Plant Quarantine Wing
Department of Agricultural Extension, Ministry of Agriculture
Government of the People's Republic of Bangladesh

Final Report

Pest Risk Analysis (PRA) of *Citrus medica* (Zara Lemon Variety) in Bangladesh

NOVEMBER 2023

BANGLADESH TRADE FACILITATION

Bangladesh Trade Facilitation Project
Concord Bilkis Tower
40/6 Madani Avenue, Gulshan 2, Dhaka-1212, Bangladesh
Website: https://btfproject.org/

Panel of Authors

Contributors to PRA of *Citrus medica* (Zara/Colombo Lemon Varieties) in Bangladesh

Team Members	Position in the Panel
1. Prof. Dr. Md. Razzab Ali Department of Entomology Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh	Team Leader cum Entomologist
2. Prof. Dr. F. M. Aminuzzaman Department of Plant Pathology Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh	Plant Pathologist
3. Dr. Md. Saleh Ahmed	Horticulturist
4. Dr. Sumon Saha Associate Consultant and Senior Manager Development Technical Consultants Pvt. Ltd Gulshan-1, Dhaka, Bangladesh	Entomologist
5. Mr. Md. Abul Hossain Director Development Technical Consultants Pvt. Ltd (DTCL) Gulshan-1, Dhaka, Bangladesh	Chief Coordinator

DTCL

Development Technical Consultants Pvt. Ltd (DTCL)
ISO Certification: 9001:2015
JB House, Plot-62, Road-14/1, Block-G, Niketon, Gulshan -1, Dhaka-1212, Bangladesh
Website: www.dtcltd.com

MESSAGE

It is great pleasure to know that Bangladesh Trade Facilitation (BTF) Project funded by United States Department of Agriculture (USDA) has conducted a time demanding study on "Pest Risk Analysis (PRA) of *Citrus medica* (*Zara*/*Colombo Lebu* variety) in Bangladesh". The *Zara*/*Colombo Lebu* export growth from Bangladesh is still very insignificant when the country holds enormous potential producer of *Zara*/*Colombo Lebu*. But the Pest Risk Analysis (PRA) of *Citrus medica* (*Zara/Colombo Lebu* varieties) is the prerequisite for exporting *Zara/Colombo Lebu* to foreign markets. However, the findings of this study will play an important role in increasing the export quantity of *Zara/Colombo Lebu* from Bangladesh by fulfilling the phytosanitary requirement to the importing countries in the world. Under the strong and visionary leadership for trade facilitation of agricultural products from Bangladesh to the potential markets of the world, Bangladesh Trade Facility (BTF) Project has undertaken measures and initiatives to conduct the "PRA of *Citrus medica* in Bangladesh" that will enhance the exports of quality *Zara/Colombo Lebu* 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 *Zara/Colombo Lebu* internationally that will contribute to the national economy of the country through export-earning.

It is expected that the report will contribute immensely to the buyer countries in the world who are interested to import *Citrus medica* (*Zara* and *Colombo Lebu* varieties) from Bangladesh. This report will also help and understanding the status of pests of *Zara* and *Colombo Lebu* 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 *Zara/Colombo Lebu* trade facilitation.

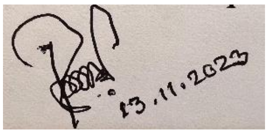
13.11.2023

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

MESSAGE

I am pleased to know that the Land O'Lakes Bangladesh Trade Facilitation (BTF) Project funded by United States Department of Agriculture (USDA) has conducted the "Pest Risk Analysis (PRA) of *Citrus medica* (*Zara* /*Colombo Lebu* variety) 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), Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh 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 *Citrus medica* (*Zara* /*Colombo Lebu* variety) in Bangladesh' taken by Bangladesh Trade Facilitation (BTF) Project will fulfill the phytosanitary requirement of the buyer countries of the world to import *Citrus medica* (*Zara* /*Colombo Lebu* variety) from Bangladesh.

I hope that this PRA report will help the exporters to take initiative in exporting quality *Zara* /*Colombo Lebu* 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 *Zara* /*Colombo Lebu* variety in Bangladesh and will help in decision making at port-of-entry in Bangladesh during export-import of *Zara* /*Colombo Lebu* variety. I look forward to the proper use of the present PRA findings for the effective performance in the arena of trade facilitation worldwide for *Zara* /*Colombo Lebu* as well as for further export-earning in Bangladesh.



(Dr. Md. Rezaul Karim)
Director
Plant Quarantine Wing
Department of Agriculture Extension
Ministry of Agriculture
Khamarbari, Dhaka, Bangladesh

FORWARD

The U.S. Department of Agriculture, Bangladesh Trade Facilitation (BTF) completed a study on "**Pest Risk Analysis (PRA) of *Citrus Medica* (Zara/Colombo Lebu) in Bangladesh"** in support of the Government of Bangladesh's initiatives to expand export of agricultural products. BTF contracted with Development Technical Consultants Pvt. Ltd. (DTCL), which conducted the PRA study over a six-month period commencing in March 2023.

The objectives of the PRA for Zara/Colombo lemon are to identify the pests impacting *Citrus Medica* in Bangladesh, (ii) to assess the risks of quarantine pests, and (iii) to identify risk management options. For this purpose, DTCL conducted field investigations in 13 Upazilas covering four major Zara/Colombo Lebu growing districts of Bangladesh. The PRA team also studied secondary information related to relevant pests of Zara/Colombo Lebu.

The PRA findings identified 26 arthropod pests, 32 diseases and three weeds. The study also identified 15 quarantine pests, including seven insect pests, three mite pests, one fungal, two bacterial, and two viral diseases that could potentially be introduced into Bangladesh through imported citrus. Based on the risk assessment and risk rating following relevant ISPMs, among 15 quarantine pests, two pests were rated as high-risk potential, one pest as medium risk, one pest as low-risk, and one pest was remarked as uncertain level of risk. DTCL provided risk management options for these quarantine pests in line with pre- and post-harvest management and phytosanitary measures consistent with the ISPMs. The findings of the PRA were validated at a national level workshop organized by BTF and the Plant Quarantine Wing.

I commend DTCL for completing the PRA study successfully and thank the Department of Agriculture Extension (DAE) and PQW for making the collaborative endeavor a success. BTF extends our special appreciation to the quarantine and other DAE officials and to lemon exporters for strong cooperation. Special thanks to the Secretary and Additional Secretary (Extension), Ministry of Agriculture; Director General, Department of Agriculture Extension; and Director, Plant Quarantine Wing for providing valuable advice and guidance.

I hope that this PRA report significantly contributes to enhance the exports of *Citrus medica* (*Zara/Colombo Lebu* variety) from Bangladesh by fulfilling the requirement of buyer countries in the world.

(Michael J. Parr)
Project Director
Bangladesh Trade Facilitation Project

Acronyms

AEZ	:	Agro-Ecological Zone
BARI	:	Bangladesh agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
BTF	:	Bangladesh trade facilitation project
CABI	:	Center for Agriculture and bio-Sciences International
DAE	:	Department of Agricultural Extension
DD	:	Deputy Director
DG	:	Director General
Dr.	:	Doctor
DTCL	:	Development Technical Consultants Private Limited
EPPO	:	European and Mediterranean Plant Protection Organization
et al.	:	and associates
EU	:	European Union
FAO	:	Food and Agriculture Organization
FAOSTAT	:	Food and Agriculture Organization Statistics
FGD	:	Focus Group Discussion
GoB	:	Government of Bangladesh
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

Executive Summary

The study "Pest Risk Analysis (PRA) of *Citrus medica* (Zara/ lemon) in Bangladesh" documents consist of the pests of Zara or Colombo lebu (Local Name) available in Bangladesh and the risks associated with the import pathway of citrus from the exporting countries namely India, Bhutan, China, Pakistan, Thailand, Australia, Egypt, South Africa, Brazil and USA into Bangladesh. The major objectives of the study included recording of major and minor insect pests, diseases, weeds or other pests, with label of infestation and economic impacts.

The study was done including several approaches such as face-to-face interview with Zara/Colombo lebu growers, Focus Group Discussion (FGDs) with farmers, Key Informant Interviews (KIIs) with different stakeholders, scanning of reports and internet searching. The survey study was conducted in the 4 major Zara/Colombo Lemongrowing districts of Bangladesh as selected by the client. A total of 13 upazila under 4 selected Zara/Colombo Lemongrowing districts were covered as PRA areas, where two unions for each upazila and 20 Zara/Colombo Lemon growers for each union were selected for face-to-face interview. Thus, a total of 520 Zara/Colombo Lemon growers were interviewed through a pre-designed structured questionnaire from all of 4 sampled districts. In addition of quantitative survey, to get the qualitative information, a total of 4 focus group discussion (FGD) meetings was also conducted considering one FGD for each of 4 sampled districts with the participation of at least 10 Zara/Colombo Lemon growers for each FGD to gather qualitative data regarding pests of Zara/Colombo Lemon available in Bangladesh. Besides, one officer designated as Additional Deputy Director (Plant Protection) from each of 4 Zara/Colombo Lemongrowing districts and one Upazila Agricultural Officer (UAO) of DAE from each of 13 sampled upazila, three quarantine officials of DAE including Quarantine Pathologist of Plant Quarantine Center at Hazrat Shahjalal International Airport and central packaging house, Dhaka, Bangladesh Fruits, Vegetables & Allied Products Exporter's Association (BFVAPEA), and two entomologists and two plant pathologists were also interviewed using semi-structured key informant interview (KII) checklists.

A total number of 26 arthropod pests of *Citrus medica* (Zara/Colombo Lemon variety) were recorded in Bangladesh as reported by the Zara/Colombo lemon growers and relevant experts collected through field survey as well as collected through literature review. Among these 26 arthropod pests, 16 were identified through field survey and the rest 10 were identified through literature review. As per field survey-based data, it was revealed that the incidence of sixteen (16) arthropod pests of *Citrus medica* (Zara/Colombo Lemon varieties) were identified, of which fifteen (15) were insect pests and one was mite pest. Among fifteen (15) insect pests those recorded for Bangladesh were lemon butterfly (*Papilio demoleus, Papilio polytes)*, citrus leaf miner *(Phyllocnistis citrella)*, citrus leaf roller (*Psorosticha zizyphi*), citrus stem borer (*Chelidonium cinctum*), citrus mealybug (*Planococcus citri*), Asian citrus psyllid bug (*Diaphorina citri*), citrus blackfly (*Aleurocanthus woglumi*), citrus greenhouse whitefly (*Trialeurodes vaporariorum*), black citrus aphid (*Toxoptera citricida*), green citrus aphid (*Aphis spiraecola*), citrus soft scale (*Coccos hesperidum*), citrus green stink bug (*Nezara viridula*), citrus thrips (*Scirtothrips dorsalis*), citrus fire ant (*Solenopsis invicta*), and termite (*Odontotermes obesus*). As per field survey-based primary data, it was also revealed that the

citrus red spider mite (Panonychus citri) of Zara/Colombo Lemon was recorded for Bangladesh. Based on the literature review, it was revealed that a total of ten (10) insect pests of *Citrus medica* were recorded for Bangladesh and these were fruit sucking moth (*Othreis* spp.), orange spined bug (*Biprorulus bibax*), citrus bug (*Rhynchocoris humeralis*), citrus whitefly (*Dialeurodes citri*), striped mealybug (*Ferrisia virgata*), citrus red scale (*Aonidiella aurantia*), citrus yellow scale (*Aonidiella citrina*), flower thrips (*Frankliniella schultzei*), bark and stem borer (*Indarbela quadrinotata*) and Oriental fruit fly (*Bactrocera dorsalis*). Among the identified insect pests, lemon butterfly, leaf miner, citrus thrips and citrus aphids were reported more damaging than other insect pests and these insects were designated as major insect pests of *Citrus medica* (Zara/Colombo Lemon variety) and caused damage with high infestation intensity.

Two mollusk pests were reported by the Zara/Colombo Lemon growers during the field survey, and these were grey garden slug (*Deroceras reticulatum*) and brown garden snail (*Cornu aspersum*). Both pests were designated as minor pest with low infestation intensity.

A total number of 33 diseases of *Citrus medica* (Zara/Colombo Lemon variety) were recorded in Bangladesh as reported by the Zara/Colombo lemon growers and relevant experts collected through field survey as well as collected through literature review. Among these 33 diseases, 13 diseases identified through field survey and the rest 20 diseases were identified through literature review. As per field survey-based data, it was revealed that the incidence of thirteen (13) diseases of *Citrus medica* (Zara/Colombo Lemon variety) were identified, of which eleven (11) were fungal diseases and another two (2) diseases were caused by bacteria. The fungal diseases of were anthracnose (*Colletotrichum gloeosporioides*), die-back (*Fusarium solani* and *Phomopsis citri*), gummosis (*Phytopthora citrophthora*), scab (*Elsinoe fawcettii*), sooty mould (*Capnodium citri*), pink disease (*Botryobasidium salmonicolor*), powdery mildew (*Oidium citri*), citrus wilt (*Fusarium* spp.), black spot (*Phyllosticta citricarpa*) and melanose (*Diaporthe citri*). The bacterial diseases of Zara/Colombo lebu varieties identified through field survey were canker (*Xanthomonas axonopoides* pv. *citri*) and citrus greening (*Candidatus liberibacter asiaticus*). A total of twenty (20) diseases of *Citrus medica* (Zara/Colombo Lebu varieties) were identified, of which eight (8) were fungal diseases, two (2) were viral diseases and rest 10 diseases were caused by nematodes. The fungal diseases of were blue/green mold (*Penicillium* sp.), damping off (*Pythium* sp. and *Rhizoctonia solani*), black mold (*Aspergillus niger*), foam disease (unknown), fruit rot (*Fusarium* sp.), bark rot (*Melanomma citricola*) and stem-end-rot (*Lasiodiplodia pseudotheobromae*). The recorded viral diseases were Tristeza (*Citrus tristeza virus*) and Psorosis (*Citrus psorosis virus*). Ten (10) diseases of Zara/Colombo Lebu varieties identified through literature review were root lesion (*Criconemoides* sp.), stem injury (*Ditylenchus dipsaci*), root decay (*Helicotylenchus* sp.), root lesion (*Hoplolaimus indicus*), root lesion (*Radopholus similis*), root lesion (*Pratylenchus* spp.), root injury (*Hoplotylus* spp.), root decay (*Tylenchus semipenetrans*), root decay (*Xiphinema* spp.) and discoloration (*Tylenchorhynchus* sp.). Among the identified diseases, four fungal diseases such as anthracnose, die-back, gummosis, scab and two bacterial disease such as citrus greening and citrus canker were reported more damaging than other diseases and these diseases were designated as major diseases of *Citrus medica* (Zara/Colombo Lemon variety) those caused damage with high infection intensity. But canker was only designated as major disease of Zara Lemon, but never caused disease on Colombolemon, i.e., the Colombo Lemon is resistant against citrus canker (*Xanthomonas campestris* pv. *citri*).

A total number of three (3) weeds were reported as the problem in the field of Zara/Colombo lemon in Bangladesh those were identified through field survey. The enlisted weeds were asthma weed (*Euphorbia hirta*), sensitive plant (*Mimosa pudica*) and Dove weed (*Murdannia nudiflora*).

Information on pests associated with citrus in the exporting countries—India, Bhutan, China, Egypt, Thailand, Pakistan, South Africa, USA, Australia, etc—reveal that pests of quarantine importance exist. The study also revealed fifteen (15) species of quarantine pests of citrus for Bangladesh were identified those were present in the above-mentioned exporting countries but not in Bangladesh. Among these 15 species of quarantine pests, 7 were insect pests, 3 were mite pests, 1 was fungi, 2 were bacteria and 2 were virus. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced citrus. The quarantine insect pests are Citrus longhorn beetle (*Anoplophora chinensis*), Citrus weevil (*Diaprepes abbreviates*), African citrus psyllid (*Trioza erytreae*), Mediterranean fruit fly/Medfly (*Ceratitis capitate*), Queensland fruit fly (*Bactrocera tryoni*), South African citrus thrips (*Scirtothrips aurantia*) and California Citrus thrips (*Scirtothrips citri*). The quarantine mite pests are Citrus rust mite (*Phyllocoptruta oleivora)*, Citrus bud mite *(Aceria sheldon)* and Lewis spider mite (*Eotetranychus lewisi*).

On the other hand, five (5) disease causing pathogens have been identified as quarantine pests of citrus for Bangladesh. Among the disease-causing quarantine pathogens 1 is fungus named Greasy spot (*Mycosphaerella citri*), 2 are bacteria named Citrus variegated chlorosis (*Xylella fastidiosa* subsp. *Pauca*) and Citrus stubborn (*Spiroplasma citri*) and 2 are virus named Citrus exocortis (*Citrus exocortis viroid*) and Indian citrus ringspot virus (*Indian citrus ringspot virus*).

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 15 quarantine pests associated with the pathway risk assessed. Out of 15 potential hazard organisms, 12 hazard organisms were identified with high-risk potential, 1 moderate, 1 low and 1 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 citrus leaf miner, Citrus thrips and citrus canker, is crucial for protecting citrus 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 citrus industry and specific phytosanitary measures are strongly recommended. While for moderate risk potential pest, specific phytosanitary measures may be necessary to reduce pest risk.

Table of Contents

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 identified as Invasive Alien Species (IAS) are prevailing in the world where Bangladesh is exclusively free from most of these pests. But Bangladesh is 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, Bangladesh is at the highest risk of entering those destructive pests because these are usually brought in along with imported agricultural commodities. On the contrary Bangladesh has successfully entered into the highly competitive international export market through which Bangladesh is earning a good amount of valuable foreign currency through exporting 10-12 lakhs metric tons of agricultural products. Bangladesh is one of the major Zara/Colombo Lemon (*Citrus medica*) producing countries. The principal producing countries of the world are Algeria, Australia, Argentina, Brazil, China, Cyprus, Greece, India, Israel, Italy, Japan, Lebanon, Mexico, Morocco, South Africa, Spain, Egypt, Tunisia, Turky, U.A.E., U.S.A., etc. The climate of Bangladesh is very congenial to the year-round production of citrus. World annual production of citrus fruits in 2021 was 161.0 million metric ton (MT). Total production in Asia was 78.67 MT, which is the highest compared to the production in other continents. In Bangladesh, the total acreage under citrus fruits in the fiscal year 2020-21 is about 162,242.69 acre while the total production is around 181,604.46 MT (BBS, 2021[2]). Zara/Colombo Lemon is the leading seasonal high value cash crop of the Sylhet and Narshingdi districts of Bangladesh and playing role in exporting earning. However, the agriculture office does not have precise information on the amount of Zara/Colombo Lebu produced in the districts annually. The *Citrus medica* (Zara/Colombo Lebu

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

[2] BBS. 2022. Yearbook of Agricultural Statistics of Bangladesh, 2021. Bangladesh Bureau of Statistics, Ministry of Planning, Bangladesh.

varieties) are exporting from Bangladesh mainly to Europe. The countries of European Union, Gulf region such as Kuwait, Saudi Arabia, UAE and Qatar are potential markets for Zara/Colombo lebu of Bangladesh (Anonymous, 2021[3]).

According to TRIDGE (2023), about 183.77 MT of lemon was exported from Bangladesh in 2021 and the export value of Bangladesh for lemon was 459.7 thousand USD. By exporting lemon to the world market, production can be increased. The significant increase of *Citrus medica* (Zara/Colombo Lemon) exports from Bangladesh can be achieved by taking effective steps by the country's regulators, lemon producers and exporters. To increase the lime export as having Bangladesh's potential, however, regulators must have to provide mindful attention to conduct Pest Risk Analysis of *Citrus medica* (Zara/Colombo Lemons) in Bangladesh, a prerequisite for exporting *C. medica* to foreign markets.

The introduction of insect pests, plant diseases and weeds are brought about mainly during the accelerated agricultural development in different countries, when plants and plant materials are brought into, or sent out with little or no concern for the insect pests, diseases and weeds that are 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 agriculture of importing countries from entering IAS by imported commodities as well as maintain and develop the market access by fulfilling the importing countries' requirement, PRA is most essential. Considering this situation, the project has taken initiative to conduct PRA of *Citrus medica* (Zara/Colombo Lemon) in Bangladesh.

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)[4] and is defined within the glossary of phytosanitary terms (FAO, 2015)[5] 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.

---

[3] Anonymous. 2021. Diagnostic Studies. Bangladesh Regional Connectivity Project-1 (BRCP-1). Ministry of Commerce, Government of Peoples Republic of Bangladesh.

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

[5] 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)[6]. A key principle of the IPPC is that contracting parties (signatories) provide 'technical justification' to support phytosanitary decision-making affecting trade (FAO, 2002)[7]. 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)[8], ISPM 11, Pest risk analysis for quarantine pests (FAO, 2013)[9] and ISPM 21, Pest risk analysis for regulated non-quarantine pests (FAO, 2004)[10].

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 and 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 as well as to assist in identifying appropriate management options.

1.3. Scope of the Pest Risk Analysis

The scope of pest risk analysis of Zara/Colombo Lebu in Bangladesh is to find out the potential hazard organisms like insect and mite pests, diseases and other pests associated with different citruses that are imported from different exporting countries such as India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. (DAE, 2023). 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 Zara/Colombo Lebu in Bangladesh is to conduct Pest Risk Analysis (PRA) on Zara/Colombo Lebu and categorize risk as high, medium, low and minimum and determine of an organism as a pest; create list of regulated pests of Zara/Colombo Lebu for the purpose of import regulation; recommend appropriate pest risk

---

[6] 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.
[7] FAO (2002). Guide to the International Plant Protection Convention (IPPC). FAO, Rome, 20 pp.
[8] FAO (2007) ISPM No. 2: Framework for pest risk analysis, FAO Rome, 35 pp.
[9] FAO (2013) ISPM No. 11: Pest risk analysis for quarantine pests, FAO Rome, 26 pp.
[10] FAO (2004) ISPM No. 21: Pest risk analysis for regulated non-quarantine pests, FAO Rome18pp.

management options in line with ISPM No. 11 in the framework of ISPM No. 2 and getting approval from the concerned authority. The study is required to identify the pests, pathway/s, evaluate their risk, endangered areas, and risk management options, etc.

For the total assessment and analysis, the following activities need to undertake for the Pest Risk Analysis of Zara/Colombo Lebu in Bangladesh (according to ISPM No. 11 and ISPM No. 21 in the framework of ISPM No. 2) are:

- To specify the area, need to do PRA with scientific evidence.
- Identification of pest and pathogen in the country and the neighboring countries with distribution information,
- Categorization the major and minor insect pests, diseases, weeds or other pests, with label of infestation and economic impacts,
- To evaluate the probability of introduction and spread of pests and potential economic consequence in the specific area,
- Identification of pathway for the pests and pathogens that may be considered for pest risk assessment,
- Cover the total PRA structure such as initiation, pest risk assessment and pest risk management,
- Align the test information as appearing in ISPM No. 3: Guidelines for export, shipment, import and release of biological control agents and other beneficial organisms (FAO, 2005)[11], ISPM No. 11: Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms (FAO, 2013)[12], ISPM No. 21: Pest risk analysis for regulated non-quarantine pests (FAO, 2004)[13] for conceptual development,
- List down the biological control agents and other beneficial organism,
- Develop specific guideline on PRA of quarantine pest, regulated non-quarantine pest, biological control agents and other beneficial organisms,
- List out the socio-demographic factors and their influences on lemon cultivators on accepting pest management practices,
- The analysis of responsibility of agricultural extension agents for enhancing farmers' knowledge on integrated pest control and improve expertise in lemon cultivation for export purpose and recommendations for PRA institutionalization in the DAE, and
- Role of the government to estimate the likelihood of establishment of a pest together with the environment affecting pest survival.

1.5. PRA Areas

The entire Bangladesh is considered as the PRA area in this risk analysis. But the Zara/Colombo Lebu are not grown all over Bangladesh. Therefore, the major Zara/Colombo Lebu growing districts such as Sylhet, Narshingdi, Moulovibazar and Tangail districts of Bangladesh are considered as the PRA area in this Pest Risk Analysis Process. Moreover, the different citruses and/or saplings of citrus are imported through different air, sea and land ports which are located

[11] FAO (2005). ISPM No. 3: Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms, 2005, FAO, Rome.
[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.

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 Zara/Colombo Lebu was done in major Zara/Colombo Lebu growing districts of Bangladesh as well as ports through which Zara/Colombo Lebu/saplings 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 Zara/Colombo Lebu. The process and methodology for undertaking import risk analyses are shown in Figure 1.

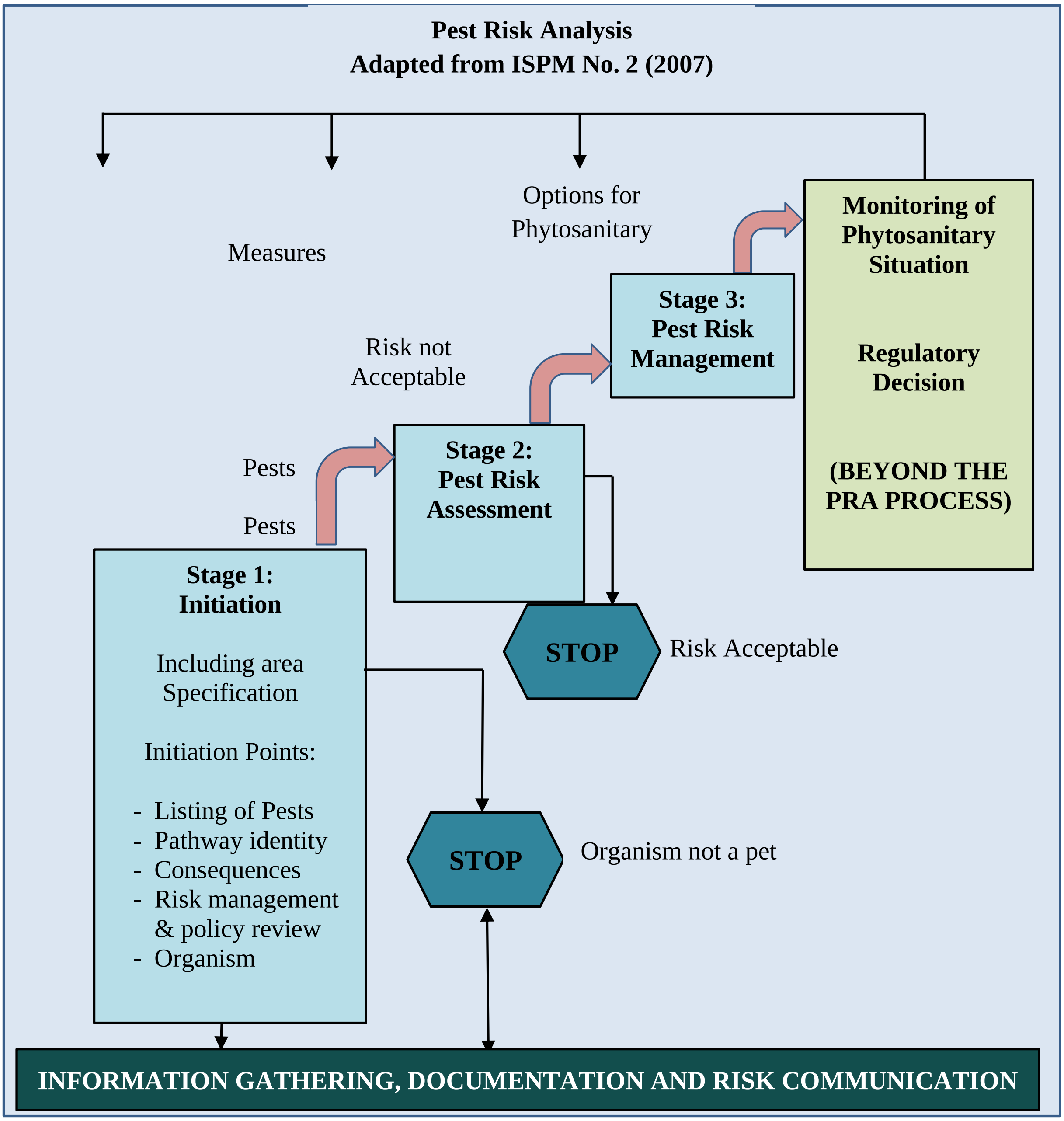


Figure-1.1: Schematic Diagram of Pest Risk Analysis Process

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 Zara/Colombo Lebu, 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 Zara/Colombo Lebu 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 Zara/Colombo Lebu 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 Zara/Colombo Lebu in Bangladesh. The most appropriate tools used in this field study were structured questionnaire for direct interview of Zara/Colombo Lebu growers, FGD guidelines, KII checklists for DAE personnel, quarantine personnel, Zara/Colombo Lebu 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 field survey was conducted with the direct interview of 520 Zara/Colombo Lebu growers in thirteen (13) upazila under four (4) major Zara/Colombo Lebu growing districts of Bangladesh for quantitative data collection aiming to identify insect and mite pests, diseases, weeds and other pests of Zara/Colombo Lebu, their damaging status including incidence and severity, and management options.

1.7.2.2. Qualitative Field survey: In addition of quantitative data collection, qualitative data were also collected through qualitative survey by means of focus group discussions (FGD) with Zara/Colombo Lebu growers and key informant interviews (KII) with extension personnel at field and headquarter level of DAE, Plant Quarantine Officials at port of entry, Zara/Colombo Lebu exporters and importers, Entomologists and Plant Pathologists of Agricultural Research Organizations and Agricultural Universities, etc. The activities of FGD sessions in Zara/Colombo Lebu growing districts as well as KII related activities are shown in the following photographs:

Following photographs showing FGD related activities in Zara/Colombo Lebu growing areas

Plate-1.2: Farmers' level FGD session conducted at Borolekha upazila under Moulovibazar district

Plate-1.2: Farmers' level FGD session conducted at Ghatail upazila under Tangail district

Plate-1.3: Farmers' level FGD session conducted at Monohordi upazila under Narshingdi district

Plate-1.4: Farmers' level FGD session conducted at Goyanghat upazila under Sylhet district

Following photographs showing KII related activities done at different level

Plate-1.5: PRA team conducted KII with Upazila Agriculture Officer of Jaintapur, Sylhet

Plate-1.6: KII with Scientist of Citrus Research Center, BARI at Jaintapur, Sylhet

Plate-1.7: PRA team conducted KII with Ditrict Training Officer at DD Office of Sylhet

Plate-1.8: PRA team visited Office of the Metropolitan Agriculure Officer of Sylhet to conduct KII with respective Officer

Plate-1.9: PRA team conducted KII with Upazila Agriculture Officer (UAO), Monohordi upazila under Narshingdi ditrict

Plate-1.10: PRA team member conducted KII with Upazila Agriculture Officer (UAO), Modhupur upazila under Tangail ditrict

Plate-1.11: PRA team member conducted KII with Quarantine Pathologist at Hazral Shahjalal International Airport, Dhaka

Plate-1.12: PRA team member conducted KII with Additional Deputy Director, Central Packing House, Plant Quarantine Wing, DAE at Shampur, Dhaka

Plate-1.13: PRA team member conducted KII with Advisor of Bangladesh Fruits, Vegetabes and Alied Products Exporters' Association, Motijheel, Dhaka

Plate-1.14: PRA team member conducted KII with Upazila Agriculture Officer (UAO), Ghatail upazila under Tangail ditrict

1.7.2.3. Field visit and observation: Experts of the PRA study team physically visited the 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 Zara/Colombo Lebu at field level and recorded the information as required for this study.

Following photographs showing PRA study related field visit and observation activities done at different stakeholders' level

Plate-1.15: Visit of Zara/Colombo Lebu farmers' field by PRA study team members at Borolekha under Moulovibazar district

Plate-1.16: Field visit and observation done by PRA study team members at Goyanghat upazila under Sylhet district

Plate-1.17: Visit of Zara/Colombo Lebu farmer's field by PRA study team at Jaintapur, Sylhet

Plate-1.18: Visit of Zara/Colombo Lebu farmer's field by PRA study team at Goyanghat, Sylhet

Plate-1.19: Experts' visit of Research field at Citrus Research Center, BARI, at Jaintapur upazila under Sylhet district

Plate-1.20: Expert's visit in the citrus field at Citrus Research Center, BARI at Jaintapur under Sylhet district

Plate-1.21: Zara Lebu field inspection by expert member of PRA team at Goyanghat under Sylhet district

Plate-1.22: Farmers' field visit by expert members of PRA team at Jaintapur under Sylhet district

Plate-1.23: Experts' visit in the farmer's Colombo Lemon field at Monohordi Upazila under Narshingdi district

Plate-1.24: Expert's visit in the farmer's Colombo Lemon field at Shibpur Upazila under Narshingdi district

Plate-1.25: Expert's visit in the farmer's Colombo Lemon field at Modhupur upazila under Tangail district

Plate-1.26: Experts' visit in the farmer's Zara Lemon field at Jaintapur upazila under Sylhet district

Plate-1.27: Expert's visit and observation of packing activities of Zara Lemon at Central Packing House at Shampur, Dhaka

Plate-1.28: Washing of Zara Lemons using 2.3% Sodium Ortho-Phenylphenate at Central Packing House at Shampur, Dhaka

1.7.2.4. Secondary data collection and 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 Zara/Colombo Lemon available in the country of Zara/Colombo Lemon exports to Bangladesh namely India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. as well as to get the information regarding PRA related activities performed there. Ultimately, study team formulated all this synthesized information based on the requirement of the current PRA.

1.7.2.5. Listing of pests of Zara/Colombo Lemon

The insect and mite pests, diseases, weeds and other pests associated Zara/Colombo Lemon 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 Zara/Colombo Lemon 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 Zara/Colombo Lebu for Bangladesh were also listed.

1.7.3. PRA location and study sampling

The survey study was conducted in the 4 major Zara/Colombo Lemon growing districts of Bangladesh as selected by the client. A total of 13 upazila under 4 selected Zara/Colombo Lemon growing districts were covered as PRA areas, where two unions for each upazila and 20 Zara/Colombo Lemon growers for each union were selected for face-to-face interview. Thus, a total of 520 Zara/Colombo Lemon growers were interviewed through a pre-designed structured questionnaire from all of 4 sampled districts. The district and upazila-wise distribution of respondents are given below:

Table-1.1: Distribution of the respondents in major Zara/Colombo Lebu growing districts of Bangladesh

Sl. No.	District	No. of upazila	No. of union	No. of village	No. of farmers per district
1.	Sylhet	Gowainghat	2	2	10
		Jointiapur	2	2	10
		Beanibazar	2	2	10
2.	Moulavibazar	Juri	2	2	10
		Barlekha	2	2	10
		Kulaura	2	2	10
		Sreemangal	2	2	10
3.	Narshingdi	Monohardi	2	2	10
		Raipura,	2	2	10
		Shibpur	2	2	10

Sl. No.	District	No. of upazila	No. of union	No. of village	No. of farmers per district
4.	Tangail	Shakhipur	2	2	10
		Madhupur	2	2	10
		Ghatail	2	2	10
Total		13	26	52	520

In addition of quantitative survey, to get the qualitative information, a total of 4 focus group discussion (FGD) meetings was also conducted considering one FGD for each of 4 sampled districts with the participation of at least 10 Zara/Colombo Lebu growers for each FGD to gather qualitative data regarding pests of Zara/Colombo Lemon available in Bangladesh. Besides, one officer designated as Additional Deputy Director (Plant Protection) from each of 4 Zara/Colombo Lemon growing districts and one Upazila Agricultural Officer (UAO) of DAE from each of 13 sampled upazila, three quarantine officials of DAE including Quarantine Pathologist of Plant Quarantine Center at Hazrat Shahjalal International Airport, Dhaka, two Zara/Colombo Lemon exporters and two citrus importers, and two entomologists and two plant pathologists were also interviewed using semi-structured key informant interview (KII) checklists.

The distribution of Zara/Colombo Lemon producers as selected for interview in the present PRA study is shown in the GIS Map of Bangladesh as follows:

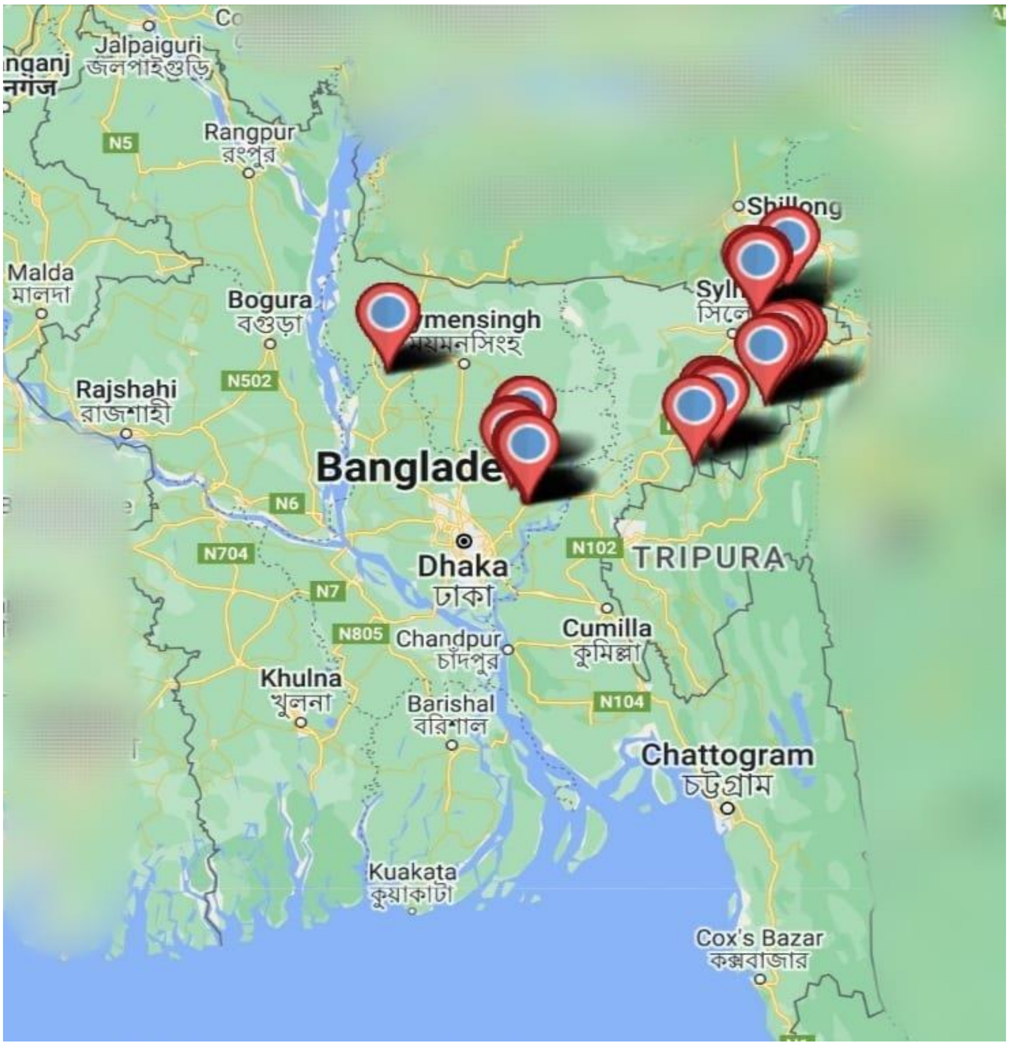


Figure-1.2. GIS Map of Bangladesh showing the plotting of Zara and Colombo Lemon Producers participated as respondeds in the PRA study

The district-wise distribution of Zara/Colombo Lemon producers as selected for interview in the present PRA study is shown in the map of selected four districts as follows:

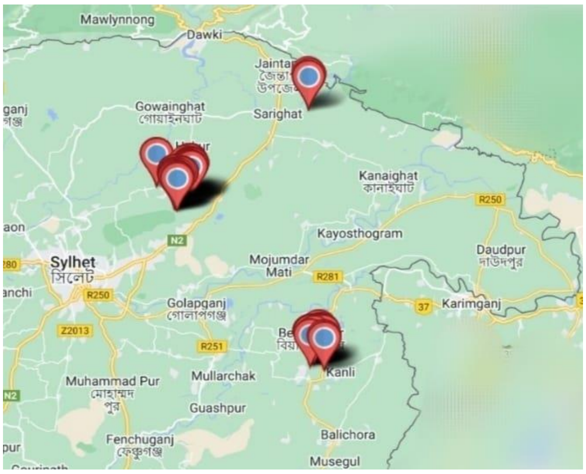


Figure-1.3: GIS Map of the Zara and Colombo Lemon Producers participated in the PRA study under Sylhet district

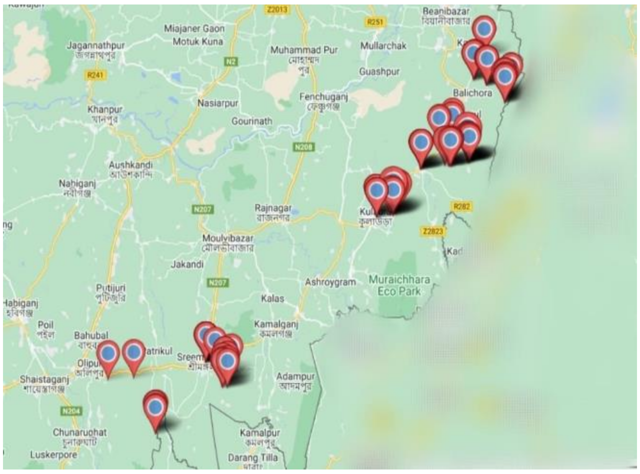
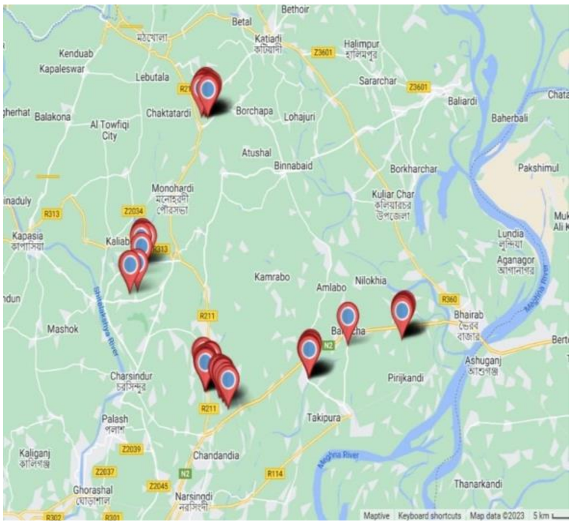


Figure-1.4: GIS Map of the Zara and Colombo Lemon Producers participated in the PRA study under Moulvibazar district



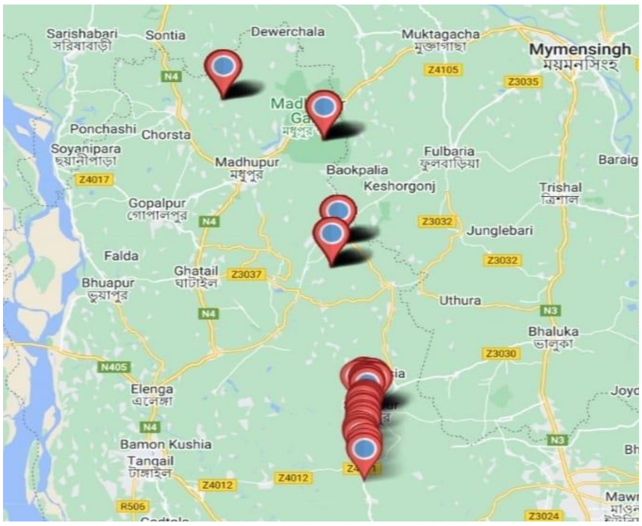


Figure-1.5: GIS Map of the Zara and Colombo Lemon Producers participated in the PRA study under Narsingdi district

Figure-1.6: GIS Map of the Zara and Colombo Lemon Producers participated in the PRA study under Tangail district

1.7.4. Interpretation of results

The collected information on pests of Zara/Colombo Lemon (*Citrus medica*), 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 Zara/Colombo Lemon were also determined based on both primary and secondary data. Subsequently, a comprehensive list of pests of Zara/Colombo Lemon was prepared based on locally available in Bangladesh as well as quarantine pests of Zara/Colombo Lemon for Bangladesh as recorded in countries of Zara/Colombo Lemon export. Finally, the necessary interpretation of the findings and risk analysis of the quarantine pests of Zara/Colombo Lemon was done as per requirement of the PRA study.

1.7.5. Photographic presentation of pests of Zara/Colombo Lemon

During field observation, the pictures of insect and mite pests, diseases, weeds and other pests associated with the Zara/Colombo Lebu and its plants as well as plant parts were captured by the camera during field level inspection. These photographs are presented in this report as evidence of various activities related to present PRA study.

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 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 Citrus in Bangladesh" previously conducted in the year of 2014 as sponsored by the "Strengthening Phytosanitary Capacity in Bangladesh (SPCB) under the Department of Agricultural Extension (DAE)", Ministry of Agriculture, Bangladesh has been considered as basis for conducting the current PRA study. As per requirement of the international standard, every five-year 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 *Citrus medica* (Zara/Colombo Lebu varieties) 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 andspread
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 belo

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

[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.

