 4=green mango, 5=mango bud, 6=ripe mango, 4=root).

e. Infestation intensity of the insect? [Code: 1=High, 2=Medium, 3=Low]

B.08.c a. Are mango stone weevil present on mango trees in your area? [Code: 1=Yes, 2=No]

b. If the answer is yes, how many years do you think this insect has been present?

[Code: 1= For 1 year, 2= For last five years, 3= For last 10 years, 4= For last 15 years, 5= For more than last 15 years, 6= Not known]

c. What stage of the plant does this insect attack?

[Code: 1=seedling, 2=growing plant, 3=growth stage of mango flower, 4=growth/ripening stage of mango fruit].

d. What part of the plant does this insect attack?

(Code: 1=mango leaf, 2=stem, 3=inflorescence, 4=green mango, 5=mango bud, 6=ripe mango, 4=root).

e. Infestation intensity of the insect? [Code: 1=High, 2=Medium, 3=Low] ☐

B.09 a. Are there any new pests currently appearing on mango trees in your area that were not present in the past? ☐
(Code: Yes=1, No=2).
b. If the answer is yes, then what are insects? Mention Name: [Insert code number in the blank below]

[Code: 1=Mango hopper, 2=Mango fruit fly, 3=Mango fruit weevil, 4=Mango stem borer, 5=Mango defoliator, 6=Mango fruit borer, 7=Mango leaf cutting weevil, 8=Mango shoot gall, 9=Mango leaf gall, 10=Mango mealy bug, 11=Mango leaf webber, 12=Mango flower webber, 13=Mango leaf miner, 14=Mango leaf caterpillar, 15=Eriophyid mite, 16=Others (if any)]

B.10 Name how many pests are causing more damage to mango trees in your area now than before?

[Code: 1=Mango hopper, 2=Mango fruit fly, 3=Mango fruit weevil, 4=Mango stem borer, 5=Mango defoliator, 6=Mango fruit borer, 7=Mango leaf cutting weevil, 8=Mango shoot gall, 9=Mango leaf gall, 10=Mango mealy bug, 11=Mango leaf webber, 12=Mango flower webber, 13=Mango leaf miner, 14=Mango leaf caterpillar, 15=Eriophyid mite, 16=Others (if any)]

B.11 a. To your knowledge, are there any pests of mangoes that have entered our country from neighboring/other countries/ which were not present in our country before? (Code: Yes=1, No=2). ☐

b. If yes, name of the insect please--

[Code: 1=Mango hopper, 2=Mango fruit fly, 3=Mango fruit weevil, 4=Mango stem borer, 5=Mango defoliator, 6=Mango fruit borer, 7=Mango leaf cutting weevil, 8=Mango shoot gall, 9=Mango leaf gall, 10=Mango mealy bug, 11=Mango leaf webber, 12=Mango flower webber, 13=Mango leaf miner, 14=Mango leaf caterpillar, 15=Eriophyid mite, 16=Others (if any)]

B.12 How do you usually control the attack of harmful insects on mango? Enter the code number in the space below:

[Code: 1= Spraying insecticides on mango trees, 2= Using fumigation under mango trees, 3= Using pheromone traps, 4= Pruning insect-infested stems, 4=

Pruning unwanted stems at the end of the mango season, 5= Planting trees in the ground by applying of granular insecticides at the base, 6= Clearing of litter/weeds from the plant base, 7= Application of insecticides with irrigation, 8= Use of resistant varieties, 9= Bird repellants, 10= Integrated pest management (IPM)), 11 = using balanced fertilizers at the base of the plant, 12 = other (please specify)]

B.13 What is the prevalence and incidence of mango diseases in your area? (Please enter the code in the blank space)

Sl. No.	Name of the harmful insects	Infestation status of the insect: [Code: Major (More damaging) insect=1, Minor (Not economically harmful) insect=2, No infestation of this pest=3]	
1.	Antracnose of mango		
2.	Powdery mildew		
3.	Malformation of mango		
4.	Fruit end rot of mango		
5.	Shooty mould of mango		
6.	Red rust of mango		
7.	Cladosporium rot		
8.	Diplodia rot		
9.	Dieback of mango		
10.	Other (Please specify).......		

B.14 Which stage/part of mango plant is affected by the disease in the field and how severe is the damage? (Enter code in blank)

Sl. No.	Name of the diseases	Stages of vulnerability of mangoes to harmful diseases [Code: 1=seedling, 2=growing plant, 3=growth stage of mango flower, 4=growth/ripening stage of mango fruit].	Plant parts infected by pests [Code: 1=mango leaf, 2=stem, 3=inflorescence, 4= green mango, 5=ripe mango 4=root].	Infection intensity (Code: 1=High, 2=Medium, 3=Low)
1.	Antracnose of mango			
2.	Powdery mildew			
3.	Malformation of mango			
4.	Fruit end rot of mango			
5.	Shooty mould of mango			
6.	Red rust of mango			
7.	Cladosporium rot			
8.	Diplodia rot			

9.	Dieback of mango			
10.	Other (Please specify).......			

B.15 a. Are there any new diseases currently appearing on mango trees in your area that were not present in the past?
(Code: Yes=1, No=2).

b. If the answer is yes, then what are diseases? Mention Name: [Insert code number in the blank below]

[Code: 1=Antracnose of mango; 2=Powdery mildew; 3=Malformation of mango; 4=Fruit end rot of mango, 5=Shooty mould of mango, 6=Red rust of mango, 7=Cladosporium rot, 8=Diplodia rot, 9=Dieback of mango, 10=Other (Please specify).......]

B.16 Name how many diseases are causing more damage to mango trees in your area now than before?

[Code: 1=Antracnose of mango; 2=Powdery mildew; 3=Malformation of mango; 4=Fruit end rot of mango, 5=Shooty mould of mango, 6=Red rust of mango, 7=Cladosporium rot, 8=Diplodia rot, 9=Dieback of mango, 10=Other (Please specify).......]

B.17 a. To your knowledge, are there any diseases of mangoes that have entered our country from neighboring/other countries/which were not present in our country before? (Code: Yes=1, No=2).

b. If yes, name of the diseases please--

[Code: 1=Antracnose of mango; 2=Powdery mildew; 3=Malformation of mango; 4=Fruit end rot of mango, 5=Shooty mould of mango, 6=Red rust of mango, 7=Cladosporium rot, 8=Diplodia rot, 9=Dieback of mango, 10=Other (Please specify).......]

B.18 How do you usually control the attack of harmful diseases on mango? Enter the code number in the space below:

[Code: 1=Fungicide applied to mango trees, 2=Fumigation under mango trees, 3=Diseased branches are pruned, 4=Unnecessary branches are pruned at the end of the mango season, 5=Herbicide is applied to the soil at the base of the tree, 6 =clearing the litter/weeds from the base of the plant, 7=using disease resistant varieties, 8=applying bio-fertilizers to the land, 9=integrated management system (IPM), 10=using balanced fertilizer at the base of the tree, 12 = Other (please specify)]

B. 19 Which stage/part of the mango tree is most affected by the weed and how severe is the damage? (Enter number in blank)

Sl. No.	Name of the Weeds	Status of Infestation [Code: Major Weed=1,	Vulnerable Stages of Mango Tree [Code: 1=Seedling,	Severity of Infestation

		Minor Weed=2, Not Infested=3]	2=Growing Plant, 3=Flowering Stage, 4=Fruiting Stage]	[Code: 1= High, 2=moderate, 3=low]
1.	*Cynodon dactylon*			
2.	*Cyperus rotundus*			
3.	Dodder plant			
4.	Loranthus			
5.	Others			

B.20 a. Are there any new weeds currently appearing on mango trees in your area that were not present in the past?
(Code: Yes=1, No=2).

b. If the answer is yes, then what are weeds? Mention Name: [Insert code number in the blank below]

[Code: 1=*Cynodon dactylon,* 2=*Cyperus rotundus,* 3=Dodder plant, 4=Loranthus, 5=Others]

B.21 Name how many weeds are causing more damage to mango trees in your area now than before?