Description	Establishment Potential
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 Zara/Colombo Lebu Pests for Bangladesh

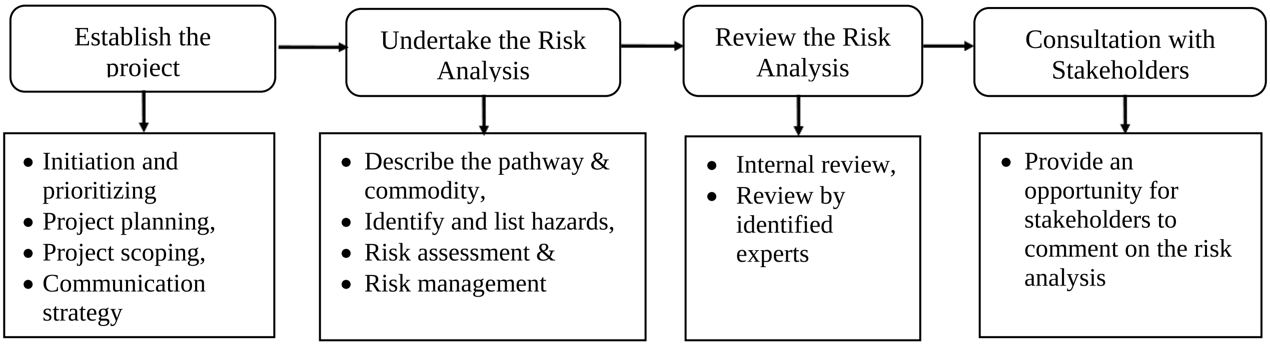
Establishment Potential	Consequence Potential	Risk Rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

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-2.1:

Figure-2.1: A summary of the risk analysis development process



2.2. Import Pathway Description

2.2.1. Import pathways of *Citrus* spp. including Zara/Colombo Lebu

For the purpose of this risk analysis, in Bangladesh, citruses are imported from anywhere of exporting countries such as India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc.

To comply with existing Bangladesh's import requirements, the commodity—here, the citruses would need to be prepared in the exporting countries 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 commodity—here, the citrus fruits and/or saplings. 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 citrus fruits and/or saplings.

2.2.2. Pathway Description

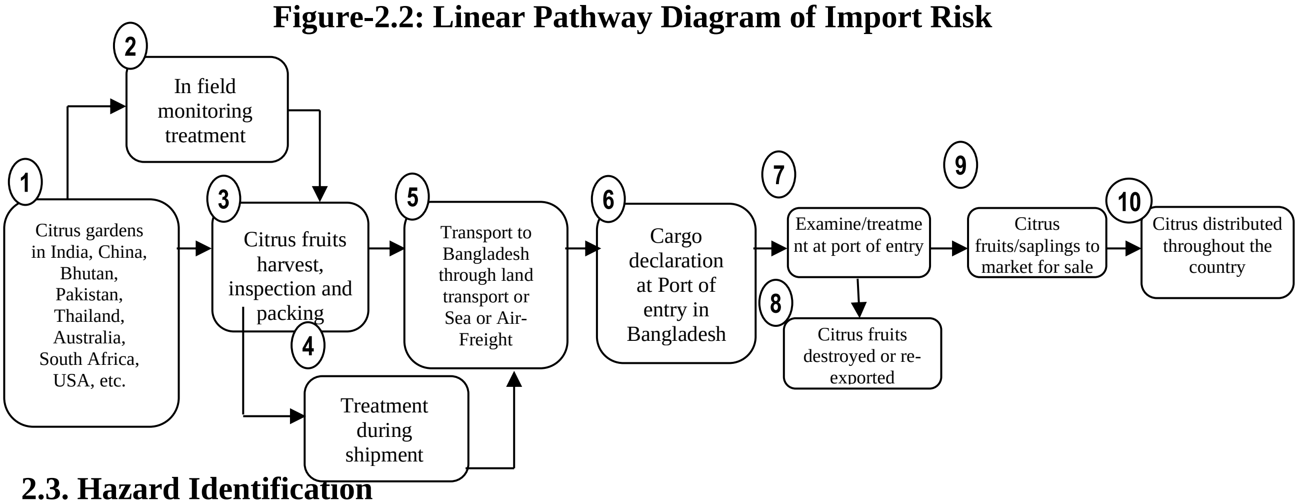
The first step in the risk analysis process is to describe the entry pathway of the commodity. This includes relevant information on:

- 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 citrus fruits and/or its saplings from any country of export to Bangladesh following the similar pathways of citrus that being imported. Considering the theme, the import pathways of citrus is described below:

- Citrus and/or saplings in the countries of export such as India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. are being grown in the orchard, either as a single crop or beside other field or horticultural crops;
- Monitoring of the insect and mite pests, diseases, weeds and any other pests of citrus is undertaken, with appropriate controls applied in the orchard in country of export;
- Citrus fruits are being harvested, inspected and after necessary sorting and grading the best quality fruits washed, pre-treated and packed in boxes;
- Post harvest disinfestations including fumigation or cold disinfestations are being undertaken either before or during transport of citrus fruits and/or 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 Citrus, any treatments completed, or other information required to help for mitigating the risks;
- Citrus fruits and/or its saplings are examined at the border to ensure compliance;
- Any citrus fruits 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 citrus 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 citrus from exporting country(ies) into Bangladesh through transportation of commodities by escaping the phytosanitary inspection in the port of entry. For example, pathogen of bacterial canker may infect citrus saplings without any visible symptoms; the disease developing when the saplings are planted in the field.
- Citrus fruits and/or its saplings are stored before being distributed to market for sale.
- Dealers and sellers of citrus fruits 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 citrus is shown in the following Figure-2.2:

Figure-2.2: Linear Pathway Diagram of Import Risk

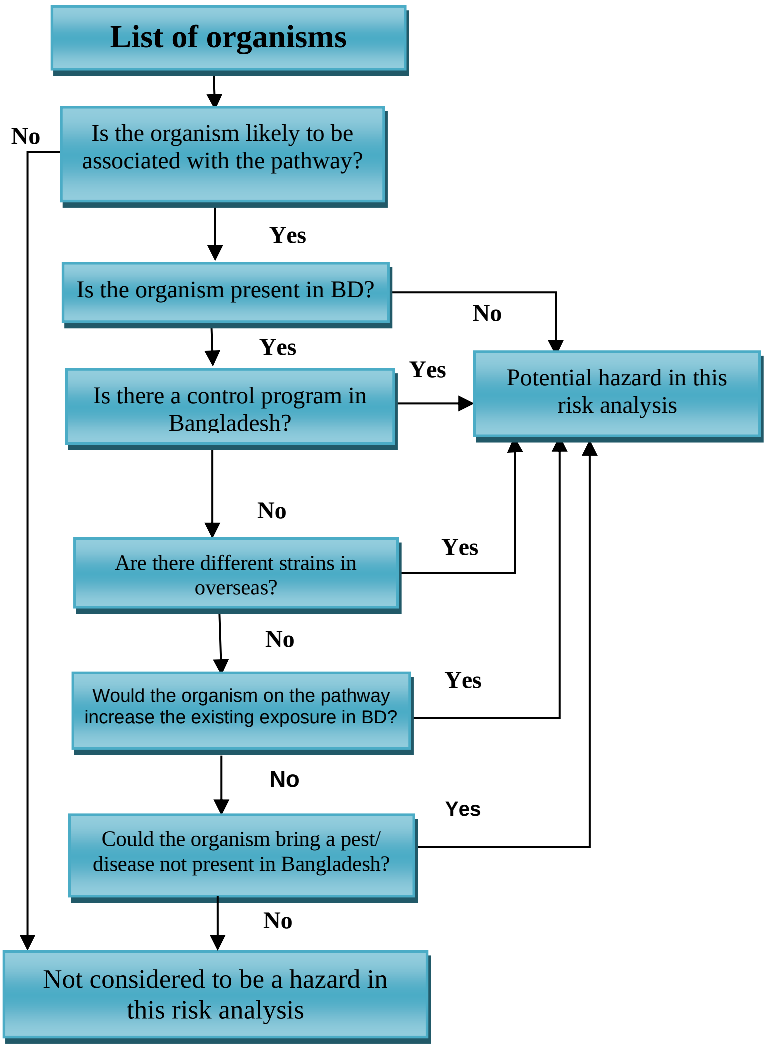


2.3. Hazard Identification

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 citrus which could be introduced into Bangladesh by risk goods, and are potentially capable of causing harm to citrus production including *Citrus medica* (Zara/Colombo Lebu varieties), must be identified. This process begins with the collection of information on insect pests, diseases (pathogen) or weed or any other pests of citrus 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—here, the citrus, 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-2.3:

Figure-2.3: 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. ISPM No. 3 recommends that NPPOs should conduct a PRA either before import or before release of biological control agents and other beneficial organisms. 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 other measures where equivalent uncertainties exist and be reviewed as soon as additional information becomes available.

2.2.6. 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

[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.

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

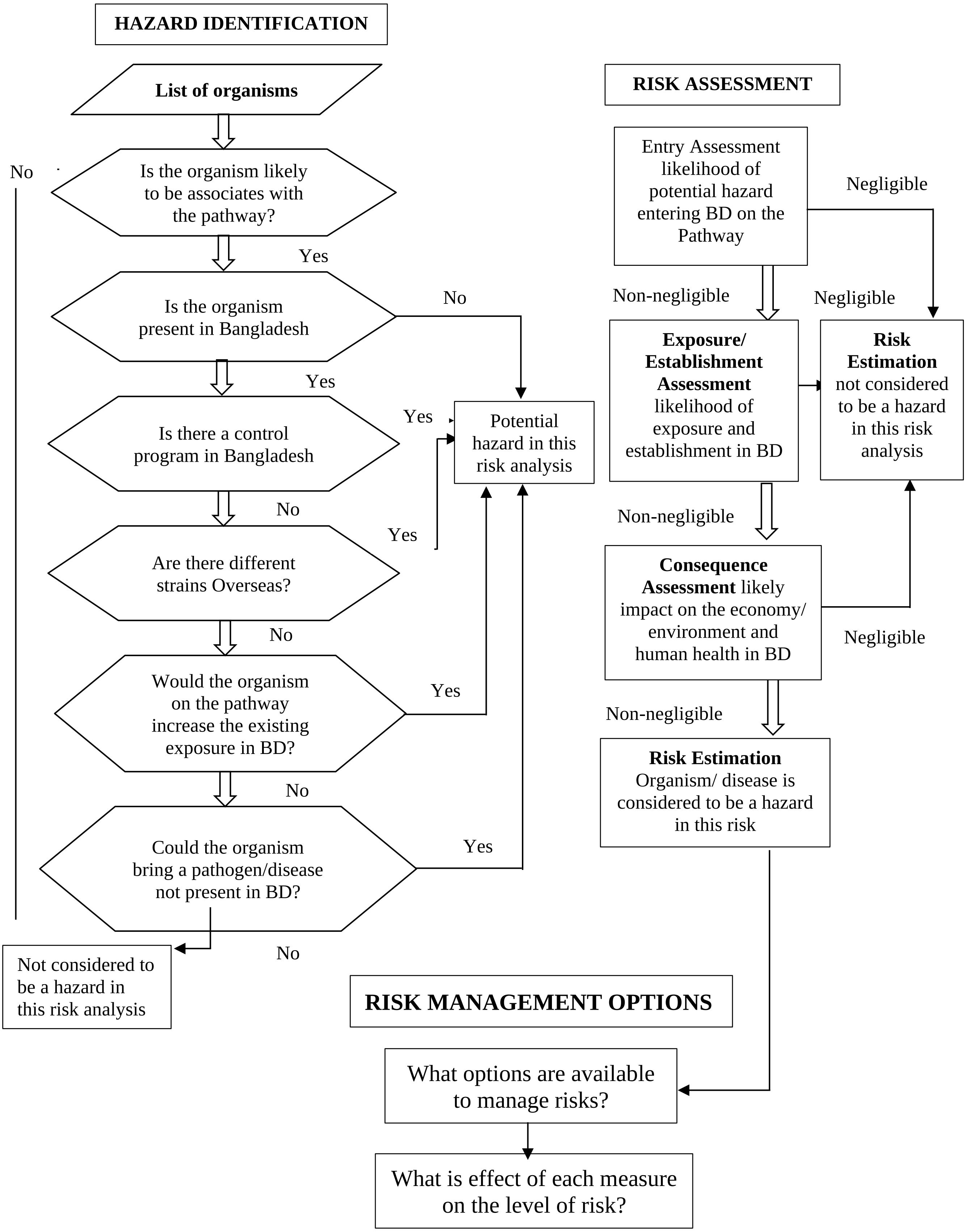
Measures that are expected to be effective against the hazard species are considered. A package of risk management measures is likely to be required to address the risk from all identified hazards. Currently the established pathways are India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. for citrus fruits and/or 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-2.4. 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 citrus. 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. Zara/Colombo Lebu: Citron (*Citrus medica*) is called "Zara Lebu" in Bangladesh. India is commonly considered as the origin location of Citron. In India, citron was found under wild conditions particularly in Nilgiris, Assam and lower Himalayas (Yaquis Liu *et al.*, 2012)[22]. Zara lemon is the first citrus fruit that is exporting from Bangladesh to Europe and other countries of the world. The countries of European Union, Gulf region such as Kuwait, Saudi Arabia, UAE and Qatar are potential markets for *Citrus medica* (Zara/Colombo Lebu varieties) in Bangladesh. Due to attack on canker disease, European Union banned Zara Lebu import from Bangladesh in 2008. Zara Lebu—a big variety of local citrus—to European countries has got a big boost over kingdom was withdrawn in November 2011 (DAE, 2012)[23].

The Zara/Colombo Lebu, *Citrus medica* belongs to the citrus family Rutaceae commonly known as Citron that is primarily grown in the Indian subcontinent, particularly in the eastern region of the country and Bangladesh. It is a type of lime that is known for its strong and distinct aroma, which is described as a combination of lime and lemon with floral notes. *Citrus medica* (Zara/Colombo lebu varieties) is often used in a variety of dishes, including marinades, dressings, and desserts, and is a key ingredient in many traditional Bengali dishes.

Zara/Colombo is highly valued for its unique flavor and fragrance and is considered to be a delicacy in South Asian cuisine. It is a seasonal fruit that is primarily available from July to September and is often used in special occasions and celebrations. In recent years, Zara lemon has gained popularity in the culinary world and has been used by chefs and mixologists in various international cuisines and beverages.

3.2.2. Zara/Colombo Plant: *Citrus medica* (Zara/Colombo Lebu varieties) is a slow-growing shrub or small tree that reaches a height of about 8 to 15 ft (2 to 5 m). It has irregular straggling branches and stiff twigs and long spines at the leaf axils. The evergreen leaves are green and lemon-scented with slightly serrate edges, ovate-lanceolate or ovate elliptic 2.5 to 7.0 inches long. Petioles are usually wingless or with minor wings. The clustered flowers of the acidic varieties are purplish tinted from outside, but the sweet ones are white-yellowish. The citron tree is very vigorous with almost no dormancy, blooming several times a year, and is

[22] Yaquis Liu, Heying, E., Tanumihardjo, S. 2012. "History, Global Distribution, and Nutritional Importance of Citrus Fruits". Comprehensive Reviews in Food Science and Food Safety. 11:6. doi:10.1111/j.1541-337.2012.00201.x.tensionsbangladesh/

[23] DAE, 2012. Plant Protection Wing, Department of Agricultural Extension, Khamarbari, Dhaka

therefore fragile and extremely sensitive to frost. The taxonomic position of *Citrus medica* (Zara/Colombo Lebu variety) is given below:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Sapindales
Family: Rutaceae
Genus: Citrus
Species: *Citrus medica*

EPPO Code: CIDME (*Citrus medica* Linnaeus)

3.2.3. Zara/Colombo Lebu Fruit: The citron fruit is usually ovate or oblong, narrowing towards the stylar end. However, the citron's fruit shape is highly variable, due to the large quantity of albedo, which forms independently according to the fruits' position on the tree, twig orientation, and many other factors. The rind is leathery, furrowed, and adherent. The inner portion is thick, white and hard; the outer is uniformly thin and very fragrant. The pulp is usually acidic, but also can be sweet, and some varieties are entirely pulpless.

Most citron varieties contain a large number of mono-embryonic seeds. The seeds are white with dark inner-coats and red-purplish chalazal spots for the acidic varieties, and colorless for the sweet ones. Some citron varieties have persistent styles which do not fall off after fecundation. Those are usually preferred for ritual *etrog* use in Judaism.

Some citrons have medium-sized oil bubbles at the outer surface, medially distant to each other. Some varieties are ribbed and faintly warted on the outer surface. A fingered citron variety is commonly called Buddha's hand.

The color varies from green, when unripe, to a yellow orange when overripe. The citron does not fall off the tree and can reach 8–10 pounds (4–5 kg) if not picked before fully mature. However, they should be picked before the winter, as the branches might bend or break to the ground and may cause numerous fungal diseases for the tree.

Despite the wide variety of forms taken on by the fruit, citrons are all closely related genetically, representing a single species. Genetic analysis divides the known cultivars into three clusters: a Mediterranean cluster thought to have originated in India, and two clusters predominantly found in China, one representing the fingered citrons, and another consisting of non-fingered varieties.

3.2.4. Varieties and hybrids: The acidic varieties include the Florentine and Diamante citron from Italy, the Greek citron and the Balady citron from Israel. The sweet varieties include the Corsican and Moroccan citrons. The pulp less varieties also include some fingered varieties and the Yemenite citron.

Plate-3.1: *Citrus medica* fruit (Zara Lebu variety) at field level

Plate-3.2: *Citrus medica* fruit (Zara Lebu variety) at market level

Plate-3.3: *Citrus medica* fruit (Colombo Lebu variety) at field level

Plate-3.4: *Citrus medica* fruits (Colombo Lebu variety) at harvest level

3.2.5 Climate: Citrus are growing in warm climates from tropical to arid conditions in a wide range of temperatures ranging from 10˚C to 35˚C and this climate is considered the most proper climate for citrus growth and productivity. The optimal temperature range for citrus cultivation is estimated to be 22–34 ºC. Temperatures above this range lead to fruit abscission and smaller fruit size. Organoleptic quality parameters such as the total soluble solids content (TSS) and total titratable acidity (TTA), are also affected. So, the range of latitude and altitude in Bangladesh is basically good for *Citrus medica* (Zara/Colombo Lebu varieties). Bangladesh's overall mean annual temperature of 18 to 30 degree centigrade, which is quite good for Zara/Colombo Lebu production. The humidity necessary to keep a citrus plant in good health is above 50% and pebble trays are a good way to localize that humidity. Water actively growing plants moderately, allowing the top inch of the potting mix to dry out between regular, thorough waterings. A rainfall of about 150 cm to 250 cm is required for citrus production. The winter should be mild and there should be no strong or hot wind during summer.

3.2.6. Soil: Citrus does best in slightly acidic, well-drained loam or sandy loam soils, but with proper irrigation that drains easily, could grow well in clay soils. Plant trees in the spring in a warm, sheltered, preferably south-facing position away from cold winds; cover plants in winter if temperatures fall below 29 degrees.

3.2.7. Planting: The best planting time of Zara/Colombo lebu at the end of the rainy season whereas in the study areas farmer started from June and continued up to August. Farmers make pit before15-20 days. The average plant to plant and line to line distance was found 3 meters and 3 meters, respectively as practiced by the farmer. Deepness of pit was found 15 cm. Most of the farmers maintain row their garden. The average number of cow-dung application, fertilizer application, weeding, number of spraying and irrigation 8.5, 3, 3.5, 4.2 and 4 times, respectively (Kaysar *et al.,* 2017)[24].

3.2.8. Zara/Colombo Lebu production in Bangladesh: Bangladesh is one of the major citrus producing countries including Zara/Colombo Lebu. Citrus grows in almost all areas of Bangladesh, but the Zara/Colombo Lebu growing areas are mainly Sylhet, Narshingdi, Moulavibazar, Tangail, etc. districts. In Bangladesh, citrus occupies about an area of 36,568 hectare of land with a production of 3,82,828 metric tons during 2021-22, whereas it was 34028 ha of land with a production of 361,824 MT in 2020-2021 (according to DAE, 2023[25]). But the specific data on Zara/Colombo Lebu regarding acreage and production is not available.

3.2.9. Export-imports of Zara/Colombo Lebu in Bangladesh

Bangladesh exports different citruses particularly Zara/Colombo Lebu, Lime, Satkora, Pumelo, Orange, Malta, etc. in different countries of the world mainly to United Kingdom and some EU Countries particularly Italy, Germany, France, Switzerland, Denmark, etc. Other destinations are Middle East, Singapore, Malaysia, Canada, etc. The Figure-3.1 depicted that the export volumes of citrus as a whole from Bangladesh are approximately 1069 MT in the fiscal year 2022-23 (as of March, 2023), which was 1252 MT in 2021-22, 1031 MT 2020-21, 734 MT in 2019-20 and 864 MT in the fiscal year 2018-19 (DAE, 2023). According to the information given by Central Packing House, Shampur, Dhaka under Plant Quarantine Wing of DAE, the export volume of *Citrus medica* (Zara/Colombo Lebu varieties) from Bangladesh to UK and European Countries was about 379 MT in the fiscal year 2022-23 (as of May, 2023). The findings of these export volumes of citrus including *Citrus medica* (Zara/Colombo Lebu varieties) in last five years revealed that the export amount is increasing continuously except the fiscal year 2019-20 and 2020-21 as because of Covid-19 Pandemic that hampered the international trading (Figure-3.2). However, the Bangladesh's export growth is still very insignificant when the country holds enormous potential producer of citrus including *Citrus medica* (Zara/Colombo Lebu varities). 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 *Citrus medica* (Zara/Colombo Lebu varieties) to foreign markets.

[24] Kaysar, I., Hoq, M.S., Mia, M.S. and Islam, M.S. 2017. An economic analysis of Zara and Colombo lemon production in Bangladesh. **15(2):** 289-296.

[25] DAE. 2023. Plant Quarantine Wing, Department of Agricultural Extension, Khamarbari, Dhaka, Bangladesh.

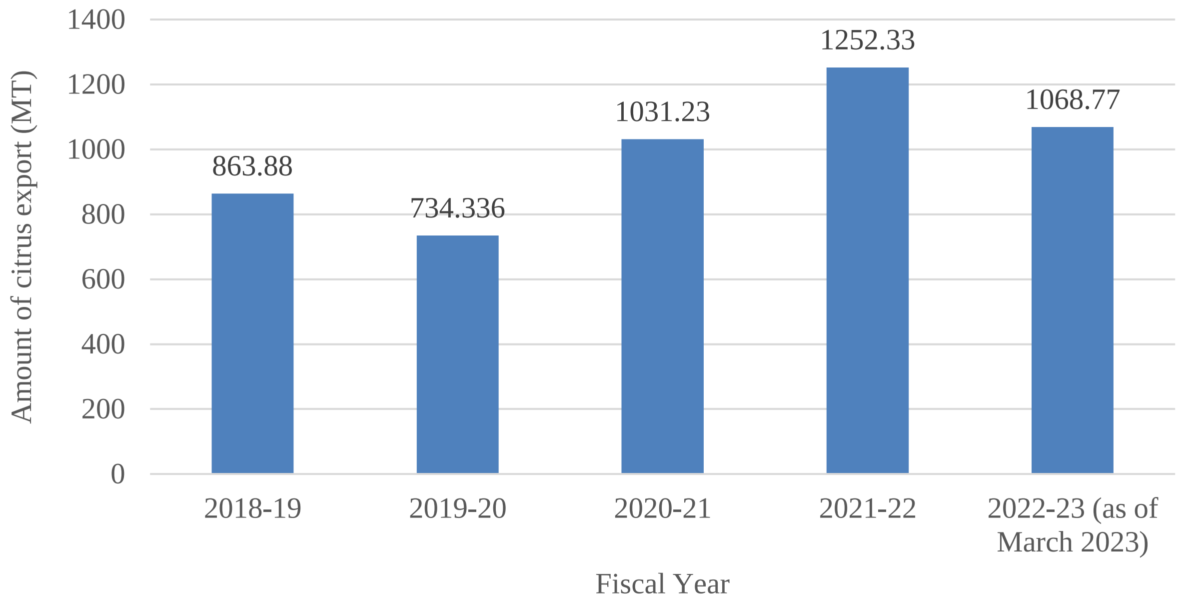


Figure-3.1: Amount of Citrus (including Zara Lebu) export from Bangladesh in last five year (2018-19 to 2022-23)

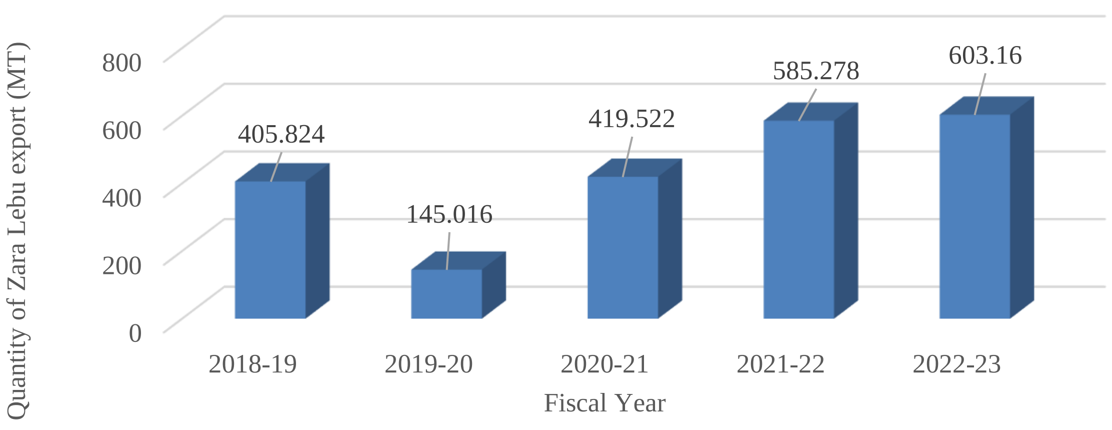


Figure-3.2. Quantity of Zara lebu (Citrus medica) export from Bangladesh in last five years (2018-19 to 2022-23)

According to the information given by DAE (2023), Bangladesh imports different kind of citruses such as sweet orange, malta, lemon, satkora, pumelo, calamondin, etc. from different citrus exporting countries viz. India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. The amount of citrus imported by Bangladesh from different exporting countries is about 216311 MT in the fiscal year 2021-22, which was 337292 MT in 2020-21, 32677 MT in 2019-20, 260814 MT in 2018-19 and 178963 MT in the fiscal year 2017-18 (Figure-3.3).

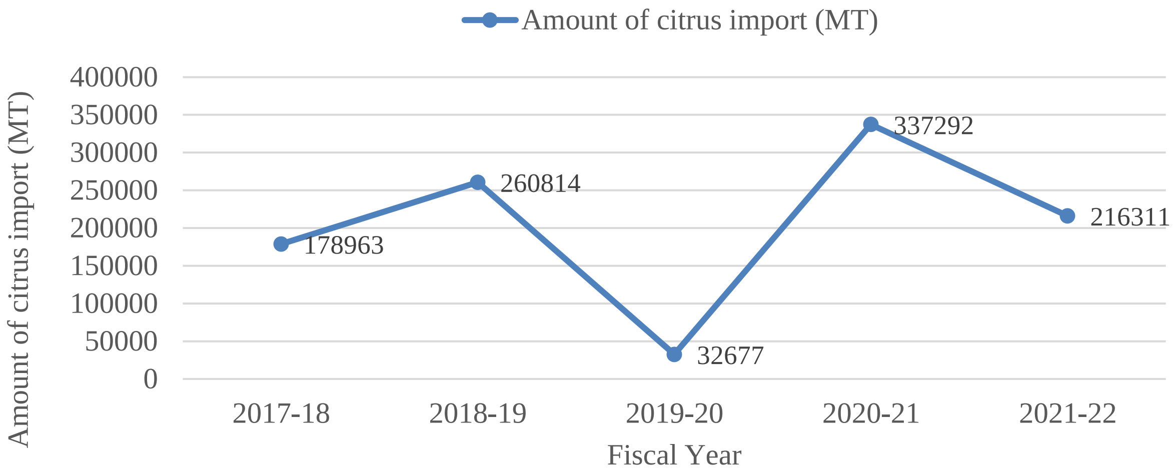


Figure-3.3: Amount of citrus import in Bangladesh in last five year (2017-18 to 2021-22)

The introduction of insect pests, plant diseases, weeds and other pests associated with commodity 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. The huge amount of import volume of citrus from different exporting countries to Bangladesh may lead to introduction of Invasive Alien Species (IAS) of pests associated with citrus during international trading and may cause severe damage to citrus including *Citrus medica* (Zara/Colombo Lebu varieties), 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 PRA of *Citrus medica* (Zara/Colombo Lebu varieties) in Bangladesh was conducted.

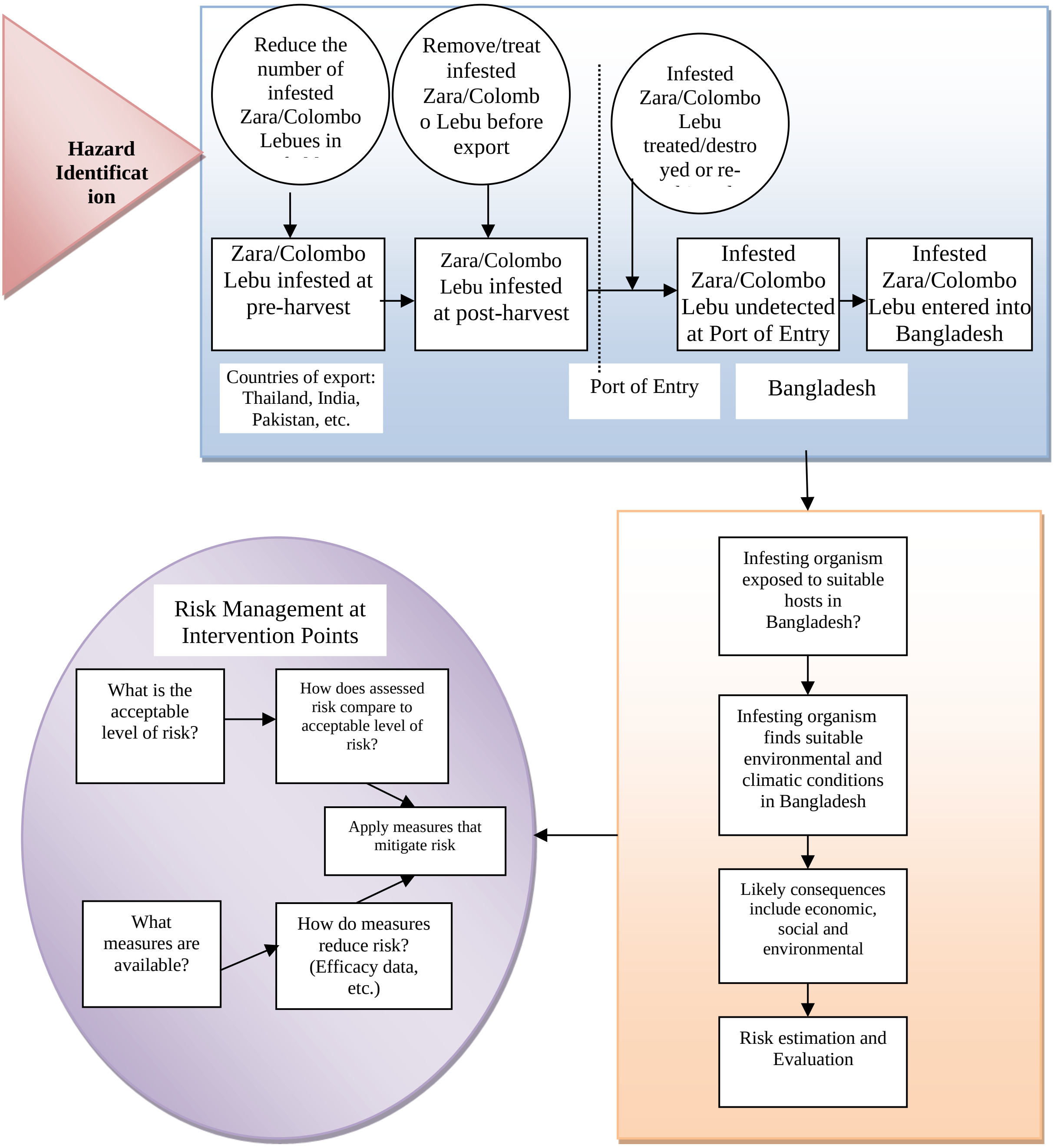
3.3. Description of the Import Pathway

For the purpose of this risk analysis, citrus fruits such as sweet orange, malta, lime, satkora, pumelo, calamondin, etc. are imported from anywhere in exporting counties particularly India, Bhutan, China, Pakistan, Thailand, Australia, South Africa, Egypt, Brazil, USA, etc. Hence, the quarantine pests of *Citrus medica* (Zara/Colombo Lebu varieties) for Bangladesh were identified based on the pests those might be associated with citruses as available in the exporting countries of the world from where Bangladesh usually imports citrus. During importation, the quarantine pests associated with citrus may enter into Bangladesh that may cause serious damage to citrus sector in the country. Considering the possibility of introduction and establishment, the risk analysis of quarantine pests of citrus including *Citrus medica* (Zara/Colombo Lebu varieties) was done to set the proper mitigation and phytosanitary measures against those quarantine pests.

Besides, Bangladesh also exports a good quantity of *Citrus medica* (Zara/Colombo Lebu varieties) along with other citrus in United Kingdom and some EU Countries particularly Italy, Germany, France, Switzerland, Denmark, etc. and other countries such as Middle East, Singapore, Malaysia, Canada, etc. To comply with existing export requirements for *Citrus medica* (Zara/Colombo Lebu varieties), 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 Zara/Colombo Lebu. The linear import pathway of *Citrus medica* (Zara/Colombo Lebu varieties) from any country of export is presented in the following figure:

Synthesis of figures 2.1 & 2.2 indicating how the risk analysis process is applied at the pathway level.

Figure-3.4: Pathway and Likelihood of Entry Assessment



3.4. Geographic Position and General Climate of Importing Country—Bangladesh

3.4.1. Geographical Position of Bangladesh

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.

3.4.2. General Climate of Bangladesh

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

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

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

The Climate of Bangladesh can be divided in different climate zones. The central and southern part can be classified as **Aw**[26] 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**[27] 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

---

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

3.5. Geographic Position and General Climate of Exporting Countries

3.5.1. India

Geographical 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).

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, except the northern states of Himachal Pradesh and Jammu & Kashmir in the north and Sikkim in the northeastern hills, which have a cooler, more continental influenced climate.

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

Geographical Position: Thailand is in the middle of mainland Southeast Asia. It has a total size of 513,120 km^2 (198,120 sq mi) which is the 50th largest in the world. The land border is 4,863 km (3,022 mile) 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[28] climate, a hot, humid climate with all months above 18°C (WeatherOnline, 2015c).

3.5.3. China

Geographical Position: China has great physical diversity. The eastern plains and southern coasts of the country consist of fertile lowlands and foothills. They are the location of most of China's agricultural output and human population. The southern areas of the country (south of the Yangtze River) consist of hilly and mountainous terrain. The west and north of the country are dominated by sunken basins (such as the Gobi and the Taklamakan), rolling plateaus, and towering massifs. It contains part of the highest tableland on earth, the Tibetan Plateau, and has much lower agricultural potential and population.

The GPS coordinates of **China** are comprised of a latitude of 35° 51' 33.46" N and a longitude of 104° 08' 10.00" E. The combination of these two coordinates mean that China is located in the northern hemisphere as well as the eastern hemisphere.

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

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

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

---

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

3.5.4. Bhutan

Geographical Position: Bhutan is a sovereign country at the crossroads of East Asia and South Asia, located towards the eastern extreme of the Himalayas Mountain range. It is fairly evenly sandwiched between the sovereign territory of two nations: first, the People's Republic of China (PRC) on the north and northwest. There are approximately 477 kilometers of border with the country's Tibet Autonomous Region (TAR), or simply Tibet. The second nation is the Republic of India on the south, southwest, and east; there are approximately 659 kilometers with the states of Arunachal Pradesh, Assam, West Bengal, and Sikkim, in clockwise order from the kingdom. The Republic of Nepal to the west, the India to the south, and the Union of Myanmar to the southeast are other close neighbors; the former two are separated by only very small stretches of Indian territory. Bhutan is a very compact landlocked nation, but with just a small bit more length than width.

The GPS coordinates of **Bhutan** are made up of two points. The latitude of Bhutan is 27.5142° N, placing the country in the northern hemisphere and above the equator. With a longitude of 90.4336° E, Bhutan is also situated in the eastern hemisphere.

General Climate: Bhutan's climate is diverse due to dramatic variations in elevation. The Duars Plain tends to be hot and humid; the Lesser Himalaya region is often cooler; while the areas in the Greater Himalayas are closest to that of alpine tundra. Like any other countries in the world, Bhutan has four seasons in a year: Spring (March to May), Summer (June to August), Autumn (September to November) and Winter (December to February).

In Bhutan, a small Asian country crossed by the Himalayas, the climate is influenced by altitude: it is subtropical in the lowlands, and becomes progressively colder as you climb the mountains slopes. In addition, the climate is influenced by the summer monsoon, which brings rains and widespread cloudiness for almost six months per year, but especially from June to late September.

In the thin flat southern region, in cities like Gelephu and Phuentsholing, the climate is subtropical. Winter is very mild, but sometimes it can get cold at night. Spring, from March to May, is hot, especially in April and May, when the temperature can reach as high as 40 °C (104 °F); in addition, afternoon thunderstorms become more frequent.

From June to mid-October, it's the monsoon season, with abundant rainfall, at times torrential, which are enhanced by the proximity to the mountains, and muggy heat. Total annual rainfall can exceed 3,000 millimeters (118 inches). The best time in this area is from November to February.

In hilly and mountainous areas up to 1,500 meters (5,000 feet), the climate becomes progressively milder, with relatively cold, dry winters and warm, rainy summers, with monsoon rains on the southern side, while in inland valleys, the summer rains are less intense. For example, in Punakha, located at 1,300 meters (4,250 feet), the average temperature ranges from 11 °C (52 °F) in January to 24 °C (75 °F) in July, so the summer is quite hot and humid despite the altitude. Here are the average temperatures. Above 2,000 meters (6,500 feet), winter are quite cold, with nights usually below freezing (0 °C or 32 °F).

In the capital, Thimphu, located in a valley, at an altitude varying between 2,200 and 2,600 meters (7,200 and 8,500 ft), the average temperature ranges from 6 °C (43 °F) in January to 21/22 °C (70/72 °F) in the period from June to August. Winter is dry and sunny, but snow can sometimes fall. Here are the average temperatures in Thimphu. In Thimphu, the rains are not abundant, although they reach or exceed 75 mm (2.9 in) per month from June to September.

The sun in Bhutan shines regularly in winter, while it does not shine very often in the monsoon season. Here are the average daily sunshine hours in Thimphu.

3.5.5. Egypt

Geographical Position: Egypt, a country linking northeast Africa with the Middle East, dates to the time of the pharaohs. Millennia-old monuments sit along the fertile Nile River Valley, including Giza's colossal Pyramids and Great Sphinx as well as Luxor's hieroglyph-lined Karnak Temple and Valley of the Kings tombs. The geographic position of the country is its highest point is 6,668 feet and the lowest point is 436 feet below sea level. The Mediterranean Sea forms Egypt's northern border, bringing cooler weather to the seaboard city of Alexandria and providing a coastal getaway for Cairo's residents. To the east, lies the mountainous Sinai Peninsula, which borders Israel and the Palestinian Territories; to the south, the deserts of Egypt roll into the deserts of Sudan; to the west, the Great Western Desert forms an almost seamless wilderness through Libya and beyond. The area of agricultural land in Egypt is confined to the Nile Valley and delta, with a few oases and some arable land in Sinai. The total cultivated area is 3.02 million ha, representing only 3 percent of the total land area.

The latitude and longitude of **Egypt** is 26°50'8.76" N and 30° 47'44.37" E, respectively. The combination of these two coordinates mean that Egypt is located in the northern hemisphere as well as the eastern hemisphere.

General Climate: Egypt's climate is dry, hot, and dominated by desert. It has a mild winter season with rain falling along coastal areas, and a hot and dry summer season (May to September). Daytime temperatures vary by season and change with the prevailing winds. Cairo, capital city of Egypt, which is located in the Nile valley has an average high temperature in July is 35˚C and an average low of 9˚C in January.

3.5.6. South Africa

Geographical Position: South Africa, officially the **Republic of South Africa** (**RSA**), is a country located in Southern Africa. It has 2,798 kilometers (1,739 miles) of coastline that stretches along the South Atlantic and Indian oceans. To the north lie the neighboring countries of Namibia, Botswana and Zimbabwe; to the east are Mozambique and Swaziland; and within it lies Lesotho, an enclave surrounded by South African territory.

Latitude and longitude of **South Africa** is 30.0000 degrees South and 25.0000 degrees East, respectively. The combination of these two coordinates mean that South Africa is located in the southern hemisphere as well as the eastern hemisphere.

General Climate: The **climate** of **South Africa** is usually 'dry' from April through to October, and the main winter period runs from May to August. During this time, altitude plays an important factor with temperatures. Along the coast, days are usually warm, but nights can be quite cool.

Average temperatures in South Africa range from 15℃ to 36℃ in the summer and -2℃ to 26℃ in the winter. South Africa is highly vulnerable to climate variability and change due to the country's high dependence on rain-fed agriculture and natural resources.

The north of the country, including Johannesburg, the Kruger National Park, Limpopo Province, the Kalahari Desert, Durban and northern KwaZulu Natal, is influenced by a sub-tropical climate and receives most rainfall during the warmer summer months from November to March.

Temperatures can soar to 4^0C at this time, especially in the 'lowveld' areas of Mpumalanga and KwaZulu/Natal, and it can also be very humid near the coast.

3.5.7. Brazil

Geographical Position: Brazil, officially the Federative Republic of Brazil, is the largest country in South America and in Latin America. Brazil is the world's fifth-largest country by area and the seventh most populous. Its capital is Brasília, and its most populous city is São Paulo.

The GPS coordinates of **Brazil** are 14.2350°S and 51.9253°W. The first point is the latitude of Brazil, placing Brazil in the southern hemisphere. The second point, known as the longitude, means that the country is positioned in the western hemisphere.

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

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

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

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

3.5.8. Australia

Geographical 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 Citrus in Exporting Countries

The availability of insect and mite pests, diseases, weeds and other pests associated with citrus in exporting countries such as India, Thailand, China, Bhutan, Egypt, South Africa, Brazil and Australia was critically reviewed after collecting information from various secondary sources. The list of these citrus pests has been categorically furnished separately for each of exporting countries in the following sub-headings:

3.6.1. India

3.6.1.1. Insect and mite pests of citrus

A total of 18 arthropod pests of citrus has been reported for **India**, out of which 15 were insect pests and one was mite pest. The available insect and mite pests of citrus as reported for 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 citrus in India

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Lemon butterfly	*Papilio demoleus*	Papilionidae	Lepidoptera	Choudhuri and Konar (2007)
Citrus leaf miner	Phyllocnistis citrella	Gracillariidae	Lepidoptera	Thakre and Soni (2017)
Swallowtail butterfly	*Papilio polytes*	Papilionidae	Lepidoptera	EPPO (2022)
Citrus leaf roller	*Psorosticha zizyphi*	Depressariidae	Lepidoptera	Wikipedia (2021)
Bark and stem borer/ Bark eating caterpillar	*Indarbela quadrinotata*	Metarbelidae	Lepidoptera	Beccaloni *et al.* (2003)
Citrus red scale	*Aonidiella aurantii*	Diaspididae	Hemiptera	Hayes (1970)
Citrus yellow scale	*Aonidiella citrina*	Diaspididae	Hemiptera	Wikipedia (2021)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	Srinivasnaik *et al.* (2016)
Asian citrus psyllid	*Diaphorina citri*	Liviidae	Hemiptera	EPPO (2022)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Singh *et al.* (2020)
Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Homoptera	EPPO (2022)
Striped mealybug	*Ferrisia virgata*	Pseudococcidae	Homoptera	Newstead (1894)
Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	Akbar *et al.* (2019)
Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Kumar and Rachana (2021)
California Citrus thrips	*Scirtothrips citri*	Thripidae	Thysanoptera	EPPO (2000)
B. Mite pests				
Citrus red mite	*Panonychus citri*	Tetranychidae	Acarida	EPPO (2022)
Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarida	EPPO (2022)
Citrus bud mite	*Aceria Sheldon*	Eriophyidae	Acarida	EPPO (2022)

3.6.1.2. Diseases of citrus

A total of 21 diseases of citrus has been reported in India, out of which 11 were fungal diseases, 2 bacterial, 3 viral and 3 nemic diseases. The available diseases of citrus 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 citrus in India

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungus				
Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Sharma *et al.* (2013)
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	Srivastava (1982)
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	ICAR (2010)
Sooty mould	*Capnodium citri*	Capnodiaceae	Caapnodiales	EPPO (2022)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Leaf spot	*Meliola mengiferae*	Meliolaceae	Meliolales	EPPO (2022)
Powdery mildew	*Oidium* sp.	Erysiphaceae	Erysiphales	Kiss *et al.* (2001)

Common name	Scientific name	Family name	Order name	Reference
Pink disease	Botryobasidium salmonicolor	Corticiaceae	Corticiales	EPPO (2022)
Fruit rot	*Fusarium* sp.	Nectriaceae	Hypocreales	EPPO (2022)
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Das *et al.* (2018)
B. Causal Organism: Bacteria				
Citrus canker	*Xanthomonas citri* pv. *citri*	Xanthomonadaceae	Xanthomonadales	Savitha *et al.* (2016)
Citrus greening	*Candidatus Liberibacter asiaticus*	Phyllobacteriaceae	Rhizobiales	Singh *et al.* (2019)
C. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Singh *et al.* (2022)
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
Indian citrus ringspot virus	*Indian citrus ringspot virus*	Alphaflexiviridae	Tymovirales	CABI/EPPO (2015)
D. Causal Organism: Nematodes				
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)
Root lesion	*Hoplolaimus indicus*	Hoplolaimidae	Tylenchida	CABI/EPPO (2013)
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	Sundararaju (2006)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	EPPO (2022)
Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	CABI/EPPO (2013)

3.6.1.3. Weeds of citrus

There were three weeds of citrus has been reported in India namely Asthma weed, sensitive plant and dove weed those have 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 citrus in India

Common name	Scientific name	Family name	Order name	Reference
Weeds				
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Nayak and Babu (2019)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Borah *et al.* (2018)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Govaerts (2017)

3.6.2. Thailand

3.6.2.1. Insect and mite pests of citrus

A total of 11 arthropod pests of citrus has been reported in Thailand, out of which 10 were insect pests and one was mite pest. The available insect and mite pests of citrus 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 citrus in Thailand

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Lemon butterfly	*Papilio demoleus*	Papilionidae	Lepidoptera	Waterhouse (1993)
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	Waterhouse (1993)
Swallowtail butterfly	*Papilio polytes*	Papilionidae	Lepidoptera	EPPO (2022)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	CABI/EPPO (1999)

Common name	Scientific name	Family name	Order name	Reference
Asian citrus psyllid	*Diaphorina citri*	Liviidae	Hemiptera	EPPO (2022)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Maciel (2015)
Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	Haq *et al.* (2016)
Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Homoptera	EPPO (2022)
Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Toda *et al.* (2014)
Black citrus aphid	*Toxoptera aurantii*	Aphididae	Homoptera	EPPO (2022)
B. Mite pests				
Citrus red mite	*Panonychus citri*	Tetranychidae	Acarida	EPPO (2022)

3.6.2.2. Diseases of citrus

A total of 13 diseases of citrus have been reported in Thailand, out of which 7 were fungal diseases, one bacterial, two viral and three nemic diseases. The available diseases of citrus 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 citrus in Thailand

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungi				
Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Weir *et al.* (2012)
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	EPPO (2022)
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	EPPO (2022)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Powdery mildew	*Oidium* sp.	Erysiphaceae	Erysiphales	Kiss *et al.* (2001)
Pink disease	*Botryobasidium salmonicolor*	Corticiaceae	Corticiales	EPPO (2022)
B. Causal Organism: Bacteria				
Citrus canker	*Xanthomonas citri* pv. *citri*	Xanthomonadaceae	Xanthomonadales	EPPO (2022)
C. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Brunt et al. (1996)
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
D. Causal Organism: Nematodes				
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	EPPO (2022)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	EPPO (2022)

3.6.2.3. Weeds of citrus

There were two weeds of citrus has been reported in Thailand namely Asthma weed, sensitive plant and dove weed those have 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 citrus in Thailand

Common name	Scientific name	Family name	Order name	Reference
Weeds				
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Holm et al. (1979)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Moody (1989)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	USDA-ARS (2017)

3.6.3. China

3.6.3.1. Insect and mite pests of citrus

A total of 15 arthropod pests of citrus have been reported in China, out of which 15 were insect pests and two was mite pest. The available insect and mite pests of citrus as reported in China 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 citrus in China

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Lemon butterfly	*Papilio demoleus*	Papilionidae	Lepidoptera	Tong (1993)
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	Gao *et al.* (2012)
Swallowtail butterfly	*Papilio polytes*	Papilionidae	Lepidoptera	EPPO (2022)
Citrus longhorn beetle	*Anoplophora chinensis*	Cerambycidae	Coleoptera	Yang *et al.* (2021)
Citrus yellow scale	*Aonidiella citrina*	Diaspididae	Hemiptera	Wikipedia (2021)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	CABI and EPPO (1999)
Asian citrus psyllid	*Diaphorina citri*	Triozidae	Homoptera	EPPO (2022)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Maciel (2015)
Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Homoptera	EPPO (2022)
Black citrus aphid	*Toxoptera citricida*	Aphididae	Homoptera	
Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	Seebens *et al.* (2017)
Mediterranean fruit fly/Medfly	*Ceratitis capitata*	Tephritidae	Diptera	CABI and EPPO (2015)
Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Mirab-Balou *et al.* (2014)
California Citrus thrips	*Scirtothrips citri*	Thripidae	Thysanoptera	Li *et al.* (2003)
B. Mite pests				
Citrus red mite	*Panonychus citri*	Tetranychidae	Acarina	EPPO (2022)
Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarina	Tropea Garzia and De Lillo (2018)

3.6.3.2. Diseases of citrus

A total of 22 diseases of citrus have been reported in China, out of which 12 were fungal diseases, two bacterial, two viral and 6 nemic diseases. The available diseases of citrus as reported in China 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 citrus in China

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungi				
Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Mo *et al.* (2018)
Die-back	*Fusarium solani*	Nectriaceae	Hypocreales	Xu *et al.* (2016)
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	Zhang and Huang (1990)

Common name	Scientific name	Family name	Order name	Reference
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	Hou *et al.* (2014)
Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	CABI/EPPO (2013)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Powdery mildew	*Oidium* sp.	Erysiphaceae	Erysiphales	Kiss *et al.* (2001)
Pink disease	*Botryobasidium salmonicolor*	Corticiaceae	Corticiales	EPPO (2022)
Fruit rot	*Fusarium* sp.	Nectriaceae	Hypocreales	
Stem-end rot	*Lasiodiplodia pseudotheobromae*	Botryosphaeriaceae	Botryosphaeriales	
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Zhang and Huang (1990)
B. Causal Organism: Bacteria				
Citrus canker	*Xanthomonas citri* pv. *citri*	Xanthomonadaceae	Xanthomonadales	Ye *et al.* (2013)
Citrus greening	*Candidatus Liberibacter asiaticus*	Phyllobacteriaceae	Rhizobiales	Qian WenJuan *et al.* (2018)
C. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Cheng *et al.* (2011)
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
D. Causal Organism: Nematode				
Root lesion	*Hoplolaimus indicus*	Hoplolaimidae	Tylenchida	CABI/EPPO (2013)
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	EPPO (2022)
Stem injury	*Ditylenchus dipsaci*	Anguinidae	Tylenchida	Seebens *et al.* (2017)
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	
Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	CABI/EPPO (2013)

3.6.3.3. Weeds of citrus

There were two weeds of citrus has been reported in China namely Asthma weed, sensitive plant and dove weed those have 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 citrus in China

Common name	Scientific name	Family name	Order name	Reference
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Mukhtar and Peer (2017)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Flora of China Editorial Committee (2017)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	

3.6.4. Bhutan

3.6.4.1. Insect and mite pests of citrus

A total of 7 arthropod pests of citrus have been reported in Bhutan, out of which all were insect pests. The available insect and mite pests of citrus as reported in Bhutan 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 pests of citrus in Bhutan

Common name	Scientific name	Family name	Order name	Reference
Lemon butterfly	*Papilio demoleus*	Papilionidae	Lepidoptera	NHM (1891)
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	EPPO (2022)
Asian citrus psyllid	*Diaphorina citri*	Liviidae	Hemiptera	Lama and Amatya (1993)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Maciel (2015)
Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	CABI/EPPO (2013)
Swallowtail butterfly	*Papilio polytes*	Papilionidae	Lepidoptera	EPPO (2022)
Black citrus aphid	*Toxoptera aurantii*	Aphididae	Homoptera	EPPO (2022)

3.6.4.2. Diseases of citrus

A total of 5 diseases of citrus have been reported in Bhutan, out of which 2 were fungal diseases, one bacterial, one viral and one nemic disease. The available diseases of citrus as reported in Bhutan 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 citrus in Bhutan

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungi				
Powdery mildew	*Oidium* sp.	Erysiphaceae	Erysiphales	Kiss *et al.* (2001)
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	EPPO (2022)
B. Causal Organism: Bacteria				
Citrus greening	*Candidatus* sp. *Liberibacter asiaticus*	Phyllobacteriaceae	Rhizobiales	Donovan *et al.* (2012)
C. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Ghosh *et al.* (2020)
D. Causal Organism: Nematode				
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)

3.6.4.3. Weeds of citrus

There were two weeds of citrus has been reported in **Bhutan** namely Asthma weed, sensitive plant and dove weed those have 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 citrus in Bhutan

Common name	Scientific name	Family name	Order name	Reference
Weed				
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Seebens *et al.* (2017)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Seebens *et al.* (2017)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Noltie (1994)

3.6.5. Egypt

3.6.5.1. Insect and mite pests of citrus

A total of 5 arthropod pests of citrus have been reported in Egypt, out of which 4 were insect pests and one was mite pest. The available insect and mite pests of citrus as reported in Egypt 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 citrus in Egypt

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	EPPO (2022)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	Adly *et al.* (2016)
Mediterranean fruit fly/Medfly	*Ceratitis capitata*	Tephritidae	Diptera	Kourti *et al.* (1992)
South African citrus thrips	*Scirtothrips aurantia*	Thripidae	Thysanoptera	Agamy *et al.* (2017)
B. Mite pest				
Citrus bud mite	*Aceria Sheldon*	Eriophyidae	Acarina	EPPO (2022)

3.6.5.2. Diseases of citrus

A total of 12 diseases of citrus has been reported in Egypt, out of which 5 were fungal diseases, one bacterial, one viral and one nemic disease. The available diseases of citrus as reported in Egypt through the review of secondary documents 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 citrus in Egypt

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungi				
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	EPPO (2022)
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Fruit rot	*Fusarium* sp.	Nectriaceae	Hypocreales	EPPO (2022)
Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	CABI/EPPO (2013)
B. Causal Organism: Bacteria				
Citrus stubborn	*Spiroplasma citri*	Mycoplasmataceae	Mycoplasmatales	CABI and EPPO (2015)
C. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Amin *et al.* (2006)
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
D. Causal Organism: Nematode				
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	EPPO (2022)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	Ibrahim and Handoo (2016)
Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	CABI/EPPO (2013)

3.6.6. South Africa

3.6.6.1. Insect and mite pests of citrus

A total of 12 arthropod pests of citrus have been reported in South Africa, out of which 9 were insect pests and three were mite pests. The available insect and mite pests of citrus as reported in South Africa through the review of secondary documents has been presented in the following Table-3.15 with their common name, scientific name, family, order and reference.

Table-3.15: Insect and mite pests of citrus in South Africa

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Citrus leaf miner	Phyllocnistis citrella	Gracillariidae	Lepidoptera	EPPO (2022)
Citrus red scale	*Aonidiella aurantia*	Diaspididae	Hemiptera	Bedford (1998)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	CABI/EPPO (1999)
African citrus psyllid	*Trioza erytreae*	Triozidae	Homoptera	Massonie *et al*. (1976)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Akrivou *et al.* (2021)
South African citrus thrips	*Scirtothrips aurantia*	Thripidae	Thysanoptera	Bara and Laing (2019)
Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	IPPC (2020)
Mediterranean fruit fly/Medfly	*Ceratitis capitata*	Tephritidae	Diptera	Munro (1929)
Black citrus aphid	*Toxoptera aurantia*	Aphididae	Homoptera	EPPO (2022)
B. Mite pests				
Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarida	Garzia and Lillo (2018)
Citrus bud mite	*Aceria Sheldon*	Eriophyidae	Acarida	EPPO (2022)
Lewis spider mite	*Eotetranychus lewisi*	Tetranychidae	Acarina	EPPO (2022)

3.6.6.2. Diseases of citrus

A total of 8 diseases of citrus have been reported in South Africa, out of which 4 were fungal diseases, one viral and three nemic diseases. The available diseases of citrus as reported in South Africa through the review of secondary documents has been presented in the following Table-3.16 with their common name, scientific name, family, order, pest status and reference.

Table-3.16: Diseases of citrus in South Africa

Common name	Scientific name	Family name	Order name	Reference
A. Causal Organism: Fungus				
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	EPPO (2022)
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	Villiers and Milne (1975)
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Martinez-Minaya *et al.* (2015)
B. Causal Organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Read and Pietersen (2017)
C. Causal Organism: Nematodes				
Stem injury	*Ditylenchus dipsaci*	Anguinidae	Tylenchida	EPPO (2022)
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	EPPO (2022)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	EPPO (2022)

3.6.6.3. Weeds of citrus

There were three weeds of citrus have been reported in South Africa namely Asthma weed, sensitive plant and dove weed those have been presented in the following Table-3.17 with their common name, scientific name, family, order, pest status and reference.

Table-3.17: Weeds of citrus in South Africa

Common name	Scientific name	Family name	Order name	Reference
Weeds				
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Holm *et al.* (1979)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Wells *et al.* (1986)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Holm *et al.* (1977)

3.6.7. Brazil

3.6.7.1. Insect and mite pests of citrus

A total of 10 arthropod pests of citrus have been reported in Brazil, out of which 7 were insect pests and three were mite pests. The available insect and mite pests of citrus as reported in Brazil through the review of secondary documents has been presented in the following Table-3.18 with their common name, scientific name, family, order and reference.

Table-3.18: Insect and mite pests of citrus in Brazil

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	Jaciani *et al.* (2009)
Citrus red scale	*Aonidiella aurantia*	Diaspididae	Hemiptera	Ebeling (1959)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	Lopes *et al.* (2019)
Asian citrus psyllid	*Diaphorina citri*	Triozidae	Homoptera	Nava *et al.* (2007)
Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Gomes *et al.* (2019)
Black citrus aphid	*Toxoptera citricida*	Aphididae	Homoptera	EPPO (2022)
Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Dias-Pini *et al.* (2018)
B. Mite pests				
Citrus red mite	*Panonychus citri*	Tetranychidae	Acarina	EPPO (2022)
Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarina	EPPO (2022)
Citrus bud mite	*Aceria sheldon*	Eriophyidae	Acarina	EPPO (2022)

3.6.7.2. Diseases of citrus

A total of 19 diseases of citrus have been reported in Brazil, out of which 10 were fungal diseases, two bacterial, two viral and 5 nemic diseases. The available diseases of citrus as reported in Brazil through the review of secondary documents has been presented in the following Table-3.19 with their common name, scientific name, family, order, pest status and reference.

Table-3.19: Diseases of citrus in Brazil

Common name	Scientific name	Family name	Order name	Reference
A. Causal organism: Fungi				
Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Lima *et al.* (2013)
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	EPPO (2022)

Common name	Scientific name	Family name	Order name	Reference
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	Mendes *et al.* (2019)
Sooty mould	*Capnodium citri*	Capnodiaceae	Caapnodiales	EPPO (2022)
Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	CABI/EPPO (2013)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Pink disease	*Botryobasidium salmonicolor*	Corticiaceae	Corticiales	EPPO (2022)
Fruit rot	*Fusarium* sp.	Nectriaceae	Hypocreales	EPPO (2022)
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Sposito *et al.* (2011)
B. Causal organism: Bacteria				
Citrus canker	*Xanthomonas citri* pv. *citri*	Xanthomonadaceae	Xanthomonadales	Lin *et al.* (2012)
Citrus variegated chlorosis	*Xylella fastidiosa* subsp. *Pauca*	Xanthomonadaceae	Xanthomonadales	Coletta-Filho *et al.* (2016)
C. Causal organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Loeza-Kuk *et al.* (2008)
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
D. Causal organism: Nematode				
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	Lima *et al.* (2013)
Stem injury	*Ditylenchus dipsaci*	Anguinidae	Tylenchida	Subbotin *et al.* (2005)
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	EPPO (2022)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	EPPO (2022)
Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	CABI/EPPO (2013)

3.6.7.3. Weeds of citrus

There were three weeds of citrus has been reported in Brazil namely Asthma weed, sensitive plant and dove weed those have been presented in the following Table-3.20 with their common name, scientific name, family, order, pest status and reference.

Table-3.20: Weeds of citrus in Brazil

Common name	Scientific name	Family name	Order name	Reference
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Lopes *et al.* (2019)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Lopes *et al.* (2019)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Aona and Pellegrini (2015)

3.6.8. Australia

3.6.8.1. Insect and mite pests of citrus

A total of 37 arthropod pests of citrus has been reported in Australia, out of which 36 were insect pests and one was mite pest. The available insect and mite pests of citrus as reported in Australia through the review of secondary documents has been presented in the following Table-3.21 with their common name, scientific name, family, order and reference.

Table-3.21: Insect and mite pests of citrus in Australia

Common name	Scientific name	Family name	Order name	Reference
A. Insect pests				
Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	Diez *et al.* (2006)
Citrus leaf folder	*Psorosticha zizyphi*	Depressariidae	Lepidoptera	Prins and Prins (2014)
Orange spined bug	*Biprorulus bibax*	Pentatomidae	Coleoptera	James (1990)
Citrus red scale	*Aonidiella aurantii*	Diaspididae	Hemiptera	Ebeling (1959)
Citrus yellow scale	*Aonidiella citrina*	Diaspididae	Hemiptera	Wikipedia (2021)
Citrus mealybug	*Planococcus citri*	Pseudococcidae	Hemiptera	Seebens *et al.* (2017)
Asian citrus psyllid	*Diaphorina citri*	Triozidae	Homoptera	EPPO (2022)
Black citrus aphid	*Toxoptera citricida*	Aphididae	Homoptera	EPPO (2022)
Mediterranean fruit fly/Medfly	*Ceratitis capitata*	Tephritidae	Diptera	Gasparich *et al.* (1997)
Queensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	EPPO (2022)
Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	EPPO (2022)
South African citrus thrips	*Scirtothrips aurantii*	Thripidae	Thysanoptera	Mound and Tree (2020)
B. Mite pests				
Citrus red mite	*Panonychus citri*	Tetranychidae	Acarina	EPPO (2022)
Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarina	EPPO (2022)
Citrus bud mite	*Aceria sheldon*	Eriophyidae	Acarina	EPPO (2022)

3.6.8.2. Diseases of citrus

A total of 18 diseases of citrus have been reported in Australia, out of which 10 were fungal diseases, one bacterial, two viral and 5 nemic diseases. The available diseases of citrus as reported in Australia through the review of secondary documents has been presented in the following Table-3.22 with their common name, scientific name, family, order, pest status and reference.

Table-3.22: Diseases of citrus in Australia

Common name	Scientific name	Family name	Order name	Reference
A. Causal organism: Fungi				
Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Shivas *et al.* (2016)
Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	Bertus (1981)
Gummosis	*Phytophthora citrophthora*	Peronosporaceae	Peronosporales	EPPO (2022)
Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	Jeffress *et al.* (2020)
Sooty mould	*Capnodium citri*	Capnodiaceae	Caapnodiales	EPPO (2022)
Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	CABI/EPPO (2013)
Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	EPPO (2022)
Pink disease	*Botryobasidium salmonicolor*	Corticiaceae	Corticiales	
Fruit rot	*Fusarium* sp.	Nectriaceae	Hypocreales	
Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Paul *et al.* (2005)
B. Causal organism: Bacteria				
Citrus canker	*Xanthomonas citri* pv. *citri*	Xanthomonadaceae	Xanthomonadales	EPPO (2022)
C. Causal organism: Virus				
Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Brlansky *et al.* (2002)

Common name	Scientific name	Family name	Order name	Reference
Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	CABI/EPPO (2013)
D. Causal organism: Nematode				
Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	EPPO (2022)
Stem injury	*Ditylenchus dipsaci*	Anguinidae	Tylenchida	EPPO (2022)
Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	Zeng *et al.* (2012)
Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	EPPO (2022)
Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	CABI/EPPO (2013)

3.6.8.3. Weeds of citrus

There were three weeds of citrus have been reported in Australia namely Asthma weed, Sensitive plant and dove weed those have been presented in the following Table-3.23 with their common name, scientific name, family, order, pest status and reference.

Table-3.23: Weeds of citrus in Australia

Common name	Scientific name	Family name	Order name	Reference
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Seebens *et al.* (2017)
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Seebens *et al.* (2017)
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Atlas of Living Australia (2017)

3.7. References

Abbas, M., Khan, M.M., Mughal, S.M. and Ji, P. (2015). Comparison of infection of *Citrus tristeza closterovirus* in Kinnow mandarin (*Citrus reticulata*) and Mosambi sweet orange (*Citrus sinensis*) in Pakistan. *Crop Protection.* **78**: 146-150.

Adly, D., Fadl, H.A.A.A. and Mousa, S.F.M. (2016). Survey and seasonal abundance of mealybug species, their parasitoids and associated predators on guava trees in Egypt. *Egy. J. Biol. Pest Con.* **26**(3): 657-664. http://www.ejbpc.com/

Agamy, E., El-Husseini, M., El- Sebaey, I. and Wafy, M. (2017). The Egyptian Thripid species in olive groves at Ismaialia, Egypt. *Egy. Aca. J. Biol. Sci. A. Entom*. **10**(4): 1-17. doi: 10.21608/eajb.2017.12180

Akbar, S.A., Nabi, S.U., Mansoor, S. and Khan, K.A, (2019). Morpho-molecular identification and a new host report of *Bactrocera dorsalis* (Hendel) from the Kashmir valley (India). *Inter. J. Trop. Insect Sci*. **40(**2): 315-325. DOI:10.1007/s42690-019-00083-w

Akrivou, A., Georgopoulou, I., Papachristos, D., Milonasm, P.G. and Kriticos, D.J. (2021). Potential global distribution of *Aleurocanthus woglumi* considering climate change and irrigation. *PLoS ONE.* **16**(12): e0261626. https://doi.org/10.1371/journal.pone.0261626

Ali, S.I. (1973). Mimosaceae. **In:** Flora of West Pakistan, **36** [ed. by Nasir E, Ali SI]. 1-41.

Amin, H.A., Fonseca, F., Santos, C. and Nolasco, G. (2006). Typing of Egyptian Citrus tristeza virus (CTV) isolates based on the capsid protein gene. *Phytopathologia Mediterranea* **45**(1): 10-14.

Aona, L.Y.S. and Pellegrini, M.O.O. (2015). (Commelinaceae in Lista de Espécies da Flora do Brasil)., Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB3481

Archana, L. and Kurl, S. P. (2020). Identification of aphid species (Homoptera : Aphididae) of economic importance from Delhi and its NCR using DNA barcodes and PCR-SSR based approach. Journal of Experimental Zoology, India, 23(2) 1791-1797.

Arshad, M., Ullah, M.I., Çagatay, N.S., Dikmen, F., Abdullah, A. and Afzal, M. (2019). *Cordia myxa* L., a new host plant record for Asian citrus psyllid, *Diaphorina citri* Kuwayama. *Southwestern Entom*. **44**(1): 331-334. DOI:10.3958/059.044.0137

Bara, G.T. and Laing, M.D. (2019). Determination of the natural host status of avocado fruit to pestiferous thrips (Thysanoptera: Thripidae) in KwaZulu-Natal, South Africa. *Afr. Entom.* **27**(1): 245-253. https://doi.org/10.4001/003.027.0245

Beccaloni, G., Scoble, M., Kitching, I., Simonsen, T., Robinson, G., Pitkin, B., Hine, A. and Lyal, C. (2003). *Indarbela quadrinotata*. The Global Lepidoptera Names Index. *Nat. His. Museum*. Retrieved May 7, 2018.

Bedford, E.C.G. (1998). Red scale *Aonidiella auranii* (Maskell). **In:** Citrus pests in the Republic of South Africa. Bedford, E.C.G., Berg, M.A.V. and Villiers, E.A.D. Dynamic Ad., Nelspruit, South Africa. pp: 132–134.

Bertus, A.L. (1981). Australasian Plant Pathology. **10**(3): 53-55.

Borah, T. R., Dutta, S. and Barman, A. R. (2018). First report of *Sclerotinia sclerotiorum* on *Mimosa pudica* in India. *New Disease Reports*. **14**. DOI:10.5197/j.2044-0588.2018.038.014

Brlansky, R.H., Howd, D.S., Broadbent, P. and Damsteegt, V.D. (2002). Histology of Sweet Orange Stem Pitting Caused by an Australian Isolate of Citrus tristeza virus. *Plant Disease*. **86**(10): 1169-1174.

Brunt, A., Crabtree, K., Dallwitz, M., Gibbs, A. and Watson, L. (1996). Viruses of plants, 409-411. CAB International, Wallingford, UK.

CABI, EPPO. (1999). *Planococcus citri*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 43. DOI:10.1079/DMPP/20066600043

CABI/EPPO. (2013). *Bactrocera dorsalis*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK:

CABI and EPPO. (2015). *Spiroplasma citri*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK:

Cheng, X.F., Wu, J.X., Ma, X.Y., Fu, H.F. and Wu, X.Y. (2011). First report of Citrus tristeza virus in *Citrus changshanensis* cv. Huyou in Zhejiang, China. *Journal of Plant Pathology*. **93**(4S): S4.68.

Choudhuri, S. and Konar, A. (2007). Population build up of lepidopteran insects on pummelo (*Citrus grandis* L.) in alluvial zone of West Bengal. *J. Entomol. Res*. **31**(2): 97-99.

Coletta-Filho, H.D., Francisco, C.S., Lopes, J.R.S., Oliveira, A.F. and Silva, L.F.O. (2016). First report of olive leaf scorch in Brazil, associated with *Xylella fastidiosa* subsp. *pauca*. *Phytopathologia Mediterranea*. **55**(1): 130-135.

Das, A.K., Nerkar, S. and Kumar, A. (2018). First report of *Phyllosticta citricarpa* causing citrus black spot on *Citrus sinensis* and *C. reticulata* in India. *Plant Disease*. **102**(8): 1661.

Dias-Pini, N.S., Lima, M.G.A., Lima, E.F.B., Maciel, G.P.S. and Duarte, P.M. (2018). *Scirtothrips dorsalis* (Thysanoptera: Thripidae): a newly introduced polyphagous pest in northeastern Brazil. *Neotrop. Entom*. **47**(5): 725-728. DOI:10.1007/s13744-018-0618-3

Diez, P.A., Peña, J.E. and Fidalgo, P. (2006). Population dynamics of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and its parasitoids in Tafí Viejo, Tucumán, Argentina. *Florida Entom*. **89**(3): 328-335. DOI:10.1653/0015-4040(2006)89[328:PDOPCL]2.0.CO;2

Donovan, N.J., Beattie, G.A.C., Chambers, G.A., Holford, P., Englezou, A., Hardy, S., Dorjee, Wangdi, P., Thinlay, and Om, N. (2012). First report of *'Candidatus Liberibacter asiaticus'* in *Diaphorina communis*. *Australasian Plant Disease Notes*. **7**(1): 1-4. http://rd.springer.com/article/10.1007/s13314-011-0031-9/fulltext.html DOI:10.1007/s13314-011-0031-9

Ebeling, W. (1959). Subtropical Fruit Pests. University of California, Los Angeles. 436 pp.

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Flora of China Editorial Committee. (2017). Flora of China. **In:** Flora of China. St. Louis, Missouri and Cambridge, Massachusetts, USA: Missouri Botanical Garden and Harvard University Herbaria. http://www.efloras.org/flora_page.aspx?flora_id=2

Gao, J.Y., Jun, G., Wang, Z.R., Zhou, D.G., Peng, M.X. and Yue, J.Q. (2012). Study on insect pest species and occurrence rule of main species in Dehong lemon orchard of Yunnan province. *Acta Agriculturae Jiangxi*. **24**(6): 70-73. http://www.jxnyxb.com

Garzia, T.G. and Lillo, D.E. (2018). Geographic distribution of *Phyllocoptruta oleivora* in the Mediterranean Basin, with particular emphasis on Italy. *Syst. App. Acarology*. **23**: 1021-1023.

Gasparich, G.E., Silva, J.G., Han, H.Y., McPheron, B.A., Steck, G.J. and Sheppard, W.S. (1997). Population genetic structure of Mediterranean fruit fly (Diptera: Tephritidae) and implications for worldwide colonization patterns. Annals of the Entomological Society of America. 90 (6), 790-797. DOI:10.1093/aesa/90.6.790

Ghosh, D.K., Kokane, A., Kokane, S., Tenzin, J., Gubyad, M.G., Wangdi, P., Murkute, A.A., Sharma, A.K. and Gowda, S. (2020). Detection and molecular characterization of '*Candidatus*

Liberibacter asiaticus' and Citrus tristeza virus associated with citrus decline in Bhutan. *Phytopathology (early view)*. https://doi.org/10.1094/PHYTO-07-20-0266-R
Gomes, A.M.S.V., Reis, F.O., Lemos, R.N.S., Mondego, J.M., Braun, H. and Araujo, J.R.G. (2019). Physiological characteristics of citrus plants infested with citrus blackfly. *Revista Brasileira de Entom*. **63**(2): 119–123. https://doi.org/10.1016/j.rbe.2019.02.002
Govaerts, R. (2017). World Checklist of Commelinaceae. Richmond, UK: Royal Botanic Gardens, Kew. http://apps.kew.org/wcsp/
Haq, I., Vreysen, M.J.B., Schutze, M., Hendrichs, J. and Shelly, T. (2016). Effects of methyl eugenol feeding on mating compatibility of Asian population of *Bactrocera dorsalis* (Diptera: Tephritidae) with African population and with *B. carambolae*. *J. Econ. Entom*. **109**(1): 148-153. http://jee.oxfordjournals.org/content/109/1/148
Hayes, W. B. (1970). Fruit growing in India. Third edition. Kitabistan, Allahabad. 512 pp.
Holm, L.R., Plucknett, D.L., Panco, J.V. and Herberger, J.P. (1977). The World's Worst Weeds: Distribution and Biology., Honolulu, USA: University Press of Hawaii.
Holm, L.G., Pancho, J.V., Herberger, J.P. and Plucknett, D.L. (1979). A geographical atlas of world weeds. New York, USA: John Wiley and Sons, 391 pp.
Hou, X., Huang, F., Zhang, T., Xu, J., Hyde, D.K. and Li, H. (2014). Pathotypes and Genetic Diversity of Chinese Collections of *Elsinoë fawcettii* Causing Citrus Scab. *J. Inte. Agri*. **13**(6): 1293-1302.
Ibrahim, I.K.A. and Handoo, Z.A. (2016). Occurrence of phytoparasitic nematodes on some crop plants in northern Egypt. *Pakistan Journal of Nematology*. **34**(2): 163-169.
ICAR. (2010). Annual Report 2009-10, ICAR Research Complex for NEH Region, Meghalaya.
IPPC. (2020). Eradication of *Bactrocera dorsalis* (Oriental Fruit Fly) in three separate areas in the Eastern Cape Province of South Africa. **In:** IPPC Official Pest Report, Rome, Italy: FAO. https://www.ippc.int/
Jaciani, F.J., Destéfano, S.A.L., Neto, R.J. and Belasque, J.J. (2009). Detection of a new bacterium related to *Xanthomonas fuscans* subsp. *aurantifolii* infecting Swingle citrumelo in Brazil. *Plant Dis*. **93**(10): 1074. DOI:10.1094/PDIS-93-10-1074B
James, D.G. (1990). Incidence of egg parasitism of *Biprorulus bibax* Breddin (Hemiptera: Pentatomidae) in southern New South Wales and northern Victoria. *Gen. App. Entom*. **22**: 55-60.
Jeffress, S., Arun-Chinnappa, K., Stodart, B., Vaghefi, N., Tan, Y.P. and Ash, G. (2020). Genome mining of the citrus pathogen *Elsinoë fawcettii*; prediction and prioritisation of candidate effectors, cell wall degrading enzymes and secondary metabolite gene clusters. PLoS One 15(5):e0227396.
Khan, A., Khanzada, K.A., Shaukat, S.S. and Shahzad, S. (2007). Nematodes associated with onion in Sindh, Pakistan. *Pakistan Journal of Nematology*. **25**(2): 291-294.
Kiss, L., Cook, R.T.A., Saenz, G.S., Cunnington, J.H., Takamatsu, S., Pascoe, I., Bardin, M., Nicot, P.C., Sato, Y.; Rossman, A. Y. (2001). Mycological Research. **105**(6): 684-697.
Kumar, P.S. and Rachana, R.R. (2021). *Scirtothrips dorsalis* (Thysanoptera: Thripidae) is a pest of celery, *Apium graveolens* (Apiales: Apiaceae): first report and diagnostic characters. *Journal of Integrated Pest Management*. **12** (46), DOI:10.1093/jipm/pmab039
Lama, T.K. and Amatya, P. (1993). Survey of the Incidence of Citrus Greening Disease and its Psylla Vector in Nepal and Bhutan. *J. Inter. Org. Citrus Vir. Con. Proc. (1957-2010)*. **12**(2): 445-446. https://escholarship.org/uc/item/6hk8p4cb DOI:10.5070/C56hk8p4cb
Li, X., Li, W., Guo, F. and Lai, B. (2003). The damage of thrips to the Navel orange fruit and its control. *South China Fruits*. **32**: 21-21.
Lima, N.B., Batista, A.M.V., Morais, M.A., Jr., Barbosa, M.A.G., Michereff, S.J., Hyde, K.D. and Câmara, M.P.S. (2013). Five Colletotrichum species are responsible for mango anthracnose in northeastern Brazil. *Fungal Divers*. **61**: 75-88.
Lin, H.C., Feng, C.Y., Chang, Y.A. and Chang, H. (2012). Molecular typing and genetic characterization of pathogenic variants of *Xanthomonas axonopodis* pv. *citri* in Taiwan. *J. Phytopath*. **160**(9): 475-483.
Lopes, F.S.C., Oliveira, J.V., Oliveira, J.E.M., Oliveira, M.D. and Souza, A.M. (2019). Host plants for mealybugs (Hemiptera: Pseudococcidae) in grapevine crops. *Pesquisa Agropecuária Trop*. DOI:10.1590/1983-40632019v4954421
Loeza-Kuk, E., Ochoa-Martínez, D.L., Mora-Aguilera, G., Rivas-Valencia, P., Gutiérrez-Espinosa, M.A., Cintra, J.J.W., Villegas-Monter, Á., Arno-Wulff, N. and Perez-Molphe-Balch, E. (2008). Detection of Citrus sudden death-associated virus and Haplotypes of Citrus tristeza virus in

Toxoptera citricida and *Aphis spiraecola* and implication on citrus sudden death in Brazil. *Agrociencia*, **42**(6): 669-678.
Lvovsky, and Fallahzadeh. (2010). *Psorosticha zizyphi* (Lepidoptera: Dressariidae) is newly recorded from Iran. Far Eastern Entom. (N.216): 14-16.
Maciel. (2015). Status sanitário da mosca negra dos citros no Brasil. Dissertação (Mestrado em Defesa Sanitária Vegetal) **-** Universidade Federal de Viçosa, Viçosa, 88 pp.
Mangrio, W.M., Sahito, H.A., Bhugro, M., Kousar, T., Shah, Z.H. and Jatoi, F.A. (2020). Incidence and distribution of lemon Butterfly (*Papilio demoleus* L.) on five alternate Citrus hosts at Sahati region, Sindh-Pakistan. *Pure App. Bio*. **9**(4): 2637-2647. DOI:10.19045/bspab.2020.90280
Martinez-Minaya, J., Conesa, D., Lopez-Quilez, A. and Vicent, A. (2015). Climatic distribution of citrus black spot caused by *Phyllosticta citricarpa*. A historical analysis of the disease spread in South Africa. *European Journal of Plant Pathology*. **143**(1): 69-83.
Mehsud, A., Mehmood, S., Muhammad, A., Khan, R. U., Khan, S. U., Khan, H. U., Wazir, R. and Hussain, Z. (2013). Morphology and anatomy of some weeds from flora of District Bannu, Pakistan. *Pakistan Journal of Weed Science Research*. **19** (4), 437-445. http://www.wssp.org.pk/vol-19-4-2013/7.%20PJWSR-23-2013-19-4-437-445.pdf
Mendes, M.A.S., Dianese, J.C. and Urben, A. (2019). Fungos em Plants no Brasil. 2ª Edição ampliada e revisada. – Brasília, DF: Escola Nacional de Gestão Agropecuária, 970 pages.
Mirab-Balou, M., Tong, X.L. and Chen, X.X. (2014). Thrips species diversity in urban green spaces of Hangzhou (Zhejiang Province), China. *J. Entomol. Acarol. Res*. **46**(3): 85-89. DOI:10.4081/jear.2014.1828
Mo, J., Zhao, G., Li, Q., Soalngi, G.S., Tang, L., Huang, S., Guo, T. and Hsiang, T. (2018). Identification and characterization of Colletotrichum species associated with mango anthracnose in Guangxi, China. *Plant Dis*. **102**: 1283-1289.
Moody, K. (1989). Weeds reported in rice in South and Southeast Asia., Los Banos, Philippines: IRRI. 442.
Mound, L.A. and Tree, D.J. (2020). *Thysanoptera australiensis*– Thrips of Australia. Lucidcentral.org, Identic Pty Ltd, Queensland, Australia. https://keys.lucidcentral.org/keys/v3/thrips_australia/keys/Thripinae_Australia/key/austhripinae/Media/Html/Entities/scirtothrips_aurantii.htm
Mukhtar, I. and Peer, A.F. (2017). First report of powdery mildew caused by *Podosphaera xanthii* on Euphorbia hirta in China. *Plant Disease*. **101**(7): 1316. DOI:10.1094/PDIS-01-17-0002-PDN
Nayak, A. K. and Babu, B. K. (2019). First report of powdery mildew caused by *Podosphaera fusca* on *Euphorbia hirta* in Odisha state, India. *Journal of Plant Pathology*. **101** (1): 191-191. DOI:10.1007/s42161-018-0143-6
Nava, D.E., Torres, M.L.G., Rodrigues, M.D.L., Bento, J.M.S. and Parra, J.R.P. (2007). Biology of *Diaphorina citri* (Hem., Psyllidae) on different hosts and at different temperatures. *J. App. Entom*. **131**(9/10): 709-715. DOI:10.1111/j.1439-0418.2007.01230.x
Newstead, R. (1894). Scale insects in Madras. *Indian Museum Notes*. **3**:21-32.
NHM. (1891). Specimen record from the collection in the Natural History Museum (London, UK)., London, UK: Natural History Museum (London).
Noltie, H.J. (1994). Flora of Bhutan, Volume 3, Part 1. Edinburgh, UK: Royal Botanic Garden.
Paul, I., van Jaarsveld, A.S., Korsten, L. and Hattingh, V. (2005). The potential global geographical distribution of Citrus Black Spot caused by *Guignardia citricarpa* (Kiely): likelihood of disease establishment in the European Union. *Crop Protection*. **24**(2): 297-308.
Prins, D.J. and Prins, D.W. (2014). Afromoths, online database of Afrotropical moth species (Lepidoptera). World Wide Web electronic publication (www.afromoths.net) (12 Aug.2014).
Read, D.A. and Pietersen, G. (2017). Diversity of Citrus tristeza virus populations in commercial grapefruit orchards in Southern Africa, determined using Illumina Mi Seq technology. *European Journal of Plant Pathology*. **148**(2): 379-391.
Safdar, A., Javed, N., Khan, S.A., Khan, H.U., Rehman, A. and Haq, I. (2010). Survey and investigation of different citrus growing areas for citrus sudden death syndrome. *Pakistan Journal of Phytopathology*. **22**(2): 71-78.
Savitha, A.S., Ajithkumar, K., Palaiah, P. and Ramesh, G. (2016). Integrated management of citrus canker caused by *Xanthomonas axonopodis* pv. *citri* (Hasse) in acid lime (*Citrus auruntifolia*). *Pest Manag. Hortil. Ecos*. **22**(2): 189-192.

Seebens, H., Blackburn, T.M., Dyer, E.E., Genovesi, P., Hulme, P.E., Jeschke, J.M., Pagad, S., Pyšek, P., Winter, M., Arianoutsou, M., Bacher, S., Blasius, B., Brundu, G., Capinha, C., Celesti-Grapow, L., Dawson, W., Dullinger, S., Fuentes, N., Jäger, H., Kartesz, J., Kenis, M., Kreft, H., Kühn, I., Lenzner, B., Liebhold, A. and Mosena, A. (2017). No saturation in the accumulation of alien species worldwide. *Nat. Comm.* **8**(2): 14435. http://www.nature.com/articles/ncomms14435

Sharma, G., Kumar, N., Weir, B.S., Hyde, K.D. and Shenoy, B.D. (2013). The ApMat marker can resolve Colletotrichum species: A case study with Mangifera indica. *Fungal Divers*. **61**: 117-138.

Shivas, R.G., Tan, Y.P., Edwards, J., Dinh, Q., Maxwell, A., Andjic, V., Liberato, J.R., Anderson, C., Beasley, D.R., Bransgrove, K., Coates, L.M., Cowan, K., Daniel, R., Dean, J.R., Lomavatu, M.F., Mercado-Escueta, D., Mitchell, R.W., Thangavel, R., Tran-Nguyen, L.T.T. and Weir, B.S. (2016). *Colletotrichum* species in Australia. ***Aus. Plant Pathol*. 45**: 447-464.

Singh, Y. H., Sharma, S. K., Sinha, B., Baranwal, V. K., Singh, N. B., Chanu, N. T., Roy, S. S., Ansari, M. A., Ningombam, A., Devi, P. S., Das, A. K., Singh, S., Singh, K. M. and Prakash, N. (2019). Genetic Variability Based on Tandem Repeat Numbers in a Genomic Locus of '*Candidatus Liberibacter asiaticus*' Prevalent in North East India. *The Plant Pathology Journal*. **35** (6), 644-653. DOI:10.5423/PPJ.OA.03.2019.0061

Singh, S., Reddy, P.V.R. and Deka, S. (2020). Sucking Pests of Citrus. **In:** Omkar (ed.) Sucking Pests of Crops Springer, 515 pp.

Singh, S., Mulani, E., Bhattacharyya, U., Palchoudhury, S., Mazumder, N., Saikia, S., Nath, P.D., Pun, K.B. and Biswas, K.K. (2022). Decline inducing Citrus tristeza virus-VT/Kpg3 genotype occurs predominantly in citrus orchards of Northeast India. *I Indian Phytopathology*. **75**: 853–861.

Sposito, M.B., Amorim, L., Bassanezi, R.B., Yamamoto, P.T., Felippe, M.R. and Czermainski, A.B.C. (2011). *Crop Protection.* **30**(12): 1546-1552.

Srinivasnaik, S., Suganthy, M., Kumar, S.M. and Jegadeeswari, V. (2016). Survey, documentation and identification of entomofauna of cocoa, *Theobroma cacao* L. in major cocoa growing regions of South India. *J. App. Nat. Sci*. **8**(3): 1444-1451. http://jans.ansfoundation.org/previous-issues/volume-8-year-2016--issue-3#TOC-Physiological-and-biochemical-response-to-higher-temperature-stress-in-hot-pepper-Capsicum-annuum-L.-

Srivastava, R.C. (1982). *Ind. J. Mycology Plant Path*. **12**(2): 244-246.

Subbotin, S.A., Madani, M., Krall, E., Sturhan, D. and Moens, M. (2005). Molecular diagnostics, taxonomy, and phylogeny of the stem nematode *Ditylenchus dipsaci* species complex based on the sequences of the internal transcribed spacer-rDNA. *Phytopathology*. **95**(11): 1308-1315. DOI:10.1094/PHYTO-95-1308

Sundararaju, P. (2006). Community structure of plant parasitic nematodes in banana plantations of Andhra Pradesh, India. *Indian Journal of Nematology*. **36**(2): 226-229.

Tayyib, M., Suhail, A., Arif, M.J. and Khan, M.A. (2014). Whiteflies (Aleyrodidae: Homoptera) of Punjab Pakistan. *Pak. Entom.* **36**(1): 31-34.

Thakre, B. and Soni, U. (2017). Incidence of suitable insecticides for the control of leaf miner (*Phyllcnistis citrella*) on Nagpur mandarin at Chhindwara district of Madhya Pradesh, India. *Ann. Plant Sci.* **6**(7): 1653-1655. DOI:10.21746/aps.2017.07.002

Toda, S., Hirose, T., Kakiuchi, K., Kodama, H., Kijima, K. and Mochizuki, M. (2014). Occurrence of a novel strain of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in Japan and development of its molecular diagnostics. *App. Entom. Zoo*. **49**(2): 231-239. DOI:10.1007/s13355-013-0241-z

Tong, X. (1993). Butterfly fauna of Zhejiang., Hangzhou, China: Zhejiang Science and Technology Publishers.

Tropea Garzia, G. and De Lillo, E. (2018). Geographic distribution of *Phyllocoptruta oleivora* in the Mediterranean Basin, with particular emphasis on Italy. *Systematic and Applied Acarology.* **23**: 1021-1023.

Ullah, F., Gul, R. and Badshah, H. (2005). Efficacy of Five Different Insecticides Against Citrus Leaf Miner *Phyllocnistis citrella* Stainton (Lepidoptera; Gracillariidae). *J. Entom*. **2**(1): 25-28. DOI:10.3923/je.2005.25.28

USDA-ARS. (2017). Germplasm Resources Information Network (GRIN). Online Database. **In:** Germplasm Resources Information Network (GRIN). Online Database. Beltsville, Maryland, USA: National Germplasm Resources Laboratory. https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysimple.aspx

Villiers, E.A. and Milne, D.L. (1975) Citrus and Sub-Tropical Fruit Journal No. 503, 5-8.

Waterhouse, D.F. (1993). The major arthropod pests and weeds of agriculture in Southeast Asia. Canberra, Australia: ACIAR. v + 141 pp.

Weir, B.S., Johnston, P.R. and Damm, U. (2012). The *Colletotrichum gloeosporioides* species complex. *Stud. Mycol*. **73**: 115-180.

Wells, M. J., Balsinhas, A. A., Joffe, H., Engelbrecht, V. M., Harding, G. and Stirton, C. H. (1986). A catalogue of problem plants in southern Africa incorporating the national weed list of South Africa. Memoirs, Botanical Survey of South Africa. v + 658pp.