[Code: 1=*Cynodon dactylon,* 2=*Cyperus rotundus,* 3=Dodder plant, 4=Loranthus, 5=Others]

B.22 a. To your knowledge, are there any weeds of mangoes that have entered our country from neighboring/other countries/which were not present in our country before? (Code: Yes=1, No=2).

b. If yes, name of the weesds please--

[Code: 1=*Cynodon dactylon,* 2=*Cyperus rotundus,* 3=Dodder plant, 4=Loranthus, 5=Others]

B.23 How do you usually control the weeds of mango? Enter the code number in the space below:

[Code: 1=Uprooting of weeds from mango orchards, 2=Spraying granular herbicides on mango orchards, 3=Uprooting weeds while fertilizing/irrigating orchards, 4=Clearing parasitic weeds from trees, 5=Raising soil at the base of mango trees, 6=Using irrigation , 7=other (specify)]

Name of the enumerator: Signature and date:

Name of the field supervisor: Signature and date:

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি সম্প্রসারণ অধিদপ্তর
রপ্তানিযোগ্য আম উৎপাদন প্রকল্প
খামারবাড়ী, ফার্মগেট, ঢাকা।
ফোনঃ ৯১০৩৭৭৪।

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh

Prepared by:
DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD. (DTCL)
Niketan, Gulshan-1, Dhaka-1212
E-mail: info@dtcltd.com, Website: www.dtcltd.com

সেট-১: আম উৎপাদনকারীদের জন্যে জরিপ প্রশ্নাবলী

কোডঃ					মোবাইল ফোন											

A.0 আম উৎপাদনকারীর ব্যক্তিগত তথ্যাদিঃ

A.1 উত্তরদাতার নাম: ---

A.2 গ্রাম -- A.3 কৃষি ব্লক: ------------------------------------

A.4 উপজেলা: -- A.5 জেলা: --

A.6 শিক্ষাগত যোগ্যতা: -------------------------------- A.7 বয়স: ------------------------------------ ।

A.8 পেশাগত: [কোড: ১=বড় উৎপাদনকারী, ২=মধ্যম উৎপাদনকারী, ৩=ক্ষুদ্র উৎপাদনকারী, ৪=প্রান্তীক উৎপাদনকারী] ☐

A.9 লিঙ্গ: (কোড: ১=পুরুষ, ২=মহিলা) ☐

B.0 আমের আবাদ ও পি.আর.এ সংক্রান্ত তথ্যাবলিঃ

B.1 উত্তরদাতার ব্যবহৃত জমির ধরণ/ প্রকৃতি:

আমচাষে ব্যবহৃত জমির ধরণ	**জমির পরিমাণ (শতাংশ)**
১. এ বছর মোট কি পরিমান জমিতে কৃষি ফসল চাষ করেছেন?	
২. এ বছর কি পরিমান জমিতে আম চাষ করেছেন?	
৩. আপনি কত বছর যাবৎ আম চাষ করছেন? পূর্ণ সংখ্যা বলুন:	

B.2 আপনি কোন কোন জাতের আম চাষ করেন, দয়া করে বলবেন কি?

চাষকৃত/ব্যবহৃত আমের জাত (নীচের খালি ঘরে আমের জাতের কোড নম্বর লিখুন)	**আপনি চাষ করেন কিনা? (কোড: ১=হ্যাঁ, ২=না)**	**উত্তর হ্যাঁ হলে, চাষকৃত জমির পরিমাণ (শতাংশ)**	**উৎপাদন (কেজি/শতাংশ*)**
১. বারি আম -১ (মহানন্দা)			
২. বারি আম -২ (নীলুম)			
৩. বারি আম -৩ (আম্রপালি)			
৪. বারি আম -৪ (হাইব্রিড আম)			
৫. ফজলী			
৬. ল্যাংড়া			
৭. খিরসাপাত			

৮. গোপালভোগ			
৯. লক্ষণভোগ			
১০. হিমসাগর			
১১. মোহনভোগ			
১২. আশ্বিনা			
১৩. কালাপাহাড়ী			
১৪. চোষা আম			
১৫. বোম্বাই			
১৬. হাড়িভাঙ্গা			
১৭. গুটি আম			
১৮. সূর্যপুরি			
১৯. অন্যান্য (যদি থাকে)----------------			

B.3 আমের বিভিন্ন জাতের প্রতি ক্ষতিকর পোকামাকড়, রোগ-বালাই এবং আগাছার সংবেদনশীল প্রতিক্রিয়া কেমন?

ইং	**আমের বিভিন্ন জাতের নাম**	**যার প্রতি সংবেদনশীল** (কোড: ১=ক্ষতিকর পোকামাকড়, ২=রোগ-বালাই, ৩=জমির আগাছা, ৪=পরজীবি আগাছা, ৫=পোকামাকড় ও রোগ, ৫=আগাছা ও রোগ, ৬=কোনটাই আক্রমন করে না)। শূন্যস্থানে কোড নাম্বার লিখুন।
১.	বারি আম -১ (মহানন্দা)	
২.	বারি আম -২ (নীলুম)	
৩.	বারি আম -৩ (আম্রপালি)	
৪.	বারি আম -৪ (হাইব্রিড আম)	
৫.	ফজলী	
৬.	ল্যাংড়া	
৭.	খিরসাপাত	
৮.	গোপালভোগ	
৯.	লক্ষণভোগ	
১০.	হিমসাগর	
১১.	মোহনভোগ	
১২.	আশ্বিনা	
১৩.	কালাপাহাড়ী	
১৪.	চোষা আম	
১৫.	বোম্বাই	
১৬.	হাড়িভাঙ্গা	
১৭.	গুটি আম	
১৮.	সূর্যপুরি	
১৯.	অন্যান্য (যদি থাকে)------------------	

B.4 আমের চাষের জন্যে সাধারণত: কোন কোন উৎস থেকে আমের চারা সংগ্রহ/ক্রয় করেন?

[কোড: ১=নিজের কলম কাঁটা চারা, ২=প্রতিবেশী কৃষক কাছ থেকে, ৩=বিএডিসি'র নার্সারী থেকে, ৪=স্থানীয় কোন নার্সারী থেকে, ৫=পার্শ্ববর্তী দেশ থেকে আমদানীকৃত চারা, ৬=বিভিন্ন গবেষনা প্রতিষ্ঠান, ৭=এনজিও, ৮=অন্যান্য (যদি থাকে)-----------]

B.5 মাঠপর্যায়ে আমের ক্ষতিকর পোকা-মাকড়ের উপস্থিতি এবং উপদ্রবের ধরণ/ অবস্থা কেমন? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

ক্রমিক নং	ক্ষতিকর পোকা-মাকড়ের নাম	পোকার আক্রমনের অবস্থা: (কোড: মূখ্য (বেশী ক্ষতিকর) পোকা=১, গৌণ পোকা (অর্থনৈতিকভাবে ক্ষতিকর নয়)=২, এই পোকার আক্রমন হয় না=৩)।
১	আমের ফড়িং পোকা/হপার (Mango hopper)	
২	ফলের মাছি (Mango fruit fly)	
৩	ফলের উইভিল (Mango fruit weevil)	
৪	কান্ড ছিদ্রকারী পোকা (Mango stem borer)	
৫	বিছা পোকা (Mango defoliator)	
৬	ফল ছিদ্রকারী পোকা (Mango fruit borer)	
৭	পাতা খেকো পোকা (Mango leaf cutting weevil)	
৮	ডগার গল পোকা (Mango shoot gall)	
৯	পাতার গল পোকা (Mango leaf gall)	
১০	মিলি বাগ/ছাত্রা পোকা (Mango mealy bug)	
১১	পাতার জাল সৃষ্টিকারী পোকা (Mango leaf webber)	
১২	ফলের জাল সৃষ্টিকারী পোকা (Mango flower webber)	
১৩	পাতা সুরঙ্গকারী পোকা (Mango leaf miner)	
১৪	পাতার লেদাপোকা (Mango leaf caterpillar)	
১৫	পাতার ক্ষুদ্র মাকড় (Eriophyid mite)	
১৬	অন্যান্য (যদি থাকে)	

B.6 আপনার এলাকায় ইঁদুর জাতীয়/মেরুদন্ডী প্রানীর আক্রমনের/উপদ্রবের অবস্থা কি? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

ক্রমিক নং	বালাইয়ের নাম	ইঁদুর জাতীয়/মেরুদন্ডী প্রানীর আক্রমনের অবস্থা: [কোড: মূখ্য (বেশী ক্ষতিকর) বালাই=১, গৌণ বালাই (অর্থনৈতিক ক্ষতিকর নয়)=২, এই বালাইয়ের আক্রমন হয় না=৩]।
১	পাখি	
২	কাঠবিড়ালী	
৪	ইঁদুর	
৫	অন্যান্য (যদি থাকে)	

B.7 মাঠে আম গাছের কোন পর্যায় ও অংশ ক্ষতিকর পোকা দ্বারা আক্রান্ত হয় এবং আক্রমনের তীব্রতা কেমন? (খালী ঘরে সংখ্যা লিখুন)