WenJuan, Q., Ying, L., YouQing, M., ZunZhong, Y., Liu, W., Rui, W., QiQi, Z., Hui, W. and Jian, W. (2018). Field detection of citrus huanglongbing associated with *'Candidatus Liberibacter asiaticus*' by recombinase polymerase amplification within 15 min. *Journal of Agricultural and Food Chemistry*. **66**(22): 5473-5480. DOI:10.1021/acs.jafc.8b01015

Wikipedia. (2021). https://en.wikipedia.org/wiki/Aonidiella_citrina#cite_note-ScaleNet-1

Wikipedia. (2021). https://en.wikipedia.org/wiki/Psorosticha_zizyphi

Xu, F., Yang, G.Q., Wang, J.M., Song, Y.L., Liu, L.L. and Zhang, J.J. (2016). Composition and variation in aggressiveness of Fusarium populations causing wheat head blight in Henan Province. *Acta Phytopathol*. *Sin*. **46**: 294-303.

Yang, W., FengMao, C., LiChao, W. and Min, L. (2021). Investigation of beetle species that carry the pine wood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle, in China. *J. Forestry Res*. **32**(4): 1745-1751. DOI:10.1007/s11676-020-01146-2

Ye, G., Hong, N., Zou, L.F., Zou, H.S., Zakria, M., Wang, G.P. and Chen, G.Y. (2013). Based genetic diversity of Chinese isolates of the citrus canker pathogen *Xanthomonas citri* subsp. *citr*i. *Plant Dis*. pp: 1187-1194.

Zeng, Y., Ye, W., Tredway, L., Martin, S. and Martin, M. (2012). Taxonomy and morphology of plant-parasitic nematodes associated with turfgrasses in North and South Carolina, USA. *Zootaxa*. **3452**: 1-46, DOI: 10.5281/zenodo.210165

Zhang, B.C. and Huang, Y.C. (1990). A list of important plant diseases in China. *Rev. Plant Path.* **69**(3): 97-118.

Chapter 4: Hazard Identification

4.1. Introduction

This chapter outlines the potential hazards associated with citrus in Bangladesh, India, Thailand, China, Bhutan, South Africa, Egypt, Brazil, Australia, etc. and considers some of the major risk characteristics of the commodity and its hazards.

An initial hazard list was made of all pests and pathogens associated with citrus including Zara/Colombo Lemon (*Citrus medica*) found in Bangladesh, India, Thailand, China, Bhutan, South Africa, Egypt, Brazil, Australia and any other citrus exporting countries of the world. The PRA study team at first reviewed a report on "Pest Risk Analysis of Citrus in Bangladesh' conducted in the year 2014 sponsored by "Strengthening Phytosanitary Capacity in Bangladesh" Project under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh. This PRA report had made the list of pests of citrus including Zara/Colombo Lemon (*Citrus medica*) those were available in Bangladesh as well as in the above-mentioned exporting countries of citrus from where Bangladesh usually imports citrus. The lists of citruses were used as basis for the current PRA of *Citrus medica* (Zara/ColomboLemon) in Bangladesh. The list of these citrus pests was later refined and finalized after adding and/or excluding the pests based on consideration of association with *Citrus medica* (Zara/Colombo Lemons) as found available in Bangladesh identified through field survey and secondary sources as well as found in the above-mentioned exporting countries 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 *Citrus medica* (Zara/ Colombo Lemon). Then all potential hazards identified through primary data collection survey and literature review were considered for pest risk assessment as well as 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 *Citrus medica* (Zara/Colombo Lebu varieties). Under their taxonomic category, i.e., Arthropods that include insect, mite, etc., Plant Pathogens like Fungi, Bacteria, Virus, Nematode, etc., Herbs such as field weeds, parasitic weeds, etc., Mollusk such as Slug, Snail, 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, pathogen, etc. 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 hitchhikers or vectors this is noted in the individual pest risk assessment.

The following categories of potential hazards are used are as follows:

A. Arthropod	**B. Pathogen**	**C. Herb**	**D. Mollusk**
• Insect pest • Mite pest	• Fungi • Bacteria • Algae • Virus • Nematode	• Weed	• Snail • Slug

4.3. Interception of Pests on *Citrus medica* (Zara/ColomboLemon) from Existing Pathways

In the past, there was no previous pest risk assessment on *Citrus medica* (Zara/ColomboLemon) in any of the exporting countries including India, China, Thailand, Bhutan, South Africa, Egypt, Brazil, Australia, etc. from where Bangladesh usually imports citrus. As reported by the Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Bangladesh, during inspection in port of entry of citrus in Bangladesh, not a pest had been intercepted yet today on the citrus imported into Bangladesh from any country of citrus export.

4.4. Review of earlier PRA

The "Pest Risk Analysis (PRA) of Citrus in Bangladesh" previously conducted in 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 citruses including *Citrus medica* (Zara/Colombo Lemon) as well as to conduct the current study on "PRA of *Citrus medica* (Zara/Colombo Lemon) in Bangladesh". As per requirement of the international standard, every five-year interval to update the pest list, PRA of any commodity need to be updated by the NPPO. Therefore, the present "PRA of *Citrus medica* (Zara/Colombo Lemon) 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 decreasing use of chemical products in agriculture and further reliance on Integrated Pest Management (IPM) strategies it is assumed that new pests enter the system at some time in the future.

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

4.5.2. Latent micro-organisms

Pests such as microbes and fungi infect *Citrus medica* (Zara/Colombo Lemon) 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 Zara/Colombo Lemon after arrival making it difficult to distinguish the origin of saprobes and pathogens without adequate identification. Consumers tend to throw away molded Zara/Colombo Lemon 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 Zara/Colombo Lemon 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 citrus in the importing countries, and preferably, any information on incidence level in pests infested citrus 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 citrus and/or saplings take to get from the field in India, Philippines, Thailand, Pakistan, Australia, or any other citrus exporting country to Bangladesh ready for wholesale, if it is transported by Land port or Sea or Air shipment.

4.11. 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 citrus 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

This chapter provides background information on possible measures to mitigate the biosecurity risk associated with citrus available in Bangladesh as well as in importing citruses from India, Thailand, China, Bhutan, Egypt, South Africa, Brazil, Australia, etc. The management options for both non-quarantine and quarantine pests of citrus including *Citrus medica* (Zara/Colombo Lemon) were reviewed and presented in this chapter separately as follows:

5.1. Management Options for Non-quarantine Pests of Citrus

The management options for non-quarantine pests (arthropod pests viz. insect and mite pests, and diseases) of citrus including *Citrus medica* (Zara/Colombo Lemon) in Bangladesh as identified through literature review are presented in this section as follows:

5.1.1. Management options for arthropod pests

The study team collected and reviewed different management options for arthropod (insect and mite) pests of citrus including *Citrus medica* (Zara/Colombo Lebu varieties) and finally presented the reviewed findings in the following subheadings:

5.1.1.1. Lemon butterfly

(a) Cultural, botanical and bio-pesticide-based control: Lemon butterfly is one of the economically important pests whose larval forms cause serious damage to the wild and cultivated species of citrus during the later stages of development. The larvae may cause complete defoliation of infested young plants (Butani and Jotwani, 1975). It is a major pest in nurseries, young seedlings and new flush in mature citrus trees. It causes 83% defoliation in young citrus plants (Narayanamma *et al.*, 2001). The caterpillars feed voraciously and cause extensive damage to nurseries and young seedlings leaving only midribs.

A research finding on the "Evaluation of new management approaches against lemon butterfly (*Papilio demoleus* L.) infesting Jara lemon in Jaintapur, Sylhet, Bangladesh" conducted in the year 2016 evident that among five management approaches viz., handpicking and killing of lemon butterfly larvae, spraying of imidacloprid (Sapta 70 WG) @ 0.5 g/L of water, bio-neem plus (Azadirachtin 1 EC) @ 1 ml/L of water, Spinosad (Tracer 45 SC) @ 1.25 ml/L of water, Chlorfenapyr (Proclaim 5 SG) @ 1 g/L of water and an untreated control (water spray only), the lowest leaf infestation (17.83%) was recorded in plants treated with Spinosad and Chlorfenapyr. The highest leaf infestation (31.83%) was recorded in untreated control plants. But the intermediate leaf infestation (20.85% to 21.33%) was recorded in plants treated with hand picking and killing of lemon butterfly larvae, Imidacloprid and Bio-neem plus. Spinosad and Chlorefenapyr treated plants produced the highest fruit yield (1.35 t ha^{-1}) and also gave the highest financial returns in terms of Marginal Benefit Cost Ratio (MBCR) (11.50: 1.0). But the lowest MBCR (7.31: 1.0) was obtained from plants treated with hand picking and killing of lemon butterfly larvae. The results clearly indicated that Spinosad (Bio-pesticide) is the most cost-effective as well as environmentally safe management approach for lemon butterfly larvae (Haque *et al.*, 2019). They also reported that the biopesticides Spinosad (Tracer 45SC) and chlorfenapyr (Intrepid 10 SG) proved to be the most effective in suppressing leaf infestation caused by lemon butterfly larvae in Zara lemon. Among the whole treated trees, the lowest percentage of leaf infestation (17.83%) was observed in the trees sprayed with spinosad (Tracer 45 SC) and chlorfenapyr (Intrepid 10 SG). In addition to leaf infestation reduction, spinosad and chlorfenapyr treated trees also gave the highest fruit yield of Zara lemon (1.35 t ha -1).

Narayanamma and Savithri (2003) reported that utilizing various plant extracts such as neem leaf extract, neem seed kernel, etc. was found an efficient method of lemon butterfly management. Segarra-Carmona *et al.* (2010) found that the highest concentrations of spinosad and *Bacillus thuringiensis* caused 100% mortality in the third instar larvae of lemon butterfly.

(b) Chemical control: Synthetic pesticides such as carbaryl, phosalone, acephate, pirimiphos-methyl, fenitrothion, permethrin, etc. can be used to control the assault of the lemon butterfly (Batra, 1990; Solunke and Deshpande, 1991).

5.1.1.2. Citrus leaf miner

(a) Cultural control: *Parietaria* is cultivated in Italy as a substitute host for the parasitoids of citrus leaf miner near citrus groves (Mineo *et al.*, 1997). Collection and elimination of falling leaves from the citrus grove is effective to reduce the infestation of citrus leaf miner. In addition, fertilization and irrigation in citrus groves are useful in preventing citrus leaf miner (Zhang *et al.*, 1994). Iordanou and Charalambous (1998) evaluated some insecticides including spinosad for the management of citrus leaf miner in the laboratory. They found that spinosad gave satisfactory protection to the infestation of leaf miner for more than one-month period.

(b) Biological control: *Bacillus thuringiensis* is effective to control citrus leaf miner (Zhang *et al.*, 1994).

(c) Host-plant resistance: In India, citrus leaf miner-resistant cultivars included Carrizo, Sacaton, Savage, Troyer, Yama Citrange, Citrumelo (*Poncirus trifoliata x grapefruit*), *Cambell Valencia*, Pomary and Rubidoux, and *Muraya koenigii* (Batra *et al.*, 1992).

(d) Chemical control: The insecticide Imidacloprid is effective against citrus leaf miner (Vargas *et al.*, 1999). imidacloprid can control leaf miner for approximately 100 days after application (Nucifora *et al.*, 1999). In Greece, Fenoxycarb is also efficient against leaf miner (Buchelos and Foudoulakis, 2000). China has been the primary user of pyrethrins. Additionally, the organophosphates phosmet, quinalphos, and dimethoate, as well as the carbamates carbaryl and cartap, have been utilized (Zhang *et al.*, 1994). Soap with fish oil resin and Pongamia oil were the most effective remedies in India (Katole *et al.*, 1993).

(e) Pheromone trap: (Z,Z,E)-7,11,13-hexadecatrienal (triene) and (Z,Z)-7,11-hexadecadienal (diene) were used as a lure to capture male insect in USA (Leal *et al.*, 2006).

(f) IPM programs: When necessary, release parasitoids and predators using Bacillus thuringiensis applications that are precisely timed. If pheromone dispensers become widely available to farmers, mating disruption should be an effective management tool, especially when combined with biological control and little chemical control (Zhang *et al.*, 1994).

5.1.1.3. Thrips

Franklinothrips megalops is a common predator of *S. dorsalis* where *Erythrothrips asiaticus* [*Aduncothrips asiaticus*], is a highly seasonal species. The predaceous species, *Scolothrips indicus*, feeds on the larvae of *S. dorsalis*. *Geocoris ochropterus* is also reported as a potential predator of *S. dorsalis*. In Japan, parasitism of larval *S. dorsalis* at rates of up to 52% by the trichogrammatid, *Megaphragma* sp. have been recorded on grapes. 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. 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).

Planes *et al.* (2015) who found that spinosad and chlorfenapyr markedly reduced the nymphal population of citrus thrips, *Pezothrips kellyanus* and showed a significant reduction in fruit infestation.

5.1.1.4. Bark eating caterpillar

(a) Cultural control: Clean and overcrowding citrus orchard can suppress the population of bark eating caterpillar (Butani, 1979).

(b) Mechanical control: When infestation levels are minimal, killing larvae by inserting an iron spike into each hole is successful (Sharma and Kumar, 1986).

(c) Host plant resistant: According to Sandhu *et al.* (1977), 'Cattley' is the most resistant cultivar of guava. Grapefruits are less susceptible to disease than oranges and mandarins (Sandhu *et al.*, 1979). The loquat cultivar 'Thames Pride' is the most resistant to *I. quadrinatata* (Lal and Singh, 1982).

(d) Chemical control: Various insecticide applications can be used to manage the pest efficiently. demeton methyl, dichlorvos and quinalphos were most effective against the caterpillar (Singh and Dhamdhere, 1989).

5.1.1.5. Citrus mealybug

P. citri has developed resistance to certain pesticides, and *P. citri* control relies mainly on natural enemies whose populations are diminished or exterminated by the same insecticides. In Tunisia, a high level of resistance to chlorpyrifos has developed, presumably as a result of repeated use. In an effort to prevent resistance, chlorpyrifos is often used solely during *P. citri* dormancy or as a postharvest treatment in California (Ramzi *et al.,* 2018). There are numerous natural enemies. In Egypt, 12 species of parasitoid wasps were found on citrus mealybugs, according to a survey. In addition, nine predatory insects, such as ladybird beetles, moths, a gall midge, and a green lacewing, were identified (Ahmed and Abd-Rabou, 2010). A number of parasitoid wasps, such as *Leptomastidea abnormis, Leptomastix dactylopii*, *Chrysoplatycerus splendens*, and *Anagyrus pseudococci*, are employed as biological control agents. The brown lacewing *Sympherobius barberi*, the green lacewing *Chrysopa lateralis*, hoverfly larvae, and the scale-feeding snout-moth larva are predators of this species (Gill, 2013).

5.1.1.6. Spiked mealybug

(a) Natural enemies: The parasitoid *Pseudaphycus utilis* is one of the most important natural enemies of *N. nipae*. Within about a year of the introduction of *P. utilis* to Hawaii, *N. nipae* had almost disappeared from Oahu and was soon almost eradicated from the Hawaiian Islands (Bartlett, 1978).

(b) 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. Infestations of *N. nipae* were eliminated in coconut plantations by chemically controlling Azteca ants which maintained and protected the mealybug colonies.

5.1.1.7. Asian citrus psyllid

Among the natural enemies of the Asian citrus psyllid are hoverflies, lacewings, various species of ladybug, and numerous species of parasitic wasp (Waterston, 1922). One of these wasps, *Tamarixia radiata*, has been successfully distributed and established in a variety of citrus-growing regions, including Florida (Hoy and Aguyen, 2001). Widespread pesticides are effective against psyllid adults and nymphs. Spraying with phosphamidon 0.3ml or quinalphos 1ml or thiometan 0.8 ml/l of water and bud burst stage gives knock down effect (Bindra et al., 1974). The most effective method for controlling citrus greening disease is an integrated approach comprising the use of healthy planting stock, the control of vectors, and the rapid removal of affected trees and branches (Korsten, 2004).

5.1.1.8. Scale insect

Spraying with methidathion, chloropyrifos and pyriproxyfen has proven efficacy in reducing the incidence of the pest. Another alternative is biological control using the parasite Aphytis melinus de Bach. This method is now commonly used in citrus orchards in many countries (Otmani *et al.*, 2011).

5.1.1.9. Black citrus aphid

Spacing between the citrus plants and pruning old branches reduces the infestation of black citrus aphid (Carver, 1978). Grafting on sour orange rootstock may be acceptable (Garnsey et al., 1996). Several systemic insecticides including acephate imidacloprid and acetamiprid have been used against *T. citricida* with various residual effects (Yamamoto et al., 2000).

5.1.1.10. Citrus blackfly

Chlorpyrifos, neonicotinoids, imidacloprid and pyrethroids cab be used against the nymph of citrus blackfly. These insecticides also suppress the population of adult citrus black flies (Knapp, 1994).

5.1.1.11. Oriental fruit fly

(a) Regulatory control: Pre-harvest control measures which would mitigate the risk of *B. dorsalis* are provided below. Post-harvest treatments against *B. dorsalis* include heat treatments, cold treatments, ionizing radiation and fumigation (Dohino *et al.*, 2017). A combination of pre-harvest measures is recommended for effective control of *B. dorsalis*.

(b) Cultural control: 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 (Shivendra and Singh, 1998). Early harvesting is also an effective control strategy for mango (Gajendra *et al.*, 1997). The removal and destruction of fallen fruits because they may harbour larvae that could form a next generation. Destruction can either be by burning, deep burrowing, feeding them to pigs, or putting the fruits in dark-coloured plastic bags and placing them in the sun. Another method is raking or disturbing the soil below the fruit trees using other means. This will expose the puparia, leading to desiccation or predation by other organisms.

(c) Biological control: Hymenopteran parasitoid, *Fopius arisanus,* was most effective to control *B. dorsalis* (Gnanvossou *et al.*, 2016). Soil application of entomopathogenic fungi in combination with protein bait sprays reduced fruit infestation by *B. dorsalis* (Ekesi *et al.*, 2011).

(d) Chemical control: A bait spray consists of a suitable insecticide (e.g., malathion, spinosad, fipronil) mixed with a protein bait. Both males and females of fruit flies are attracted to protein sources emanating ammonia, and so insecticides can be applied to just a few spots in an orchard and the flies will be attracted to these spots. The protein most widely used is hydrolysed protein, but some supplies of this are acid hydrolysed and so highly phytotoxic. Smith and Nannan (1988) have developed a system using autolysed protein.

(e) IPM Programs: Using pheromone traps along with different cultural control methods is practiced to control *B. dorsalis.* The trap used will usually be modelled on the Steiner trap (White and Elson-Harris, 1994) or Jackson trap.

5.1.1.12. Termite

(a) 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.

(b) Cultural Control and Sanitary Methods: 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 (Kirton *et al.* 1999b).

(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, while field-derived cultures of *Conidiobolus coronatus* have been demonstrated to be highly pathogenic to *C. curvignathus* (Sajap *et al.*, 1997).

(d) Chemical Control: Termiticides including chlorpyrifos, cypermethrin, alpha-cypermethrin and new generation insecticides such as fipronil and imidacloprid are used for termites. 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. Chlorpyrifos, has been shown to give at least 4 years protection to *Gmelina arborea* grown in Sabah. 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. 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 (Tho and Kirton, 1992).

(e) IPM Programs: 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*.

5.1.1.13. Citrus Red Mite

(a) Cultural control: 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: The predatory mites, including the western predatory mite, *Galendromus* (formerly *Metaseiulus*) *occidentalis*, and Phytoseiulus mite species are mostly used against mites. Predatory mites are about the same size as plant-feeding mites but have longer legs and are more active. Other 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, big-eyed 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.

(c) Chemical control: 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 several 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).

Khan *et al.* (2018) conducted a study in the farmer's Jara lemon orchard at Bagerkhal village under Fatehpur union, Jaintapur upazila, Sylhet during January to July 2016 to develop cost-effective management approach against red mite (*Panonychus citri*) of Jara lemon. Treatments applied in the study were spraying of soap powder @ 5g L-1 of water, abamectin (Vertimec 018 EC) @ 1.5ml L-1 of water, bioneem plus (Azadirachtin 1 EC) @ 1ml L-1 of water, propargite (Omite 57 EC) @ 2ml L-1 of water and the control. The results revealed that lowest fruit infestation (12.33%) was found from propargite (Omite 57 EC) treated plants followed by bio-neem plus (Azadirachtin 1 EC) (18.66%) treated plants. The propargite treated plants produced the highest fruit yield (1.79 t ha-1) which was closely followed by boineem plus (1.68 t ha-1) treated plants. The results indicated that spraying of propargite and bioneem plus are cost-effective miticides against red mite of Jara lemon.

5.1.2. Management Options for Diseases of Citrus

This section includes the management options reviewed for the diseases of citrus including *Citrus medica* (Zara/Colombo Lemon) and finally presented here in the following subheadings:

5.1.2.1. Anthracnose

a) Cultural control: Anthracnose is reduced via orchard hygiene, modulation of blooming, and integrated management of chemical, physical, and biological controls (Akem, 2006). Cooke et al. (1998) observed that levels of endophytic organisms such as Botryosphaeria spp. were dramatically reduced in mango orchards where a pruning program was introduced as a preharvest management tool. Korsten (2006) discovered that preventing water stress during fruit development and maturity and avoiding placing fruits on the ground inhibited the development of illness.

(b) 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). Several 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).

(c) Chemical control: The use of fungicides is hampered by the limited number of effective products on the market and by regulations in producing and/or destination countries (Ploetz, 2018). Copper fungicides are typically the most common, however their efficiency is frequently limited, and they are typically combined with other fungicides. In South Africa, it has been demonstrated that monthly applications of copper oxychloride mixed with mancozeb are effective against most post-harvest illnesses, however, the registration of di-thiocarbamate fungicides such as mancozeb varies among production areas. To control anthracnose, mango growers in Brazil most frequently choose for preventative treatments with fungicides containing copper or triazoles. Another effective contact fungicide, chlorothalonil, is phytotoxic to fruit larger than a golf ball and should not be used after early fruit set (Ploetz, 2018).

5.1.2.2. Die-back

Avoid mechanically damaging plants. Prevent termites and longicorn beetles from causing plant harm. Reduce plant stress, including that resulting from drought and nutrient deficits. Reduce sunburn on the trunk and branches when doing intensive tree pruning. Remove diseased branches by severing them below the margin of the diseased or symptomatic parts. Disinfect the pruning instrument between each plant. Remove from the orchard any symptomatic trimmed branches. Do not prune mango trees when the canopy is moist or when it is raining. Adhere to the 'come clean, go clean' principle, and be sure to clean and disinfect tree pruning equipment before transporting it between farms. Although mango mulch is an important source of nutrients, it may be advantageous to remove mango mulch/litter from under mango trees in orchards with a high disease burden, as it is a potential source of inoculum.

5.1.2.3. Gummosis

Always maintain cleanliness in the orchard. Remove branches that are unproductive, dry, and diseased/infested by insects. The unproductive branches are rapidly ascending. Use Bordeaux-paste 10 percent on pruning wounds and the main trunk from the ground up to approximately one meter in height. After harvest, saturate the entire plant with a 1 percent Bordeaux mixture and repeat during fruit setting. Check the orchard frequently. Immediately apply Bordeaux-pest 10 percent if the bark is cracking or has mechanical damage. Similarly, if there is gum discharge on any area of the tree, remove it and apply Bordeaux-pest as described previously. Always use protective clothes and follow the recommendations on the product label, including dosage, timing of administration, and pre-harvest interval, while applying a pesticide (Thapa, 2014).

5.1.2.4. 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 sprays (oxychloride, hydroxide, or oxide) must be administered as soon as the blooms begin to appear and continued until the fruit has reached a size of around 50 percent. Typically, the fruit is sprayed every week until it reaches the half-size stage, and then every two-to-three week thereafter (Terry, 2014). Fungus infections are more likely to originate and spread in wetter climates. Rain can diminish the efficacy of the fungicide treatment, necessitating more frequent administrations under these conditions.

5.1.2.5. Sooty mold

As sooty mold is caused by the presence of honeydew, it is more effective to exclude and control the honeydew-producing insects than the mold itself, which typically disappears once the insects are eliminated. In instances when the mold itself must be controlled, mancozeb mixed with a detergent has apparently been employed with some effectiveness in Mexico, while Sulphur, Benomyl, Binapacryl, and Bordeaux mixture have produced successes against other kinds of sooty mould. Mineral oils help control insects and clean trees by facilitating the production of dry plaques, which can then be separated from fruit by precipitation and wind (Horst, 2008). Indirectly, parasitoids have a negative impact on sooty mold by reducing the number of honeydew-producing insects (Perez *et al.*, 2009).

5.1.2.6. Pink disease

Frequent rounds of trimming and the burning of diseased waste can provide effective cultural control. After diseased branches are removed from the tree, the pink encrustation and conidial pustules of the fungus remain alive for a lengthy length of time. Copper formulations (e.g., Bordeaux mixture, copper oxychloride, copper carbonate); tridemorph paints in an ammoniated latex base; triadimefon granules; chlorothalonil paints in a latex/bitumen base; and fenpropimorph (in vitro) have been shown to be active against *E. salmonicolor* (Chee and Chiu, 1999).

5.1.2.7. Canker

(a) Cultural control: Utilizing nursery plants free of citrus canker is the first crucial step in managing citrus canker. Establishing windbreaks around citrus plants reduces the illness. Pruning of angular branches containing canker lesions eliminates overripe inoculum (Goto, 1992).

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

(c) Botanical control: Rahman *et al.* (2020) carried out a study on "Efficacy of chemicals and botanical extracts to control citrus canker on Kinnow in Sargodha region" applying nine treatments, control (no chemical was applied), Neemsol @ 5 ml, copper oxychloride @ 3 g, streptomycin sulphate @ 1 g, potassium acetyl benzoic acid @ 10 ml, difenoconazole @ 0.5 ml, extracts of Acacia nilotica @ 10 ml, *Datura alba* @ 10 ml, and *Allium cepa* @ 10 ml. The results showed that among botanicals, the disease control was 74%, 64%, 59%, and 52% due to application of extract solutions of *A. cepa*, *D. alba*, Neem Oil, and *A. nilotica*, respectively. The use of copper oxychloride, difenconazole, and extracts of *A. cepa* and *D. alba* are recommended to citrus growers to control canker in Kinnow plantations during the critical period.

(d) Biological control: Different biocontrol agents such as antagonistic bacteria (*Pseudomonas* spp. and *Bacillus* spp.) and bacteriophages have been reported against *X. citri* pv. *citri*. 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 (Poveda *et al.*, 2021). 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.

(e) Chemical control: Once citrus canker disease has reached epidemic proportions, it cannot be managed with chemical treatments. Copper compounds are sprayed 10 to 14 days after the first spring shoots develop to avoid primary infection on spring shoots. Copper sprayed prior to wounding and/or inoculation reduced citrus canker incidence by greater than 90 percent. Copper sprays administered from 24 h prior to 0.5 h after wounding and inoculation reduced wound-associated canker by 91.8% to 96.1%, whereas copper sprays applied up to 8 h after wounding and inoculation reduced wound-associated canker by 67.8%. (Machado *et al.*, 2021).

Rahman *et al.* (2020) carried out a study on "Efficacy of chemicals and botanical extracts to control citrus canker on Kinnow in Sargodha region" applying nine treatments, control (no chemical was applied), Neemsol @ 5 ml, copper oxychloride @ 3 g, streptomycin sulphate @ 1 g, potassium acetyl benzoic acid @ 10 ml, difenoconazole @ 0.5 ml, extracts of *Acacia nilotica* @ 10 ml, *Datura alba* @ 10 ml, and *Allium cepa* @ 10 ml. The results showed that copper oxychloride controlled the disease up to 74%, difenconazole up to 56%. The use of copper oxychloride, difenconazole, and extracts of *A. cepa* and *D. alba* are recommended to citrus growers to control canker in Kinnow plantations during the critical period.

Citrus canker is mainly controlled by the application of various chemicals such as fungicides and bactericides at different times of the year. Various chemicals such as copper oxychloride (Khan *et al.*, 2018), streptomycin sulphate (Graham and Myers, 2011), streptomycin +

oxytetracycline (Graham *et al.*, 2008), streptomycin in combination with copper oxide (Graham *et al.*, 2008), sodium arsenate and copper sulphate have been found effective in controlling citrus canker in different citrus growing areas (Behlau *et al.*, 2008). Understanding the ecological conditions of citrus canker proliferation, are also very important aspect (Riasat *et al.*, 2020). Genome editing has been started for those genes which are sensitive to citrus canker (Jia *et al.*, 2017).

(f) IPM Programs: The relative contribution of three control measures, i.e., windbreak with *Casuarina cunninghamiana* trees, copper sprays and leaf miner 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.

5.1.2.8. Powdery mildew

(a) Cultural control: Regular inspection of orchards and removal/pruning of infected leaves and malformed panicles reduce the load of primary inoculum and improve fungicidal control (Prakash and Raoof, 1994).

(b) Biological control: An isolate of *Ampelomyces quisqualis* parasitized powdery mildew and reduced the disease in field trials. 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.

(c) Chemical control: Numerous fungicides have been employed to combat this disease in various jackfruit-growing nations. In addition to dormant sprays, multiple applications of suitable fungicides at intervals of 15 to 20 days are necessary to effectively control the disease. Initially, inorganic copper or sulfur-based compounds were utilized, followed by the introduction of a variety of organic and systemic fungicides that served as eradicants, protectants, or both (Nasir *et al.*, 2014). The most effective fungicides against powdery mildew were copper-based fungicides, sulphur-based fungicides, chlorothalonil, nitro compounds, and systemic fungicides (benzimidazols, imidazols, morpholines, organophosphorus, oxathiins, piperazine, pyridimines, strobilurins, and triazoles).

5.1.2.9. Tristeza virus

When grafting or topworking, use only certified, virus-free budwood. The Citrus Clonal Protection Program (CCPP) provides virus-free and true-to-type bud lines to nurseries and growers in California. Need to keep nurseries and greenhouses free from insect vectors. The aphid is the main vector for this vector so the measurement practices against aphid control is needed to follow to control this virus disease (Albiach-Marti, 2013).

5.1.2.10. Nematode

The endoparasitic microorganism *Pasteuria penetrans* and the egg-parasitic fungus *Purpureocillium lilacinum* (*Paecilomyces lilanicus*) are the biological agent against nematodes. Chemical control may be used on high-value crops, and a wide range of chemicals are available. 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).

5.2. Management Options for Quarantine Pests of Citrus for Bangladesh

The management options for quarantine pests of citrus including *Citrus medica* (Zara/Colombo Lemon) as identified through literature review for Bangladesh are presented in this section as follows:

5.2.1. Management Options for Quarantine Insect and Mite Pests

5.2.1.1. Citrus longhorn beetle

The main control measures against the spread of *A. chinensis* consist of the destruction and the removal of infested trees including roots. Using root grinding equipment can help ensure effectiveness. In addition, for effective control of *A. chinensis* in urban areas, the collaboration of citizens is essential, for this reason it is very important to replace the destroyed infested plants with non-host plants.

(a) Natural control: CLHB larvae are most susceptible to natural enemies in the early larval instar stage, or approximately the first two months of development. In China, predation by the weaver/red ants, *Oecophylla smaragdina* (Fab.) prevented the need for chemical control (Lieu 1945, Yang 1984).

(b) Sanitation: Field sanitation including cutting and burning/chipping of infested plant parts can eliminate immature stages.

(c) Mechanical exclusion: Since eggs are laid under the bark at the base of the trunk, wire nettings or spiral guards at the trunk base can serve as physical barrier for female oviposition.

(d) Biological control: The pathogenic fungi *Beauveria brongniartii* (Sacc.) is known to cause high adult mortality. In Japan, studies demonstrated adult mortality of 46 to 100% when sheets of polyurethane forms impregnated with *Beauveria brongniartii* were wrapped around the lower portion of the trunk or hung from the crotch (CABI 2004).

(e) Chemical control: Systemic insecticides are injected into base of a tree from where it is circulated to the branches, twigs, and foliage. The tree injection has been a successful component of the Asian longhorned beetle eradication program and imidacloprid was recommended for use during the eradication program for CLHB (WSDA 2002, Anonymous 2002b). Both adults and larvae are exposed to insecticides when treated by tree injection.

5.2.1.2. Citrus weevil

Chemical controls using chlorinated hydrocarbons against *D. abbreviatus* were successful. Neem oil, neem leaf extract, and other botanicals are helpful in controlling *D. abbreviates* by preventing egg laying on leaves and lowering egg viability. A wide range of substances, including ants, parasitic wasps, at least one virus, Bacillus thuringiensis, and a fungus adulticide, are being researched as potential biological pest treatments for the weevil. To tackle the pest, irrigation water in affected crops in Florida is released with the nematode *Steinernema riobravis* (Jetter and Godfrey, 2009).

5.2.1.3. Mites

Successful natural enemies against *P. oleivora* include *Amblyseius victoriensis*, *Hirsutella thompsonii*, *Tydeus* sp., *Agistemus exsertus*, etc. (CABI, 2021). To avoid conditions of water stress and the ensuing flare-up, water wisely, especially during the summer. Spray 1000–1500 litres of water per hectare with monocrotophos 36 SL 1.5 L or dicofol 18.5 EC 1.0 L.

Narrow-range oil is applied annually to control citrus bud mite numbers (Hare et al., 1999). Numerous predatory mites have been linked to the citrus bud mite, but because they are shielded inside the buds, none seem to have an impact on the pest's populations or harm. Immersion in hot water is helpful against *E. lewisi*.

5.2.2. Management Options for Quarantine Diseases

5.2.2.1. Citrus variegated chlorosis

It should be forbidden or strongly limited to import citrus fruits and plant materials from nations where *X. fastidiosa* subsp. *pauca* is present. If imported planting material is used, it must be kept in post-entry quarantine for two years and proven to be pest-free. Vector-free plants and fruits should be imported, maybe with the help of a suitable treatment. According to Goheen et al. (1973), a temperature treatment that kills the bacteria (45°C for at least 3 hours) may be useful as a phytosanitary measure.

5.2.2.2. Citrus exocortis virus

It is important to take precautions to sterilise equipment before trimming or cutting another plant since CEV can easily mechanically transmitted on infected knives and cutting tools. Cutting tools should be sterilised using sodium hypochlorite or similar sterilant that has been shown to successfully inactivate viroids. Only Poncirus trifoliata and hybrids made up of *P. trifoliata*, limes, lemons, and citrons are symptomatic hosts, even though other Citrus species are susceptible to CEV. To establish a trifoliate-type rootstock with tolerance for CEV, intergeneric somatic hybrids between red tangerine (*C. reticulata*) and *P. trifoliata* have been created in China (Guo et al., 2002).

5.2.2.3. Indian citrus ringspot virus

By subjecting infected Kinnow mandarin (*Citrus nobilis* x *Citrus deliciosa*) bud-sticks to dry heat for 30 minutes or more at 50°C or for 120 minutes at 45°C, the virus was destroyed. For the effective and efficient control of ICRSV, the creation, multiplication, and distribution of such virus-free plants are advised (Singh *et al.*, 2006).

5.3 References

Ahmed, N. and S. Abd-Rabou. (2010). Host plants, geographical distribution, natural enemies and biological studies of the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae). Egypt. Acad. J. Biolog. Sci. 3(1), 39-47.

Akem, C.N. (2006). Mango anthracnose disease: Present status and future research priorities. Plant Pathology Journal. **5**: 266–273.

Albiach-Marti, R.M. (2013). The Complex Genetics of Citrus tristeza virus. In: V. Romanowski (Ed.), Current Issues in Molecular Virology-Viral Genetics and Biotechnological Applications. http://dx.doi.org/10.5772/56122

Anonymous. (2002b). Washington's tree slayer: The citrus longhorned beetle. Citrus longhorned beetle eradication project. Washington State Department of Agriculture. (No longer available online).

Arthurs, S.P., Aristizábal, L.F. and Avery, P.B. (2013). Evaluation of entomopathogenic fungi against chilli thrips, *Scirtothrips dorsalis*. *Journal of Insect Science (Madison)*. **13**(31): (18 April 2013).

Bartlett, B.R. (1978). Pseudococcidae. **In:** Introduced Parasites and Predators of Arthropod Pests and Weeds: a World Review. Clausen, C.P. (ed.). *Agriculture Handbook*. **480**: 137-170.

Batra, R.C. (1990). Citriculture in North-Western India. Proceedings of a Citrus Show-cum-Seminar on Prospects and Problems of Kinnow Cultivation, Ludhiana, India, 6-7 January, 1989 [edited by Gill, K.S.; Kanwar, J.S.; Raghbir Singh] Ludhiana, India; Punjab Agricultural University, 189-195.

Batra, R.C., Sharma, D.R. and Chanana, Y.R. (1992). Screening of citrus germplasm for their resistance against citrus leaf miner, *Phyllocnistis citrella* Stainton. Journal of Insect Science, 5(2):150-152.

Behlau, F., Belasque, J., Bergamin, A., Graham, J.H., Leite, R.P. and Gottwald, T.R., 2008. Copper sprays and windbreaks for control of citrus canker on young orange trees in southern Brazil. Crop Protection, 27(3-5): 807-813.

Behlau, F., Belasque, J.J., Leite, R.P.J., Bergamin-Filho, A., Gottwald, T.R., Graham, J.H., Scandelai, L.H.M., Primiano, I.V., Bassanezi, R.B. and Ayres, A.J. (2021). Relative contribution of windbreak, copper sprays, and leaf miner control for citrus canker management and prevention of crop loss in sweet orange trees. *Plant Disease.* **105**(8): 2097-2105.

Bindra, O.S., Sohi, B.S. and Batra, R.C. (1974). "Note on the comparative efficacy of some contact and systemic insecticides for the control of citrus psylla in Punjab". Indian Journal of Agricultural Science. 43: 1087–1088.

Buchelos, C.T. and Foudoulakis, M. (2000). Evaluation of effectiveness of Insegar (fenoxycarb 250 g/kg) WP against *Phyllocnistis citrella* Stainton (Lep., Gracillariidae) and its effect on Cales noacki How. (Hym., Aphelinidae). Anzeiger fu^umlaut~r Scha^umlaut~dlingskunde, 73(1):19-21.

Butani, D. K. (1979). Insects of fruit crops. Periodical Expert Book Agency, Vivek Vihar, Delhi, 415p.

CABI. (2004). Crop Protection Compendium. http://www.cabicompendium.org/ (20 July 2018).

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

CABI. (2021). *Papilio demoleus*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK.

Carver, M. (1978). The black citrus aphids, *Toxoptera citricida* (Kirkaldy) and *T. aurantii* (Boyer de Fonscolombe) (Homoptera: Aphididae). Journal of the Australian Entomological Society, 17(3):263-270.

Chee, K.H. and Chiu, S.B. (1999). Notes on rubber pink disease control using sulphur slurry. Planter, 75(874):21-23.

Cooke, A.W., van der Kruyssen, A. and Johnson, G.I. (1998). The effect of comercial pruning on colonization of mango by endophytic Dothiorella species. **In:** Post-harvest Handling of Tropical Fruit. Champ, B.R., Highley, E. and Johnson, G.I (eds.). Australian Centre for International Agricultural Research (ACIAR), Canberra. pp: 128–130.

Dohino, T., Hallman, G.J., Grout, T.G., Clarke, A.R., Follett, P.A., Cugala, D.R., Tu, D.M., Murdita, W., Hernandez, E., Pereira, R. and Myers, S.W. (2017). Phytosanitary treatments against *Bactrocera dorsalis* (Diptera: Tephritidae): current situation and future prospects. Journal of Economic Entomology, 110(1) 67-79.

Dreistadt, S.H., Clark, J.K. and Flint, M.L. (2004). Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide, 2nd ed. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3359.

Ekesi, S., Maniania, N.K. and Mohamed, S.A. (2011. Efficacy of soil application of *Metarhizium anisopliae* and the use of GF-120 spinosad bait spray for suppression of *Bactrocera invadens* (Diptera: Tephritidae) in mango orchards. Biocontrol Science and Technology, 21(3) 299-316.

Gajendra, S., Singh, G., Lavi, U., Degani, C., Gazit, S., Lahav, E., Pesis, E., Prusky, D., Tomer, E. and Wysoki, M. (1997). Integrated management of *Bactrocera (Dacus) dorsalis* (Hendel) in mangos. **In:** Acta Horticulturae [Proceedings of the 5th international mango symposium, Tel Aviv, Israel, 1-6 September 1996, Volume 2.], 455821-828.

Garnsey, S.M., Gottwald, T.R. and Yokomi, R.K. (1996). Control strategies for citrus tristeza virus. **In:** Hadidi A, Khetarpal RK, Koganezawa H, eds. Plant Viral Disease Control: Principles and Practices. St. Paul, USA: APS Press, (in press).

Gill, H. K. (2013). Citrus Mealybug, *Planococcus citri* (Risso) (Insecta: Hemiptera: Pseudococcidae). EENY-537. Entomology and Nematology, Florida Cooperative Extension Service. University of Florida IFAS. Published 2012, revised 2013.

Gnanvossou, D., Hanna, R., Bokonon-Ganta, A.H., Ekesi, S. and Mohamed, S.A. (2016). Release, establishment and spread of the natural enemy *Fopius arisanus* (Hymenoptera: Braconidae) for control of the invasive Oriental fruit fly *Bactrocera dorsalis* (Diptera: Tephritidae) in Benin, West Africa. In: Fruit fly research and development in Africa - towards a sustainable management strategy to improve horticulture, [ed. by Ekesi S, Mohamed SA, de Meyer M]. Springer International Publishing. 575-600.

Goheen, A.C., Nyland, G. and Lowe, S.K. (1973). Association of a rickettsia like organism with Pierce's disease of grapevines and alfalfa dwarf and heat therapy of the disease in grapevines. Phytopathology, 63(3):341-345.

Goto, M. (1992). Citrus canker. **In:** Plant Diseases of International Importance, Vol. III, Diseases of Fruit Crops, [ed. by Kumar, J., Chaube, H.S., Singh, U.S., Mukhopadhyay, A.N.]. Englewood Cliffs, USA: Prentice Hall. 170-208.

Govender, V., Korsten, L. and Sivakumar, D. (2005). Semi-commercial evaluation of *Bacillus licheniformis* to control mango postharvest diseases in South Africa. *Postharvest Biology and Technology*. **48:** 254–258.

Graham, J.H. and Myers, M.E., 2011. Soil application of SAR inducers imidacloprid, thiamethoxam, and acibenzolar-S-methyl for citrus canker control in young grapefruit trees. Plant Disease, 95(6): 725-728.

Graham, J.H., Leite, J.R.P., Yonce, H.D. and Myers, M., 2008. Streptomycin controls citrus canker on sweet orange in Brazil and reduces risk of copper burn on grapefruit in Florida. In Proceedings of the Florida State Horticultural Society. Florida State Horticultural Society, US., 121: 118-123.

Guo, W.W., Cheng, Y.J. and Deng, X.X. (2002). Regeneration and molecular characterization of intergeneric somatic hybrids between *Citrus reticulata* and *Poncirus trifoliata*. Plant Cell Reports. 20(9):829-834.

Hansen, J.D., Hara, A.H. and Tenbrink, V.L. (1992 b). Vapor heat: a potential treatment to disinfest tropical cut flowers and foliage. *HortScience*. **27**(2): 139-143.

Hansen, J.D., Hara, A.H. and Tenbrink, V.L. (1992a). Insecticidal dips for disinfesting commercial tropical cut flowers and foliage. *Trop. Pest Manag.* **38**(3): 245-249.

Haque, R., M. A. Maleque, S. M. L. Rahman, A. U. Khan and M. A. H. Liton Bhuiyan. 2019. Evaluation of new management approaches against lemon butterfly (*Papilio demoleus* L.) infesting Zara lemon in Jaintapur, Sylhet, Bangladesh *Bangladesh J. Entomol*. **29**(2): 1-12.

Hare, J.D., Rakha, M. and Phillips, P.A. (1990). Citrus Bud Mite (Acari: Eriophyidae): an Economic Pest of California Lemons? Journal of Economic Entomology, Volume 92, Issue 3, 1 June 1999, Pages 663–675.

Horst, R.K. (2008). Westcott's Plant Disease Handbook, Ed.7 [ed. by Horst, R. K.]. Heidelberg, Germany: Springer-Verlag GmbH, xiii + 1317 pp.

Hoy, M.A. and Nguyen, R. (2001). Classical biological control of Asian citrus psylla. Citrus Industry 81: 48-50.

Iordanou, N. and Charalambous, P. 1998. Chemical control of the citrus leaf miner, *Phyllocnistis citrella* (Stainton) (Lepidoptera, Phyllocnistidae), in Cyprus. Technical Bulletin of Cyprus Agricultural Research Institute, TechBull. No. 197, pp. 1-16.

Islam, M.N., Ali, M.S., Choi, S.J., Hyun, J. W. and Baek, K.H. (2019). Biocontrol of citrus canker disease caused by *Xanthomonas citri* subsp. *citri* using an endophytic *Bacillus thuringiensis*. *Plant Pathology Journal*. **35**(5): 486-497.

Jeffries, P. and Koomen, I. (1992). Strategies and prospects for biological control of diseases caused by Colletotrichum. **In:** Colletotrichum: Biology, Pathology and Control. Bailey, J.A. and Jeger, M.J. (eds.). Published by CAB International, WalIingford, UK. Pp. 337–357.

Jetter, K. M. and K. Godfrey. (2009). Diaprepes root weevil, a new California pest, will raise costs for pest control and trigger quarantines. California Agriculture 63:3 121-6.

Jia, H., Zhang, Y., Orbović, V., Xu, J., White, F.F., Jones, J.B. and Wang. N., 2017. Genome editing of the disease susceptibility gene Cs LOB 1 in citrus confers resistance to citrus canker. Plant Biotechnology Journal, 15(7): 817-823.

Katole, S.R., Thakare, H.S. and Mahajan, R.K. (1993). Effects of some plant products and insecticides on the infestation of citrus leaf miner on Nagpur mandarin. Journal of Maharashtra Agricultural Universities, 18(1):67-68.