ইং	পোকা-মাকড়ের নাম	ক্ষতিকর কীটপতঙ্গের প্রতি আমের ঝুঁকিপূর্ণ ধাপসমূহ [কোড: ১=চারা, ২=বাড়ন্ত গাছ, ৩=আমের ফুলের বৃদ্ধি পর্যায়, ৪= আমের ফলের বৃদ্ধি/পাকার পর্যায়]।	গাছের অংশ যা ক্ষতিকর পোকা দ্বারা আক্রান্ত হয় (কোড: ১=আম গাছের পাতা, ২=কান্ড, ৩=পুষ্প মঞ্জুরী, ৪=আমের গুটি, ৫=পাকা আম ৪=শিকড়)।	আক্রমনের তীব্রতা (কোড: ১=বেশী, ২=মধ্যম, ৩=কম আক্রমন হয়)
১	আমের ফড়িং/হপার			
২	ফলের মাছি			
৩	ফলের উইভিল			
৪	কান্ড ছিদ্রকারী পোকা			
৫	বিছা পোকা			
৬	ফল ছিদ্রকারী পোকা			
৭	পাতা খেকো পোকা			
৮	ডগার গল পোকা			
৯	পাতার গল পোকা			
১০	আমের মিলি বাগ			
১১	পাতার জাল সৃষ্টিকারী পোকা (leaf webber)			
১২	ফলের জাল সৃষ্টিকারী পোকা (flower webber)			

১৩	পাতা সুরঙ্গকারী পোকা			
১৪	পাতার লেদাপোকা			
১৫	পাতার ক্ষুদ্র মাকড়			
১৬	অন্যান্য (যদি থাকে)			

B.08 **ক. আপনার এলাকায় আম গাছে আমের মিলি বাগ** (mango mealy bug/giant mealy bug) **-এর উপস্থিতি আছে কি?** (কোড: হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে কত বৎসর যাবৎ এপোকার উপস্থিতি দেখা যাচ্ছে বলে মনে করেন?

[কোড: ১= ১ বৎসর যাবৎ, ২=গত পাঁচ বৎসর যাবৎ, ৩=গত ১০ বৎসর যাবৎ, ৪=গত ১৫ বৎসর যাবৎ, ৫= গত ১৫ বৎসরের অধিক সময় যাবৎ, ৬= জানা নাই]

গ. এই পোকায় গাছের কোন পর্যায় আক্রমন করে?

[কোড: ১=চারা, ২=বাড়ন্ত গাছ, ৩=আমের ফুলের বৃদ্ধি পর্যায়, ৪= আমের ফলের বৃদ্ধি/পাকার পর্যায়]।

ঘ. এই পোকায় গাছের কোন অংশে আক্রমন করে?

(কোড: ১=আম গাছের পাতা, ২=কান্ড, ৩=পুষ্প মঞ্জুরী, ৪=আমের গুটি, ৫=আমের বোঁটা, ৬=পাকা আম, ৪=শিকড়)।

ঙ.এই পোকার কারণে আক্রমনের তীব্রতা কেমন? (কোড: ১=বেশী, ২=মধ্যম, ৩=কম আক্রমন হয়)

B.09 **ক. আপনার এলাকায় আম গাছে বর্তমানে এমন নতুন কোন পোকা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না?** (কোড: হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে পোকাগুলোর কি কি? নাম উল্লেখ করুন: [নিচের খালী ঘরে কোড নম্বর বসান]

[কোড: ১=আমের হপার, ২=ফলের মাছি, ৩=ফলের উইভিল, ৪=কান্ড ছিদ্রকারী পোকা, ৫=বিছা পোকা, ৬=ফল ছিদ্রকারী পোকা, ৭=পাতা খেকো পোকা, ৮=ডগার গল পোকা, ৯=পাতার গল পোকা, ১০=আমের মিলি বাগ, ১১=পাতার জাল সৃষ্টিকারী পোকা, ১২=ফলের জাল সৃষ্টিকারী পোকা, ১৩=পাতা সুরঙ্গকারী পোকা, ১৪=পাতার লেদাপোকা, ১৫=পাতার ক্ষুদ্র মাকড়, ১৬=অন্যান্য----------]

B.10 **আপনার এলাকায় আম গাছে আগের তুলনায় বর্তমানে অধিকর ক্ষতি করে এমন কতগুলো অনিষ্টকারী পোকার নাম বলুন?**

[কোড: ১=আমের হপার, ২=ফলের মাছি, ৩=ফলের উইভিল, ৪=কান্ড ছিদ্রকারী পোকা, ৫=বিছা পোকা, ৬=ফল ছিদ্রকারী পোকা, ৭=পাতা খেকো পোকা, ৮=ডগার গল পোকা, ৯=পাতার গল পোকা, ১০=আমের মিলি বাগ, ১১=পাতার জাল সৃষ্টিকারী পোকা, ১২=ফলের জাল সৃষ্টিকারী পোকা, ১৩=পাতা সুরঙ্গকারী পোকা, ১৪=পাতার লেদাপোকা, ১৫=পাতার ক্ষুদ্র মাকড়, ১৬=অন্যান্য----------]

B.11 **আপনার জানামতে আমের এমন কোন ক্ষতিকর পোকা আছে কি, যেগুলো পার্শ্ববর্তী/অন্য কোন দেশ/ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পূর্বে ছিল না?** (কোড: হ্যাঁ=১, না=২)।

ক. যদি উত্তর হ্যাঁ হয়, তাহলে সে সব পোকার নাম বলুন?

[কোড: ১=আমের হপার, ২=ফলের মাছি, ৩=ফলের উইভিল, ৪=কান্ড ছিদ্রকারী পোকা, ৫=বিছা পোকা, ৬=ফল ছিদ্রকারী পোকা, ৭=পাতা খেকো পোকা, ৮=ডগার গল পোকা, ৯=পাতার গল পোকা, ১০=আমের মিলি বাগ, ১১=পাতার জাল সৃষ্টিকারী পোকা, ১২=ফলের জাল সৃষ্টিকারী পোকা, ১৩=পাতা সুরঙ্গকারী পোকা, ১৪=পাতার লেদাপোকা, ১৫=পাতার ক্ষুদ্র মাকড়, ১৬=অন্যান্য----------]

খ. আপনার এলাকায় আম গাছে এমন কোন ক্ষতিকর পোকা-মাকড় আছে কিনা, যেগুলো দ্বারা ব্যাপক ক্ষতির সম্ভাবনা আছে কিন্তু বর্তমানে সেগুলো বিভিন্ন দমন পদ্ধতির মাধ্যমে নিয়ন্ত্রিত অবস্থায় আছে?

[কোড: ১=হ্যাঁ, ২=না, ৩=জানা নেই]

(গ) যদি উত্তর হ্যাঁ হয়, তাহলে পোকা-মাকড়গুলো কি কি? নাম উল্লেখ করুন:

[কোড: ১ আমের ফড়িং/হপার, ২=ফলের মাছি, ৩=ফলের উইভিল, ৪=কান্ড ছিদ্রকারী পোকা, ৫=বিছা পোকা, ৬=ফল ছিদ্রকারী পোকা, ৭=পাতা খেকো পোকা, ৮=ডগার গল পোকা, ৯=পাতার গল পোকা, ১০=আমের মিলি বাগ, ১১=পাতার জাল সৃষ্টিকারী পোকা (leaf webber), ১২=ফলের জাল সৃষ্টিকারী পোকা (flower webber), ১৩=পাতা সুরঙ্গকারী পোকা, ১৪=পাতার লেদাপোকা, ১৫=পাতার ক্ষুদ্র মাকড়, ১৬=অন্যান্য ----------------(যদি থাকে নাম উল্লেখ করুন)]

B.12 আপনি সাধারণত কিভাবে আমের ক্ষতিকর পোকামাকড়ের আক্রমণ দমন করেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ

(কোডঃ ১= আম গাছে কীটনাশক স্প্রে করে, ২= আম গাছের নীচে ধোঁয়া (ফিউমিগেশন) দিয়ে, ৩=ফেরোমন ফাঁদ ব্যবহার করে, ৪=পোকায় আক্রান্ত ডালপালা ছেঁটে, ৫=ব্যাগিং করা, ৬=আমের মৌসুম শেষে অপ্রয়োজনীয় ডালপালা ছেঁটে দিয়ে, ৭=মাটিতে গাছের গোড়ায় দানাদার কীটনাশক ব্যবহার করে, ৮=গাছের গোড়ার আবর্জনা/আগাছা পরিস্কার করে, ৯= সেচের সাথে কীটনাশক প্রয়োগ করে, ১০=প্রতিরোধী জাত ব্যবহার করে, ১১= পাখি তাড়ানোর ব্যবস্থা করে, ১২= সমন্বিত বালাই পদ্ধতি (আই.পি.এম.), ১৩= গাছের গোড়ায় সুষম সার ব্যবহার করে, ১৪= অন্যান্য------------ (উল্লেখ করুন)]