Khan, W.A., Atiq, M., Sahi, S.T., Khan, A.A., Ali, S., Younas, M., Ali, Y., Bashir M.R. and Sajid, M., 2018. Induction of resistance against citrus canker through chemicals and plant activators. Advances in Zoology and Botany, 6(1): 26-30.

Kirton, L.G., Brown, V.K. and Azmi, M. (1999 b). The pest status of the termite *Coptotermes curvignathus* in *Acacia mangium* plantations: incidence, mode of attack and inherent predisposing factors. *J. Trop. Forest Sci.* **11**(4): 822-831.

Knapp, J.S.L. (1994). Control of insects, mites and diseases of Florida's Dooryard Citrus trees [Internet]. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, (Circular, 139). 1994.

Korsten, L. (2004). "Citrus Huanglongbing: Review, Present status and Future Strategies". Diseases of Fruits and Vegetables Volume I: 229–245.

Korsten, L. (2006). Advances in control of postharvest diseases in tropical fresh produce. *International Journal of Postharvest Technology and Innovation*. **1**: 48–61.

Lal, H. and Singh, Y.P. (1982). Incidence of bark-eating caterpillar on different loquat (*Eriobotrya japonica* Lindl.) cultivars. Science and Culture, 48(3):98-100.

Leal, W.S., Parra-Pedrazzoli, A.L., Cossé, A.A., Murata, Y., Bento, J.M.S. and Vilela, E.F. (2006). Identification, synthesis, and field evaluation of the sex pheromone from the citrus leafminer, *Phyllocnistis citrella*. Journal of Chemical Ecology, 32(1):155-168.

Lieu KOV. 1945. The study of wood borers in China -- I: Biology and control of the citrus-root-cerambycids, *Melanauster chinensis*, Forster (Coleoptera). Florida Entomologist 27: 61-101.

Machado, F.J., Marin, T.G.S., Canôas, F., Silva Junior, G.J. and Behlau, F. (2021). Timing of copper sprays to protect mechanical wounds against infection by *Xanthomonas citri* subsp. *citri*, causal agent of citrus canker. *European Journal of Plant Pathology*. **160**(3): 683-692.

Mineo, G., Sinacori, A., Rizzo, M.C. and Massa, B. (1997). On the arthropod fauna of *Parietaria* spp. (Urticaceae). 3rd contribution. Parasitoids of *Cosmopterix pulchrimella* Chambers (Lepidoptera Cosmopterigidae). *Bollettino di Zoologia Agraria e di Bachicoltura*, **29**(2): 195-198.

Monfort, W.S., Kirkpatrick, T.L., Long, D.L. and Rideout, S. (2006). Efficacy of a novel nematicidal seed treatment against *Meloidogyne incognita* on cotton. *Journal of Nematology*. **38**(2): 245-249.

Narayanamma, V.L. and Savithri, P. (2003). Evaluation of biopesticides against citrus butterfly, *Papilio demoleus* L. on sweet orange. Indian Journal of Plant Protection, 31(2):105-106.

Nasir, M., Muhammad Mughal, S., Mukhtar, T. and Zaman Awan, M. (2014). Powdery mildew of mango: A review of ecology, biology, epidemiology and management. *Crop Protection*. **64**: 19–26.

Ndemueda, A., Pereira, I., Faustino, M.A.F. and Cunha, Â. (2020). Photodynamic inactivation of the phytopathogenic bacterium *Xanthomonas citri* subsp. c*itri*. *Letters in Applied Microbiology*. **71**(4): 420-427.

Nguyen, R., Sailer, R.I. and Hamon, A.B. (1993). Catalogue of Aleyrodidae on citrus and their natural enemies (Homoptera: Aleyrodidae). Occasional Papers of the Florida State Collection of Arthropods, 8:11.

Nofal, M.A. and Haggag, W.A. (2006). Integrated management of powdery mildew of mango in Egypt. *Crop Protection*. **25**: 480-486.

Nucifora, A. and Nucifora, M.T. (1999). The citrus bud miner in Sicily: current strategies of control and future perspectives. Proceedings 5th World Congress of the International Society of Citrus Nurserymen, Montpellier, France, 5-8 March, 1997., 251-260.

Otmani, M.E., Oubahou, A.A. and Zacarias, L. (2011). *Citrus* spp.: orange, mandarin, tangerine, clementine, grapefruit, pomelo, lemon and lime. Woodhead Publishing Series in Food Science, Technology and Nutrition. Pages 437-514, 515e-516e.

Parry-Jones, E. (1936). Bionomics and ecology of red scale in Southern Rhodesia. Publication Mazoe Citrus Experimental Station 5: 11–52.

Perez, J.L., French, J.V., Summy, K.R., Baines, A.D. and Little, C.R. (2009). Fungal phyllosphere communities are altered by indirect interactions among trophic levels. Microbial Ecology, 57(4):766-774.

Planes, L., Catalán, J., Jaques, J. A., Urbaneja, A. and Tena, A. 2015. *Pezothrips kellyanus* (Thysanoptera: Thripidae) Nymphs on orange fruit: Importance of the second generation for its management. *The Florida Entomologist*. **98**(3): 848-855.

Ploetz, R.C. (2018). Integrated disease management in mango cultivation. **In:** Achieving Sustainable Cultivation of Mangoes. Galán-Saúco, V. and Lu. P. (eds.). Burleigh Dodds Series in Agriculture Science, Number 34. Published by Burleigh Dodds Science Publising Limited, Cambrigde, UK. Pp. 459-496.

Poveda, J., Roeschlin, R.A., Marano, M.R. and Favaro, M.A. (2021). Microorganisms as biocontrol agents against bacterial citrus diseases. *Biological Control*. 158104602.

Prakash, O. and Raoof, M.A. (1994). Studies on powdery mildew (*Oidium mangiferae*) disease of mango: distribution, perpetuation, losses and chemical control. *Biological Memoirs*. **20**: 31-45.

Prusky, D., Kobiler, I., Miyara, I. and Alkan, N. (2009). Fruit diseases. **In:** The Mango: Botany, Production and Uses (2nd Edition). Litz, R. (ed.). Published by CAB International, Oxfordshire, UK. pp: 210-230.

Ramzi, M., Belzunces, L.P., Suma, P., Zappalà, L., Gaetana, M., Kaouthar, G.L., Agatino, R. and Antonio, B. (2018). Vine and citrus mealybug pest control based on synthetic chemicals. A review. Agronomy for Sustainable Development. Institut National de la Recherche Agronomique (Springer). 38 (4): 1–20.

Rehman, M.A., Ali, S., Afzal, M.B.S., Khan, M.N. and Ali, M., 2020. Efficacy of chemicals and botanical extracts to control citrus canker on Kinnow in Sargodha region. *Journal of Innovative Sciences*, **6**(2): 101-107.

Riasat, A., Ghazanfar, M.U. and Raza, W., 2020. Interaction of citrus canker with *Phyllocnistis citrella* Stainton. Pakistan Journal of Phytopathology, 32(1): 01-07.

Sajap, A.S., Atim, A.B., Husim, H. and Wahab, Y.A. (1997). Isolation of *Conidiobolus coronatus* (Zygomycetes: Entomophthorales) from soil and its effect on *Coptotermes curvignathus* (Isoptera: Rhinotermitidae). *Sociobiology*. **30**(3): 257-262.

Sandhu, G.S., Khangura, J.S. and Deol, I.S. (1977). Varietal susceptibility of guava cultivars to bark eating caterpillar. Punjab Horticulture Journal, 17:1-2.

Segarra-Carmona, A. E., Cabrera-Asencio, I., Flores-López, L.E. and Morales-Collado, L. 2010. Life cycle and control of the Asian lime swallowtail, *Papilio demoleus* (Lepidoptera: Papilionidae): A new invasive pest in Puerto Rico. *J. Agric. Univ. Puerto Rico*, **94**(1/2): 165-174.

Sharma, D.D. and Kumar, H. (1986). How to control bark-eating caterpillars. Indian Horticulture, 31(1):25.

Shivendra, S. and Singh, R.P. (1998). Neem (*Azadirachta indica*) seed kernel extracts and azadirachtin as oviposition deterrents against the melon fly (*Bactrocera cucurbitae*) and the oriental fruit fly (*Bactrocera dorsalis*). Phytoparasitica, 26(3) 191-197.

Singh, B., Sharma, S., Rani, G., Zaidi, A.A., Hallan, V., Virk, G.S. and Nagpal, A. (2006). In vitro production of Indian citrus ringspot virus-free plants of Kinnow mandarin (*Citrus nobilis* Lour × *C. deliciosa* Tenora) by nucellar embryo culture. Plant Pathology Journal (Faisalabad), 5(3):274-282.

Singh, U.C. and Dhamdhere, S.V. (1989). Field screening of some guava varieties against the bark eating caterpillar, *Indarbela quadrinotata* (Walker). Indian Journal of Entomology, 51(2): 216-217.

Smith, D. and Nannan, L. (1988). Yeast autolysate bait sprays for control of Queensland fruit fly on passionfruit in Queensland. Queensland Journal of Agricultural and Animal Sciences, 45(2):169-177.

Solunke, B.R. and Deshpande, S.V. (1991). Studies on use of plant products for the control of lemon butterfly larvae. Journal of Maharashtra Agricultural Universities, 16(2):302-303.

Terry, M. (2014). Disease management in mango. *International Pest Control*. **56**(2): 104–107.

Thapa, K.S. (2014). Citrus gummosis: *Phytophthora* spp. PlantwisePlus Knowledge Bank. https://doi.org/10.1079/pwkb.20147801443

Tho, Y.P. and Kirton, L.G. (1992). The economic significance of Coptotermes termites in Malaysian forestry. Proceedings of the 3rd International Conference on Plant Protection in the Tropics (edited by Ooi, P. A. C.; Lim, G. S.; Teng, P. S.) Kuala Lumpur, Malaysia; Malaysian Plant Protection Society, No. **4**:193-199.

Vargas, O.H., Bobadilla, D., JimTnez, R.M. and Vargas, C.H. (1999). A preliminary trial about larval susceptibility of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) to insecticides sprayed on the foliage. IDESIA, 16:23-27.

Waterston, J. (1922). On the chalcidoid parasites of psyllids (Hemiptera, Homoptera). Bulletin of Entomological Research 13: 41-58.

White, I.M. and Elson-Harris, M. M. (1994). Fruit flies of Economic Significance: Their Identification and Bionomics. Wallingford, UK: CAB International.

WSDA. (2002). Citrus longhorned beetle eradication project: Tree injection: Another weapon against the Citrus longhorned beetle.

Yamamoto, P.T., Roberto, S.R. and Pria, W.D. (2000). Systemic insecticides applied on citrus tree trunk to control *Oncometopia facialis*, *Phyllocnistis citrella* and *Toxoptera citricida*. Scientia Agricola, 57(3):415-420.

Yang P. 1984. The application of *Oecophylla smaragdina* Fabr. in South Fujian. Fujian Agricultural Science and Technology, No. 5:23-25 (CAB abstracts).

Zhang, A.G., O'Leary, C. and Quarles, W. (1994). Chinese IPM for citrus leafminer [*Phyllocnistis citrella*] (update). IPM Practitioner, 16(8):10-13.

Chapter 6: Identification of Pests

6.1. Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measures for the pests of citrus, which are being imported in Bangladesh from any one of the citrus exporting countries viz. India, China, Thailand, Bhutan, South Africa, Egypt, Brazil and Australia, etc. The insect and mite pests, diseases, weeds and other pests such as snails and slugs, etc. associated with *Citrus medica* (Zara/Colombo Lebu varieties) have been identified through primary field survey at growers' level as well as through literature review of secondary documents, reports, journals, proceedings, web-based publications such as CABI, EPPO bulletin, and others. Such identified pests then presented in this chapter as follows:

6.2. Pests of *Citrus medica* (Zara/Colombo lebu varieties) recorded in Bangladesh

The primary data collected survey at field level for conducting "Pest Risk Analysis (PRA) of *Citrus medica* (Zara/Colombo Lemon) in Bangladesh" was done in four (4) major Zara/Colombo Lebu growing districts viz. Narshingdi, Sylhet, Moulovibazar and Tangail of Bangladesh. From the field survey and literature review, the precise findings of the study in line with the presence of insect and mite pests, diseases, weed pests and other pests associated with Zara/Colombo Lemon along with their identity (scientific name, family and order), plant parts affected, pest status, infestation severity and district-wise farmers response (maximum and minimum) on the incidence of respective pest have been presented in the following sub-headings:

6.2.1. Insect and mite pests of *Citrus medica* (Zara/Colombo Lebu varieties) in Bangladesh

A total number of 26 arthropod pests of *Citrus medica* (Zara/Colombo Lemon) were recorded in Bangladesh as reported by the Zara/Colombo Lemon growers and relevant experts collected through field survey as well as collected through literature review. Among these 26 arthropod pests, 25 were insect pests and one was mite pest. The incidence and damage potential of reported insect and mite pests of Zara/ColomboLemonhave been presented below:

6.2.1.1. Insect pests of Zara/Colombo Lebu recorded: There were two ways considered to record the insect and mites of *Citrus medica* (Zara/Colombo Lemon) available in Bangladesh. The ways were field level survey and literature review. The insect and mite pests of Zara/Colombo Lemon identified through those ways are illustrated below:

(a) Field survey-based findings: The study team made a list of insect and mite pests of Zara/Colombo Lemon identified through interviews of Zara/Colombo Lemon farmers in the pre-selected PRA areas as well as gathered information from the field level officials of Department of Agriculture Extension (DAE) and other experts. As per field survey-based data, it was revealed that the incidence of sixteen (16) arthropod pests of *Citrus medica* (Zara/Colombo Lemonwere identified, of which fifteen (15) were insect pests and one was mite pest. Among fifteen (15) insect pests those recorded for Bangladesh were lemon butterfly (*Papilio demoleus, Papilio polytes)*, citrus leaf miner *(Phyllocnistis citrella)*, citrus leaf roller (*Psorosticha zizyphi*), citrus stem borer (*Chelidonium cinctum*), citrus mealybug (*Planococcus citri*), Asian citrus psyllid bug (*Diaphorina citri*), citrus blackfly (*Aleurocanthus woglumi*), citrus greenhouse whitefly (*Trialeurodes vaporariorum*), black citrus aphid (*Toxoptera citricida*), green citrus aphid (*Aphis spiraecola*), citrus soft scale (*Coccos hesperidum*), citrus green stink bug (*Nezara viridula*), citrus thrips (*Scirtothrips dorsalis*), citrus fire ant (*Solenopsis invicta*), and termite (*Odontotermes obesus*) (Table-6.1).

(b) Literature review-based findings: Besides, field level survey-based findings, the study team also made a list of insect and mite pests of *Citrus medica* (Zara/Colombo Lemon) through reviewing the secondary documents collected from different sources. As per literature review, it was revealed that a total of ten (10) insect pests of *Citrus medica* were recorded for Bangladesh and these were fruit sucking moth (*Othreis* spp.), orange spined bug (*Biprorulus bibax*), citrus bug (*Rhynchocoris humeralis*), citrus whitefly (*Dialeurodes citri*), striped mealybug (*Ferrisia virgata*), citrus red scale (*Aonidiella aurantia*), citrus yellow scale (*Aonidiella citrina*), flower thrips (*Frankliniella schultzei*), bark and stem borer (*Indarbela quadrinotata*) and Oriental fruit fly (*Bactrocera dorsalis*) (Table-6.2).

6.2.1.2. Mite pest recorded: As per field survey-based primary data, it was also revealed that the citrus red spider mite (*Panonychus citri)* of Zara/ColomboLemonwas recorded for Bangladesh. This mite was designated as minor pest with low infestation intensity (Table-6.1).

6.2.1.3. Mollusk pests recorded: As per field survey findings, it was also revealed that the two mollusk pests were reported by the Zara/Colombo Lemon growers and these were grey garden slug (*Deroceras reticulatum*) and brown garden snail (*Cornu aspersum*). Both of these pests were designated as minor pest with low infestation intensity (Table-6.4).

6.2.1.4. Damage potentiality of insect and mite pests

Among the identified insect pests, lemon butterfly, leaf miner and citrus aphids were reported more damaging than other insect pests and these insects were designated as major insect pests of *Citrus medica* (Zara/Colombo Lemon) and caused damage with high infestation intensity. In case of lemon butterfly, larvae cause severe damage through feeding on leaf lamina leaving only the mid-rib. The larvae also cause damage the young twig when they become more voracious. Other insect pests presented in the list were designated as minor pests and cause damage to Zara/ColomboLemonwith low infestation intensity, whereas the citrus thrips was also designated as major pest but cause damage with medium infestation on fruits, where the damage symptoms are shown as whitish color due to scrapped out the green content from the fruit surface and subsequently turned straw color on full grown matured fruit that reduces the market value of the fruits (Table-6.1).

6.2.1.5. Location-wise incidence and diversity of insect pests

Considering the location-wise variation of farmers' response on the incidence of insect pests of *Citrus medica* (Zara/Colombo Lemon), most (75 to 95%) of the farmers of Sylhet, and Tangail districts reported that incidence of lemon butterfly, leaf miner and citrus aphid was occurred on Zara/ColomboLemon. These pests were designated as major pests and caused severe damage with high infestation intensity (Table 6.1). The farmers' response on the incidence of other insect pests on Zara/Colombo Lemon were also shown in the Table 6.3.

Table-6.1. Insect and mite pests of *Citrus medica* (Zara/Colombo lebu varieties), their identity, status and infestation severity as recorded in Bangladesh through field survey

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infestation severity	Incidence occurred or not		
						Zara Lemon	**Colombo** Lemon	**Other citrus**
A. Insect pests								
1	Lemon butterfly	*Papilio demoleus*, *P. polytes* Family: Papilionidae Order: Lepidoptera	Young leaf, twig	Major	High	Yes	Yes	Yes
2	Citrus leaf miner	*Phyllocnistis citrella* Family: Gracillariidae Order: Lepidoptera	Fruit, Leaf	Major	High	Yes	Yes	Yes
3	Citrus leaf roller	*Psorosticha zizyphi* Family: Depressariidae Order: Lepidoptera	Leaf	Minor	Low	Yes	Yes	Yes
4	Citrus stem borer	*Chelidonium cinctum* Family: Cerambycidae Order: Coleoptera	Stem	Minor	Low	Yes	Yes	Yes
5	Citrus mealybug	*Pseudococcus filamentosus* *Planococcus citri* Risso Family: Pseudococcidae Order: Homoptera	Fruit, leaf, stem, flower	Minor	Low	Yes	Yes	Yes
6	Asian citrus psyllid bug	*Diaphorina citri* Family: Liviidae Order: Hemiptera	Stem, leaf	Minor	Low	Yes	Yes	Yes
7	Citrus blackfly	*Aleurocanthus woglumi* Family: Aleyrodidae Order: Homoptera	Leaf, fruit	Minor	Low	No	Yes	Yes
8	Greenhouse whitefly	*Trialeurodes vaporariorum* Family: Aleyrodidae Order: Homoptera	Leaf, fruit	Minor	Low	No	Yes	Yes

9	Black citrus aphid	*Toxoptera citricida* Family: Aphididae Order: Homoptera	Leaf, shoot, flower, fruit	Major	High	Yes	Yes	Yes
10	Green citrus aphid	*Aphis spiraecola* Family: Aphididae Order: Homoptera	Leaf, shoot, flower, fruit	Major	High	Yes	Yes	Yes
11	Citrus soft scale	*Coccus hesperidum* Family: Coccidae Order: Homoptera	Leaf, stem, twig, fruit	Minor	Low	Yes	Yes	Yes
12	Citrus green stink bug	*Nezara viridula* Family: Pentatomidae Order: Hemiptera	Fruit, young shoot	Minor	Low	Yes	Yes	Yes
13	Citrus thrips	*Scirtothrips dorsalis* Family: Thripidae Order: Thysanoptera	Leaf, flower, young fruit	Major	Medium	Yes	Yes	Yes
14	Citrus fire ant	*Solenopsis invicta* Family: Formicidae Order: Hymenoptera	Flower, young developing fruit	Minor	Low	Yes	Yes	Yes
15	Termite	*Odontotermes obesus* Family: Termitidae Order: Isoptera	Stem, root	Minor	Low	No	Yes	Yes
B. Mite pest								
16	Citrus red spider mite	*Panonychus citri* Family: Tetranychidae Order: Acarina	Leaf, fruit	Minor	Low	Yes	Yes	Yes

Table-6.2. Insect pests of citrus present in Bangladesh, their status, plant parts affected and infestation severity identified through literature review

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infestation severity	Present in citrus			Reference
						Zara Lemon	**Colombo** Lemon	**Others citrus**	
1	Fruit sucking moth	*Othreis* spp. Family: Noctuidae Order: Lepidoptera	Fruit	Major	High	No	No	Yes	EPPO (2022)
2	Orange spined bug	*Biprorulus bibax* Family: Pentatomidae Order: Coleoptera	Fruit	Minor	Low	No	No	Yes	Ahmed *et al.* (2014)
3	Citrus bug	*Rhynchocoris humeralis* Family: Pentatomidae Order: Hemiptera	Fruit	Minor	Low	No	No	Yes	Ahmed *et al.* (2014)
4	Citrus whitefly	*Dialeurodes citri* Family: Aleyrodidae Order: Homoptera	Leaf	Minor	Low	No	Yes	Yes	Ahmed *et al.* (2014) EPPO (2022)
5	Striped mealybug	*Ferrisia virgata* Family: Pseudococcidae Order: Homoptera	Stem, leaf, fruit	Minor	Low	No	No	Yes	Ahmed *et al.* (2014)
6	Citrus red scale	*Aonidiella aurantia* Family: Diaspididae Order: Homoptera	Stem, leaf, fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014)
7	Citrus yellow scale	*Aonidiella citrina* Family: Diaspididae Order: Homoptera	Leaf, stem, fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014) Alam (1962)
8	Flower thrips	*Frankliniella schultzei* Family: Thripidae Order: Thysanoptera	Flower	Minor	Low	No	No	Yes	Ahmed *et al.* (2019)

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infestation severity	Present in citrus			Reference
						Zara Lemon	**Colombo** Lemon	**Others citrus**	
9	Bark and stem borer	*Indarbela quadrinotata* Family: Metarbelidae Order: Lepidoptera	Bark, trunk	Minor	Low	No	Yes	Yes	Ahmed *et al.* (2014)
10	Oriental fruit fly	*Bactrocera dorsalis* Family: Tephritidae Order: Diptera	Fruit	Minor	Low	No	No	Yes	Ahmed *et al.* (2014)

Table-6.3. District-wise farmers' response (%) on the incidence of insect and mite pests of *Citrus medica* (Zara/Colombo Lebu varieties) and other citruses in Bangladesh as identified through field survey

SN	Common Name	Farmers' response* (%) on the incidence of insect and mite pests of citrus by district			
		Incidence on Zara Lemon		**Incidence on Colombo**Lemon	
		Maximum (%)	**Minimum (%)**	**Maximum (%)**	**Minimum (%)**
A. Insect pests					
1	Lemon butterfly	Moulvibazar (75.6%)	Tangail (0%)	Narsingdi (94.2%)	Moulvibazar (6.3%)
2	Citrus leaf miner	Sylhet (95.0%)	Tangail (0%)	Tangail (95.0%)	Moulvibazar (8.1%)
3	Citrus leaf roller	Moulvibazar (10.0%)	Tangail (0%)	Sylhet (7.5%)	Narsingdi (1.7%)
4	Citrus stem borer	Sylhet (14.2%)	Moulvibazar, Tangail (0%)	Tangail (15.0%)	Narsingdi (2.5%)
5	Citrus mealybug	Sylhet (25.8%)	Moulvibazar, Tangail (0%)	Narsingdi (15.0%)	Moulvibazar (1.9%)
6	Asian citrus psyllid bug	Moulvibazar (10.6%)	Tangail (0.83%)	Narsingdi (12.5%)	Sylhet, Moulvibazar, Tangail (0%)
7	Citrus blackfly	None	None	Sylhet (9.2%)	Narsingdi (2.5%)
8	Greenhouse whitefly	Sylhet (10.1%)	Tangail (0.83%)	Narsingdi (9.2%)	Sylhet (2.5%)
9	Black citrus aphid	Sylhet, Moulvibazar (66.8%)	Tangail (0%)	Narsingdi (100%)	Sylhet (5.8%)
10	Green citrus aphid	Sylhet, Moulvibazar (66.8%)	Tangail (0%)	Narsingdi (100%)	Sylhet (5.8%)

11	Citrus soft scale	Sylhet (5.0%)	Moulvibazar, Tangail (0%)	Narsingdi (4.2%)	Tangail, Moulvibazar, Sylhet (0%)
12	Citrus green stink bug	Moulvibazar (3.1%)	Sylhet, Tangail (0%)	Narsingdi (5.0%)	Tangail (2.5%)
13	Citrus thrips	Sylhet (49.2%)	Tangail (0.83%)	Narsingdi (38.3%)	Tangail (6.7%)
14	Citrus fire ant	Moulvibazar (8.8%)	Tangail (0%)	Tangail (8.3%)	Narsingdi (2.5%)
15	Termite	Sylhet (5.8%)	Moulvibazar, Tangail (0%)	Sylhet (9.2%)	Narsingdi, Tangail, Moulvibazar (0%)
B. Mite pest					
16	Citrus red spider mite	Moulvibazar (4.4%)	Tangail (0.83%)	Narsingdi (5.8%)	Tangail (2.5%)

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

Table-6.4. Mollusk pests of *Citrus medica* (Zara/Colombo Lebu varieties), their status, plant parts affected and infestation severity as recorded in Bangladesh through field survey

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infestation severity	Present in citrus		
						Zara Lemon	**Colombo** Lemon	**Other citrus**
1	Grey garden slug	*Deroceras reticulatum*, Family: Limacidae Order: Stylommatophora, Phylum: Mollusca	Citrus young foliage and fruit	Minor	Low	Yes	Yes	Yes
2	Brown garden snail	*Cornu aspersum*, Family: Helicidae, Order: Stylommatophora, Phylum: Mollusca	Leaves and bark of young plant, ripening fruit	Minor	Low	Yes	Yes	Yes

6.2.1.6. Comparison of recorded arthropod and mollusk pests identified through present PRA study (2023) with the previous PRA report (2014)

There was a study on “Pest Risk Analysis (PRA) of Citrus in Bangladesh” conducted in the year of 2014 sponsored by the “Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under the Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh”. The study team of present PRA study compared the findings of previous ‘PRA of Citrus in Bangladesh’ with the current ‘PRA of *Citrus medica* (Zara/Colombo Lebu varieties) in Bangladesh’ conducted in 2023. It was noted that the previous PRA study was conducted for different citruses, but the present PRA study was conducted only for Zara/Colombo Lebu varieties (*Citrus medica*). However, in case of pest listing, the present PRA study identified a total of 16 arthropod pests of *Citrus medica* (Zara/Colombo Lebu varieties) through field survey, of which 15 were insect pests and one mite pest those were shown in the Table-6.1. Besides field survey, the present PRA study also identified additional 10 insect pests of *Citrus medica* (Zara/Colombo Lebu varieties) through literature review as shown in the Table-6.2. Whereas the previous PRA study identified a total of 21 arthropod pests for different citruses including Zara/Colombo Lebu, among which 16 insect and one mite pests were identified only for Zara/Colombo Lebu varieties.

Conversely, a number (4) of insect pests of Zara/Colombo Lebu varieties those were reported in the previous PRA study, which were not identified through the field survey of present PRA study but reported in the present PRA study identified through literature review. These insect pests were citrus whitefly (*Dialeurodes citri*), citrus red scale (*Aonidiella aurantia*), citrus yellow scale (*Aonidiella citrina*), bark and stem borer (*Indarbela quadrinotata*). Whereas in the present PRA study, a number of additional insect pests (5) were also recorded for Zara/Colombo Lebu varieties as identified through field survey, but not reported in the previous PRA study. The newly listed insect pests were greenhouse whitefly (*Trialeurodes vaporariorum*), green citrus aphid (*Aphis spiraecola*), citrus soft scale (*Coccus hesperidum*), citrus green stink bug (*Nezara viridula*), citrus fire/red ant (*Solenopsis invicta*) as shown in the Table-6.1.

In addition of insect and mite pests, two mollusk pests in the field of Zara/Colombo Lebu varieties were also identified through field survey of the current PRA study, but not identified through the previous PRA study. The newly reported mollusk pests were grey garden slug (*Deroceras reticulatum*) and brown garden snail (*Cornu aspersum*). Both of these pests are designated as minor pest with low infestation intensity (Table-6.4).

6.2.1.7. Pictorial presentation of insect and mite pests of Zara/Colombo Lebu: During field visit and observation, the PRA study team captured photographs of available insect and mite pests associated with Zara/Colombo Lebu and affected plants/plant parts. Simultaneously, study team collected relevant photographs from secondary sources. These pictures have been presented as evidence of infestation as follows:

Following photographs showing the infestation of insect and mite pests of Zara/Colombo Lebu at farmers' field in the PRA study areas

(a) Lemon butterfly visiting Zara Lebu flowers at field level

(a) Lemon butterfly laid egg singly on young leaves of citrus

(c) Caterpillars of lemon butterfly feeding on leaf lamina of citrus

(d) Infested leaves of Zara Lebu damaged by lemon butterfly larva

(e) Infested leaves on a twig of Zara Lebu caused by lemon butterfly larvae

(f) Infested leaves on the twigs of Colombo Lebu caused by lemon butterfly larvae

Plate-6.1: Infestation of lemon butterfly (*Papilio demoleus,* Lepidoptera: Papilionidae) and its damages

(a) Citrus leaf miner adult

(b) Leaf miner larva causing mining on leaf

(c) Leaf miner infested citrus leaf showing conspicous mining on leaf lamina

(d) Severely infested leaf of Zara Lebu showing straw color symptoms caused by citrus leaf miner

(e) Severely damage citrus leaves casused by leaf miner

(f) Severely damage citrus twig by curling leaves due to leaf miner infestation

(g) Leaf miner infested leaves on a twig of Colombo Lebu

(h) Severely damage citrus leaves casused by leaf miner

Plate-6.2: Citrus leaf miner (*Phyllocnistis citrella*, Lepidoptera: Gracillariidae) and its damages

(a) Catepillar of citrus leafroller making roll on the citrus leaf

(b) Citrus leafroller folded the citrus leaves

Plate-6.3: Citrus leafroller (*Psorosticha zizyphi,* Lepidoptera: Depressariidae) infestation and its damages

(a) Zara Lebu stem showing infestation caused by citrus stem borer

(b) Stem borer infested Zara Lebu stem showing dried apex of a twig after infestation

(c) Stem borer infested Zara Lebu stem showing larva inside the stem after broken

(d) Stem borer infested Zara Lebu stem showing larva inside the stem after broken

Plate-6.4: Citrus stem borer (*Chelidonium cinctum,* Coleoptera: Cerambycidae) infestation on Zara Lebu and its damages

(a) Adult mealybug infestation on citrus stem

(b) Mealybug infestation on citrus leaf

(c) Mealybug infestation on citrus fruit

(d) Mealybug infestation on citrus leaf and leaf petiol

Plate-6.5: Citrus mealybug (*Planococcus citri,* Homoptera: Pseudococcidae) infestation on stem, leaves and fruit of citrus and its damage

(a) Citrus psyllid bug infestation on newly growing citrus leaves and twigs

(b) Severe infestation of citrus psyllid bug on the ventral side of leaf

(c) Citrus psyllid bug transmitted citrus greening disease

(d) Severely damaged plant due to psyllid bug transmitted citrus greening disease infection

Plate-6.6: Citrus psyllid bug (*Diaphorina citri,* Hemiptera: Liviidae) infestation on citrus and its damages

(a) Citrus blackfly adult

(b) Citrus blackfly laid eggs on citrus leaf in a circular manner

(c) Citrus blackfly (nymphs) infestation on the ventral surface of Zara Lebu variety

(d) Severe infestation of citrus blackfly on citrus leaves making black markings

Plate-6.7: Citrus blackfly (*Aleurocanthus woglumi,* Homoptera: Aleyrodidae) infestation on citrus and its damages

(a) Citrus leaf showing adult whitefly infestation on the ventral surface of leaf

(b) Citrus leaf showing infestation of spiralling adult whitefly on the ventral surface

Plate-6.8: Citrus whitefly (*Trialeurodes vaporariorum,* Homoptera: Aleyrodidae) and its damages

(a) Green citrus aphid infestation on the ventral surface of young leaf

(a) Black citrus aphid infestation on the ventral surface of older leaf

Plate-6.9: Black citrus aphid (*Toxoptera citricida*, Homoptera: Aphididae) infestation on Zara Lebu and its damaging symptoms

(c) Severely infested leaves on a twig by black citrus aphid

(c) Severe infestation of green citrus aphid on the ventral surface of young leaves of Zara Lebu

Plate-6.10: Green citrus aphid (*Aphis spiraecola*, Homoptera: Aphididae) infestation on Zara Lebu and its damaging symptoms

(a) Citrus soft scale (brown) insect infestation on citrus stem

(b) Citrus soft scale (brown) insect infestation on citrus leaf

Plate-6.11: Citrus brown soft scale (*Coccus hesperidum*, Homoptera: Coccidae) infestation and its damages

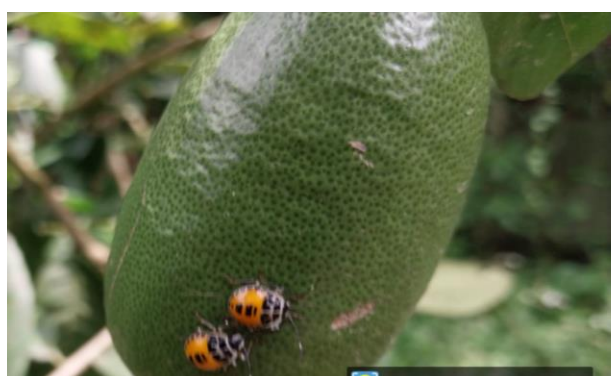
(a) Adult green stink bug sucking juices from citrus fruit

(b) Stink bug laid eggs in a special arrangement on citrus leaf

(c) Citrus green stink bug infestation on young leaves

(d) Stink bug infestation causing damage by sucking juices from young stem

(e) Zara Lebu showing stink bug infestation causing damage by sucking juices from fruit



(f) Zara Lebu showing infestation caused by stink bug nymphs that suck juices from fruit

Plate-6.12: Citrus green stink bug (*Nezara viridula*, Hemiptera: Pentatomidae) infestation on Zara Lebu and its damaging symptoms

(a) Thrips infested Zara Lebu showing whitish surface on the fruit at very early stage due to scraped out of green content

(b) Thrips infested Zara Lebu showing whitish symptom spreaded over the surface of fruit due to scraped out of green content

(c) Thrips infested Colombo Lebu showing whitish symptom spreaded over the surface of the fruit due to scraped out of green content

(d) Severely infested Zara Lebu by Thrips showing straw color symptom spreaded out over the fruit surface at later stage of scrapped out green content from the fruit surface

(f) Severely damaged Zara Lebu by Thrips infestation showing straw color symptom at later stage of scrapped out green content from the surface of fruit

Plate-6.13: Citrus thrips (*Scirtothrips dorsalis*, Thysanoptera: Thripidae) infestation on Zara Lebu and its damaging symptoms

(a) Incidence of citrus fire ant on Zara Lebu plant at field level

(b) Citrus fire ant infestation on leaves and twig of Zara Lebu at field level

Plate-6.14: Citrus fire ant (*Solenopsis invicta,* Hymenoptera: Formicidae) infestation on stem and leaves of Zara Lebu plant and its damage

(a) Citrus red scale infestation on leaf

(a) Citrus red scale infestation on fruit

Plate-6.15: Citrus red scale (*Aonidiella aurantia,* Homoptera: Diaspididae) infestation and its damages on citrus

(a) Red spider mite (tiny sized) infestation on citrus leaf by sucking cell sap and forming webs

(b) Adult red spider mite on on citrus leaf surface

(c) Red spider mite infested citrus leaves showing yellow color and drop-off from twig

(d) Red spider mite infested lemon showing tiny red mites on fruit surface

Plate-6.16: Citrus red spider mite (*Panonychus citri,* Acarina: Tetranychidae, Class: Arachnida) infestation and its damages on citrus

(a) Slug infestation on Zara Lebu leaf

Plate-6.17: Grey garden slug (*Deroceras reticulatum,* Family*:* Limacidae, *Order:* Stylommatophora, Phylum: Mollusca) infestation and its damage

(a) Snail infestation on Zara Lebu leaf

Plate-6.18: Brown arden snail (*Cornu aspersum,* Family*:* Helicidae, *Order:* Stylommatophora, Phylum: Mollusca) infestation and its damage

6.2.2. Diseases of *Citrus medica* (Zara/Colombo lebu varieties) in Bangladesh

Two ways were considered to record the diseases of *Citrus medica* (Zara/Colombo Lebu varieties) available in Bangladesh. The ways were field survey and literature review. A total number of 33 diseases of *Citrus medica* (Zara/Colombo Lebu varieties) were recorded in Bangladesh as reported by the Zara/Colombo lebu growers and relevant experts collected through field survey as well as collected through literature review. Among these 32 diseases, 12 diseases identified through field survey and the rest 20 diseases were identified through literature review. The incidence and damage potential of reported diseases of Zara/Colombo lebu varieties have been presented below:

6.2.2.1. Field survey-based findings: The study team made a list of diseases of Zara/Colombo Lebu through interviews of Zara/Colombo Lebu farmers in the pre-selected PRA areas as well as gathered information from the field level officials of Department of Agriculture Extension (DAE) and other experts. As per field survey-based data, it was revealed that the incidence of thirteen (13) diseases of *Citrus medica* (Zara/Colombo Lebu varieties) were identified, of which eleven (11) were fungal diseases and another two (2) diseases were caused by bacteria. The fungal diseases of were anthracnose (*Colletotrichum gloeosporioides*), die-back (*Fusarium solani* and *Phomopsis citri*), gummosis (*Phytopthora citrophthora*), scab (*Elsinoe fawcettii*), sooty mould (*Capnodium citri*), pink disease (*Botryobasidium salmonicolor*), powdery mildew (*Oidium citri*), citrus wilt (*Fusarium* spp.), black spot (*Phyllosticta citricarpa*) and melanose (*Diaporthe citri*). The bacterial diseases of Zara/Colombo lebu varieties identified through field survey were canker (*Xanthomonas axonopoides* pv. *citri*) and citrus greening (*Candidatus liberibacter asiaticus*).

6.2.2.2. Literature review-based findings: The study team made a list of diseases of *Citrus medica* (Zara/Colombo Lebu varieties) through review of secondary documents collected from different secondary sources. As per literature review findings, it was revealed that a total of twenty (20) diseases of *Citrus medica* (Zara/Colombo Lebu varieties) were identified, of which eight (8) were fungal diseases, two (2) were viral diseases and rest 10 diseases were caused by nematodes as shown in the Table-6.6. The fungal diseases of were blue/green mold (*Penicillium* sp.), damping off (*Pythium* sp. and *Rhizoctonia solani*), black mold (*Aspergillus niger*), foam disease (unknown), fruit rot (*Fusarium* sp.), bark rot (*Melanomma citricola*) and stem-end-rot (*Lasiodiplodia pseudotheobromae*). The recorded viral diseases were Tristeza (*Citrus tristeza virus*) and Psorosis (*Citrus psorosis virus*). Ten (10) diseases of Zara/Colombo Lebu varieties identified through literature review were root lesion (*Criconemoides* sp.), stem injury (*Ditylenchus dipsaci*), root decay (*Helicotylenchus* sp.), root lesion (*Hoplolaimus indicus*), root lesion (*Radopholus similis*), root lesion (*Pratylenchus* spp.), root injury (*Hoplotylus* spp.), root decay (*Tylenchus semipenetrans*), root decay (*Xiphinema* spp.) and discoloration (*Tylenchorhynchus* sp.).

6.2.2.3. Isolation, purification and morphological characterization of Causal organism of Canker (*Xanthomonas citri* pv *citri*) in vitro

Xanthomonas citri pv. *citri* were isolated from infected leaf and infected fruit of citrus those were collected from different locations Sylhet and Moulobibazar. The isolates were purified by streak plate method on nutrient agar media where pale yellow to yellow pigmented bacterial colonies were formed on the medium after 72 hours of incubation at 28 ± 2^{o}C which were identical to *Xanthomonas citri* pv *citri* (Fig. 1). The colonies were creamy white in color. The isolates were rod shaped, yellow or pale yellow in color. Elevation, margin and surface of all isolates were convex, even and mucoid, respectively. The unique opaque yellow colour colonies were obtained in the medium.

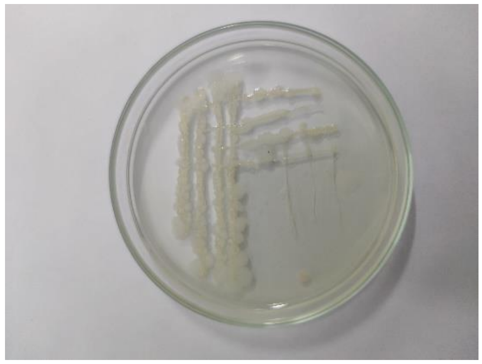


Figure-6.1. *Xanthomonas citri* pv *citri* on nutrient agar media

Biochemical Characteristics of *Xanthomonas citri* pv *citri*

Biochemical characteristics of isolates were studied in order to check similarity of biochemical features with genus Xanthomonas by subjecting to various biochemical tests. In gram staining results indicated, Gram-negative bacteria have a thinner layer (10% of cell envelope), and are stained pink with safranin. Here, the isolated bacteria found to gram negative, motile and rod shaped under light microscope at 100X magnification. After adding the kovac's reagent, bacteria did not produce red/pink color band on the top of the tube and H_2S was not produced as no black precipitation was formed. In Kovac's test, medium containing filter paper and oxidizing agent reagent did not produce any color. The isolated bacteria were considered as gram negative enteric bacteria. Similar outcome was obtained by Kajal *et al.*, (2021), Ali *et al.*, (2017) and Soares *et al.*, (2010), with *Xanthomonas citri* pv *citri* in medium. Bacteria isolated from Citrus aurantifolia by Abu baker *et al*., (2016) also showed similar results by different biochemical test. Our results confirmed the work of Mubeen *et al.*, (2015), Islam *et al.*, (2014) and Hussain *et al.*, (2010) who used several biochemical tests to identify and characterize different strains of citrus canker causing bacteria.

6.2.2.4. Damage potentiality of diseases

Among the identified diseases, four fungal diseases such as anthracnose, die-back, gummosis, scab and one bacterial disease such as citrus greening were reported more damaging than other diseases and these diseases were designated as major diseases of *Citrus medica* (Zara/Colombo Lebu varieties) those caused damage with high infection intensity. Whereas another bacterial disease such as canker also reported more damaging than other diseases, which was designated as major disease of Zara Lebu variety, but never caused disease on Colombo variety, i.e., the Colombo Lebu variety is resistant against citrus canker (*Xanthomonas campestris* pv. *citri*). Other diseases of Zara/Colombo Lebu varieties as shown in the Table-6.5 and Table-6.6 were designated as minor status those caused damage with low infection intensity.

6.2.2.5. Location-wise incidence and diversity of diseases

Considering the location-wise variation of farmers' response on the incidence of diseases of *Citrus medica* (Zara/Colombo Lebu varieties), almost all (95%) farmers of Sylhet district reported that incidence of gummosis disease was occurred on Zara Lebu variety, which was lowest in Tangail district (0%). Whereas 95% farmers of Tangail district reported that the incidence of gummosis disease was occurred on Colombo Lebu variety, which was lowest in Sylhet district (9.2%). The maximum and minimum level of incidences of other major diseases such as anthracnose, die-back, scab, canker and greening diseases on Zara/Colombo Lebu varieties were found 0 to 80%, 0 to 72%, 0.83 to 86%, 0 to 66% and 0 to 69%, respectively as reported by the Zara/Colombo Lebu growers in various sample districts. The district-wise farmers' responses (maximum and minimum) on the incidence of other diseases as recorded in Bangladesh are also shown in the Table 6.7.