B.13 আপনার এলাকায় আম গাছ/ আমের রোগসমূহের উপস্থিতি এবং আক্রমনের ধরণ/অবস্থা কেমন? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

ক্রমিক নং	আমের রোগসমূহের নাম	রোগের আক্রমনের অবস্থা [কোড: মূখ্য (বেশী ক্ষতিকর) রোগ=১, গৌণ রোগ (অর্থনৈতিক ক্ষতিকর নয়)=২, এই রোগের আক্রমন হয় না=৩]	
১	আমের এ্যানত্রাকনোজ রোগ (Antracnose of mango)		
২	আমের মুকুলের পাউডারি মিলডিউ রোগ (Powdery mildew)		
৩	Malformation of mango		
৪	আমের ফল পঁচা রোগ (Fruit end rot of mango)		
৫	আমের মোল্ড রোগ (Shooty mould of mango)		
৬	আমের রাস্ট রোগ (Red rust of mango)		
৭	Cladosporium rot		
৮	Diplodia rot		
৯	আমের আগা মরা রোগ (Dieback of mango)		
১০	অন্য কোন রোগ (যদি থাকে)---------		

B.14 মাঠপর্যায়ে আম গাছের কোন পর্যায়/ অংশ রোগ দ্বারা আক্রান্ত হয় এবং ক্ষতির তীব্রতা কেমন? (খালী ঘরে সংখ্যা লিখুন)

নং	রোগসমূহের নাম	আম গাছের ঝুঁকিপূর্ণ ধাপসমূহ [কোড: ১=চারা, ২=বাড়ন্ত গাছ, ৩=আমের ফুলের বৃদ্ধি পর্যায়, ৪= আমের ফলের বৃদ্ধি/পাকার পর্যায়]।	গাছের অংশ যা রোগ দ্বারা আক্রান্ত হয় (কোড: ১=আম গাছের পাতা, ২=কান্ড, ৩=পুষ্প মঞ্জুরী, ৪=আমের গুটি, ৫=পাকা আম ৪=শিকড়)।	আক্রমনের তীব্রতা (কোড: ১=বেশী, ২=মধ্যম, ৩=কম আক্রমন হয়)
১	এ্যানত্রাকনোজ রোগ			
২	মুকুলের পাউডারি মিলডিউ রোগ			
৩	Malformation of mango			
৪	ফল পঁচা রোগ			
৫	সুটি মোল্ড রোগ			
৬	রাস্ট রোগ			
৭	Cladosporium rot			
৮	Diplodia rot			
৯	আগা মরা রোগ			
১০	অন্যান্য---------			

B.15 ক. আপনার এলাকায় আম গাছে বর্তমানে এমন কোন নতুন রোগের আক্রমন দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না?
(কোড: হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে রোগসমূহ কি কি? নাম উল্লেখ করুন:

[কোড: ১= এ্যানথ্রাকনোজ রোগ, ২=মুকুলের পাউডারি মিলডিউ রোগ, ৩=Malformation of mango, ৪=ফল পঁচা রোগ, ৫=সুটি মোল্ড রোগ, ৬=রাস্ট রোগ, ৭=Cladosporium rot, ৮=Diplodia rot, ৯=আগা মরা রোগ, ১০=অন্যান্য------]

B.16 **আপনার এলাকায় আমের আগের তুলনায় বর্তমানে বেশী ক্ষতি করে এমন কতগুলো রোগের নাম বলুন?**

[কোড: ১= এ্যানথ্রাকনোজ রোগ, ২=মুকুলের পাউডারি মিলডিউ রোগ, ৩=Malformation of mango, ৪=ফল পঁচা রোগ, ৫=সুটি মোল্ড রোগ, ৬=রাস্ট রোগ, ৭=Cladosporium rot, ৮=Diplodia rot, ৯=আগা মরা রোগ, ১০=অন্যান্য---------]

B.17 **ক. আপনার জানামতে আমের এমন কোন রোগ আছে কি, যেগুলো পার্শ্ববর্তী দেশ/বিদেশ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পূর্বে ছিল না? (কোড: হ্যাঁ=১, না=২)।**

খ. যদি উত্তর হ্যাঁ হয়, তাহলে এ সকল রোগের নাম বলুন?

গ. আপনার এলাকায় আম গাছে এমন কোন ক্ষতিকর রোগ-বালাই আছে কিনা, যেগুলো দ্বারা ব্যাপক ক্ষতির সম্ভাবনা আছে কিন্তু বর্তমানে সেগুলো বিভিন্ন দমন পদ্ধতির মাধ্যমে নিয়ন্ত্রিত অবস্থায় আছে?

[কোড: ১=হ্যাঁ, ২=না, ৩=জানা নেই]

(গ) যদি উত্তর হ্যাঁ হয়, তাহলে সেসব রোগ-বালাইয়ের নাম বলুন:

[কোড: ১= এ্যানথ্রাকনোজ রোগ, ২=মুকুলের পাউডারি মিলডিউ রোগ, ৩=Malformation of mango, ৪=ফল পঁচা রোগ, ৫=সুটি মোল্ড রোগ, ৬=রাস্ট রোগ, ৭=Cladosporium rot, ৮=Diplodia rot, ৯=আগা মরা রোগ, ১০=অন্যান্য-------------- (যদি থাকে, তাহলে উল্লেখ করুন)]

B.18 **আপনি কিভাবে আমের রোগ দমন করে থাকেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ**

[কোডঃ ১= আম গাছে ছত্রাকনাশক স্প্রে করে, ২=আম গাছের নীচে ধোঁয়া (ফিউমিগেশন) দিয়ে, ৩=রোগে আক্রান্ত ডালপালা ছেঁটে ফেলে, ৪= আমের মৌসুম শেষে অপ্রয়োজনীয় ডালপালা ছেঁটে দিয়ে, ৫=মাটিতে গাছের গোড়ায় বালাইনাশক ব্যবহার করে, ৬=গাছের গোড়ার আবর্জনা/আগাছা পরিষ্কার করে, ৭= রোগ প্রতিরোধী জাত ব্যবহার করে, ৮= জমিতে জৈব-সার প্রয়োগ করে, ৯=সমন্বিত বালাই পদ্ধতি (আই.পি.এম.), ১০= গাছের গোড়ায় সুষম সার ব্যবহার করে, ১২= অন্যান্য (দয়া করে উল্লেখ করুন)]

B.19 **আম গাছের কোন পর্যায়/অংশ আগাছা দ্বারা বেশী আক্রান্ত হয় এবং ক্ষতির তীব্রতা কেমন? (খালী ঘরে সংখ্যা লিখুন)**

নং	**ইাম**	**আক্রমনের অবস্থা** [কোড: মুখ্য আগাছা=১, গৌণ আগাছা=২, আক্রমন হয় না=৩]	**আমগাছের ঝুঁকিপূর্ণ ধাপসমূহ** চারা, ২=বাড়ন্ত গাছ, ৩=ফুলের বৃদ্ধি পর্যায়, ৪=ফলের বৃদ্ধি পর্যায়]	**আক্রমনের তীব্রতা** [কোড: ১=বেশী, ২=মধ্যম, ৩=কম আক্রমন হয়]
১	দূর্বা (*Cynodon dactylon)*			
২	মুথা (*Cyperus rotundus*)			
৩	স্বর্ণলতা (dodder plant)			
৪	লোরান্থাস পরজীবি গাছ (Loranthus)			
৫	অন্যান্য			

B.20 **ক. আপনার এলাকায় আম গাছে বা বাগানে বর্তমানে নতুন এমন কোন আগাছা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না?** (কোড: হ্যাঁ=১, না=২)। ☐

খ. যদি উত্তর হ্যাঁ হয়, তাহলে আগাছাসমূহ কি কি? নাম উল্লেখ করুন:

[কোড: ১=দূর্বা, ২=মুথা, ৩=স্বর্ণলতা, ৪=লোরান্থাস পরজীবি গাছ, ৫=অন্যান্য---------]

B.21 **আপনার এলাকায় আম গাছে বা বাগানে ক্ষেতে আগের তুলনায় বর্তমানে বেশী ক্ষতি করে এমন কতগুলো আগাছার নাম বলুন?**

[কোড: ১=দূর্বা, ২=মুথা, ৩=স্বর্ণলতা, ৪=লোরান্থাস পরজীবি গাছ, ৫=অন্যান্য---------]

B.22 **ক. আপনার জানামতে আমের এমন কোন আগাছা আছে কি, যেগুলো পার্শ্ববর্তী দেশ/বিদেশ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পুর্বে ছিল না?** ([কোড: হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে এ সকল আগাছাগুলোর নাম বলুন?