Table-6.5. Diseases of *Citrus medica* (Zara/Colombo Lebu varieties) and other citrus, their occurrence in Bangladesh, identify, plant parts affected, pest status and infection severity identified through field survey

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infection severity	Incidence occurred or not		
						Zara lebu	Colombo lebu	Others citrus
A. Causal organism: Fungi								
1	Anthracnose	*Colletotrichum gloeosporioides* Family: Glomerellaceae Order: Glomerellales	Branch, leaf	Major	High	Yes	Yes	Yes
2	Die-back	*Fusarium solani* Family: Nectriaceae Order: Hypocreales	Branch	Major	High	Yes	Yes	Yes
3	Die-back	*Phomopsis citri* Family: Valsaceae Order: Diaporthales	Branch	Major	High	Yes	Yes	Yes
4	Gummosis	*Phytophthora citrophthora* Family: Peronosporaceae Order: Peronosporales	Stem	Major	High	Yes	Yes	Yes
5	Scab	*Elsinoe fawcettii* Family: Elsinoaceae Order: Myriangiales	Leaf, Fruit	Major	High	Yes	Yes	Yes
6	Sooty mold	*Capnodium citri* Family: Capnodiaceae Order: Capnodiales	Leaf	Minor	Low	Yes	Yes	Yes
7	Pink disease	*Botryobasidium salmonicolor* Family: Corticiaceae Order: Corticiales	Leaf	Minor	Low	Yes	Yes	Yes
8.	Powdery mildew	*Oidium citri* Family: Erysiphaceae Order: Erysiphales	Leaf	Minor	Low	Yes	Yes	Yes
9.	Citrus wilt	*Fusarium* spp. Family: Nectriaceae Order: Hypocreales	Leaf	Minor	Low	Yes	Yes	Yes
10.	Black spot	*Phyllosticta citricarpa* Family: Botryosphaeriaceae Order: Botryosphaeriales	Leaf	Major	Low	Yes	Yes	Yes
11.	Melanose	*Diaporthe citri*	Stem, fruit	Minor	Low	No	Yes	Yes

SN	Common Name	Pest Identity	Plant parts affected	Pest status	Infection severity	Incidence occurred or not		
						Zara lebu	Colombo lebu	Others citrus
		Family: Diaporthaceae Order: Diaporthales						
B. Causal organism: Bacteria								
12.	Canker	*Xanthomonas axonopodis* pv. *citri* Family: Xanthomonadaceae Order: Xanthomonadales	Leaf, stem, Fruit	Major	High	No	Yes	Yes
13.	Citrus greening	*Candidatus liberibacter asiaticus*, Family: Rhizobiaceae, Order: Hyphomicrobiales	Leaf, Fruit	Major	High	Yes	Yes	Yes

Table-6.6. Disease pests of citrus present in Bangladesh, their status, plant parts affected and infestation severity

SN	Common Name	Pest identity	Plant parts affected	Pest status	Infestation severity	Incidence occurred or not			References
						Zara lebu	Colombo lebu	Others citrus	
A. Causal organism: Fungi									
1	Blue/green mold	*Penicillium* sp. Family:Trichocomaceae Order: Eurotiales	Fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014)
2	Damping off	*Pythium* sp. Family: Pythiaceae Order: Peronosporales	Stem/Root	Minor	Low	No	Yes	Yes	Ahmed *et al.* (2014)
3.	Damping off	*Rhizoctonia solani* Family: Ceratobasidiaceae Order: Cantharellales	Stem/Root	Minor	Low	No	Yes	Yes	Ahmed *et al.* (2014)
4.	Black mold	*Aspergillus niger* Family: richocomaceae Order: Eurotiales	Leaf	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
5.	Foam disease	Unknown	Leaf/stem	Minor	Low	No	No	Yes	Ahmed *et al.* (2014)
6.	Fruit rot	*Fusarium* sp. Family: Nectriaceae Order: Hypocreales	Fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)

SN	Common Name	Pest identity	Plant parts affected	Pest status	Infestation severity	Incidence occurred or not			References
						Zara lebu	**Colombo lebu**	**Others citrus**	
7.	Bark rot	*Melanomma citricola* Family: Melanommataceae Order: Pleosporales	Fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
F38.	Stem-end rot	*Lasiodiplodia pseudotheobromae* Family: Botryosphaeriaceae Order: Botryosphaeriales	Fruit	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
B. Causal agent: Virus									
9.	Tristeza	*Citrus tristeza virus* Family: Closteroviridae Order: Martellivirales	Leaf	Minor	Low	Yes	Yes	Yes	Akhter *et al.* (2022)
10.	Psorosis	*Citrus psorosis virus* Family: Aspiviridae Order: Serpentovirales	Leaf, stem	Minor	Low	No	Yes	Yes	Ahmed *et al.* (2014)
C. Causal organism: Nematode									
11.	Root lesion	*Criconemoides* sp. Family: Criconematidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
12.	Stem injury	*Ditylenchus dipsaci* Family: Anguinidae Order: Tylenchida	Stem, Leaf	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
13.	Root decay	*Helicotylenchus* sp. Family: Hoplolaimidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
14.	Root lesion	*Hoplolaimus indicus* Family: Hoplolaimidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	CABI/EPPO (2013)
15.	Root lesion	*Radopholus similis* Family: Pratylenchidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014)
16.	Root lesion	*Pratylenchus* spp. Family: Pratylenchidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014)
17.	Root injury	*Hoplotylus* spp. Family: Pratylenchidae	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)

SN	Common Name	Pest identity	Plant parts affected	Pest status	Infestation severity	Incidence occurred or not			References
						Zara lebu	Colombo lebu	Others citrus	
		Order: Tylenchida							
18.	Root decay	*Tylenchus semipenetrans* Family: Tylenchulidae Order: Tylenchida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2014)
19.	Root decay	*Xiphinema* spp. Family: Longidoridae Order: Dorylaimida	Root	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)
20.	Discoloration	*Tylenchorhynchus* sp. Family: Belonolaimidae Order: Tylenchida	Root, Stem, Bark	Minor	Low	Yes	Yes	Yes	Ahmed *et al.* (2019)

Table-6.7. District-wise farmers' response (%) on the incidence of diseases of *Citrus medica* (Zara/Colombo Lebu varieties) as recorded in Bangladesh through field survey

SN	Common Name	District-wise farmers' response* (%) on the incidence of diseases by district			
		Incidence on Zara lebu		Incidence on Colombo lebu	
		Maximum (%)	Minimum (%)	Maximum (%)	Minimum (%)
1.	Anthracnose	Sylhet (80.2%)	Tangail (0%)	Narsingdi (74.4%)	Sylhet (9.2%)
2.	Die-back	Sylhet (71.7%)	Tangail (0%)	Tangail (68.2%)	Sylhet (9.2%)
3.	Gummosis	Sylhet (95.0%)	Tangail (0%)	Tangail (95.0%)	Sylhet (9.2%)
4.	Scab	Sylhet (85.7%)	Tangail (0.83%)	Narsingdi (91.8%)	Sylhet (9.2%)
5.	Sooty mould	Moulvibazar (30.7%)	Tangail (0%)	Narsingdi (22.5%)	Tangail (6.7%)
6.	Pink disease	Sylhet (10.1%)	Tangail (0%)	Tangail (6.1%)	Narsingdi (2.5%)
7.	Powdery mildew	Sylhet (20.4%)	Tangail (0%)	Sylhet (9.2%)	Narsingdi (2.5%)
8.	Citrus wilt	Sylhet (60.6%)	Tangail (0%)	Tangail (58.3%)	Sylhet (5.8%)
9.	Black spot	Moulvibazar (20.6%)	Tangail (0%)	Narsingdi (22.9%)	Tangail (3.7%)
10.	Melanose	Moulvibazar (10.3%)	Tangail (0%)	Narsingdi (12.6%)	Tangail (1.7%)
11.	Canker	Sylhet (65.7%)	Tangail (0%)	None	None
12.	Citrus greening	Sylhet (69.3%)	Tangail (0%)	Narsingdi (64.6%)	Sylhet (5.0%)

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

6.2.2.6. Comparison of identified diseases through present PRA study (2023) with the previous PRA report (2014)

The expert team of present PRA study compared the findings of previous 'PRA of Citrus in Bangladesh' conducted in the year of 2014 with the current 'PRA of *Citrus medica* (Zara/Colombo Lebu varieties) in Bangladesh' conducted in 2023. In case of disease listing, the present PRA study identified a total of 13 diseases of *Citrus medica* (Zara/Colombo Lebu varieties) through field survey, of which 11 were fungal diseases and two diseases were caused by bacteria as shown in the Table-6.5. Besides field survey, the present PRA study also identified additional 20 diseases of *Citrus medica* (Zara/Colombo Lebu varieties) through literature review as shown in the Table-6.6. Whereas the previous PRA study identified a total of 16 diseases for Zara/Colombo Lebu, of which eleven (11) fungal, two (2) viral and three (3) nemic diseases.

Conversely, four (4) diseases namely blue/green mold (*Penicillium* sp.), damping off *Pythium* sp., *Rhizoctonia solani*), Tristeza (*Citrus tristeza virus*) and Psorosis (*Citrus psorosis virus*) of Zara/Colombo Lebu varieties were reported in the previous PRA study, which were not identified through the field survey of present PRA study, but reported in the disease list of present PRA study identified through literature review (Table-6.6). Whereas in the present PRA study, ten (10) additional diseases (10) were also reported for Zara/Colombo Lebu varieties as identified through field survey, of which five (5) diseases caused by fungi and five (5) diseases caused by nematodes. But these ten (10) diseases were not reported in the previously (2014) conducted PRA study report. The newly enlisted five (5) fungal diseases were black mold (*Aspergillus niger*), foam disease (unknown), fruit rot (*Fusarium* sp.), bark rot (*Melanomma citricola*) and stem-end-rot (*Lasiodiplodia pseudotheobromae*). The newly enlisted five (5) nemic diseases were root lesion caused by two species of nematodes such as *Criconemoides* sp. and *Hoplolaimus indicus;* stem injury caused by *Ditylenchus dipsaci*; root decay caused by two (2) species of nematode such as *Helicotylenchus* sp. and *Xiphinema* spp.; root injury caused by *Hoplotylus* spp. and discoloration disease caused by *Tylenchorhynchus* sp. as shown in the Table-6.6.

6.2.2.7. Pictorial presentation of diseases of Zara/Colombo Lebu: During field observation, the PRA study team captured photographs of diseases associated with the Zara/Colombo Lebu and affected 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 of zara lemon on leaf

(b) Anthracnose disease of Colombo Lebu on leaf

(c) Severe anthracnose symptom on citrus leaf

(d) Anthracnose disease symptom on fruit

Plate-6.19. Anthracnose of zara and Colombo lemon (*Colletotrichum gloeosporioides*, Family: Glomerellaceae, Order: Glomerellales) and its damages

(a) Die back disease of zara lemon

Plat-6.20. Die back *(Phomopsis citri,* Family: Valsaceae, Order: Diaporthales) and its damages

(b) Die back disease of Colombo lemon

Plate-6.21. Die back (*Fusarium solani,* Family: Nectriaceae, Order: Hypocreales) and its damages

(a) Citrus gummosis on stem (b) Citrus gummosis on stem

Plate-6.22. Gummosis *(Phytophthora citrophthora,* Family: Peronosporaceae, Order: Peronosporales) and its damages

(a) Citrus scab on leaf (b) Citrus scab on stem

(c) Citrus scab on fruit (b) Citrus scab on fruit

Plate-6.23. Citrus scab (*Elsinoe fawcettii,* Family: Elsinoaceae, Order: Myriangiales) and its damages

(a) Sooty mould on leaf

(b) Citrus leaf severely infected by sooty mould fungus on leaf

Plate-6.24. Sooty mould (*Capnodium citri*,Family: Capnodiaceae, Order: Capnodiales) and its damages

(a) Pink disease on leaf

(a) Pink disease on stem

Plate-6.25. Pink disease *(Botryobasidium salmonicolor,* Family: Corticiaceae, Order: Corticiales) and its damages

(a) Powdery mildew disease on leaf

(b) Powdery mildew disease on leaf and stem

Plate-6.26. Powdery mildew (*Oidium citri*, Family: Erysiphaceae, Order: Erysiphales) and its damages

(a) Citrus wilt symptom

(b) Dead plant after severe wilting

Plate-6.27. Wilt of citrus (Fusarium spp., Family: Nectriaceae; Order: Hypocreales) and its damages

(a) Citrus blackspot on leaf

(b) Citrus blackspot on leaf

(c) Citrus blackspot on fruit

(d) Citrus blackspot on fruit (enlarged view)

Plate-6.28. Citrus black spot (*Phyllosticta citricarpa*, Family: Botryosphaeriaceae; Order: Botryosphaeriales) and its damages

(a) Citrus melanose on fruit

(b) Severely infected citrus fruit by citrus melanose

Plate-6.29. Citrus melanose (*Phyllosticta citricarpa*, Family: Botryosphaeriaceae; Order: Botryosphaeriales) and its damages

(a) Citrus canker on leaf (Jaintapur, Sylhet)

(b) Citrus canker on leaf and twig

(c) Citrus stem canker

(d) Severely infected citrus fruit by citrus canker

(e) Citrus canker on fruit

(f) Citrus canker on fruit (enlarged view)

(g) Citrus canker on fruit of zara lemon

(h) Citrus canker on fruit (Goyanghat, Sylhet)

Plate-6.29. Citrus canker (*Xanthomonas axonopodis* pv. c*itri* Family: Xanthomonadaceae Order: Xanthomonadales) and its damages

(a) Citrus greening disease on leaf

(b) Severe citrus greening symptom on leaf

Plate-6.30. Citrus greening (*Candidatus liberibacter asiaticus,* Family: Rhizobiaceae, Order: Hyphomicrobiales) and its damage

6.2.3. Weeds of *Citrus medica* (Zara/Colombo lebu varieties) in Bangladesh

6.2.3.1. Incidence of weeds in the field of Zara/Colombo Lebu: A total number of three (3) weeds (Table-6.8) were reported as the problem in the field of Zara/Colombo lebu in Bangladesh those were identified through field survey. The enlisted weeds were asthma weed (*Euphorbia hirta*), sensitive plant (*Mimosa pudica*) and dove weed (*Murdannia nudiflora*).

Table-6.8. Weeds of Zara/Colombo lebu, their identity, status and infestation severity

Common name	Scientific name	Family	Order	Plant stage affected	Pest status	Infestation severity
Asthma weed	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Seedling	Major	Medium
Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Seedling	Major	Medium
Dove weed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Seedling	Minor	Low

6.2.3.2. Damage potentiality of weeds: Among three (3) weeds identified as the problem, all these weeds affect the field during seedling stage of the Zara/Colombo Lemon, out of which asthma weed and sensitive plant were designated as major weeds and caused damage with medium infestation intensity, whereas the dove weed was designated as minor weed and caused damage with low infestation intensity (Table-6.8). It is noted that all these weeds cause damages the Zara/ColomboLemonfield during seedling stages through up-taking soil nutrients as competitor.

6.2.3.3. Pictorial presentation of weeds: During field observation, the PRA study team captured photographs of weeds associated with the Zara/Colombo Lemon field. Simultaneously, study team also collected relevant photographs from secondary sources. These pictures have been presented as follows:

Plate-6.31: Asthma weed (*Euphorbia hirta,* Family: Euphorbiaceae, Order: Euphorbiales) infestation

Plate-6.32: Sensitive weed (*Mimosa pudica,* Family: Fabaceae, Order: Fabales) infestation

Plate-6.33: Dove weed (*Murdannia nudiflora,* Family: Commelinaceae, Order: Commelinales) infestation

6.3. Management options for combating pests of Zara/Colombo Lemon

6.3.1. 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 Zara/Colombo Lemonwere spraying insecticides in the orchard followed by removal of unnecessary branches of the trees after harvesting fruits. Other important management options are the use of balanced fertilizer, use of pheromone traps for capturing and killing of fruit flies, removal of weeds from the orchards, irrigating the field along with granular insecticides to control soil dwelling pests, cultivation of pest tolerant variety, application of IPM package.

6.3.2. Management options for diseases: The most effective and commonly practiced management options against the diseases of Zara/Colombo Lemon were spraying of fungicide in the orchards, pruning of the diseased and unnecessary branches from the trees. Other important management options for controlling Zara/Colombo Lemon diseases were the removal of weeds from the orchards, application of granular pesticides at the base of the Zara/Colombo lebu trees, cultivation of disease tolerant variety, application of IPM packages.

6.3.3. Management options for weeds: According to the responses by the stakeholders, the most effective and commonly practiced management options against the weeds of Zara/Colombo lebu were weeding from the orchards particularly during seedling stages, spraying of herbicide at severe stage of weed infestation in the orchard.

6.4. Possible ways of entry of quarantine pests into Bangladesh

Bangladesh usually imports most of the fresh citrus mainly from India and Bhutan through land ports, while imports from other exporting countries such as Thailand, China, South Africa, Egypt, Brazil and Australia through Airports. But no pests of citruses had yet been intercepted at port of entry through any of the consignment of citrus imported in Bangladesh as reported by the Officials of Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture, Bangladesh. However, there is a great possibility to enter any potential hazards (pests) into Bangladesh through any consignment of fresh citrus fruits/saplings during importation if the citrus is being imported without considering the standard phytosanitary system of International Standard Phytosanitary Measures (ISPM).

6.5. Effective ways to prevent the entry of quarantine pests into Bangladesh

The entry of quarantine pests of *Citrus medica* (Zara/Colombo Lemonvarieties) can be prevented by the consideration of phytosanitary measures as prescribed by the ISPM. Following steps can be considered as reported by the stakeholders participated in the study:

- Assurance of phytosanitary certificate during importation of fresh citrus fruit/saplings from exporting countries into Bangladesh;
- In case of high-risk rating pests, pre-inspection of fruits/saplings 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 activities and monitoring system of quarantine centers under PQW, DAE in Bangladesh;
- Illegal entry of seed and saplings of citruses 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 particularly from where Bangladesh usually imports citruses;
- Strengthening the laboratory capacity with modern equipment to inspect the imported product properly considering standard phytosanitary system;
- Action oriented training should be provided for skill development of the quarantine personnel of Plant Quarantine Wing (PQW) of Department of Agriculture Extension (DAE).

6.6. Options to prevent the spread of quarantine pests of citrus within Bangladesh

The quarantine pests of citrus, 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 citrus from pest infested areas to pest free areas;
- Production of pest free citrus by the application of proper management for pests;
- Intensive and frequent inspection of citrus orchards by the experts;
- Following of 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.

6.7. Measures need to be taken by the exporters to export Zara/Colombo Lemon

- Pest free Zara/Colombo Lemon should be produced;
- Pre-and post-harvest phytosanitary technique should be followed;
- Pest infested/infected Zara/Colombo Lemon should be discarded from the lots;
- Proper grading for the quality Zara/Colombo Lemon fruits should be ensured;
- Before packing fruits should be treated with 2.3% sodium ortho-phenylephenate as practiced by the Central Packing House, Plant Quarantine Wing, DAE;
- Proper packing should be followed;
- Graded and packed Zara/Colombo Lemon fruits should be preserved in cold storage;
- Phytosanitary certificate must be ensured before exporting Zara/Colombo Lemon.

6.8. References

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T., Latif, M.A. and Ahmed, S. (2014). Pest Risk Analysis (PRA) of Citrus under Strengthening Phytosanitary Capacity in Bangladesh Project (SPCB), DAE. Strengthening Phytosanitary Capacity in Bangladesh Project, Department of Agricultural Extension, Kharmarbhari, Farmgate, Dhaka-1215.

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T., Latif, M.A., Rahman, M.A. and Ahmed, S. (2019). Developing pest list of plants and plant products in Bangladesh. Strengthening phytosanitary capacity in Bangladesh project. Plant Quarantine Wing. Department of Agricultural Extension. Khamarbari, Farmgate, Dhaka-1215.

Akhter, M., Hasan, M., Tipu, M., Rahman, M., Islam, R., Faruk, M. and Nakahara, K.S. (2022). First report of Citrus tristeza virus in Bangladesh. *Australasian Plant Disease Notes*. **17**(12).

Alam, M.Z. (1962). Insect and Mite Pest of Fruits and Trees in East Pakistan and Their Control. East Pakistan Govt. Press, Department of Agriculture, Dacca. 48-59p.

CABI/EPPO. (2013). *Bactrocera dorsalis*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK:

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Chapter 7: Potential Hazard Organism for Risk Assessment

7.1. Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding the citrus imported from any exporting countries of Bhutan, Brazil, China, India, Egypt, Pakistan, South Africa, USA, Thailand, Australia, and others into Bangladesh.

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

7.2.1. Pests of citrus in the world

The pests associated with fresh fruits and planting materials of citrus 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-eight (78) species of pests were recorded for citrus in the world of which 33 species were insect pests, 4 species were mite pests, and 2 species were mollusks; the species of disease-causing fungi were 18, bacteria 4, virus 4 and nematode 10. On the other hand, 3 species of weeds for citrus were recorded in the world.

Among Table 7.1 depicted the lists of pests associated with the citrus that also occur in Bhutan, Brazil, India, China, Egypt, Thailand, Pakistan, South Africa, USA 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 citrus for Bangladesh

Fifteen (15) species of quarantine pests of citrus for Bangladesh were identified those were present in Bhutan, Brazil, China, India, Egypt, Thailand, Pakistan, South Africa, USA and Australia, but not in Bangladesh. Among these 15 species of quarantine pests, 7 were insect pests, 3 were mite pests, 1 was fungi, 2 were bacteria and 2 were virus (Table 7.2).

The quarantine insect pests are Citrus longhorn beetle (*Anoplophora chinensis*), Citrus weevil (*Diaprepes abbreviates*), African citrus psyllid (*Trioza erytreae*), Mediterranean fruit fly/Medfly (*Ceratitis capitate*), Queensland fruit fly (*Bactrocera tryoni*), South African citrus thrips (*Scirtothrips aurantia*) and California Citrus thrips (*Scirtothrips citri*) (Table 7.2).

The quarantine mite pests are Citrus rust mite (*Phyllocoptruta oleivora),* Citrus bud mite *(Aceria sheldon)* and Lewis spider mite (*Eotetranychus lewisi*).

On the other hand, five (5) disease causing pathogens identified as quarantine pests of citrus for Bangladesh. Among the disease-causing quarantine pathogens 1 is fungus named Greasy spot (*Mycosphaerella citri*), 2 are bacteria named Citrus variegated chlorosis (*Xylella fastidiosa* subsp. *Pauca*) and Citrus stubborn (*Spiroplasma citri*) and 2 are virus named Citrus exocortis (*Citrus exocortis viroid*) and Indian citrus ringspot virus (*Indian citrus ringspot virus*).

Table 7.1. Pests associated with citrus 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	Lemon butterfly	*Papilio demoleus*	Papilionidae	Lepidoptera	Major	Yes	No	Bangladesh	APPPC (1987)
								Afghanistan	EPPO (2022)
								Bhutan	NHM (1891)
								China	Tong (1993)
								India	Choudhuri and Konar (2007)
								Indonesia	Matsumoto (2002)
								Kuwait	Al-Houty (1983)
								Malaysia	Corbet and Pendlebury (1992)
								Myanmar	Waterhouse (1993)
								Nepal	Smith (1990)
								Pakistan	Mangrio *et al.* (2020)
								Philippines	Corbet and Pendlebury (1992)
								Saudi Arabia	EPPO (2022)
								Singapore	Waterhouse (1993)
								Sri Lanka	Talbot (1939)
								Thailand	Waterhouse (1993)
								United Arab Emirates	EPPO (2022)
2	Citrus leaf miner	*Phyllocnistis citrella*	Gracillariidae	Lepidoptera	Major	Yes	No	Bangladesh	EPPO (2022)
								Bhutan	
								China	Gao *et al.* (2012)
								India	Thakre and Soni (2017)
								Indonesia	Waterhouse (1993)
								Israel	EPPO (2022)
								Japan	Mafi and Ohbayashi (2004)
								Malaysia	EPPO (2022)
								Myanmar	Waterhouse (1993)
								Nepal	EPPO (2022)
								Pakistan	Ullah *et al.* (2005)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Philippines	Waterhouse (1993)
								Saudi Arabia	EPPO (2022)
								Singapore	AVA (2001)
								Sri Lanka	EPPO (2022)
								Thailand	Waterhouse (1993)
								Turkey	Gözel and Gözel (2014)
								Vietnam	Waterhouse (1993)
								France	Seebens *et al.* (2017)
								Greece	EPPO (2022)
								Italy	Seebens *et al.* (2017)
								United States	Seebens *et al.* (2017)
								Australia	Liu ZhongMin *et al.* (2008)
								Argentina	Diez *et al.* (2006)
								Brazil	Jaciani *et al.* (2009)
								Egypt	EPPO (2022)
								South Africa	
								Afghanistan	
3	Fruit sucking moth	*Othreis* spp.	Noctuidae	Lepidoptera	Major	Yes	No	Bangladesh	EPPO (2022)
4	Swallowtail butterfly	*Papilio polytes*	Papilionidae	Lepidoptera	Major	Yes	No	Bangladesh	EPPO (2022)
								India	
								China	
								Myanmar	
								Bhutan	
								Thailand	
								Sri Lanka	
								Pakistan	
								Japan	
								Malaysia	
5	Citrus leaf folder	*Psorosticha zizyphi*	Depressariidae	Lepidoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	Lvovsky and Fallahzadeh (2010)
								Iran	
								United Arab Emirates	Prins and Prins (2014)
								Sri Lanka	
								Australia	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
6	Bark and stem borer/ Bark eating caterpillar	*Indarbela quadrinotata*	Metarbelidae	Lepidoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	Beccaloni *et al.* (2003)
								Sri Lanka	Beccaloni *et al.* (2003)
7	Orange spined bug	*Biprorulus bibax*	Pentatomidae	Coleoptera	Major	Yes	No	Bangladesh	Ahmed (2019)
								Australia	James (1990)
8	Citrus stem borer	*Chelidonium cinctum*	Cerambycidae	Coleoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								United Kingdom	Straw *et al.* (2015)
								United States	Haack *et al.* (2010)
								Italy	Hérard and Roques (2009)
9	Citrus longhorn beetle	*Anoplophora chinensis*	Cerambycidae	Coleoptera	Major	No	Yes	China	Yang *et al.* (2021)
								Indonesia	EPPO (2022)
								France	
								Malaysia	
								Philippines	
								Turkey	Yıldız (2017)
								Japan	Fujiwara-Tsujii *et al.* (2012)
								Italy	Seebens *et al.* (2017)
10	Citrus weevil	*Diaprepes abbreviatus*	Curculionidae	Coleoptera	Minor	No	Yes	United States	EPPO (2022)
								United Kingdom	
								Netherlands	
								Sweden	
11	Citrus red scale	*Aonidiella aurantii*	Diaspididae	Hemiptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								Australia	Ebeling (1959)
								Argentina	
								Brazil	
								South Africa	Bedford (1998)
								India	Hayes (1970)
12	Citrus yellow scale	*Aonidiella citrina*	Diaspididae	Hemiptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	Wikipedia (2021)
								Iran	
								Australia	
								Japan	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								China	
								USA	
13	Citrus mealybug	*Planococcus citri* Pseudococcus filamentosus	Pseudococcidae	Hemiptera	Minor	Yes	No	Bangladesh	CABI and EPPO (1999)
								China	
								Indonesia	
								Malaysia	
								Pakistan	
								Thailand	
								United Arab Emirates	
								Italy	
								South Africa	
								India	Srinivasnaik *et al.* (2016)
								Sri Lanka	Sirisena *et al.* (2013)
								Myanmar	Waterhouse (1993)
								France	Seebens *et al.* (2017)
								Germany	
								United States	
								Australia	
								Greece	Szita *et al.* (2017)
								Switzerland	Kozár *et al.* (1994)
								Unite Kingdom	Malumphy and Badmin (2012)
								Argentina	Ben-Dov (1994)
								Brazil	Lopes *et al.* (2019)
								Egypt	Adly *et al.* (2016)
14	Citrus blackfly	*Aleurocanthus woglumi*	Aleyrodidae	Hemiptera	Major	Yes	No	Bangladesh	Akrivou *et al.* (2021)
								Malaysia	
								South Africa	
								India	Singh *et al.* (2020)
								Bhutan	Maciel (2015)
								China	
								Myanmar	
								Nepal	
								Singapore	
								Sri Lanka	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Thailand	
								United Arab Emirates	
								Vietnam	
								Pakistan	Tayyib (2014)
								Argentina	Lopez *et al.* (2011)
								Brazil	Gomes *et al.* (2019)
								United States	Fletcher *et al.* (2004)
15	Citrus bug	*Rhynchocoris humeralis*	Pentatomidae	Hemiptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
16	Asian citrus psyllid	*Diaphorina citri*	Triozidae	Homoptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								Afghanistan	
								China	
								India	
								Indonesia	
								Saudi Arabia	
								Singapore	
								Sri Lanka	
								Thailand	
								United Arab Emirates	
								France	
								Australia	
								Argentina	
								Malaysia	Leong *et al.* (2018)
								Myanmar	Waterhouse (1993)
								Bhutan	Lama and Amatya (1993)
								Nepal	EPPO (2022)
								Pakistan	Muhammad Arshad *et al.* (2019)
								Vietnam	Waterhouse (1993)
								United States	Martini *et al.* (2018)
								Brazil	Nava *et al.* (2007)
17	African citrus psyllid	*Trioza erytreae*	Triozidae	Homoptera	Minor	No	Yes	South Africa	Massonie *et al.* (1976)
								Saudi Arabia, Belgium,	EPPO (2022)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Italy, Netherlands, Portugal	
18	Greenhouse whitefly	*Trialeurodes vaporariorum*	Aleyrodidae	Homoptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								Egypt	Nada *et al.* (2022)
								South Africa	EPPO (2022)
								China	Seebens *et al.* (2017)
								India	Patial and Mehta (2008)
								Indonesia	Nasruddin and Mound (2016)
								Japan	Seebens *et al.* (2017)
								Pakistan	Tayyib *et al.* (2014)
								Philippines	EPPO (2022)
								Sri Lanka	EPPO (2022)
								Turkey	Erdogan *et al.* (2012)
								France	EPPO (2022)
								Germany	Seebens *et al.* (2017)
								Greece	EPPO (2022)
								Italy	Nannini *et al.* (2011)
								Netherlands	Malumphy *et al.* (2009)
								Spain	Alfaro-Fernández *et al.* (2010)
								Sweden	Byrne *et al.* (1990)
								United Kingdom	Seebens *et al.* (2017)
								Mexico	Méndez-Lozano *et al.* (2012)
								United States	Byrne *et al.* (1990)
								Australia	Gambley *et al.* (2010)
								New Zealand	Seebens *et al.* (2017)
								Argentina	Van Nieuwenhove *et al.* (2016)
								Brazil	Fernandez *et al.* (2022)
19	Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Homoptera	Minor	Yes	No	Bangladesh	EPPO (2022)
								Afghanistan	
								China	
								India	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Japan	
								United States	
								Argentina	
								Sri Lanka	
								Thailand	
								Vietnam	
								France	Seebens *et al.* (2017)
								Italy	
								Pakistan	Tayyib *et al.* (2014)
								Spain	Franco *et al.* (2006)
20	Striped mealybug	*Ferrisia virgata*	Pseudococcidae	Homoptera	Major	Yes	No	Bangladesh	Ahmed (2019)
								India	Newstead (1894)
								Sri Lanka	Green (1896)
21	Black citrus aphid	*Toxoptera citricida*	Aphididae	Homoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								South Africa	EPPO (2022)
								Bhutan	
								China	
								Australia	
								Argentina	
								Brazil	
								Malaysia	
								Myanmar	
								Nepal	
								Singapore	
								Sri Lanka	
								Thailand	
								Italy	
								United States	Seebens *et al.* (2017)
22	Oriental fruit fly	*Bactrocera dorsalis*	Tephritidae	Diptera	Major	Yes	No	Bangladesh	Leblanc *et al.* (2013)
								Bhutan	CABI/EPPO (2013)
								China	Seebens *et al.* (2017)
								India	Akbar *et al.* (2019)
								Malaysia	Leblanc *et al.* (2015)
								Myanmar	Aketarawong *et al.* (2014)
								Nepal	Ganie *et al.* (2013a)
								Pakistan	Abro *et al.* (2020)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Singapore	Mahmood (2004)
								Sri Lanka	Khamis *et al.* (2012)
								Thailand	Haq *et al.* (2016)
								United Arab Emirates	EPPO (2022)
								France	
								Italy	Nugnes *et al.* (2018)
								United States	Leblanc *et al.* (2015)
								South Africa	IPPC (2020)
23	Mediterranean fruit fly/Medfly	*Ceratitis capitata*	Tephritidae	Diptera	Minor	No	Yes	Egypt	Kourti *et al.* (1992)
								South Africa	Munro (1929)
								Australia	Gasparich *et al.* (1997)
								China	CABI and EPPO (2015)
24	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)
25	Termite	*Odontotermes obesus*	Termitidae	Isoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
26	Flower thrips	*Frankliniella schultzei*	Thripidae	Thysanoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
27	Citrus thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Minor	Yes	No	Bangladesh	Ahmed (2019)
								China	Mirab-Balou *et al.* (2014)
								India	Kumar and Rachana (2021)
								Japan	Toda *et al.* (2014)
								Malaysia	Aliakbarpour and Rawi (2011)
								Myanmar	EPPO (2022)
								Pakistan	
								Sri Lanka	
								Australia	
								Vietnam	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Netherlands	NPPO of the Netherlands (2013)
								United States	Seebens *et al.* (2017)
								Thailand	Toda *et al.* (2014)
								Brazil	Dias-Pini *et al.* (2018)
28	South African citrus thrips	*Scirtothrips aurantii*	Thripidae	Thysanoptera	Minor	No	Yes	Egypt	Agamy *et al.* (2017)
								South Africa	Bara and Laing (2019)
								United Kingdom	EFSA PLH Panel (2018)
								Australia	Mound and Tree (2020)
29	California Citrus thrips	*Scirtothrips citri*	Thripidae	Thysanoptera	Minor	No	Yes	China	Li *et al.*, 2003
								India	EPPO, 2000
								Iran	Akbari and Seraj, 2007
30	Green citrus aphid	*Aphis spiraecola*	Aphididae	Homoptera	Minor	Yes	No	Bangladesh	UK, CAB International (1969)
								Egypt	Wijs (1974)
								Morocco	UK, CAB International (1969)
								South Africa	Gilbert (1994)
								China	Zhang *et al.* (1997)
								India	Joshi and Sangma (2015)
								Iran	Hodjat and Eastop (1983)
								Israel	Swirski *et al.* (1991)
								Japan	UK, CAB International (1969)
								Malaysia	UK, CAB International (1969)
								Maldives	UK, CAB International (1969)
								Nepal	UK, CAB International (1969)
								Pakistan	Riaz *et al.* (2022)
								Philippines	Quimio and Calilung (1993)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Singapore	UK, CAB International (1969)
								Sri Lanka	UK, CAB International (1969)
								Thailand	UK, CAB International (1969)
								Turkey	Alaserhat *et al.* (2021)
								France	Seebens *et al.* (2017)
								Greece	Katsoyannos *et al.* (1997)
								Italy	Seebens *et al.* (2017)
								Netherlands	Furk (1979)
								Spain	Cambra *et al.* (2004)
								Switzerland	UK, CAB International (1969)
								United Kingdom	Borbély *et al.* (2021)
								United States	Seebens *et al.* (2017)
								Australia	UK, CAB International (1969)
								New Zealand	Seebens *et al.* (2017)
								Argentina	Portillo (1988)
								Brazil	UK, CAB International (1969)
31	Citrus soft scale	*Coccus hesperidum*	Coccidae	Homoptera	Minor	Yes	No	Bangladesh	CABI/EPPO (2013)
								India	
								Nepal	
								Bhutan	
								Myanmar	
								Sri Lanka	
								Pakistan	
								Afghanistan	
								Myanmar	
								Thailand	
								Indonesia	
								Malaysia	
								Australia	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								New Zealand	
								Japan	
								Sweden	
								United Kingdom	
								Netherlands	
								France	
								Spain	
								Greece	
								Egypt	
								United Arab Emirates	
								Germany	
								Italy	
								Argentina	
								Brazil	
								United States	
								Mexico	
32	Citrus green stink bug	*Nezara viridula*	Pentatomidae	Hemiptera	Minor	Yes	No	Bangladesh	Uddin *et al.* (2013)
								Egypt	Rizk *et al.* (1990)
								South Africa	Annecke and Moran (1982)
								Afghanistan	Hoberlandt (1984)
								China	Li (1985)
								India	Vidya *et al.* (2015)
								Indonesia	Chu (1979)
								Japan	Yukawa *et al.* (2007)
								Malaysia	UK, CAB International (1970)
								Myanmar	Waterhouse (1993)
								Nepal	Gautam and Acharya (2014)
								Pakistan	UK, CAB International (1970)
								Philippines	Waterhouse (1993)
								Saudi Arabia	UK, CAB International (1970)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Sri Lanka	Rajendram and Devarajah (1990)
								Thailand	Waterhouse (1993)
								France	UK, CAB International (1970)
								Germany	UK, CAB International (1970)
								Greece	UK, CAB International (1970)
								Italy	Colazza and Bin (1995)
								Spain	UK, CAB International (1970)
								United Kingdom	Seebens *et al.* (2017)
								United States	Looney *et al.* (2019)
								Australia	Clarke (1992)
								New Zealand	Seebens *et al.* (2017)
								Argentina	Porta (1992)
								Brazil	Ricalde *et al.* (2015)
33	Citrus fire ant	*Solenopsis invicta*	Formicidae	Hymenoptera	Minor	Yes	No	Bangladesh	Ahmed *et al.* (2019)
								China	Seebens *et al.* (2017)
								Malaysia	ISSG (2014)
								Mexico	Salas-Araiza *et al.* (2012)
								United States	Williams *et al.* (2021)
								Australia	IPPC (2010)
								Argentina	Folgarait *et al.* (2008)
								Brazil	Pesquero and Penteado-Dias (2004)
B. Mite									
34	Citrus red mite	*Panonychus citri*	Tetranychidae	Acarina	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	EPPO (2022)
								Sri Lanka	
								China	
								Thailand	
								Taiwan	
								Philippines	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Malaysia	
								Russia	
								France	
								United Kingdom	
								Spain	
								Turkey	
								Switzerland	
								United States	
								Argentina	
								Brazil	
35	Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarina	Minor	No	Yes	China	Tropea Garzia and De Lillo (2018)
								United States	Hoy (2011)
								Vietnam	EPPO (2022)
								Argentina	
								Italy	
								Brazil	
								India	
								Philippines	
								Australia	Tropea Garzia and De Lillo (2018)
								Japan	
								Turkey	
								South Africa	
36	Citrus bud mite	*Aceria sheldon*	Eriophyidae	Acarina	Minor	No	Yes	Egypt	EPPO (2022)
								South Africa	
								Argentina	
								Brazil	
								United States	
								India	
								Indonesia	
								Greece	
								Italy	
								Australia	
37	Lewis spider mite	*Eotetranychus lewisi*	Tetranychidae	Acarina	Minor	No	Yes	South Africa, Japan, Iran, Taiwan	EPPO (2022)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
C. Mollusk									
38	Grey garden slug	*Deroceras reticulatum*	Limacidae	Stylommatophora	Minor	Yes	No	Bangladesh	Field survey
								South Africa	Seebens *et al.* (2017)
								Sri Lanka	Maheshini *et al.* (2019)
								Turkey	Yıldırım and Kebapçı (2004)
								France	Hommay (1995)
								Germany	Kerney *et al.* (1979)
								Netherlands	Ester and Nijënstein (1996)
								Spain	Castillejo (1996)
								Sweden	Kerney *et al.* (1979)
								Switzerland	Kerney *et al.* (1979)
								United Kingdom	Glen *et al.* (1991)
								United States	McDonnell *et al.* (2014)
								Australia	Young (1996)
								New Zealand	Barker (1989)
								Argentina	Seebens *et al.* (2017)
39	Brown garden snail	*Cornu aspersum*	Helicidae	Stylommatophora	Minor	Yes	No	Bangladesh	Field survey
								Egypt	Zidan *et al.* (1997)
								South Africa	Seebens *et al.* (2017)
								China	Seebens *et al.* (2017)
								Philippines	Khalil *et al.* (1991)
								Saudi Arabia	El-Wakil *et al.* (2011)
								Thailand	Pattarmanon (1987)
								Turkey	Yıldırım *et al.* (2004)
								France	Beeby and Richmond (2010)
								Germany	Seebens *et al.* (2017)
								Greece	Vokou *et al.* (1998)
								Italy	Godan (1983)
								Netherlands	Kerney (1999)
								Spain	Iglesias and Castillejo (1999)
								Sweden	Taylor (1914)
								Switzerland	Seebens *et al.* (2017)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								United Kingdom	Seebens *et al.* (2017)
								Mexico	Godan (1983)
								United States	Grimm *et al.* (2009)
								Australia	CFIA (2009)
								New Zealand	Seebens *et al.* (2017)
								Argentina	González *et al.* (2009)
								Brazil	Escargots Funcia (2009)
Disease pests									
A. Fungi									
40	Anthracnose	*Colletotrichum gloesporiodies*	Glomerellaceae	Glomerellales	Major	Yes	No	Bangladesh	Ahmed (2019)
								Brazil	Lima *et al.* 2013
								India	Sharma *et al.* 2013
								Australia	Shivas *et al.* 2016
								China	Mo *et al.* 2018)
								Philippines	Weir *et al.* 2012
								Thailand	Weir *et al.* 2012
41	Die-back	*Fusarium solani*	Nectriaceae	Hypocreales	Major	Yes	No	Bangladesh	Ahmed (2019)
								China	Xu *et al.* 2016
	Die-back	*Phomopsis citri*	Valsaceae	Diaporthales	Major	Yes	No	Bangladesh	Ahmed (2019)
								Egypt	EPPO (2022)
								South Africa	
								Argentina	
								Brazil	
								Myanmar	
								Pakistan	
								Philippines	
								Thailand	
								United Kingdom	
								United States	Farr *et al.* (1989)
								China	Zhang and Huang (1990)
								India	Srivastava (1982)
								Indonesia	Fawcett (1936)
								Australia	Bertus (1981)
42	Gummosis		Peronosporaceae	Peronosporales	Major	Yes	No	Bangladesh	Ahmed (2019)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
		Phytophthora citrophthora						South Africa	EPPO (2022)
								United Kingdom	
								China	
								United States	
								Vietnam	
								Malaysia	
								Australia	
								Brazil	
								Egypt	
								France	
								Greece	
								India	
								Indonesia	
								Italy	
								Malaysia	
								Pakistan	
								Philippines	
								Thailand	
43	Scab	*Elsinoe fawcettii*	Elsinoaceae	Myriangiales	Major	Yes	No	Bangladesh	Ahmed (2019)
								South Africa	Villiers and Milne (1975)
								Brazil	Mendes *et al.* (2019)
								United States	Whiteside (1980)
								China	Hou *et al.* (2014)
								India	ICAR (2010)
								Indonesia	EPPO (2022)
								Malaysia	
								Myanmar	
								Nepal	
								Pakistan	
								Philippines	
								Sri Lanka	
								Thailand	
								Australia	Jeffress *et al.* (2020)
44	Sooty mould	*Capnodium citri*	Capnodiaceae	Caapnodiales	Minor	Yes	No	Bangladesh	DAE (2019)
								India	EPPO (2022)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Pakistan	
								Australia	
								Italy	
								Brazil	
								United States	
45	Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	Minor	No	Yes	United States	CABI/EPPO (2013)
								Argentina	
								Brazil	
								Egypt	
								China	
								Japan	
								Australia	
46	Black mould	*Aspergillus niger*	Trichocomaceae	Eurotiales	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	EPPO (2022)
								Pakistan	
								Sri Lanka	
								Nepal	
								Myanmar	
								Thailand	
								China	
								Philippines	
								Indonesia	
								Australia	
								Egypt	
								Greece	
								Italy	
								France	
								Germany	
								United Kingdom	
								United States	
								Brazil	
								Argentina	
47	Powdery mildew	*Oidium citri*	Erysiphaceae	Erysiphales	Minor	Yes	No	Bangladesh	Ahmed (2019)
								France	Lemaire *et al.* (1999)
								Germany	Lebeda and Mieslerova (2002)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Italy	Stravato (1993)
								Switzerland	Bolay (1998)
								United Kingdom	Fletcher *et al.* (1988)
								Bhutan	Kiss *et al.* (2001)
								China	
								India	
								Malaysia	
								Nepal	
								Thailand	
								Argentina	Weht *et al.* (1997)
48	Pink disease	*Botryobasidium salmonicolor*	Corticiaceae	Corticiales	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	EPPO (2022)
								Pakistan	
								Nepal	
								Sri Lanka	
								Myanmar	
								Thailand	
								China	
								Indonesia	
								Philippines	
								Australia	
								Brazil	
								United States	
49	Wilt	*Fusarium* spp.	Nectriaceae	Hypocreales	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	EPPO (2022)
								Pakistan	EPPO (2022)
								Nepal	EPPO (2022)
								China	
								Australia	
								Sweden	
								United Kingdom	
								France	
								Egypt	
								United States	
								Brazil	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Argentina	
50	Bark rot	*Melanomma citricola*	Melanommataceae	Pleosporales	Minor	Yes	No	Bangladesh	Ahmed (2019)
51	Stem-end rot	*Lasiodiplodia pseudotheobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Yes	No	Bangladesh	Ahmed (2019)
								China	EPPO (2022)
52	Black spot of citrus	*Phyllosticta citricarpa*	Phyllostictaceae	Botryosphaeriales	Minor	No	Yes	South Africa	Martinez-Minaya *et al.* (2015)
								Argentina	Duran *et al.*, (2005)
								Brazil	Sposito *et al.* (2011)
								United States	Stocks (2012)
								Bhutan	EPPO (2022)
								China	Zhang and Huang (1990)
								India	Das *et al.* (2018)
								Indonesia	USDA (1982)
								Philippines	
								Australia	Paul *et al.* (2005)
53	Melanose	*Diaporthe citri*	Diaporthaceae	Diaporthales	Minor	Yes	No	Bangladesh	EPPO (2022)
								India	EPPO (2022)
								Pakistan	EPPO (2022)
								Myanmar	EPPO (2022)
								Thailand	EPPO (2022)
								China	EPPO (2022)
								Indonesia	EPPO (2022)
								Philippines	EPPO (2022)
								Japan	EPPO (2022)
								Australia	EPPO (2022)
								New Zealand	EPPO (2022)
								Egypt	EPPO (2022)
								Turkey	EPPO (2022)
								United Arab Emirats	EPPO (2022)
								United States	EPPO (2022)
								Mexico	EPPO (2022)
								Argentina	EPPO (2022)
								Brazil	EPPO (2022)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								South Africa	EPPO (2022)
54	Blue/Green mold	*Penicillium* sp.	Trichocomaceae	Eurotiales	Minor	Yes	No	Bangladesh	Ahmed (2014)
55	Damping off	*Pythium* sp.	Pythiaceae	Peronosporales	Minor	Yes	No	Bangladesh	Ahmed (2014)
								India	EPPO (2022)
								Pakistan	EPPO (2022)
								Sri Lanka	EPPO (2022)
								Thailand	EPPO (2022)
								Indonesia	EPPO (2022)
								China	EPPO (2022)
								Philippines	EPPO (2022)
								Japan	EPPO (2022)
								Australia	EPPO (2022)
								Norway	EPPO (2022)
								United Kingdom	EPPO (2022)
								Netherlands	EPPO (2022)
								France	EPPO (2022)
								Spain	EPPO (2022)
								Greece	EPPO (2022)
								Egypt	EPPO (2022)
								United States	EPPO (2022)
								Mexico	EPPO (2022)
								Argentina	EPPO (2022)
								Brazil	EPPO (2022)
56	Damping off	*Rhizoctonia solani*	Ceratobasidiaceae	Cantharellales	Minor	Yes	No	Bangladesh	Ahmed (2014)
								United Kingdom	Wikipedia (2023)
								Australia	Wikipedia (2023)
								Canada	Wikipedia (2023)
								India	Wikipedia (2023)
57	Foam disease	Unknown	Unknown	Unknown	Minor	Yes	No	Bangladesh	Ahmed (2014)
				Bacteria					
58	Citrus canker		Xanthomonadaceae	Xanthomonadales	Major	Yes	No	Bangladesh	Vernière *et al.* (2013)
								China	Ye *et al.* (2013)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
		Xanthomonas axonopodis pv. *citri*						India	Savitha *et al.* (2016)
								Indonesia	Li *et al.* (2007)
								Italy	
								Sri Lanka	
								Myanmar	
								Nepal	EPPO (2022)
								Pakistan	
								Philippines	
								Australia	
								Thailand	
								United Arab Emirates	
								Malaysia	Arshadi *et al.* (2013)
								Argentina	Paola *et al.* (2013)
								United States	Lin *et al.* (2012)
								Brazil	
59	Citrus greening	*Candidatus Liberibacter asiaticus*	Phyllobacteriaceae	Rhizobiales	Minor	Yes	No	Bangladesh	Tipu *et al.* (2017)
								Bhutan	Donovan *et al.* (2012)
								Indonesia	Wirawan *et al.* (2019)
								China	Qian WenJuan *et al.* (2018)
								India	Singh *et al.* (2019)
								Malaysia	EPPO (2022)
								Myanmar	
								Nepal	Chhetri *et al.* (2019)
60	Citrus variegated chlorosis	*Xylella fastidiosa* subsp. *pauca*	Xanthomonadaceae	Xanthomonadales	Minor	No	Yes	France	EPPO (2022)
								Italy	
								Spain	
								Argentina	Tolocka *et al.* (2017)
								Brazil	Coletta-Filho *et al.* (2016)
61	Citrus stubborn	*Spiroplasma citri*	Mycoplasmataceae	Mycoplasmatales	Minor	No	Yes	Egypt	CABI and EPPO (2015)
								France	
								Greece	
								Italy	
								Spain	
								Turkey	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Pakistan	
								Saudi Arabia	
								United States	
Virus									
62	Citrus Tristeza Virus	*Citrus tristeza virus*	Closteroviridae	Martellivirales	Minor	Yes	No	Bangladesh	Akhter *et al.* (2022)
								Bhutan	Ghosh *et al.* (2020)
								China	Cheng *et al.* (2011)
								India	Singh *et al.* (2022)
								Indonesia	Kusmo (1990)
								Japan	Nagaoka-Nakazono *et al.* (2020)
								Malaysia	Reuther *et al.* (1978)
								Nepal	Brunt *et al.* (1996)
								Pakistan	Abbas *et al.* (2015)
								Philippines	Price (1971)
								Sri Lanka	Brunt *et al.* (1996)
								Thailand	
								United Arab Emirates	Al Shuraiki (1997)
								Vietnam	Brunt *et al.* (1996)
								France	NPPO (2013)
								Greece	Chatzivassiliou and Nolasco (2014)
								Italy	Ferretti *et al.* (2014)
								Spain	Ann. (2007)
								Australia	Brlansky *et al.* (2002)
								Egypt	Amin *et al.* (2006)
								South Africa	Read and Pietersen (2017)
								Argentina	Read *et al.* (2018)
								Brazil	Loeza-Kuk *et al.* (2008)
								United States	Ali *et al.* (2021)
63	Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	Minor	No	Yes	India	CABI/EPPO (2013)
								Pakistan	
								Thailand	
								China	
								Japan	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Philippines	
								Indonesia	
								Australia	
								Egypt	
								United Arab Emirates	
								Saudi Arabia	
								Turkey	
								Greece	
								Italy	
								France	
								Unites States	
								Argentina	
								Brazil	
64	Indian citrus ringspot virus	*Indian citrus ringspot virus*	Alphaflexivirida e	Tymovirales	Minor	No	Yes	India	CABI and EPPO (2015)
								Pakistan	
65	Psorosis	Citrus Psorosis virus	Aspiviridae	Serpentoviral es	Minor	Yes	No	Bangladesh	Ahmed (2014)
								South Africa	EPPO (2022)
								Argentina	EPPO (2022)
								United States	EPPO (2022)
								India	EPPO (2022)
								Pakistan	EPPO (2022)
								France	EPPO (2022)
								Greece	EPPO (2022)
								Italy	EPPO (2022)
Nematode									
66	Root lesion	*Criconemoides* sp.	Criconematidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
67	Root lesion	*Hoplolaimus indicus*	Hoplolaimidae	Tylenchida	Minor	Yes	No	Bangladesh	CABI/EPPO (2013)
								India	
								Pakistan	
								Nepal	
								China	
68	Root lesion	*Radopholus similis*	Pratylenchidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								Egypt	EPPO (2022)
								South Africa	
								China	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Australia	
								Indonesia	
								Pakistan	
								Philippines	
								Singapore	
								Sri Lanka	
								Thailand	
								France	
								Italy	
								Netherlands	NPPO of the Netherlands (2013)
								India	Sundararaju (2006)
								United States	Wang and Hooks (2009)
								Malaysia	Rahman *et al.* (2014)
								Brazil	Lima *et al.* (2013)
69	Root lesion	*Pratylenchus* spp.	Pratylenchidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
70	Stem injury	*Ditylenchus dipsaci*	Anguinidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								South Africa	EPPO (2022)
								Japan	
								Denmark	
								Sweden	
								United Kingdom	
								Turkey	
								Australia	
								Argentina	
								China	Seebens *et al.* (2017)
								Indonesia	Ajri *et al.* (2021)
								Pakistan	Khan *et al.* (2007)
								France	Subbotin *et al.* (2005)
								Germany	Mwaura *et al.* (2015)
								Greece	Archidona-Yuste *et al.* (2020)
								Italy	Greco (2021)
								United States	French *et al.* (2017)
								Brazil	Subbotin *et al.* (2005)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
71	Root decay	*Helicotylenchus* sp.	Hoplolaimidae	Tylenchida	Minor	Yes	No	Bangladesh	DAE (2019)
								Australia	Zeng *et al.* (2012)
								United States	
								Turkey	Akyazi *et al.* (2017)
								India	EPPO (2022)
								Pakistan	
								Sri Lanka	
								Bhutan	
								Thailand	
								Indonesia	
								Philippines	
								China	
								Japan	
								Germany	
								Italy	
								Egypt	
								Brazil	
72	Root decay	*Tylenchus semipenetrans*	Tylenchulidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								Egypt	Ibrahim and Handoo (2016)
								South Africa	EPPO (2022)
								Afghanistan	
								China	
								India	
								Japan	
								Malaysia	
								Philippines	
								Saudi Arabia	
								Sri Lanka	
								Thailand	
								Turkey	
								France	
								Greece	
								Italy	
								United States	
								Australia	
								Argentina	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Brazil	
								Pakistan	Safdar *et al.* (2010)
73	Root decay	*Xiphinema* spp.	Longidoridae	Dorylaimida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								Japan	EPPO (2022)
								France	
								United States	
74	Root injury	*Hoplotylus* spp.	Pratylenchidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								Japan	Palomares-Rius *et al.* (2016)
								United States	
								New Zealand	
								Poland	
								Spain	
75	Discoloration	*Tylenchorhynchus* sp.	Belonolaimidae	Tylenchida	Minor	Yes	No	Bangladesh	Ahmed (2019)
								India	CABI/EPPO (2013)
								Pakistan	
								China	
								Nepal	
								Sri Lanka	
								Malaysia	
								Philippines	
								Singapore	
								Australia	
								Japan	
								Turkey	
								Egypt	
								Brazil	
								United States	
Weed									
76	Bara dudhia	*Euphorbia hirta*	Euphorbiaceae	Euphorbiales	Minor	Yes	No	Bangladesh	Holm *et al.* (1979)
								Saudi Arabia	
								Sri Lanka	
								Thailand	
								United Arab Emirates	
								Vietnam	

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Argentina	
								South Africa	
								China	Mukhtar and Peer (2017)
								India	Nayak and Babu (2019)
								Indonesia	Waterhouse (1993)
								Myanmar	
								Japan	Ohwi (1965)
								Malaysia	Hakim *et al.* (2013)
								Nepal	Moody (1989)
								Pakistan	Mehsud *et al.* (2013)
								Singapore	Seebens *et al.* (2017)
								Bhutan	
								United States	
								Australia	
								Mexico	Vázquez-Marrufo *et al.* (2014)
								Brazil	Lopes *et al.* (2019)
77	Sensitive plant	*Mimosa pudica*	Fabaceae	Fabales	Major	Yes	No	Bangladesh	Moody (1989)
								Bhutan	Seebens *et al.* (2017)
								Nepal	
								Singapore	
								Sweden	
								Australia	
								China	Flora of China Editorial Committee (2017)
								India	Borah *et al.* (2018)
								Indonesia	Affandi *et al.* (2019)
								Japan	PIER (2017)
								Maldives	
								Malaysia	Aliakbarpour and Rawi (2011)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Philippines	Waterhouse (1993)
								Myanmar	
								Vietnam	
								Pakistan	Ali (1973)
								Sri Lanka	Fairchild (1902)
								Thailand	Moody (1989)
								United States	USDA-NRCS (2017)
								Brazil	Lopes *et al.* (2019)
								South Africa	Wells *et al.* (1986)
78	Doveweed	*Murdannia nudiflora*	Commelinaceae	Commelinales	Minor	Yes	No	Bangladesh	Galinato *et al.* (1999)
								Bhutan	Noltie (1994)
								China	Flora of China Editorial Committee (2017)
								India	Govaerts (2017)
								Malaysia	
								Philippines	
								Japan	USDA-ARS (2017)
								Myanmar	
								Nepal	
								Pakistan	
								Sri Lanka	
								Thailand	
								Vietnam	
								United States	
								Australia	Atlas of Living Australia (2017)
								Brazil	Aona and Pellegrini (2015)
								South Africa	Holm *et al.* (1977)

Table 7.2. Quarantine pests for Bangladesh likely to be associated with citrus imported from fruit/planting materials exporting countries

Sl. No.	Common name	Scientific name	Distribution to citrus exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect pests					
1	Citrus longhorn beetle	*Anoplophora chinensis* Family: Cerambycidae Order: Coleoptera	China	Woody plants	EPPO (2002)
2	Citrus weevil	*Diaprepes abbreviates* Family: Curculionidae Order: Coleoptera	USA, United Kingdom	Plant material	EPPO (2002)
3	Aftican citrus psyllid	*Trioza erytreae* Family: Triozidae Order: Homoptera	South Africa	Leaf, stem	EPPO (2022)
4	Mediterranean fruit fly/Medfly	*Ceratitis capitate* Family: Tephritidae Order: Diptera	Egypt, South Africa, Australia, China	Fruit	CABI and EPPO (2015)
5	Queensland fruit fly	*Bactrocera tryoni* Family: Tephritidae Order: Diptera	United States, Australia	Fruit	EPPO (2022)
6	South African citrus thrips	*Scirtothrips aurantia* Family: Thripidae Order: Thysanoptera	Egypt, South Africa, Australia, United Kingdom	Plant, Fruit, Leaf	Wikipedia (2021)
7	California Citrus thrips	*Scirtothrips citri* Family: Thripidae Order: Thysanoptera	China, India	Plant, Fruit, Leaf	EPPO (2022)
Mite					
8	Citrus rust mite	*Phyllocoptruta oleivora* Family: Eriophyidae Order: Acarina	China, USA, India, South Africa, Argentina, Brazil	Plant parts	Hoy (2011)
9	Citrus bud mite	*Aceria Sheldon* Family: Eriophyidae Order: Acarina	Egypt, South Africa, United States, Argentina, Brazil, India, Australia	Plant parts	EPPO (2002)
10	Lewis spider mite	*Eotetranychus lewisi* Family: Tetranychidae Order: Acarina	South Africa	Plant parts	EPPO (2022)
Diseases					
Fungi					

Sl. No.	Common name	Scientific name	Distribution to citrus exporting countries	Plant parts likely to carry the pest	References
11	Greasy spot	*Mycosphaerella citri* Family: Mycosphaerellaceae Order: Capnodiales	Egypt, China, Australia, United States, Argentina, Brazil	Plant material	CABI/EPPO (2013)
Bacteria					
12	Citrus variegated chlorosis	*Xylella fastidiosa* subsp. *Pauca* Family: Xanthomonadaceae Order: Xanthomonadales	Argentina, Brazil	Plant material	EPPO (2022)
13	Citrus stubborn	*Spiroplasma citri* Family: Mycoplasmataceae Order: Mycoplasmatales	Egypt, Pakistan, United States	Plant material	EPPO (2022)
Virus					
14	Citrus exocortis	*Citrus exocortis viroid* Family: Pospiviroidae Order: Incertae sedis	India, Pakistan, China, Egypt, Thailand, Australia, United States, Argentina, Brazil	Plant material	EPPO (2022)
15	Indian citrus ringspot virus	*Indian citrus ringspot virus* Family: Alphaflexiviridae Order: Tymovirales	India, Pakistan	Plant material	CABI and EPPO (2015)

7.2.3 References

Abbas, M., Khan, M.M., Mughal, S.M. and Ji, P. (2015). Comparison of infection of Citrus tristeza closterovirus in Kinnow mandarin (*Citrus reticulata*) and Mosambi sweet orange (*Citrus sinensis*) in Pakistan. *Crop Protection.* **78**: 146-150.

Abro, Z.A., Baloch, N., Memon, R.M., Khuhro, N.H., Soomro, Q.A. (2020). Population variations of fruit flies, *Bactrocera* spp. in mango orchards of Hyderabad and Larkana Sindh. *Pure App. Bio*. **9**(1): 949-955. DOI:10.19045/bspab.2020.90099

Adly, D., Fadl, H.A.A.A. and Mousa, S.F.M. (2016). Survey and seasonal abundance of mealybug species, their parasitoids and associated predators on guava trees in Egypt. *Egy. J. Biol. Pest Con.* **26**(3): 657-664. http://www.ejbpc.com/

Agamy, E., El-Husseini, M., El- Sebaey, I. and Wafy, M. (2017). The Egyptian Thripid species in olive groves at Ismaialia, Egypt. *Egy. Aca. J. Biol. Sci. A. Entom*. **10**(4): 1-17. doi: 10.21608/eajb.2017.12180

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T., Latif, M.A. and Ahmed, S. (2014). Pest Risk Analysis (PRA) of Citrus under Strengthening Phytosanitary Capacity in Bangladesh Project (SPCB), DAE. Strengthening Phytosanitary Capacity in Bangladesh Project, Department of Agricultural Extension, Kharmarbhari, Farmgate, Dhaka-1215.

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T., Latif, M.A., Rahman, M.A. and Ahmed, S. (2019). Developing pest list of plants and plant products in Bangladesh. Strengthening phytosanitary capacity in Bangladesh project. Plant Quarantine Wing. Department of Agricultural Extension. Khamarbari, Farmgate, Dhaka-1215.

Ajri, M., Indarti, S., Soffan, A., Huu, N.N. (2021). Morphological and phylogenetic characteristics of *Ditylenchus dipsaci* among garlic plants. *Jordan Journal of Biological Sciences (JJBS)*. **14**(4): 769-773. https://jjbs.hu.edu.jo/files/vol14/n4/Binder14n4.pdf

Akbar, S.A., Nabi, S.U., Mansoor, S. and Khan, K.A, (2019). Morpho-molecular identification and a new host report of *Bactrocera dorsalis* (Hendel) from the Kashmir valley (India). *Inter. J. Trop. Insect Sci*. **40(**2): 315-325. DOI:10.1007/s42690-019-00083-w

Aketarawong, N., Guglielmino, C.R., Karam, N., Falchetto, M., Manni, M., Scolari, F., Gomulski, L.M., Gasperi, G. and Malacrida, A.R. (2014). The oriental fruitfly *Bactrocera dorsalis* s.s. in East Asia: disentangling the different forces promoting the invasion and shaping the genetic make-up of populations. *Genetica*. **142**(3): 201-213. DOI:10.1007/s10709-014-9767-4

Akhter, M., Hasan, M., Tipu, M., Rahman, M., Islam, R., Faruk, M. and Nakahara, K.S. (2022). First report of Citrus tristeza virus in Bangladesh. *Australasian Plant Disease Notes*. **17**(12).

Akrivou, A., Georgopoulou, I., Papachristos, D., Milonasm, P.G. and Kriticos, D.J. (2021). Potential global distribution of *Aleurocanthus woglumi* considering climate change and irrigation. *PLoS ONE*. **16**(12): e0261626. https://doi.org/10.1371/journal.pone.0261626

Akyazi, F., Yigit, U. and Tonkaz, T. (2017). Distribution of spiral nematodes (*Helicotylenchus* spp.) in corn growing areas in coastal provinces of Turkey bordering the Black sea. *Comm. Appl. Biol. Sci, Ghent University*. **82**(3): 287-294.

Alfaro-Fernández, A., Córdoba-Sellés, M., Juárez, M., Herrera-Vásquez, J.Á., Sánchez-Navarro, J.Á., Cebrián, M.C., Font, M.I. and Jordá, C. (2010). Occurrence and geographical distribution of the 'Torrado' disease in Spain. *Journal of Phytopathology*. **158**(7/8): 457-469.

Al-Houty, W. (1983). Butterflies and hawkmoths of Kuwait. Entom. Rec. J. Var. **95**(9-10): 202-204.

Alaserhat, İ., Canbay, A. and Özdemir, I. (2021). Aphid species, their natural enemies in vegetables from erzincan, Turkey: first record of the parasitoid wasp Aphelinus Mali (haldeman) parasitizing *Lipaphis erysimi* (kaltenbach). *Tarim Bilimleri Dergisi*. **27**(1): 16-25.

Al Shuraiki, R.K. (1997). Disease and pest outbreaks – United Arab Emirates. Citrus tristeza in the United Arab Emirates. *Arab and Near East Plant Protection Newsletter (FAO)*. no. 25, p 27.

Ali, E., Bennett, A., Stackhouse, T., Walliullah, S. and Oliver, J.E. (2021). First report of citrus tristeza virus infecting citrus trees in Georgia, USA. *Plant Disease*. **105**(7): 2024.

Aliakbarpour, H. and Rawi, M.C.S. (2011). Seasonal abundance and spatial distribution of larval and adult thrips (Thysanoptera) on weed host plants in mango orchards in Penang, Malaysia. *App. Entom. Zoo*. **46**(2): 185-194. DOI:10.1007/s13355-011-0030-5

Amin, H.A., Fonseca, F., Santos, C. and Nolasco, G. (2006). Typing of Egyptian Citrus tristeza virus (CTV) isolates based on the capsid protein gene. *Phytopathologia Mediterranea* **45**(1): 10-14.

Annecke, D.P. and Moran, V.C. (1982). Insects and mites of cultivated plants in South Africa. *Durban, South Africa: Butterworth*. xiv + 383 pp.

Anonymous. (2007). Incidencia de plagas y enfermedades en las Comunidades Autónomas en 2006. *Phytoma-España*. no. 187, 19-52 and no. 188, 16-56.

APPPC. (1987). Insect pests of economic significance affecting major crops of the countries in Asia and the Pacific region. **In:** Technical Document No. 135, Bangkok, Thailand: Regional Office for Asia and the Pacific region (RAPA).

Archidona-Yuste, A., Cantalapiedra-Navarrete, C., Palomares-Rius, J.E., Castillo, P. and Tzortzakakis, E.A. (2020). Plant-parasitic nematodes associated with cultivated and wild olive trees in Crete, Greece. *Hellenic Plant Protection Journal*. **13**(1): 24-28. DOI:10.2478/hppj-2020-0003

Arshad, M., Ullah, M.I., Çagatay, N.S., Dikmen, F., Abdullah, A. and Afzal, M. (2019). *Cordia myxa* L., a new host plant record for Asian citrus psyllid, *Diaphorina citri* Kuwayama. *Southwestern Entom*. **44**(1): 331-334. DOI:10.3958/059.044.0137

Arshadi, F., Sijam, K. and Awang, Y. (2013). Genetic diversity of *Xanthomonas citri* subsp. *citri*, causal agent of citrus canker. *J. Plant Prot. Res*. **53**(4): 312-316.

AVA. (2001). Diagnostic records of the Plant Health Diagnostic Services., Singapore: Plant Health Centre Agri-food & Veterinary Authority.

Bara, G.T. and Laing, M.D. (2019). Determination of the natural host status of avocado fruit to pestiferous thrips (Thysanoptera: Thripidae) in KwaZulu-Natal, South Africa. *Afr. Entom.* **27**(1): 245-253. https://doi.org/10.4001/003.027.0245

Barker, G.M. (1989). Slug problems in New Zealand pastoral agriculture. **In:** Monograph - British Crop Protection Council, 59-68.

Beccaloni, G., Scoble, M., Kitching, I., Simonsen, T., Robinson, G., Pitkin, B., Hine, A. and Lyal, C. (2003). *Indarbela quadrinotata*. The Global Lepidoptera Names Index. *Nat. His. Museum*. Retrieved May 7, 2018.

Bedford, E.C.G. (1998). Red scale *Aonidiella auranii* (Maskell). **In:** Citrus pests in the Republic of South Africa. Bedford, E.C.G., Berg, M.A.V. and Villiers, E.A.D. Dynamic Ad., Nelspruit, South Africa. pp: 132–134.

Beeby, A. and Richmond, L. (2007). Differential growth rates and calcium-allocation strategies in the garden snail *Cantareus aspersus*. *Journal of Molluscan Studies*. **73**(1): 105-112.

Ben-Dov, Y. (1994). A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. **In:** A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Andover, UK: Intercept Limited. 686 pp.

Bertus, A.L. (1981). Australasian Plant Pathology. **10**(3): 53-55.

Bolay, A. (1998). Revue Suisse de Viticulture. *d'Arboriculture et d'Horticulture*. **30**(6): 373-378.

Borbély, C., György, Z., Jacobsen, S.K., Musa, F., Ouredníccková, J., Sigsgaard, L., Skalský, M. and Markó, V. (2021). First records of the invasive aphid species, *Aphis spiraecola*, in Kosovo, Slovakia, the Czech Republic, the United Kingdom and Denmark. *Plant Protection Science*. **57**(1): 70-74.

Brlansky, R.H., Howd, D.S., Broadbent, P. and Damsteegt, V.D. (2002). Histology of Sweet Orange Stem Pitting Caused by an Australian Isolate of Citrus tristeza virus. *Plant Disease*. **86**(10): 1169-1174.

Brunt, A., Crabtree, K., Dallwitz, M., Gibbs, A. and Watson, L. (1996). Viruses of plants, 409-411. CAB International, Wallingford, UK.

Byrne, D.N., Bellows, T.S. and Parella, M.P. (1990). Whiteflies in agricultural systems. **In:** Whiteflies: their bionomics, pest status and management, [ed. by Gerling D]. Andover, UK: Intercept Limited. P227-261.

CABI/EPPO. (2013). *Bactrocera dorsalis*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK:

CABI, EPPO. (1999). *Planococcus citri*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 43. DOI:10.1079/DMPP/20066600043

Cambra, M., Gorris, M.T., Capote, N., Asensio, M., Martínez, M.C., Bertolini, E., Collado, C., Hermoso, Mendoza, A., Mataix, E. and López, A. (2004). Epidemiology of Plum pox virus in Japanese plums in Spain. *Acta Horticulturae*. 195-200.

Castillejo, J. (1996). (Las babosas come plaga en la agricultura. Claves de identification y mapas de distribucion). **In:** Revista Real Academia Galega de Ciencias, 15 93-142.

CFIA. (2009). *Helix aspersa* (Müller) - European brown garden snail. In: Pest Fact Sheet. Ottawa, Canada: Canadian Food Inspection Agency. http://www.inspection.ca/english/plaveg/pestrava/helasp/tech/helaspe.shtml

Chatzivassiliou, E.K. and Nolasco, G. (2014). Detection of a new variant of Citrus tristeza virus in Greek citrus crops. *Phytopathologia Mediterranea*. **53**(1): 140-147.

Cheng, X.F., Wu, J.X., Ma, X.Y., Fu, H.F. and Wu, X.Y. (2011). First report of Citrus tristeza virus in *Citrus changshanensis* cv. Huyou in Zhejiang, China. *Journal of Plant Pathology*. **93**(4S): S4.68.

Choudhuri, S. and Konar, A. (2007). Population build up of lepidopteran insects on pummelo (*Citrus grandis* L.) in alluvial zone of West Bengal. *J. Entomol. Res*. **31**(2): 97-99.

Chu, Y.I. (1979). Some notes on the lepidopterous rice insect pests at Jawa Timur, Indonesia. *NTU [National Taiwan University] Phytopathologist and Entomologist*. 38-43.

Clarke, A.R. (1992). Current distribution and pest status of *Nezara viridula* (L.) (Hemiptera: Pentatomidae) in Australia. *Journal of the Australian Entomological Society*. **31**(4): 289-297.

Colazza, S. and Bin, F. (1995). Efficiency of *Trissolcus basalis* (Hymenoptera: Scelionidae) as an egg parasitoid of *Nezara viridula* (Heteroptera: Pentatomidae) in Central Italy. *Environmental Entomology*. **24**(6): 1703-1707.

Corbet, A.S. and Pendlebury, H.M. (1992). The Butterflies of the Malay Peninsula. 4th edn., Kuala Lumpur, Malaysia: United Selangor Press.

Das, A.K., Nerkar, S. and Kumar, A. (2018). First report of *Phyllosticta citricarpa* causing citrus black spot on *Citrus sinensis* and *C. reticulata* in India. *Plant Disease*. **102**(8): 1661.

Dias-Pini, N.S., Lima, M.G.A., Lima, E.F.B., Maciel, G.P.S. and Duarte, P.M. (2018). *Scirtothrips dorsalis* (Thysanoptera: Thripidae): a newly introduced polyphagous pest in northeastern Brazil. *Neotrop. Entom*. **47**(5): 725-728. DOI:10.1007/s13744-018-0618-3

Diez, P.A., Peña, J.E. and Fidalgo, P. (2006). Population dynamics of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and its parasitoids in Tafí Viejo, Tucumán, Argentina. *Florida Entom*. **89**(3): 328-335. DOI:10.1653/0015-4040(2006)89[328:PDOPCL]2.0.CO;2

Duran, E.L., Ploper, L.D., Ramallo, J.C., Grandi, R.A.P., Giancoli, A.C.H. and Azevedo, J.L. (2005). Canadian Journal of Botany. **83**(4): 350-355.

Ebeling, W. (1950). Subtropical entomology. Lithotype Process Co., San Francisco, California. 747 pp.

Ebeling, W. (1959). Subtropical Fruit Pests. University of California, Los Angeles. 436 pp.

EFSA PLH Panel (EFSA Panel on Plant Health). (2018). Scientific Opinion on the pest categorisation of Scirtothrips aurantii. *EFSA Journal* **16**(3): 5188, 21 pp. https://doi.org/10.2903/j.efsa.2018.5188

El-Wakil, H.B., Banaja, A.E.A. and Amer, S.A.M. (2011). Morphometric and genetic insights for three terrestrial snails in Taif province of Saudi Arabia. *World Applied Sciences Journal*. **14**(4): 546-551.

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

EPPO. (2002). Plant Quarantine Information Retrieval System v 4.1. Paris, France: European and Mediterranean Plant Protection Organization.

Erdogan, C., Velİoglu, A.S., Gurkan, M.O., Denholm, I. and Moores, G.D. (2012). Chlorpyrifos ethyl-oxon sensitive and insensitive acetylcholinesterase variants of greenhouse whitefly *Trialeurodes vaporariorum* (Westw.) (Hemiptera: Aleyrodidae) from Turkey. *Pesticide Biochemistry and Physiology*. **104**(3): 273-276.

Escargots Funcia. (2009). *Cornu aspersum*. **In:** Escargots Funcia, http://www.escargot.com.br/eng/index.html

Ester, A. and Nijënstein, J.H. (1996). Molluscicidal seed treatment of barley, wheat and perennial ryegrass to control the field slug (*Deroceras reticulatum*). *Netherlands Journal of Agricultural Science*. **44**(3): 241-248.

Farr, D.F., Bills, G.F., Chamuris, G.P. and Rossman, A.Y. (1989). Fungi on plants and plant products in the United States. APS Press, St Paul, USA. p: 1252.

Fawcett, H.S. (1936). Citrus diseases and their control (2nd edition). McGraw-Hill Book Co., New York, USA. pp: 440-448.

Fernandez, P.S.C., Aguiar-Menezes, E.L., Lima, A.F., Frade, P.M.R.M., Teixeira, A.J. and Bucher, C.A. (2022). Aleyrodid (Hemiptera) diversity in hop varieties grown in Brazil. *Bioscience Journal*. DOI:10.14393/BJ-v38n0a2022-54011

Ferretti, L., Fontana, A., Sciarroni, R., Schimio, R., Loconsole, G., Albanese, G. and Saponari, M. (2014). Molecular and biological evidence for a severe seedling yellows strain of Citrus tristeza virus spreading in southern Italy. *Phytopathologia Mediterranea*. **53**(1): 3-13.

Fletcher, J.T., Smewin, B.J. and Cook, R.T.A. (1988). Plant Pathology. **37**(4): 594-598.

Fletcher, R.S., Everitt, J.H., Davis, M.R. and Escobar, D.E. (2004). Integrating airborne imagery and GIS technology to map and compare citrus blackfly infestations occurring in different years. *Hort.Tech.* **14**(3): 398-401. https://doi.org/10.21273/HORTTECH.14.3.0398

Folgarait, P.J., Patrock, R.J.W., Albioni-Montenegro, G., Saldua, L. and Gilbert, L.E. (2008). *Solenopsis invicta*: evidence for recent internal immigration across provinces in Argentina. *Florida Entomologist*. **91**(1): 131-132.

Fujiwara-Tsujii, N., Yasui, H., Wakamura, S., Hashimoto, I. and Minamishima, M. (2012). The white-spotted longicorn beetle, *Anoplophora malasiaca* (Coleoptera: Cerambycidae), with a blueberry as host plant, utilizes host chemicals for male orientation. *App. Entom. Zoo*. **47**(2): 103-110. DOI:10.1007/s13355-012-0095-9

French, J.M., Beacham, J., Garcia, A., Goldberg, N.P., Thomas, S.H. and Hanson, S.F. (2017). First report of stem and bulb nematode *Ditylenchus dipsaci* on garlic in New Mexico. *Plant Health Progress*. PHP-12-16-0069-BR. http://www.plantmanagementnetwork.org/php/elements/sum2.aspx?id=10972

Furk, C. (1979). A British record of *Aphis citricola* van der Goot. *Plant Pathology*. **28**(3): 157.

Gambley, C.F., Thomas, J.E., Persley, D.M. and Hall, B.H. (2010). First report of Tomato torrado virus on tomato from Australia. *Plant Disease*. **94**(4): 486.

Ganie, S.A., Khan, Z.H. and Padder, S.A. (2013a). Identification and Taxonomical Studies of Fruit Flies on Cucurbits in Kashmir Valley. **8**(1): 263-269. http://www.thebioscan.in/journal%20supplement/81sup07%20s.%20a.%20ganie.pdf

Gao, J.Y., Jun, G., Wang, Z.R., Zhou, D.G., Peng, M.X. and Yue, J.Q. (2012). Study on insect pest species and occurrence rule of main species in Dehong lemon orchard of Yunnan province. *Acta Agriculturae Jiangxi*. **24**(6): 70-73. http://www.jxnyxb.com

Garzia, T.G. and Lillo, D.E. (2018). Geographic distribution of *Phyllocoptruta oleivora* in the Mediterranean Basin, with particular emphasis on Italy. *Syst. App. Acarology.* **23**: 1021-1023.

Gautam, J. and Acharya, B. (2014). Survey and monitoring of insect pest and disease of ginger in Nepal. *Nepalese Journal of Agricultural Sciences*. 118-123.

Ghosh, D.K., Kokane, A., Kokane, S., Tenzin, J., Gubyad, M.G., Wangdi, P., Murkute, A.A., Sharma, A.K. and Gowda, S. (2020). Detection and molecular characterization of '*Candidatus Liberibacter asiaticus*' and Citrus tristeza virus associated with citrus decline in Bhutan. *Phytopathology (early view)*. https://doi.org/10.1094/PHYTO-07-20-0266-R

Gilbert, M.J. (1994). The first record of the spirea aphid, *Aphis spiraecola* Patch (Homoptera: Aphidoidea), on citrus in South Africa. *Citrus Journal*. **4**(4): 23.

Glen, D.M., Cuerden, R. and Butler, R.C. (1991). Impact of the field slug *Deroceras reticulatum* on establishment of ryegrass and white clover in mixed swards. *Annals of Applied Biology*. **119**(1): 155-162.

Godan, D. (1983). Pest Slugs and Snails. Biology and Control., Berlin; Heidelberg; New York, Springer-Verlag.

Gomes, A.M.S.V., Reis, F.O., Lemos, R.N.S., Mondego, J.M., Braun, H. and Araujo, J.R.G. (2019). Physiological characteristics of citrus plants infested with citrus blackfly. *Revista Brasileira de Entom.* **63**(2): 119–123. https://doi.org/10.1016/j.rbe.2019.02.002

González, O., Pérez, C.G., Membiela, M., Frezza, D., Bartoloni, N. and Vieites, C. (2009). Discrete observations of the spatial distributions of the *Helix aspersa* snail in an outdoor system. *Ciencia e Investigación Agraria*. **36**(1): 123-130.

Gözel, Ç. and Gözel, U. (2014). The potential use of entomopathogenic nematodes against tomato leaf miner *Tuta absoluta* (Lep: Gelechiidae) [Conference poster]. **In:** Proceedings, 4th ESENIAS Workshop: International Workshop on IAS in Agricultural and Non-Agricultural Areas in ESENIAS Region, Çanakkale, Turkey, 16-17 December 2013 [Proceedings, 4th ESENIAS Workshop: International Workshop on IAS in Agricultural and Non-Agricultural Areas in ESENIAS Region, Çanakkale, Turkey, 16-17 December 2013.], [ed. by Uludağ A, Trichkova T, Rat M, Tomov R]. Ankara, Turkey: Çanakkale Onsekiz Mart University. 116.

Greco, N. (2021). Sustainable management of major nematode parasites of chickpea and broad bean in the Mediterranean region. **In:** Integrated nematode management: state-of-the-art and visions for the future. Sikora, R.A., Desaeger, J. and Molendijk, L. (eds.). Wallingford, UK: CABI. pp: 138-144. DOI:10.1079/9781789247541.0020

Grimm, F.W., Forsyth, R.G., Schueler, F.W. and Karstad, A. (2009). Identifying land snails and slugs in Canada., iv Ottawa, 168 pp.

Haack, R.A., Hérard, F., Sun, J. and Turgeon, J.J. (2010). Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: A worldwide perspective. *Ann. Rev. Entom*. **55**: 521–546.

Haq, I., Vreysen, M.J.B., Schutze, M., Hendrichs, J. and Shelly, T. (2016). Effects of methyl eugenol feeding on mating compatibility of Asian population of *Bactrocera dorsalis* (Diptera: Tephritidae) with African population and with *B. carambolae*. *J. Econ. Entom*. **109**(1): 148-153. http://jee.oxfordjournals.org/content/109/1/148

Hérard, F. and Roques, A. (2009). Current status of *Anoplophora* spp. in Europe and an update on suppression efforts. **In:** Proceedings of 20th US Department of Agriculture interagency research forum on invasive species, 2009 January 13-16, Annapolis, MD. Gen. Tech. Rep., PA: US Department of Agric. p.: 35.

Hoberlandt, L. (1984). Heteroptera of Afghanistan. Acanthosomatidae, Cydnidae, Scutelleridae and Pentatomidae. *Acta Faunistica Entomologica Musei Nationalis Pragae*. **17**(193): 69-128.

Hodjat, S.H. and Eastop, V.F. (1983). *Aphis citricola* van der Goot, a new aphid pest of citrus in Iran. *Entomologie et Phytopathologie Appliquées*. **50**(1/2): 57-66.

Hommay, G. (1995). The slugs injurious to crops. (Les limaces nuisibles aux cultures.). *Revue Suisse d'Agriculture*. **27**(5): 267-286.

Hou, X., Huang, F., Zhang, T., Xu, J., Hyde, D.K. and Li, H. (2014). Pathotypes and Genetic Diversity of Chinese Collections of *Elsinoë fawcettii* Causing Citrus Scab. *J. Inte. Agri.* **13**(6): 1293-1302.

Hoy, M.A. (2011). Agricultural Acarology: Introduction to Integrated Mite Management. CRC Press, Boca Raton, Florida, 430.

Ibrahim, I.K.A. and Handoo, Z.A. (2016). Occurrence of phytoparasitic nematodes on some crop plants in northern Egypt. *Pakistan Journal of Nematology*. **34**(2): 163-169.

ICAR. (2010). Annual Report 2009-10, ICAR Research Complex for NEH Region, Meghalaya.

Iglesias, J. and Castillejo, J. (1999). Field observations on feeding of the land snail *Helix aspersa* Müller. *Journal of Molluscan Studies*. **65**(4): 411-423.

IPPC. (2010). Red Imported Fire Ant (RIFA) in Queensland, Australia. **In:** IPPC Official Pest Report, Rome, Italy: FAO. https://www.ippc.int/

IPPC. (2020). Eradication of *Bactrocera dorsalis* (Oriental Fruit Fly) in three separate areas in the Eastern Cape Province of South Africa. **In:** IPPC Official Pest Report, Rome, Italy: FAO. https://www.ippc.int/

ISSG. (2014). Global Invasive Species Database (GISD). **In:** Invasive Species Specialist Group of the IUCN Species Survival Commission, http://www.issg.org/database/welcome/

Jaciani, F.J., Destéfano, S.A.L., Neto, R.J. and Belasque, J.J. (2009). Detection of a new bacterium related to *Xanthomonas fuscans* subsp. *aurantifolii* infecting Swingle citrumelo in Brazil. *Plant Dis*. **93**(10): 1074. DOI:10.1094/PDIS-93-10-1074B

James, D.G. (1990). Incidence of egg parasitism of *Biprorulus bibax* Breddin (Hemiptera: Pentatomidae) in southern New South Wales and northern Victoria. *Gen. App. Entom*. **22**: 55-60.

Jeffress, S., Arun-Chinnappa, K., Stodart, B., Vaghefi, N., Tan, Y.P. and Ash, G. (2020). Genome mining of the citrus pathogen *Elsinoë fawcettii*; prediction and prioritisation of candidate effectors, cell wall degrading enzymes and secondary metabolite gene clusters. PLoS One 15(5):e0227396.

Joshi, S. and Sangma, R.H.C. (2015). Natural enemies associated with aphids and coccids from Sikkim, India. *Journal of Biological Control*. **29**(1): 3-7.

Katsoyannos, P., Kontodimas, D.C., Stathas, G.J. and Tsartsalis, C.T. (1997). Establishment of *Harmonia axyridis* on citrus and some data on its phenology in Greece. *Phytoparasitica*. **25**(3): 183-191.

Kerney, M.P., Cameron, R.A.D. and Jungbluth, J.H. (1979). (Die Landschnecken Nord- und Mitteleuropas)., Hamburg, Germany: Paul Parey.

Kerney, M.P. (1999). Atlas of the land and freshwater molluscs of Britain and Ireland. Colchester, UK: Harley Books.

Khalil, S.K., Anwar, M., Naeem, M., Ali, I.I., Shah, F. and Jabbar, A. (1991). Studies on the population dynamics, host preference and chemical control of brown garden snail *Helix aspersa* Muller. *Sarhad Journal of Agriculture*. **7**(2): 83-89.

Khamis, F.M., Masiga, D.K., Mohamed, S.A., Salifu, D., Meyer, M. and Ekesi, S. (2012). Taxonomic Identity of the Invasive Fruit Fly Pest, *Bactrocera invadens*: Concordance in Morphometry and DNA Barcoding. *PLoS ONE*. **7**(9). DOI:10.1371/journal.pone.0044862

Khan, A., Khanzada, K.A., Shaukat, S.S. and Shahzad, S. (2007). Nematodes associated with onion in Sindh, Pakistan. *Pakistan Journal of Nematology*. **25**(2): 291-294.

Kiss, L., Cook, R.T.A., Saenz, G.S., Cunnington, J.H., Takamatsu, S., Pascoe, I., Bardin, M., Nicot, P.C., Sato, Y.; Rossman, A. Y. (2001). Mycological Research. **105**(6): 684-697.

Kozár, F., Guignard, E., Bachmann, F., Mani, E. and Hippe, C. (1994). The scale insect and whitefly species of Switzerland (Homoptera: Coccoidea and Aleyrodoidea). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft*. **67**(1-2): 151-161.

Kumar, P.S. and Rachana, R.R. (2021). Scirtothrips dorsalis (Thysanoptera: Thripidae) is a pest of celery, Apium graveolens (Apiales: Apiaceae): first report and diagnostic characters. Journal of Integrated Pest Management. 12 (46), DOI:10.1093/jipm/pmab039

Kusumo, S. (1990). Indonesian Agricultural Research & Development Journal. **12**(3): 35-39.

Lama, T.K. and Amatya, P. (1993). Survey of the Incidence of Citrus Greening Disease and its Psylla Vector in Nepal and Bhutan. *J. Inter. Org. Citrus Vir. Con. Proc. (1957-2010)*. **12**(2): 445-446. https://escholarship.org/uc/item/6hk8p4cb DOI:10.5070/C56hk8p4cb

Lebeda, A. and Mieslerova, B. (2002). Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz. **109**(2): 129-141.

Leblanc, L., Hossain, M.A., Khan, S.A. and Jose, S.M., Rubinoff, D. (2013). A preliminary survey of the fruit flies (Diptera: Tephritidae: Dacinae) of Bangladesh. *Proc. Hawaiian Entomol.l Soc.* **45**:51-58.

Leblanc, L., Jose, S.M.M, Barr, N. and Rubinoff, D. (2015). A phylogenetic assessment of the polyphyletic nature and intraspecific color polymorphism in the *Bactrocera dorsalis* complex (Diptera, Tephritidae). **ZooKeys.**. pp: 339-367.

Lemaire, J.M., Conus, M., Burgerjon, A. and Mas, P. (1999). PHM Revue Horticole No. 402. pp: 21-24.

Leong, S.S., Leong, S.C.T., Abang, F., Beattie, G.A.C. and Kueh, J.H. (2018). Distribution patterns of *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) eggs, nymphs and adults in a Malaysian citrus orchard. *Israel J. Entom*. **48**(1): 49-62. DOI:10.5281/zenodo.1298369

Li, C.Q. (1985). On vertical distribution of natural enemies in paddy fields. *Natural Enemies of Insects*. **7**(3): 149-151.

Li, W.B., Song, Q.J., Brlansky, R.H. and Hartung, J.S. (2007). Genetic diversity of citrus bacterial canker pathogens preserved in herbarium specimens. *Proc. Nation. Aca. Sci. U.S.A*. **104**(47): 18427-18432.

Lima, N.B., Batista, A.M.V., Morais, M.A., Jr., Barbosa, M.A.G., Michereff, S.J., Hyde, K.D. and Câmara, M.P.S. (2013). Five Colletotrichum species are responsible for mango anthracnose in northeastern Brazil. *Fungal Divers*. **61**: 75-88.

Lin, H.C., Feng, C.Y., Chang, Y.A. and Chang, H. (2012). Molecular typing and genetic characterization of pathogenic variants of *Xanthomonas axonopodis* pv. *citri* in Taiwan. *J. Phytopath*. **160**(9): 475-483.