[কোড: ১=দূর্বা, ২=মুথা, ৩=স্বর্ণলতা, ৪=লোরান্থাস পরজীবি গাছ, ৫=অন্যান্য---------]

B.23 **আমের বাগানে সাধারণত: কিভাবে আগাছা দমন করে থাকেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ**

[কোডঃ ১=আমের বাগান থেকে আগাছা উঠিয়ে, ২=আমের বাগানে দানাদার আগাছানাশক ছিটিয়ে, ৩=বাগানে সার/সেচ দেয়ার সময় আগাছা উঠিয়ে, ৪=পরজীবি আগাছা গাছ থেকে পরিস্কার করে, ৫=আম গাছের গোড়ায় মাটি উঠিয়ে, ৬= সেচ দিয়ে, ৭=অন্যান্য (উল্লেখ করুন)]

তথ্য সংগ্রহকারীর নামঃ স্বাক্ষর ও তারিখঃ

ফিল্ড সুপারভাইজারের নামঃ স্বাক্ষর ও তারিখঃ

Appendix 2: Questionnaire for Focus Group Discussion for PRA

Government of the People's Republic of Bangladesh
Department of Agricultural Extension
Exportable Mango Production Project,
Khamarbari, Farmgate, Dhaka, Phone: 9103774

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh

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Set-2: FGD Guidelines

Code				

A.0 Place of the FGD:

A.1 Village: A.2 Agri-block

A.4 Upazila A.5 District

B.1 What are the most popular mango varieties grown in your orchard?

B.2 What are the seedling sources for the mango varieties you grow?

B.3 What types of harmful insects are commonly seen in mango trees in your area? (specify name)

a. Major insect:

b. Minor insect:

B.4 What types of harmful diseases are commonly seen in mango trees in your area? (specify name)

a. Major diseases:

b. Minor diseases:

B.5 What types of weeds are commonly seen in mango trees in your area? (specify name)

a. Major weed:

b. Minor weed:

B.6 a. Is there presence of mango mealybug in your area?

b. If so, when do you think its presence in your area?

c. If present, when (season) and to what extent does it damage mango trees?

B.7 Which growth stages of mango tree are most affected by pests, diseases and weeds?

a. Harmful insects:

b. Diseases

c. Weeds

B.8 Which part of the mango tree is more affected by harmful insects and diseases?

a. Harmful insects:

b. Diseases

B.9 What is the severity of damage to mango trees/fruits caused by pests, diseases and weeds?

a. Harmful insects:

b. Diseases

c. Weeds

B.10 Are there any new pests, diseases and weeds currently appearing on mango trees or orchards in your area that were not present in the past? If so, what are they? Specify Name:

a. Harmful insects:

b. Diseases

c. Weeds

B.11 Name how many pests, diseases and weeds are causing more damage to mango trees or orchards in your area now than before?

a. Harmful insects:

b. Diseases

c. Weeds

B.12 What effective measures are taken to control harmful insects, diseases and weeds in mango orchard in your area?

a. Control measures for harmful insects:

b. Control measures for diseases:

c. Control measures for weeds:

B. 13 To your knowledge, are there any harmful insects, diseases and weeds of mangoes, which seem to have entered our country from neighboring countries/abroad, but they were not present in our country before? If so, tell them their names?

a. Harmful insects:

b. Diseases

c. Weeds

List of the participants in the Focus Group Discussion (FGD)

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

Name of the facilitator:

Signature and Date:

Mobile No:

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি সম্প্রসারণ অধিদপ্তর
রপ্তানিযোগ্য আম উৎপাদন প্রকল্প

উদ্ভিদ সংরক্ষণ উইং, খামারবাড়ী, ফার্মগেট, ঢাকা।

ফোনঃ ৯১০৩৭৭৪।

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh

Prepared by:

DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD. (DTCL)

Niketan, Gulshan-1, Dhaka-1212

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সেট-২: এফ.জি.ডি. গাইডলাইনসমূহ

কোড:				

A.0 **এফজিডি এর স্থানঃ** ---।

A.2 গ্রাম -- **A.3** কৃষি ব্লক: ---

A.4 উপজেলা: -- **A.5** জেলা: --

B.1 **আপনাদের বাগানে চাষকৃত আমের জাতগুলোর মধ্যে সবচেয়ে জনপ্রিয় জাতগুলো কি কি?**

B.2 **আপনারা যেসকল আমের জাত চাষ করেন, এর চারার উৎসসমূহ কি কি?**

B.3 **আপনার এলাকায় সাধারণত আম গাছে কোন ধরনের ক্ষতিকর পোকামাকড়ের আক্রমন দেখা যায়? (নাম উল্লেখ করুন)**

ক. মুখ্য ক্ষতিকর পোকামাকড়:

খ. গৌণ ক্ষতিকর পোকামাকড়:

B.4 **আপনাদের এলাকায় সাধারণত আমের বাগানে/আমের কোন কোন রোগ গুলো দেখা যায়? (রোগের নাম উল্লেখ করুন)**

ক. মুখ্য রোগ:

খ. গৌণ রোগ:

B.5 **আপনার এলাকায় সাধারণত আমের বাগানে/গাছে কোন কোন আগাছাসমূহের আক্রমন দেখা যায়? (নাম উল্লেখ করুন))**

ক. মুখ্য আগাছা:

খ. গৌণ আগাছা:

B.6

ক. আপনাদের এলাকায় আমের মিলি বাগের উপস্থিতি আছে কি?

খ. যদি থেকে থাকে আপনাদের এলাকায় এর উপস্থিতি কবে থেকে দেখা যাচ্ছে বলে মনে হয়?

গ. যদি উপস্থিত থেকে থাকে তাহলে তা আম গাছে কখন (মৌসুম) এবং কি পরিমানে ক্ষতি করে?

B.7

ক্ষতিকর পোকা-মাকড়, রোগ ও আগাছা দ্বারা আম গাছের কোন কোন বৃদ্ধি পর্যায়/ধাপসমূহ বেশী আক্রান্ত হয়?

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ:

গ. আগাছা:

B.8 ক্ষতিকর পোকা-মাকড় ও রোগ দ্বারা আম গাছের কোন কোন অংশ বেশী আক্রান্ত হয়?

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ বালাই:

B.9 ক্ষতিকর পোকা-মাকড়, রোগ-বালাই ও আগাছার আম গাছ/ফলের ক্ষতির তীব্রতা কেমন হয়?

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ:

গ. আগাছা:

B.10 আপনার এলাকায় আম গাছে বা বাগানে বর্তমানে এমন কোন নতুন পোকা-মাকড়, রোগ ও আগাছা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না? যদি থেকে থাকে, তাহলে সেগুলো কি কি? নাম উল্লেখ করুন:

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ:

গ. আগাছা:

B.11 আপনার এলাকায় আম গাছে বা বাগানে আগের তুলনায় বর্তমানে অনেক বেশী ক্ষতি করে এমন কতগুলো অনিষ্টকারী পোকা-মাকড়, রোগ ও আগাছার নাম বলুন?

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ:

গ. আগাছা:

B.12 আপনাদের এলাকার আলু ক্ষেতে ক্ষতিকর পোকা-মাকড়, রোগ ও আগাছা দমনে কি কি কার্যকর ব্যবস্থা গ্রহন করা হয়?

ক. ক্ষতিকর পোকামাকড় দমনে কার্যকর ব্যবস্থা:

খ. রোগ বালাই দমনে কার্যকর ব্যবস্থা:

গ. আগাছা দমনে কার্যকর ব্যবস্থা:

B.13 আপনাদের জানামতে আমের এমন কোন ক্ষতিকর পোকা-মাকড়, রোগ ও আগাছা আছে কি, যেগুলো পার্শ্ববর্তী দেশ/বিদেশ থেকে আমাদের দেশে প্রবেশ করেছে মনে হয়, অথচ সেগুলো পূর্বে আমাদের দেশে ছিল না? যদি থেকে থাকে, তাহলে তাদের নাম বলুন?

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ:

গ. আগাছা:

ফোকাস গ্রুপ ডিসকাশন (এফ.জি.ডি.)-এ অংশগ্রহনকারীদের তালিকা

নং	নাম	গ্রাম	পেশা	মোবাইল	স্বাক্ষর
১					
২					
৩					
৪					
৫					
৬					
৭					
৮					
৯					
১০					

এফজিডি পরিচালনাকারীর নামঃ-- ।

স্বাক্ষর ও তারিখ: -- ।

মোবাইল নম্বর:--- ।

Appendix 3: Questionnaire for Interview of Field Level Officers for PRA

Government of the People's Republic of Bangladesh
Department of Agricultural Extension
Exportable Mango Production Project
Khamarbari, Farmgate, Dhaka
Phone: 9103774

Checklist for Key Informant Interview (KII) on Conducting Pest Risk Analysis (PRA) of Mango in Bangladesh

Prepared by:
DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD. (DTCL)
Niketan, Gulshan-1, Dhaka-1212
E-mail: info@dtcltd.com, Website: www.dtcltd.com

Set-3: KII Checklists on PRA of Mango

Name of Key Informant…….. ………………………………. Designation ………………………..….

Organization:…………………………..…………… Working area: …………………………

Mobile:……….…………...……………..…………

Checklist for Review/ Key informant discussions on Pests of Mango

DAE Head office (PQW & PPW), Director Field Service (FSD); BARI Scientist, BADC, SCA, Agricultural University, Mango Importers' Association, District offices of DAE (ADDITIONAL DEPUTY DIRECTOR (PP)/PPS)

1.0 INFORMATION ABOUT INSECT PESTS OF MANGO

1.1 What are the major insect pests that cause potential damage to mango in Bangladesh (HQ)/your area? [PQW & PPW-DAE), SCA, **ADDITIONAL DEPUTY DIRECTOR (PP)/PPS**, BADC, BARI, Agricultural University, Mango Importers' Association]

1.2 What are the key insect pests of mango that cause potential damage in every year in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

1.3 What are the minor insect pests that may harm to mango, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

1.4 What are the insect pests of mango, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Mango Importers Association]

1.5 What is the status of Mango mealy bug in Bangladesh/your area? [DAE-HQ (PQW & PPW, FSD), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University] Is it present or absent in your area?

1.6 From which countries, the mangoes are being usually imported into Bangladesh? [DAE-HQ (PQW & PPW), Secretary (MoA), SCA, Mango Importers Association]

1.7 Is there any information about the insect pests of mango available in the exporting country of mango to Bangladesh? If yes, what are those insect pests? Please mention the name of insect pests? [DAE-HQ (PQW & PPW), SCA, Mango Importers Association]

1.8 What are the quarantine insect pests of mango that might already be entered into Bangladesh through importation of mango seeds from other countries or through cross boundary from neighboring countries that were not seen earlier? [PQW/PPW-DAE), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University, Mango Importers Association]

1.9 Is there any record, the consignment of mango imported from foreign country that was intercepted and returned from Bangladesh, due to occurrence of any insect pests in the consignment? If yes, which country and what are those insect pests? Please mention the name. [DAE-HQ (PQW & PPW), Secretary (MoA), SCA]

1.10 What are the possible ways of entry of newly introduced insect pests of mango that were not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University, Mango Importers Association]

1.11 What are the options to prevent the entry and spread of potential insect pests of mango within Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University, Mango Importers Association]

1.12 What are the effective options to control the quarantine insect pests of mango that are found in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

1.13 What are the effective ways to prevent the entry of quarantine insect pests of mango into Bangladesh from the countries of mango export? [DAE-HQ (PQW & PPW), SCA, Agril. University]

1.14 What steps are being taken by the PQW of DAE to prevent the entry of quarantine insect pests of mango through imported mango? [DAE-HQ (PQW & PPW), SCA]

1.15 Give your suggestions for the better management of the insect pests of mango in Bangladesh.
[DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

2.0 INFORMATION ABOUT DISEASES OF MANGO

2.1 What are the major diseases that cause potential damage to mango in Bangladesh (HQ)/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Mango Importers Association]

2.2 What are the key diseases of mango that cause potential damage in every year in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.3 What are the minor diseases that may harm to mango, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS** BARI, Agricultural University]

2.4 Among the diseases of mango available in Bangladesh/your area, which insect pests cause severe damage to mango every year in Bangladesh? [**Additional DD (PP)/PPS**, BARI, Agricultural University]

2.5 What are the diseases of mango, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

2.6 Is there any information about the diseases of mango available in the exporting country of mango to Bangladesh? If yes, what are those diseases? Please mention the name of diseases? [DAE-HQ (PQW & PPW), SCA, Mango Importers Association]

2.7 What are the quarantine diseases of mango that might already be entered into Bangladesh through importation of mango from other countries or through cross boundary from neighboring countries that were not seen earlier? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University, Mango Importers Association]

2.8 Is there any record, the consignment of mango imported from foreign country that was intercepted and returned by Bangladesh, due to occurrence of any diseases in the consignment? If yes, from which country and what are the diseases? Please mention the name. [DAE-HQ (PQW & PPW), SCA, Mango Importers Association]

2.9 What are the possible ways of entry of newly introduced diseases of mango that were not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/ PPS**, BARI, Agril. University, Mango Importers Association]

2.10 What are the options to prevent the entry and spread of potential diseases of mango within Bangladesh? [DAE(PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

2.11 What are the effective options to control the quarantine diseases that are found in the mango in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

2.12 What are the effective ways to prevent the entry of quarantine diseases of mango into Bangladesh from the countries of mango export? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS** BARI, Agricultural University]

2.13 What steps are being taken by the PQW of DAE to prevent the entry of quarantine diseases of mango through imported mango? [DAE-HQ (PQW & PPW), SCA]

2.14 Give your suggestions for the better management of the diseases of mango in Bangladesh. [DAE(PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, BADC, Agril. University]

3.0 INFORMATION ABOUT WEEDS OF MANGO

3.1 What are the major weeds that cause potential damage to mango in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

3.2 What are the minor weeds that may harm to mango, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

3.3 Among the weeds of mango available in Bangladesh/your area, which weeds cause severe damage every year in Bangladesh? [**Additional DD (PP)/PPS**, BARI, Agril. University]

3.4 What are the weeds of mango, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS,** BARI, Agricultural University]

3.5 Is there any information about the weeds of mango available in the exporting country of mango to Bangladesh? If yes, what are those weeds? Please mention the name of weeds? [DAE-HQ (PQW & PPW), Secretary (MoA), SCA]

3.6 What are the quarantine weeds of mango that might already be entered into Bangladesh through importation of mango from other countries or through cross boundary from neighboring countries that were not seen earlier? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.7 Is there any record, the consignment of mango imported from foreign country that was intercepted and returned from Bangladesh, due to occurrence of any weeds/weed seeds in the consignment? If yes, which country and what are the weeds? Please mention the name. [DAE-HQ (PQW & PPW), Secretary (MoA), SCA]

3.8 What are the possible ways of entry of quarantine weeds of mango that were not seen earlier in your area/Bangladesh? [DAE (PQW&PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.9 What are the options to prevent the entry and spread of potential weeds of mango within Bangladesh? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

3.10 What are the effective options to control the quarantine weeds that are found in the mango in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.11 What are the effective ways to prevent the entry of quarantine weeds of mango into Bangladesh from the countries of mango export? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.12 What steps are being taken by the PQW of DAE to prevent the entry of quarantine weeds of mango through imported mango? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**]

3.13 Give your suggestions for the better management of the weeds of mango in Bangladesh. [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

Appendix 4: Data Tables of Field Survey Study

Data Table for Pest Risk Analysis (PRA) of Mango

Table-1: Distribution of the farmers by their land size

Sl No.	Types of farmers	Number of farmers	% response
01.	Big producer	258	9.3
02.	Medium producer	1120	40.6
03.	Small producer	1115	40.4
04.	Marginal producer	267	9.7
Total		**2760**	**100.0**

Table-2: Total land under cultivation in the current year

Range	Land size (decimal)
Minimum	50
Maximum	2500
Average	418.71
SD	373.05

Table-3: Total land under mango production in the current year

Range	Land size (decimal)
Minimum	30
Maximum	2000
Average	329.14
SD	322.89

Table-4: Year of involvement in mango production

Range	Year
Minimum	1
Maximum	50
Average	10.42
SD	7.2

Table-5: Distribution of the farmers by their cultivated mango varieties

Name of the variety	Number of farmers involved in production	Avg. Land under cultivation (decimal)	Avg. Per unit production (Kg/decimal)
BARI Aam-1 (*Mahananda*)	332	44.99	65.22
BARI Aam-2 (*Nilum*)	256	55.19	79.58
BARI Aam-3 (*Aamrupali*)	2219	156.57	102.19
BARI Aam-4 (Hybird Aam)	817	134.81	96.91
Fozli	269	63.22	92.18
Langra	609	81.21	94.48
Khirshapat	200	51.22	68.74
Gopalvog	168	51.55	62.22
Lakhonvog	108	38.25	59.61
Himsagor	467	90.09	102.80
Mohonvog	35	64.11	98.74

Name of the variety	Number of farmers involved in production	Avg. Land under cultivation (decimal)	Avg. Per unit production (Kg/decimal)
Arsina	38	135.34	61.60
Kalapahari	6	12.16	81.66
Chosa Aam	9	61.66	87.22
Bombai	92	34.76	94.21
Harivanga	275	71.54	101.44
Guti Aam	64	30.95	42.09
Surjopuri	30	88.33	111.83
Rangui	223	141.92	95.84
Gourmoti	31	382.58	81.80
Multiple Answer			

Table-6: District wise incidence of major insect infestation in mango

Name of the district	Name of the insect	No. of respondent	% response
Rajshahi	Mango hopper	97	32.3
	Mango fruit fly	57	19.0
	Mango fruit weevil	60	20.0
	Mango stem borer	64	21.3
	Mango defoliator	46	15.3
	Mango fruit borer	50	16.7
	Mango leaf cutting weevil	27	9.0
	Mango shoot gall	17	5.7
	Mango leaf gall	28	9.3
	Mango mealy bug	35	11.7
	Mango leaf webber	33	11.0
	Mango flower webber	29	9.7
	Mango leaf miner	32	10.7
	Mango leaf caterpillar	32	10.7
	Eriophyid mite	22	7.3
	N	**300**	
Chapainawabganj	Mango hopper	3	1.0
	Mango fruit weevil	2	0.7
	Mango stem borer	3	1.0
	Mango shoot gall	3	1.0
	Mango leaf gall	3	1.0
	Mango mealy bug	9	3.0
	Mango leaf caterpillar	3	1.0
	N	**300**	
Naogaon	Mango hopper	155	64.6
	Mango fruit fly	150	62.5
	Mango fruit weevil	27	11.3
	Mango stem borer	18	7.5
	Mango defoliator	12	5.0
	Mango fruit borer	12	5.0
	Mango leaf cutting weevil	9	3.8

Name of the district	Name of the insect	No. of respondent	% response
	Mango shoot gall	6	2.5
	Mango leaf gall	9	3.8
	Mango mealy bug	9	3.8
	Mango leaf webber	12	5.0
	Mango flower webber	6	2.5
	Mango leaf miner	12	5.0
	Mango leaf caterpillar	6	2.5
	Eriophyid mite	27	11.3
	N	**240**	
Natore	Mango hopper	124	51.7
	Mango fruit fly	130	54.2
	Mango fruit weevil	44	18.3
	Mango stem borer	40	16.7
	Mango defoliator	8	3.3
	Mango fruit borer	20	8.3
	Mango leaf cutting weevil	8	3.3
	Mango shoot gall	16	6.7
	Mango leaf gall	12	5.0
	Mango mealy bug	12	5.0
	Mango leaf webber	12	5.0
	Mango flower webber	16	6.7
	Mango leaf miner	8	3.3
	Mango leaf caterpillar	4	1.7
	N	**240**	
Rangamati	Mango hopper	64	35.6
	Mango fruit fly	60	33.3
	Mango fruit weevil	22	12.2
	Mango stem borer	2	1.1
	Mango defoliator	10	5.6
	Mango fruit borer	14	7.8
	Mango leaf cutting weevil	32	17.8
	Mango shoot gall	16	8.9
	Mango leaf gall	24	13.3
	Mango mealy bug	6	3.3
	Mango leaf webber	12	6.7
	Mango flower webber	12	6.7
	Mango leaf miner	20	11.1
	Mango leaf caterpillar	4	2.2
	Eriophyid mite	14	7.8
	N	**180**	
Bandarban	Mango hopper	58	32.2
	Mango fruit fly	49	27.2
	Mango fruit weevil	68	37.8
	Mango stem borer	88	48.9
	Mango defoliator	37	20.6
	Mango fruit borer	48	26.7

Name of the district	Name of the insect	No. of respondent	% response
	Mango leaf cutting weevil	30	16.7
	Mango shoot gall	17	9.4
	Mango leaf gall	16	8.9
	Mango mealy bug	27	15.0
	Mango leaf webber	32	17.8
	Mango flower webber	44	24.4
	Mango leaf miner	37	20.6
	Mango leaf caterpillar	37	20.6
	Eriophyid mite	23	12.8
	N	**180**	
Khagrachhari	Mango hopper	28	23.3
	Mango fruit fly	32	26.7
	Mango fruit weevil	18	15.0
	Mango defoliator	4	3.3
	Mango fruit borer	2	1.7
	Mango leaf cutting weevil	4	3.3
	Mango shoot gall	6	5.0
	Mango leaf gall	2	1.7
	Mango mealy bug	8	6.7
	Mango leaf webber	2	1.7
	Mango flower webber	10	8.3
	Mango leaf miner	2	1.7
	Mango leaf caterpillar	2	1.7
	N	**120**	
Rangpur	Mango hopper	234	97.5
	Mango fruit fly	102	42.5
	Mango fruit weevil	60	25.0
	Mango defoliator	6	2.5
	Mango fruit borer	66	27.5
	Mango leaf cutting weevil	42	17.5
	Mango leaf gall	6	2.5
	Mango leaf caterpillar	12	5.0
	N	**240**	
Thakurgaon	Mango hopper	76	63.3
	Mango fruit fly	66	55.0
	Mango fruit weevil	28	23.3
	Mango stem borer	18	15.0
	Mango defoliator	8	6.7
	Mango fruit borer	36	30.0
	Mango leaf cutting weevil	30	25.0
	Mango leaf webber	2	1.7
	Mango flower webber	4	3.3
	Mango leaf miner	2	1.7
	Mango leaf caterpillar	8	6.7
	Eriophyid mite	8	6.7
	N	**120**	

Name of the district	Name of the insect	No. of respondent	% response
Dinajpur	Mango hopper	212	88.3
	Mango fruit fly	164	68.3
	Mango fruit weevil	36	15.0
	Mango stem borer	24	10.0
	Mango defoliator	12	5.0
	Mango fruit borer	12	5.0
	Mango leaf gall	12	5.0
	Mango mealy bug	12	5.0
	Mango leaf webber	8	3.3
	Mango leaf caterpillar	8	3.3
	Eriophyid mite	12	5.0
	N	**240**	
Jashore	Mango hopper	104	86.7
	Mango fruit fly	80	66.7
	Mango fruit weevil	64	53.3
	Mango stem borer	64	53.3
	Mango defoliator	44	36.7
	Mango fruit borer	36	30.0
	Mango leaf cutting weevil	32	26.7
	Mango shoot gall	32	26.7
	Mango leaf gall	40	33.3
	Mango mealy bug	28	23.3
	Mango leaf webber	32	26.7
	Mango flower webber	32	26.7
	Mango leaf miner	24	20.0
	Mango leaf caterpillar	44	36.7
	Eriophyid mite	24	20.0
	N	**120**	
Satkhira	Mango hopper	138	76.7
	Mango fruit fly	144	80.0
	Mango fruit weevil	6	3.3
	Mango stem borer	12	6.7
	Mango defoliator	6	3.3
	Mango fruit borer	6	3.3
	Mango leaf cutting weevil	6	3.3
	Mango leaf gall	6	3.3
	Mango leaf webber	6	3.3
	Mango flower webber	6	3.3
	N	**180**	
Chuadanga	Mango hopper	2	3.3
	Mango fruit weevil	2	3.3
	Mango stem borer	2	3.3
	Mango leaf cutting weevil	2	3.3
	Mango shoot gall	2	3.3
	Mango leaf webber	4	6.7
	Mango flower webber	4	6.7

Name of the district	Name of the insect	No. of respondent	% response
	Mango leaf miner	2	3.3
	N	**60**	
Kushtia	Mango hopper	104	86.7
	Mango fruit fly	96	80.0
	Mango fruit weevil	8	6.7
	Mango stem borer	8	6.7
	Mango defoliator	6	5.0
	Mango fruit borer	2	1.7
	Mango leaf cutting weevil	4	3.3
	Mango shoot gall	18	15.0
	Mango leaf gall	10	8.3
	Mango mealy bug	4	3.3
	Mango leaf miner	2	1.7
	N	**120**	
Meherpur	Mango hopper	86	71.7
	Mango fruit fly	12	10.0
	Mango stem borer	6	5.0
	Mango defoliator	2	1.7
	Mango fruit borer	8	6.7
	Mango leaf cutting weevil	12	10.0
	Eriophyid mite	2	1.7
	N	**120**	
	Multiple Answer		

Table-7: District wise incidence of Rodent/bird attack in mango

Name of the district	Name of the species	No. of Respondent	% response
Rajshahi	Birds	68	22.7
	Squirrel	17	5.7
	Rat	20	6.7
	N	105	**300**
Chapainawabganj	Birds	15.0	5.0
	Squirrel	6.0	2.0
	Rat	5	1.7
	N	**26**	**300**
Naogaon	Birds	3	1.3
	N	**3**	**240**
Natore	Birds	29	12.1
	Squirrel	12	5.0
	Rat	8	3.3
	N	**49**	**240**
Rangamati	Birds	2	1.1
	Squirrel	4	2.2
	Rat	6	3.3
	N	**12**	**180**
Bandarban	Birds	30	16.7

	Squirrel	6	3.3
	Rat	33	18.3
	N	**69**	**180**
Khagrachhari	Birds	18	15.0
	Squirrel	34	28.3
	Rat	28	23.3
	N	**80**	**120**
Rangpur	Squirrel	72	30.0
	N	**72**	**240**
Thakurgaon	Birds	2	1.7
	Squirrel	2	1.7
	Rat	2	1.7
	N	**6**	**120**
Dinajpur	Birds	72	30.0
	N	**72**	**240**
Jashore	Birds	84	70.0
	Squirrel	8	6.7
	Rat	24	20.0
	N		**120**
Chuadanga	Birds	2	3.3
	Squirrel	8	13.3
	N	**10**	**60**
Kushtia	Birds	4	3.3
	Squirrel	12	10.0
	N	**16**	**120**
Meherpur	Birds	26.0	21.7
	Squirrel	8.0	6.7
	Rat	12.0	10.0
	N	**46**	**120**
	Multiple Answer		

Table-8: District wise incidence of major disease infection in mango

Name of the district	Name of the disease	No. of respondent	% response
Rajshahi	Antracnose of mango	57	19.0
	Powdery mildew	49	16.3
	Malformation of mango	38	12.7
	Fruit end rot of mango	54	18.0
	Shooty mould of mango	44	14.7
	Red rust of mango	28	9.3
	Cladosporium rot	16	5.3
	Diplodia rot	22	7.3
	Dieback of mango	35	11.7
	N	**300**	
Chapainawabganj	Shooty mould of mango	3	1.0
	N	**300**	
Naogaon	Antracnose of mango	196	81.7

Name of the district	Name of the disease	No. of respondent	% response
	Powdery mildew	33	13.8
	Malformation of mango	32	13.3
	Fruit end rot of mango	21	8.8
	Shooty mould of mango	4	1.7
	Red rust of mango	13	5.4
	Cladosporium rot	6	2.5
	Diplodia rot	3	1.3
	Dieback of mango	14	5.8
	N	**240**	
Natore	Antracnose of mango	101	42.1
	Powdery mildew	8	3.3
	Malformation of mango	12	5.0
	Fruit end rot of mango	23	9.6
	Shooty mould of mango	32	13.3
	Red rust of mango	23	9.6
	Cladosporium rot	4	1.7
	Diplodia rot	4	1.7
	Dieback of mango	20	8.3
	N	**240**	
Rangamati	Antracnose of mango	62	34.4
	Powdery mildew	8	4.4
	Malformation of mango	16	8.9
	Fruit end rot of mango	48	26.7
	Shooty mould of mango	42	23.3
	Red rust of mango	26	14.4
	Cladosporium rot	12	6.7
	Diplodia rot	10	5.6
	Dieback of mango	4	2.2
	N	**180**	
Bandarban	Antracnose of mango	26	14.4
	Powdery mildew	49	27.2
	Malformation of mango	23	12.8
	Fruit end rot of mango	69	38.3
	Shooty mould of mango	46	25.6
	Red rust of mango	54	30.0
	Cladosporium rot	12	6.7
	Diplodia rot	19	10.6
	Dieback of mango	42	23.3
	N	**180**	
Khagrachhari	Antracnose of mango	14	11.7
	Powdery mildew	14	11.7
	Malformation of mango	10	8.3
	Fruit end rot of mango	6	5.0
	Shooty mould of mango	4	3.3
	Red rust of mango	16	13.3
	Dieback of mango	2	1.7

Name of the district	Name of the disease	No. of respondent	% response
	N	**120**	
Rangpur	Antracnose of mango	228	95.0
	Powdery mildew	12	5.0
	Malformation of mango	54	22.5
	Fruit end rot of mango	120	50.0
	Shooty mould of mango	108	45.0
	N	**240**	
Thakurgaon	Antracnose of mango	50	41.7
	Powdery mildew	28	23.3
	Malformation of mango	32	26.7
	Fruit end rot of mango	36	30.0
	Shooty mould of mango	14	11.7
	Red rust of mango	8	6.7
	Cladosporium rot	4	3.3
	Diplodia rot	4	3.3
	Dieback of mango	12	10.0
	N	**120**	
Dinajpur	Antracnose of mango	196	81.7
	Powdery mildew	8	3.3
	Malformation of mango	4	1.7
	Fruit end rot of mango	28	11.7
	Shooty mould of mango	4	1.7
	Cladosporium rot	4	1.7
	N	**240**	
Jashore	Antracnose of mango	72	60.0
	Powdery mildew	72	60.0
	Malformation of mango	56	46.7
	Fruit end rot of mango	48	40.0
	Shooty mould of mango	56	46.7
	Red rust of mango	36	30.0
	Cladosporium rot	24	20.0
	Diplodia rot	12	10.0
	Dieback of mango	48	40.0
	N	**120**	
Satkhira	Antracnose of mango	90	50.0
	Powdery mildew	30	16.7
	Malformation of mango	18	10.0
	Fruit end rot of mango	12	6.7
	Shooty mould of mango	24	13.3
	Red rust of mango	18	10.0
	Cladosporium rot	6	3.3
	Diplodia rot	6	3.3
	Dieback of mango	12	6.7
	N	**180**	
Chuadanga	Powdery mildew	2	3.3
	Malformation of mango	2	3.3

Name of the district	Name of the disease	No. of respondent	% response
	Red rust of mango	6	10.0
	Dieback of mango	4	6.7
	N	**60**	
Kushtia	Antracnose of mango	90	75.0
	Powdery mildew	50	41.7
	Malformation of mango	8	6.7
	Fruit end rot of mango	12	10.0
	Shooty mould of mango	14	11.7
	Red rust of mango	16	13.3
	Diplodia rot	2	1.7
	Dieback of mango	10	8.3
	N	**120**	
Meherpur	Antracnose of mango	70	58.3
	Powdery mildew	6	5.0
	Fruit end rot of mango	12	10.0
	Shooty mould of mango	6	5.0
	Dieback of mango	6	5.0
	N	**120**	
	Multiple Answer		

Table-9: District wise incidence of major weed problem in mango

Name of the district	Name of the disease	No. of Respondent	% response
Rajshahi	Cynodon dactylon	54	18.0
	Cyperus rotundus	22	7.3
	Dodder plant	4	1.3
	Loranthus	14	4.7
	N	**300**	
Chapainawabganj	Cynodon dactylon	8	2.7
	Cyperus rotundus	2	0.7
	Dodder plant	13	4.3
	Loranthus	2	0.7
	N	**300**	
Naogaon	Cynodon dactylon	31	12.9
	Cyperus rotundus	15	6.3
	Loranthus	9	3.8
	N	**240**	
Natore	Cynodon dactylon	34	14.2
	Dodder plant	4	1.7
	N	**240**	
Rangamati	Cynodon dactylon	8	4.4
	Cyperus rotundus	2	1.1
	Dodder plant	2	1.1
	N	**180**	
Bandarban	Cynodon dactylon	17	9.4
	Cyperus rotundus	5	2.8
	Loranthus	2	1.1

Name of the district	Name of the disease	No. of Respondent	% response
	N	180	
Khagrachhari	Cynodon dactylon	12	10.0
	Cyperus rotundus	2	1.7
	Dodder plant	6	5.0
	N	120	
Rangpur	Cynodon dactylon	174	72.5
	Cyperus rotundus	12	5.0
	N	240	
Thakurgaon	Cynodon dactylon	24	20.0
	N	120	
Dinajpur	Cynodon dactylon	68	28.3
	N	240	
Jashore	Cynodon dactylon	12	10.0
	Dodder plant	8	6.7
	Loranthus	8	6.7
	N	120	
Satkhira	Cynodon dactylon	30	16.7
	Cyperus rotundus	12	6.7
	Dodder plant	6	3.3
	N	180	
Chuadanga	Cyperus rotundus	4	6.7
	Loranthus	4	6.7
	N	60	
Kushtia	Cynodon dactylon	6	5.0
	N	120	
Meherpur	Cynodon dactylon	36	30.0
	Loranthus	2	1.7
	N	120	
	Multiple Answer		

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