Liu, Z.M., Meats, A. and Beattie, G.A.C. (2008). Seasonal dynamics, dispersion, sequential sampling plans and treatment thresholds for the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae),

in a mature lemon block in coastal New South Wales, Australia. *Aus. J. Entom*. **47**(3): 243-250. DOI:10.1111/j.1440-6055.2008.00651.x
Looney, C., Tilbury, M., Carman, B., Murray, T. and Bush, M.R. (2019). An established population of the southern green stink bug, *Nezara viridula* (Linnaeus), in Washington state. *Proceedings of the Entomological Society of Washington*. **121**(4): 735-740.
Loeza-Kuk, E., Ochoa-Martínez, D.L., Mora-Aguilera, G., Rivas-Valencia, P., Gutiérrez-Espinosa, M.A., Cintra, J.J.W., Villegas-Monter, Á., Arno-Wulff, N. and Perez-Molphe-Balch, E. (2008). Detection of Citrus sudden death-associated virus and Haplotypes of Citrus tristeza virus in *Toxoptera citricida* and *Aphis spiraecola* and implication on citrus sudden death in Brazil. *Agrociencia*, **42**(6): 669-678.
Lopez, S.N., Peralta, C., Aguirre, A. and Caceres, S. (2011). First record of the citrus blackfly *Aleurocanthus woglumi* (Hemiptera: Aleyrodidae) in Argentina. [Primer registro de "la mosca negra de los cítricos" *Aleurocanthus woglumi* (Hemiptera: Aleyrodidae) en la Argentina]. *Revista de la Sociedad Entom. Arg*. **70**: 373-374. http://www.scielo.org.ar/pdf/rsea/v70n3-4/v70n3-4a23.pdf
Lopes, F.S.C., Oliveira, J.V., Oliveira, J.E.M., Oliveira, M.D. and Souza, A.M. (2019). Host plants for mealybugs (Hemiptera: Pseudococcidae) in grapevine crops. *Pesquisa Agropecuária Trop*. DOI:10.1590/1983-40632019v4954421
Lvovsky, and Fallahzadeh. (2010). *Psorosticha zizyphi* (Lepidoptera: Dressariidae) is newly recorded from Iran. *Far Eastern Entom*. (N.216): 14-16.
Maciel. (2015). Status sanitário da mosca negra dos citros no Brasil. Dissertação (Mestrado em Defesa Sanitária Vegetal) - Universidade Federal de Viçosa, Viçosa, 88 pp.
Mafi, S.A. and Ohbayashi, N. (2004). Seasonal prevalence of the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) and its parasitoids in controlled and uncontrolled Citrus iyo groves in Ehime Prefecture, Japan. *App. Entom. Zoo*. **39**(4): 597-601. DOI:10.1303/aez.2004.597
Maheshini, P.W.D.B., Thilakarathne, K.G.D.D., Hirimuthugoda, G.N., Ranawana, K.B. and Kumburegama, S. 2019. The distribution of terrestrial pest gastropods and their damage to agricultural crops in Kandy and Nuwara Eliya districts in Sri Lanka. Ceylon Journal of Science. 48 (2), 177-184.
Mahmood, K. (2004). Identification of pest species in oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) species complex. *Pak. J. Zoo*. **36**(3): 219-230.
Malumphy, C., Walsh, K., Suarez, M.B., Collins, D.W. and Boonham, N. (2009). Morphological and molecular identification of all developmental stages of four whitefly species (Hemiptera: Aleyrodidae) commonly intercepted in quarantine. *Zootaxa*. 1-29. DOI:10.5281/zenodo.188030 ; 10.15468/oqy9m1
Malumphy, C. and Badmin, J.S. (2012). Scale insects and whiteflies (Hemiptera: Coccoidea and Aleyrodoidea) of Watsonian Kent; with a discussion on the impact of naturalised non-native species. *Bri. J. Entom. Nat. His*. **25**: 15-49.
Mangrio, W.M., Sahito, H.A., Bhugro, M., Kousar, T., Shah, Z.H. and Jatoi, F.A. (2020). Incidence and distribution of lemon Butterfly (*Papilio demoleus* L.) on five alternate Citrus hosts at Sahati region, Sindh-Pakistan. *Pure App. Bio*. **9**(4): 2637-2647. DOI:10.19045/bspab.2020.90280
Martinez-Minaya, J., Conesa, D., Lopez-Quilez, A. and Vicent, A. (2015). Climatic distribution of citrus black spot caused by *Phyllosticta citricarpa*. A historical analysis of the disease spread in South Africa. *European Journal of Plant Pathology*. **143**(1): 69-83.
Martini, X., Paret, M., Bodrey, R., Lovestrand, E. and McConnell, J. (2018). Distribution of Asian citrus psyllid in the Florida panhandle. *Proc. Florida State Hortil. Soc*. pp: 85-87. https://journals.flvc.org/fshs/article/view/114723/110050
Massonie G, Garnier M, Bove J M, 1976. Transmission of Indian citrus decline by *Trioza erytreae* (Del Guercio), the vector of South African greening. In: Proceedings of the Seventh Conference of the International Organization of Citrus Virologists. [Proceedings of the Seventh Conference of the International Organization of Citrus Virologists.], [ed. by Calavan E C]. Riverside, USA: Univ. California. 18-20.
Matsumoto, K. (2002). *Papilio demoleus* (Papilionidae) in Borneo and Bali. *J. Lep. Soc*. **56**(2): 108-111.
McDonnell, R.J., Robinson, D.G., Barr, N., Ley, I.T., Ley, P. and Paine, T.D. (2014). First report of the invasive slug *Boettgerilla pallens* Simroth, 1912 (Boettgerillidae) in the United States. *American Malacological Bulletin*. **32**(2): 209-210.
Mendes, M.A.S., Dianese, J.C. and Urben, A. (2019). Fungos em Plants no Brasil. 2ª Edição ampliada e revisada. – Brasília, DF: Escola Nacional de Gestão Agropecuária, 970 pages.
Méndez-Lozano, J., Magallanes-Tapia, M.A., Romero-Romero, J.L., Camacho-Beltrán, E., Orduño-Vega, W.L., Leyva-López, N.E., Santos-Cervantes, M.E. and Félix-Gastélum, R. (2012). Tomato infectious chlorosis virus associated with tomato diseases in Baja California, Mexico. *Plant Disease*. **96**(8): 1229.
Mirab-Balou, M., Tong, X.L. and Chen, X.X. (2014). Thrips species diversity in urban green spaces of Hangzhou (Zhejiang Province), China. *J. Entomol. Acarol. Res*. **46**(3): 85-89. DOI:10.4081/jear.2014.1828
Mo, J., Zhao, G., Li, Q., Soalngi, G.S., Tang, L., Huang, S., Guo, T. and Hsiang, T. (2018). Identification and characterization of Colletotrichum species associated with mango anthracnose in Guangxi, China. *Plant Dis*. **102**: 1283-1289.

Mound, L.A. and Tree, D.J. (2020). *Thysanoptera Australiensis*– Thrips of Australia. Lucidcentral.org, Identic Pty Ltd, Queensland, Australia. https://keys.lucidcentral.org/keys/v3/thrips_australia/keys/Thripinae_Australia/key/austhripinae/Media/Html/Entities/scirtothrips_aurantii.htm

Mwaura, P., Niere, B. and Vidal, S. (2015). Resistance and tolerance of potato varieties to potato rot nematode (*Ditylenchus destructor*) and stem nematode (*Ditylenchus dipsaci*). *Annals of Applied Biology*. **166**(2): 257-270. DOI:10.1111/aab.12180

Nada, M.S.E, Ebrahim, A.M.E. and El-Hawagry, M.S.A. (2022). First record of the genus Acletoxenus (Diptera: Drosophilidae) and its predaceous species *A. formosus* (Leow, 1864) in Egypt, with some field observations and biological remarks. *Egyptian Journal of Biological Pest Control*. **32**(68). DOI:10.1186/s41938-022-00567-x

Nagaoka-Nakazono, E., Uechi, N., Katoh, H., Fujikawa, T., Miyata, S., Furukawa, T., Asakawa, T., Sasaki, M., Kuwahara, R., Kim, O.K., Shinohara, H. and Iwanami, T. (2020). Limited occurrence of tristeza in yuzu and possible tristeza-free cultivation in northernmost commercial yuzu-producing areas of Japan. *Japan Agricultural Research Quarterly*. **54**(4): 307-316.

Nannini, M., Foddi, F., Murgia, G., Pisci, R., Sanna, F., Testa, M. and Accotto, G.P. (2011). A survey of TYLCD epidemics in Sardinia (Italy) - estimating the environmental inoculum and correlating it with whitefly population trends. *Acta Horticulturae*. pp: 181-184.

Nasruddin, A. and Mound, L.A. (2016). First record of *Trialeurodes vaporariorum* Westwood (Hemiptera: Aleyrodidae) severely damaging field grown potato crops in South Sulawesi, Indonesia. *Journal of Plant Protection Research*. **56**(2): 199-202.,

Nava, D.E., Torres, M.L.G., Rodrigues, M.D.L., Bento, J.M.S. and Parra, J.R.P. (2007). Biology of *Diaphorina citri* (Hem., Psyllidae) on different hosts and at different temperatures. *J. App. Entom*. **131**(9/10): 709-715. DOI:10.1111/j.1439-0418.2007.01230.x

NHM. (1891). Specimen record from the collection in the Natural History Museum (London, UK)., London, UK: Natural History Museum (London).

NPPO. (2018). Surveys conducted in 2013 in Corse showed that European strains of CTV are established in Haute-Corse and can no longer be eradicated. More recent surveys confirmed that the situation is stable and that only mild strains occur without causing economic impact.

NPPO of the Netherlands. (2013). Pest status of harmful organisms in the Netherlands., Wageningen, Netherlands:

Nugnes, F., Russo, E., Viggiani, G. and Bernardo, U. (2018). First record of an invasive fruit fly belonging to *Bactrocera dorsalis* complex (Diptera: Tephritidae) in Europe. *Insects*. **9**(4): 182. https://www.mdpi.com/2075-4450/9/4/182

Palomares-Rius, J.E., Cantalapiedra-Navarrete, C., Archidona-Yuste, A. and Castillo, P. (2016). *Hoplotylus feminas'*Jacob, 1960 (Nematoda: Pratylenchidae) from Spain with molecular phylogenetic relationships inferred by D2-D3 expansion fragments of 285 and the partial 185 rRNA sequences. *Nematology*. **18**(5): 559-569.

Paola, R., Mariana, M., Raquel, C. and Mercedes, P. (2013). Characterization of *Xanthomonas citri* sbsp strains. citrus, the causative agent of citrus cancer. (Caracterización de cepas de *Xanthomonas citri* sbsp. *citri*, agente causal del cancro cítrico). *Agrociencia*. **17**(2): 64-74.

Patial, A. and Mehta, P.K. (2008). Pest complex of brinjal and their succession under mid hills of Himachal Pradesh. *Journal of Insect Science (Ludhiana)*. **21**(1): 67-71.

Pattarmanon, T. (1987). Life cycle and growth of the escargot (*Helix aspersa* Müller) reared in Thailand. *Journal of the National Research Council, Thailand*. **19**(2): 47-71.

Paul, I., van Jaarsveld, A.S., Korsten, L. and Hattingh, V. (2005). The potential global geographical distribution of Citrus Black Spot caused by *Guignardia citricarpa* (Kiely): likelihood of disease establishment in the European Union. *Crop Protection.* **24**(2): 297-308.

Pesquero, M.A. and Penteado-Dias, A.M. (2004). New records of *Orasema xanthopus* (Hymenoptera: Eucharitidae) and *Solenopsis daguerrei* (Hymenoptera: Formicidae) from Brazil. *Brazilian Journal of Biology*. **64** (3b): 737.

Porta, N.C. (1992). Population dynamics of *Trissolcus basalis* (Wollaston) 1858 (Hymenoptera: Scelionidae). I. Life statistics. (Dinámica poblacional de Trissolcus basalis (Wollaston) 1858 (Hymenoptera: Scelionidae). I. *Estadisticos vitales*.). *Revista de la Sociedad Entomológica Argentina*. **50**(1-4): 267-275.

Portillo, M.M. (1988). Bioecological inventory of aphids on citrus plants and population densities of the principal species. (Inventario bioecologico de los afidos que viven en plantas citricas, y curvas poblacionales de las principales especies.). *Revista de la Sociedad Entomológica Argentina*. **47**(1-4): 79-93.

Price, W.C. (1971). United Nations Development, Programme, FAO No. TA 3037, 30 pp.

Prins, D.J. and Prins, D.W. (2014). Afromoths, online database of Afrotropical moth species (Lepidoptera). World Wide Web electronic publication (www.afromoths.net) (12 Aug.2014).

Quimio, G.M. and Calilung, V.J. (1993). Survey of flying viruliferous aphid species and population build-up of *Aphis glycines* Matsumura in soybean fields. *Philippine Entomologist*. **9**(1): 52-100.

Rahman, S.A.S.A., Zain, S.N.M., Mat, M.Z.B., Sidam, A.K., Othman, R.Y. and Mohamed, Z. (2014). Population distribution of plant-parasitic nematodes of bananas in Peninsular Malaysia. *Sains Malaysiana*. **43**(2): 175-183. http://www.ukm.my/jsm/pdf_files/SM-PDF-43-2-2014/03%20S.A.%20Sayed%20Abdul%20Rahman.pdf

Rajendram, G.F. and Devarajah, F.R. (1990). Survey of some rice insect pests and their predators in three districts of Sri Lanka. *Journal of the National Science Council of Sri Lanka*. **18**(1): 79-92.

Read, D.A. and Pietersen, G. (2017). Diversity of Citrus tristeza virus populations in commercial grapefruit orchards in Southern Africa, determined using Illumina Mi Seq technology. *European Journal of Plant Pathology.* **148**(2): 379-391.

Read, D.A., Palacios, M.F., Kleynhans, J., Figueroa, J., Foguet, L., Stein, B. and Pietersen. (2018). Survey of Citrus tristeza virus (CTV) diversity in pigmented in Citrus x paradisi (Macfad.) Burm f. (grapefruit) trees in north-western Argentina. *European Journal of Plant Pathology*. **151**(2), 329-340.

Reuther, W., Calavan, E.C. and Carman, G.E. (1978). The citrus industry, Vol. IV. University of Callifornia, Davis, USA.

Riaz, M.F., Raza, A.B.M., Majeed, M.Z. and Talha, N. (2022). Diversity and species distribution of aphids (Hemiptera: Aphididae) in district Sargodha (Punjab, Pakistan). *Sarhad Journal of Agriculture*. **38**(2): 540-547. DOI:10.17582/journal.sja/2022/38.2.540.547

Ricalde, M.P., Nava, D.E., Loeck, A.E., Coutinho, E.F., Bisognin, A. and Garcia, F.R.M. (2015). Insects related to olive culture in Rio Grande do Sul State, Brazil. *Ciência Rural*. **45**(12): 2125-2130.

Rizk, G.A., Moftah, E.A., Karaman, G.A. and Abdel-Naby, A.A. (1990). Effectiveness of different planting dates on the population density of some sucking pests attacking soyabean plants in Minia Region. *Assiut Journal of Agricultural Sciences*. **21**(3): 141-151.

Safdar, A., Javed, N., Khan, S.A., Khan, H.U., Rehman, A. and Haq, I. (2010). Survey and investigation of different citrus growing areas for citrus sudden death syndrome. *Pakistan Journal of Phytopathology*. **22**(2): 71-78.

Salas-Araiza, M. D., Mackay, W.P. and Salazar-Solís, E. (2012). First report of the red imported fire ant *Solenopsis invicta* Buren (Hymenoptera: Formicidae) from Central México. *Entomological News*. **122**(1): 93-94.

Savitha, A.S., Ajithkumar, K., Palaiah, P. and Ramesh, G. (2016). Integrated management of citrus canker caused by *Xanthomonas axonopodis* pv. *citri* (Hasse) in acid lime (*Citrus auruntifolia*). *Pest Manag. Hortil. Ecos*. **22**(2): 189-192.

Seebens, H., Blackburn, T.M., Dyer, E.E., Genovesi, P., Hulme, P.E., Jeschke, J.M., Pagad, S., Pyšek, P., Winter, M., Arianoutsou, M., Bacher, S., Blasius, B., Brundu, G., Capinha, C., Celesti-Grapow, L., Dawson, W., Dullinger, S., Fuentes, N., Jäger, H., Kartesz, J., Kenis, M., Kreft, H., Kühn, I., Lenzner, B., Liebhold, A. and Mosena, A. (2017). No saturation in the accumulation of alien species worldwide. *Nat. Comm.* **8**(2): 14435. http://www.nature.com/articles/ncomms14435

Sharma, G., Kumar, N., Weir, B.S., Hyde, K.D. and Shenoy, B.D. (2013). The ApMat marker can resolve Colletotrichum species: A case study with Mangifera indica. *Fungal Divers*. **61**: 117-138.

Shivas, R.G., Tan, Y.P., Edwards, J., Dinh, Q., Maxwell, A., Andjic, V., Liberato, J.R., Anderson, C., Beasley, D.R., Bransgrove, K., Coates, L.M., Cowan, K., Daniel, R., Dean, J.R., Lomavatu, M.F., Mercado-Escueta, D., Mitchell, R.W., Thangavel, R., Tran-Nguyen, L.T.T. and Weir, B.S. (2016). *Colletotrichum* species in Australia. *Aus. Plant Pathol***. 45**: 447-464.

Singh, S., Mulani, E., Bhattacharyya, U., Palchoudhury, S., Mazumder, N., Saikia, S., Nath, P.D., Pun, K.B. and Biswas, K.K. (2022). Decline inducing Citrus tristeza virus-VT/Kpg3 genotype occurs predominantly in citrus orchards of Northeast India. *I Indian Phytopathology*. **75**: 853–861.

Singh, S., Reddy, P.V.R. and Deka, S. (2020). Sucking Pests of Citrus. **In:** Omkar (ed.) Sucking Pests of Crops Springer, 515 pp.

Sirisena, U.G.A.I., Watson, G.W., Hemachandra, K.S. and Wijayagunasekara, H.N.P. (2013). Mealybugs (Hemiptera: Pseudococcidae) species on economically important fruit crops in Sri Lanka. *Trop. Agril. Res*. **25**(1): 69-82. http://www.pgia.ac.lk/sites/default/files/congress/journel/v25/Journal-No%201/Papers/7%20U.G.A.I.%20Sirisena_final_final_edited.pdf

Smith, C. (1990). Beautiful butterflies: a colourful introduction to Nepal's most beautiful insects., Bangkok, Thailand: Craftsman Press.

Sposito, M.B., Amorim, L., Bassanezi, R.B., Yamamoto, P.T., Felippe, M.R. and Czermainski, A.B.C. (2011). *Crop Protection.* **30**(12): 1546-1552.

Srinivasnaik, S., Suganthy, M., Kumar, S.M. and Jegadeeswari, V. (2016). Survey, documentation and identification of entomofauna of cocoa, *Theobroma cacao* L. in major cocoa growing regions of South India. *J. App. Nat. Sci*. **8**(3): 1444-1451. http://jans.ansfoundation.org/previous-issues/volume-8-year-2016--issue-3#TOC-Physiological-and-biochemical-response-to-higher-temperature-stress-in-hot-pepper-Capsicum-annuum-L.-

Srivastava, R.C. (1982). *Ind. J. Mycology Plant Path*. **12**(2): 244-246.

Stocks, S. (2012). Citrus black spot detected in Polk county, Florida. NPDP First Detector Network News. **7**(10). p: 4.

Stravato, V.M. (1993). Informatore Agrario. **49**(47): 36-37.
Straw, N.A., Fielding, N.J., Tilbury, C., Williams, D.T. and Inward, D. (2015). Host plant selection and resource utilisation by Asian longhorn beetle *Anoplophora glabripennis* (Coleoptera: Cerambycidae) in southern England. Forestry Inter. J. For. Res. **88**: 84–95.
Subbotin, S.A., Madani, M., Krall, E., Sturhan, D. and Moens, M. (2005). Molecular diagnostics, taxonomy, and phylogeny of the stem nematode *Ditylenchus dipsaci* species complex based on the sequences of the internal transcribed spacer-rDNA. *Phytopathology*. **95**(11): 1308-1315. DOI:10.1094/PHYTO-95-1308
Sundararaju, P. (2006). Community structure of plant parasitic nematodes in banana plantations of Andhra Pradesh, India. *Indian Journal of Nematology*. **36**(2): 226-229.
Swirski, E., Izhar, Y. and Wysoki, M. (1991). Appearance of *Aphis gossypii* Glover and *Aphis spiraecola* Patch (Rhynchota: Aphidoidea) on avocado, persimmon and macadamia. *Alon Hanotea*. **45**(5): 416.
Szita, É., Fetykó, K.G., Benedicty, Z.K., Kozár, F., Partsinevelos, G., Milonas. P. and Kaydan, M.B. (2017). Data on the scale insect (Hemiptera: Coccomorpha) fauna of Greece, with description of two new species. *Zootaxa*. **4329**(5): 463-476. http://www.mapress.com/j/zt/article/view/zootaxa.4329.5.4 DOI:10.11646/zootaxa.4329.5.4
Talbot, G. (1939). The Fauna of British India, including Ceylon and Burma. Butterflies, Vol. 1. [ed. by Sewell R B S]. London, UK: Taylor & Francis. xxix + 600 pp.
Taylor, J.W. (1914). Monograph of the Land and Freshwater Mollusca of the British Isles, Zonitidae, Endodontidae, Helicidae. Leeds, UK: Taylor Brothers.
Tayyib, M., Suhail, A., Arif, M.J. and Khan, M.A. (2014). Whiteflies (Aleyrodidae: Homoptera) of Punjab Pakistan. *Pak. Entom.* **36**(1): 31-34.
Thakre, B. and Soni, U. (2017). Incidence of suitable insecticides for the control of leaf miner (Phyllcnistis citrella) on Nagpur mandarin at Chhindwara district of Madhya Pradesh, India. *Ann. Plant Sci.* **6**(7): 1653-1655. DOI:10.21746/aps.2017.07.002
Toda, S., Hirose, T., Kakiuchi, K., Kodama, H., Kijima, K. and Mochizuki, M. (2014). Occurrence of a novel strain of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in Japan and development of its molecular diagnostics. *App. Entom. Zoo*. **49**(2): 231-239. DOI:10.1007/s13355-013-0241-z
Tong, X. (1993). Butterfly fauna of Zhejiang., Hangzhou, China: Zhejiang Science and Technology Publishers.
Uddin, M.S., Rahman, M.M., Alam, M.Z., Awal, A. and Mazed, M.A. (2013). Insect pests of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) in major growing areas of Bangladesh. *The Agriculturists*. **11**(2): 66-73.
UK, CAB International. (1970). *Nezara viridula*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 27 (Revised). DOI:10.1079/DMPP/20056600027
UK, CAB International, 1969. *Aphis spiraecola*. [Distribution map]. In: Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 256. DOI:10.1079/DMPP/20056600256
UK, CAB International, 1969. *Coccus hesperidum*. [Distribution map]. In: Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 256. DOI:10.1079/DMPP/20056600256
Ullah, F., Gul, R. and Badshah, H. (2005). Efficacy of Five Different Insecticides Against Citrus Leaf Miner *Phyllocnistis citrella* Stainton (Lepidoptera; Gracillariidae). *J. Entom*. **2**(1): 25-28. DOI:10.3923/je.2005.25.28
USDA. (1982). Pests not known to occur in the United States or of limited distribution. No. 28. Citrus black spot, *Guignardia citricarpa*. USDA APHIS-PPQ, Beltsville, USA.
Van Nieuwenhove, G.A., Oviedo, A.V.F., Dalto, Y.M., Perez, J., Horak, C.I., Gastaminza, G.A., Willink, E. and Hallman, G.J. (2016). Gamma radiation phytosanitary treatment against *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). *Florida Entomologist*. **99**(2): 130-133.
Vernière, C., Vital, K., Boyer, C., Pruvost, O. and Carter, B.A. (2013). First report of sequence type 1, pathotype A *Xanthomonas citri* pv. *citri* from lime and lemon fruit originating from Bangladesh. *Plant Dis*. **97**(6): 836.
Vidya, M., Rajanna, K.M., Reddy, M.N.N. and Babu, V. (2015). Insect pest complex of cashew and influence of biotic and abiotic factors on the incidence of cashew pests in maidan parts of Karnataka. *Acta Horticulturae*. 409-414.
Villiers, E.A. and Milne, D.L. (1975) Citrus and Sub-Tropical Fruit Journal No. 503, 5-8.
Vokou, D., Tziolas, M. and Bailey, S.E.R. (1998). Essential-oil-mediated interactions between oregano plants and *Helicidae grazers*. *Journal of Chemical Ecology*. **24**(7): 1187-1202.
Wang, K.H. and Hooks, C.R.R. (2009). Plant-parasitic nematodes and their associated natural enemies within banana (*Musa* spp.) plantings in Hawaii. *Nematropica*. **39**(1): 57-73. http://fulltext10.fcla.edu/DLData/SN/SN00995444/0039_001/57-74.pdf
Waterhouse, D.F. (1993). The major arthropod pests and weeds of agriculture in Southeast Asia. Canberra, Australia: ACIAR. v + 141 pp.
Weht, S., Brandán, E.Z. and Ploper, J. (1997). *Fitopatología*. **32**(1): 81-84.
Weir, B.S., Johnston, P.R. and Damm, U. (2012). The *Colletotrichum gloeosporioides* species complex. *Stud. Mycol*. **73**: 115-180.

Whiteside, J.O. (1980). Proceedings of the International Society of Citriculture 1978, pp. 200-204. Griffith, NSW, Australia.
Wijs. J.J. (1974). The correlation between the transmission of passionfruit ringspot virus and populations of flying aphids. *Netherlands Journal of Plant Pathology*. **80**(4): 133-144.
Wikipedia. (2021). https://en.wikipedia.org/wiki/Aonidiella_citrina#cite_note-ScaleNet-1
Wikipedia. (2021). https://en.wikipedia.org/wiki/Psorosticha_zizyphi
Wikipedia. (2023). https://en.wikipedia.org/wiki/ Rhizoctonia_solani
Williams, K., Ali, A. and Zandy, C. (2021). Evaluation of funnel cone traps with different baits for capturing nuisance arthropods in college station, Texas. INSTARS: A Journal of Undergraduate Research. 6 (1), https://journals.tdl.org/instars/index.php/instars/article/view/367
Xu, F., Yang, G.Q., Wang, J.M., Song, Y.L., Liu, L.L. and Zhang, J.J. (2016). Composition and variation in aggressiveness of Fusarium populations causing wheat head blight in Henan Province. *Acta Phytopathol*. *Sin*. **46**: 294-303.
Yang, W., FengMao, C., LiChao, W. and Min, L. (2021). Investigation of beetle species that carry the pine wood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle, in China. *J. Forestry Res*. **32**(4): 1745-1751. DOI:10.1007/s11676-020-01146-2
Ye, G., Hong, N., Zou, L.F., Zou, H.S., Zakria, M., Wang, G.P. and Chen, G.Y. (2013). Based genetic diversity of Chinese isolates of the citrus canker pathogen *Xanthomonas citri* subsp. *citr*i. *Plant Dis*. pp: 1187-1194.
Yıldırım, M.Z. and Kebapçı, Ü. (2004). Slugs (Gastropoda: Pulmonata) of the Lakes Region (Göller Bölgesi) in Turkey. *Turkish Journal of Zoology*. **28**(2): 155-160.
Yıldırım, M.Z., Kebapçı, Ü. and Gümüş, B.A. (2004). Edible snails (terrestrial) of Turkey. *Turkish Journal of Zoology*. **28**(4): 329-335.
Yıldız, Y. (2017). *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae) reported at new location in Turkey. *App. Ecol. Environ. Res*. **15**(4): 111-116. DOI:10.15666/aeer/1504_111116
Young, C. (1996). Metal chelates as stomach poison molluscicides for introduced pests, *Helix aspera*, *Theba pisana*, *Cernuella virgata* and *Deroceras reticulatum* in Australia. **In:** Slug & snail pests in agriculture. Proceedings of a Symposium, University of Kent, Canterbury, UK, 24-26 September 1996. [Slug & snail pests in agriculture. Proceedings of a Symposium, University of Kent, Canterbury, UK, 24-26 September 1996.], Farnham, UK: British Crop Protection Council. 237-243.
Yukawa, J., Kiritani, K., Gyoutoku, N., Uechi, N., Yamaguchi, D. and Kamitani, S. (2007). Distribution range shift of two allied species, *Nezara viridula* and *N. antennata* (Hemiptera: Pentatomidae), in Japan, possibly due to global warming. *Applied Entomology and Zoology*. **42**(2): 205-215.
Zeng, Y., Ye, W., Tredway, L., Martin, S. and Martin, M. (2012). Taxonomy and morphology of plant-parasitic nematodes associated with turfgrasses in North and South Carolina, USA. *Zootaxa*. **3452**: 1-46, DOI: 10.5281/zenodo.210165
Zhang, B.C. and Huang, Y.C. (1990). A list of important plant diseases in China. *Rev. Plant Path.* **69**(3): 97-118.
Zhang, Y.M., Li, D.X., Chen, G.Q. and Zhang, G.H. (1997). Studies on the population dynamics of spirea aphid in apple orchards. *Acta Agriculturae Universitatis Henanensis*. **31**(2): 197-200.
Zidan, Z.H., El-Deeb, H.I., Wilson, M. and Asran, F.D.A. (1997). Molluscicidal activity of certain weed extracts and fertilizers against the brown garden snail, *Helix aspersa*. *Annals of Agricultural Science (Cairo)*. **42**(2): 687-695.

7.3 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 citrus 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 citrus identified for Bangladesh has been analyzed details as follows:

7.3.A. Arthropod: Insect and mites pests

7.3.A.1.	Citrus longhorn beetle, Anoplophora chinensis

7.3.A.1.1. Hazard identification

Preferred Common names: Citrus longhorn beetle
Scientific name: *Anoplophora chinensis*
Synonyms: *Anoplophora chinensis* Breuning 1944
Anoplophora macularia (Breuning)
Anoplophora malasiaca (Thomson)
Anoplophora malasiaca malasiaca Samuelson 1965
Anoplophora perroudi Pic 1953
Anoplophora sepulchralis Breuning 1944
Callophora afflicta Thomson 1865
Callophora luctuosa Thomson 1865
Cerambyx chinensis Forster 1771
Lamia punctator Fabricius 1777
Melanauster chinensis (Forster)
Melanauster chinensis Matsumura 1908

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Cerambycidae
Genus: Anoplophora
Species: *Anoplophora chinensis*

EPPO Code: ANOLCN. This pest has been included in EPPO A2 list: No. 187

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

7.3.A.1.2. Biology

The life cycle of *Anoplophora chinensis* typically lasts one year, although on rare occasions it might last two years (Haack *et al.*, 2010). From May to October, adults can be seen, with their peak emergence often occurring between May and July. However, adults can be watched until December if the environmental conditions are ideal. Before locating a mate and copulating, newly emerging adults spend 10 to 15 days eating on leaves, twigs, petioles, and bark (Maspero *et al.*, 2007; Haack *et al.*, 2010; EPPO, 2013; Wang, 2017).

Following copulation, the females lay their eggs one at a time along the root collar, on exposed roots, and beneath the lower trunk's bark. They produce "T-shaped" incisions on the bark of the host plant during oviposition with their mandibles in order to introduce the ovipositor and lay the eggs. The average female lays 70 eggs during her lifetime (Haack *et al.*, 2010; Wang, 2017). Long feeding tunnels are dug by larvae in exposed roots and trunks, initially in the cambial region, and later in the heartwood and sapwood of the lowest parts of the woody tissues (Haack *et al.,* 2010). Depending on the egg-laying cycle, the majority of *A. chinensis* individuals overwinter as larvae at varying stages of development. The mature wintering larvae typically pupate in the spring (Maspero *et al.,* 2007; Haack *et al.,* 2010).

7.3.A.1.3. Hosts

A. chinensis is a polyphagous xylophile, which means that it attacks a variety of living tree species. Attacks can occur on more than 100 species in at least 30 families (Kojima and Nakamura, 1986; Lingafelter and Hoebeke, 2002; Haack *et al.*, 2010; EPPO 2020), particularly in orchards where it is regarded as a serious pest of citrus (Kojima and Nakamura, 1986; Lingafelter and Hoebeke, 2002; Haack *et al.*, 2010; EPPO 2020 (Yamaguchi and Ohtake, 1986; Mitomi *et al.,* 1990). Malus, Pyrus, Alnus, and Platanus also sustain significant harm (Research Group of Alder-tree-pests, 1972; Aono and Murakoshi, 1980; Ito *et al.,* 1980; Yamaguchi and Ohtake, 1986; Ohga *et al.,* 1995). Additionally, hosts are found in the genera Pinus and Cryptomeria's conifer species (Lingafelter and Hoebeke, 2002). The main hosts of interest are fruit trees: *Citrus, Citrus aurantiifolia* (lime), *Citrus aurantium* (sour orange), *Citrus deliciosa* (mediterranean mandarin), *Citrus limonia* (mandarin lime), *Citrus maxima* (pummelo), ***Citrus medica* (Zara/Colombo),** *Citrus natsudaidai* (natsudaidai), *Citrus nobilis* (tangor), *Citrus reticulata* (mandarin), *Citrus sinensis* (sweet orange), *Citrus unshiu* (satsuma), *Malus domestica* (apple*)*.

7.3.A.1.4. Distribution

Asia is the native home of *Anoplophora chinensis*. This species has been reported in Vietnam, Taiwan, the Philippines, Myanmar, Malaysia, and Indonesia in addition to China, Japan, and the Korean peninsula, where it is most common (Lingafelter & Hoebeke, 2002). *A. chinensis* was discovered in the USA in 1999 and 2001, and it was deemed extinct in 2005. *A. chinensis* was previously only known to exist in Hawaii in the USA (Gyeltshen & Hodges, 2005). This species was initially identified in the EPPO region in the Netherlands in 1980 (Haack *et al.*, 2010), and from 2000 to the present, there have been a number of outbreaks. *A. chinensis* was discovered in Italy for the first time in the Lombardy Region in 2000. It was later discovered in the Lazio Region (2008) and the Tuscany Region (2014 and 2017). *A. chinensis* has been eradicated from some outbreaks while containment measures are in place in others (EPPO, 2019). *A. chinensis* has been recorded and then eliminated in the Netherlands (2003, 2010, 2017, and 2019), Germany (2008, 2017), Denmark (2011, 2015), and Switzerland (2014, 2019). (EFSA, 2019; EPPO, 2020a). Additionally, where eradication measures are in place, this beetle has been observed in France (2003 and 2008), Croatia (2007), and Turkey (2015). (EPPO, 2020a).

EPPO Region: Croatia, France (mainland), Italy (mainland), Türkiye

Asia: China (APPPC 1987), Indonesia (CABI and EPPO 2008), Japan (Gressitt 1951), Malaysia (Lingafelter and Hoebeke 2002), Myanmar (Gressitt 1951), North Korea (Lee 1982), Philippines (CABI and EPPO 2008), South Korea (Gressitt 1951), Taiwan (Gressitt 1951) and Turkey (IPPC 2016).

7.3.A.1.5. Hazard identification conclusion

Considering the facts that *A. chinensis* -

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- Eastern Asia is the natural habitat of the black and white citrus longhorn beetle. It is a polyphagous species that consumes both broad-leaved and coniferous plants from at least 30

different plant groups. Citrus trees, apple, pear, and other fruit and nut trees, as well as forestry plantations and woody ornamentals, are all significantly harmed. Females harm the surface of the trunk and exposed roots as they cut slits for oviposition, while adults nibble on the sensitive bark of new twigs. The main harm is done by larvae tunneling in the lower stem and roots of hosts. Growing plants for international trade, particularly plants that have been intentionally shrunk, can spread *A. chinensis* (bonsai and penjing). *A. chinensis* is currently established in Italy, where measures are being taken to prevent future spread.

- *A. chinensis* is highly polyphagous. The availability of host plants is not a limiting factor for its establishment and spread in the EPPO countries as well as climatic conditions, except in the most northern areas. The findings and outbreaks that have occurred in Europe from 2000 to date demonstrate the beetle's adaptation to different climates and environments; due to this, the risk of establishment, spread and damage is considered very high (Van Der Gaag *et al.,* 2008).
- Detection of *A. chinensis* infestations is very problematic because often the infested plants are without signs and infestations may remain undetected for many years and allow the growth of a large population. In this case, eradication and control activities become long and costly.
- It is a serious pest of China from where a large number of citrus fruits are imported to Bangladesh.
- It can establish in Bangladesh through imports of the citrus and apple. It has capability to cause direct and indirect economic and ecological damage to many valuable fruits.
- *A. chinensis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.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 species occurs primarily in China, Japan and the Korean peninsula and it is also reported in Vietnam, Taiwan, the Philippines, Myanmar, Malaysia and Indonesia (Gressitt, 1951; Lingafelter & Hoebeke, 2002). In 1999 and 2001, it was found in the USA and was considered eradicated in 2005. In the EPPO region, this species was first reported in 1980 in the Netherlands (Haack *et al.,* 2010) and several outbreaks occurred from 2000 to the present day. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Adults live for about 30 days in China and can be found from April to August, but are most abundant from May to July. In Japan adults live about 70 days between June and August. Adults are not active at temperatures below approximately 10°C (Adachi, 1994) and when active during the daytime they feed on leaves, petioles and the young bark of host trees. This period of time taken for shipment through transportation pathways from the above-mentioned exporting countries to Bangladesh is sufficient enough	**Yes and Moderate**

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.

- *A. chinensis* larvae bore into the wood of trees where they feed and develop, a behavior that can provide protection during transport if infested wood is moved. Eggs are laid in tree bark and can be overlooked during inspections, potentially surviving transport if proper phytosanitary measures are not in place.
- Besides, the beetle spends most of its life cycle inside the tree, which provides a protective environment that could allow it to survive transport in infested wood.
- While the beetle prefers warmer climates, it can survive in a variety of temperatures and humidity levels, increasing its chances of surviving transport.
- Adult beetles can live up to a year, which enhances their chances of survival during transport.

c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,

- *A. chinensis* can move via international trade. It is most likely to be moved as eggs, larvae or pupae in woody growing plants for planting or finished miniature plants (bonsai or penjing). Individuals (larvae and adults) have entered Europe and the USA on bonsai plants of *Acer buergeranum, A. palmatum, Celastrus, Cydonia sinensis, Malus micromalus* and *Sagereti*a from China and Japan (Anon., 1986, 1988; EPPO, 2001, 2002a). But it is not transmitted with citrus fruits. From china, we only imported citrus fruit. So, there is no risk for this pest to enter into 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

- *A. chinensis* is a polyphagous xylophile, which means that it attacks a variety of living tree species. Attacks can occur on more than 100 species in at least 30 families. The main hosts of interest are fruit trees: *Citrus*, *Citrus aurantiifolia* (lime), *Citrus aurantium* (sour orange), *Citrus deliciosa* (mediterranean mandarin), *Citrus limonia* (mandarin lime), *Citrus maxima* (pummelo), *Citrus medica* (Zara/Colombo), *Citrus reticulata* (mandarin) and *Citrus sinensis* (sweet orange).
- *Anoplophora chinensis*, or the citrus long-horned beetle, has a broad tolerance for climatic conditions, but it typically thrives in areas with hot, humid summers and cold winters, which are typical in many parts of East Asia. The beetle's optimal growth occurs between 20°C and 30°C, and it tends to favor humid environments (EPPO 2021).
- Bangladesh has a tropical monsoon climate characterized by high temperatures, high humidity, and relatively high rainfall, particularly during the monsoon season. Average temperatures in Bangladesh range from about 11°C in January to over 30°C in April and May. It is generally very humid in Bangladesh, with relative humidity ranging from about 80% in the dry season to nearly 100% during the monsoon season.

• Given these conditions, it seems possible that *A. chinensis* could survive in Bangladesh if it were introduced there. The temperatures and humidity levels in Bangladesh are within the range that *A. chinensis* can tolerate, and the beetle would likely be able to find suitable host trees in Bangladesh. • 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

7.3.A.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. • *A. chinensis* is a polyphagous xylophile, which means that it attacks a variety of living tree species. Attacks can occur on more than 100 species in at least 30 families. The main hosts of interest are fruit trees: *Citrus*, *Citrus aurantiifolia* (lime), *Citrus aurantium* (sour orange), *Citrus deliciosa* (mediterranean mandarin), *Citrus limonia* (mandarin lime), *Citrus maxima* (pummelo), *Citrus medica* (Zara/Colombo), *Citrus reticulata* (mandarin) and *Citrus sinensis* (sweet orange). Therefore, it is a high risk, if plant and plant material are imported from China there is possibility to establish the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits for Bangladesh. **b. Economic Impact and Yield Loss** • The most important damage is caused by larvae. These bore into the wood of living trees reducing the quality and value of the wood and causing the death of trees (Eschen *et al.,* 2015). • As previously reported, in Asia *A. chinensis* is considered a serious pest of citrus orchards where it causes important economic losses (Gressitt, 1942; Lieu, 1945; Mitomi *et al.,* 1990; Smith *et al.,* 1997). Because of this, citrus plantations near import locations are risk areas that should be considered for surveillance and monitoring, particularly in regions where citrus cultivation is of economic relevance (EFSA, 2019). • In Asia, *A. chinensis* is also an important pest of many stone and pome fruit, and mulberry trees (Li *et al.,*1997). Due to its wide host range, *A. chinensis* could have extremely high economic impacts in countries where it is introduced. • In North America and Europe, *A. chinensis* has been found mostly in urban areas. Often the destruction of infested plants is required to prevent its spread. In the case of private gardens this may involve not only economic costs, but also have a social impact on local inhabitants.	**Yes and High**

c. Environmental Impact • The most direct environmental impact of *A. chinensis* is the damage it causes to trees. Both the larvae and the adult beetles bore into the wood of trees, which can severely weaken the trees and eventually cause them to die. This can impact the structure and health of forests, orchards, and other wooded ecosystems (Haack *et al.*,2010). • While it's not a primary concern with *A. chinensis,* it's worth noting that invasive pests can sometimes facilitate the spread of diseases among trees, which can further amplify their environmental impact.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.A.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

7.3.A.1.9. Risk Management Measures

- Since movement of live plants are the main pathway of movement of *A. chinensis,* it is important that the host plants are only imported from pest-free areas. Alternatively, the plants should be grown under carefully supervised conditions in registered nurseries. Suitable precautions would be to grow the plants for at least two years before dispatch in an insect-proof enclosure, inspecting them several times a year for the presence of *A. chinensis.*
- As a general approach, it has also been recommended that when importing plants for planting (except seeds) and wood commodities of Castanea, Quercus, Betula, Populus, Salix, Fagus, Ulmus and Juglans from countries where *A. chinensis* occurs, precautions should have been taken to avoid any infestations while the consignments are transported through possibly infested areas (EPPO, 2017a,b,c,d,2018, 2020a,b).

7.3.A.1.10. References

APPPC, 1987. Insect pests of economic significance affecting major crops of the countries in Asia and the Pacific region. Technical Document No. 135., Bangkok, Thailand: Regional Office for Asia and the Pacific region (RAPA).

CABI, EPPO, 2008. *Anoplophora chinensis*. [Distribution map]. In: Distribution Maps of Plant Pests, Wallingford, UK: CABI. Map 595. DOI:10.1079/DMPP/20083279223

EPPO Global Database. (n.d.). Anoplophora chinensis (ANOLCN) - Citrus longhorn beetle. Retrieved September 2021, from https://gd.eppo.int/taxon/ANOLCN/distribution.

EPPO, 2020. EPPO Global database. In: EPPO Global database. Paris, France: EPPO.

Gressitt J L, 1951. Longicorn beetles of China. Longicornia. 1-667.

Haack R A, Hérard F, Sun J, & Turgeon JJ (2010) Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: a worldwide perspective. Annual review of entomology, 55, 521-546.

Haack, R. A., Hérard, F., Sun, J. H., Turgeon, J. J., 2010. Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: a worldwide perspective.Annual Review of Entomology, 55521-546.

Ito Y, Kitamura T, Hagiwara Y, 1980. The seasonal occurrence and control of white spotted longicorn of apple trees in Nagano district. Annual Report of The Kanto-Tosan Plant Protection Society, 27:28-34.

Kojima K, Nakamura S, 1986. Food plants of cerambycid beetles (Cerambycidae, Coleoptera) in Japan. Shobara, Japan: Hiba Society of Natural History. 128-133.

Lingafelter S W, Hoebeke E R, 2001. Variation and homology in elytral maculation in the *Anoplophora malasiaca/macularia* species complex (Coleoptera : Cerambycidae) of Japan and Taiwan. Proceedings of the Entomological Society of Washington. 103 (3), 757-769.

Lingafelter SW, Hoebeke ER, 2002. Revision of the genus Anoplophora (Coleoptera: Cerambycidae). Revision of the genus italic~Anoplophora^roman (Coleoptera: Cerambycidae), 236 pp.; many ref.

Maspero M, Cavalieri G, D'Angelo G, Jucker C, Valentini M, Colombo M, Herard F, Lopez J, Ramualde,N, Ciampitti M, Caremi G & Cavagna B (2007) *Anoplophora chinensis* - Eradication programme in Lombardia (Italy).

Research Group of Alder-tree-pests, 1972. Insect pests in the stands of the alder tree, Alnus Inokumai Murai et Kusaka. Bulletin of the Government Forest Experiment Station, 248:69-87.

Van Der Gaag DJ, Ciampitti M, Cavagna B, Maspero M & Herard F (2008) Pest Risk Analysis for Anoplophora chinensis. Plant Protection Service., Wageningen, the Netherlands. https://edepot.wur.nl/117610 [accessed on 26 June 2020].

Wang Q (Ed.) (2017) Cerambycidae of the world: Biology and Pest Management. CRC press.

7.3.A.2.	Citrus weevil, *Diaprepes abbreviates*

7.3.A.2.1. Hazard identification

Preferred Common names: Citrus weevil
Scientific name: *Diaprepes abbreviates*
Synonyms: *Diaprepes spengleri* (Linnaeus)
Exophthalmus abbreviates (Linnaeus)

Taxonomic tree

Domain: Eukaryota
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Family: Curculionidae

Genus: *Diaprepes*
Species: *Diaprepes abbreviatus*

EPPO Code: DPREAB. It is listed as A1 pest at Chile, Jordan, Turkey, APPPC and PPPO in 2019, 2013, 2016, 1988 and 1993, respectively and as quarantine pest at Mexico and China in 2018 and 2021, respectively (EPPO, 2022).

7.3.A.2.2. Biology

The citrus root weevil is about 1 cm long when it is an adult. Its head and legs are black, and its elytra are glossy black with broad bands of small yellowish-orange scales. It can stick to very smooth surfaces because to the adhesive pads on its legs. The larva is a 2.5 cm long, plump, pale grub with a dark head. A female weevil may lay 5,000 eggs, which she will scatter on leaves in clusters. The larvae hatch from the eggs after a week, drop to the ground, and then tunnel down to the host plant's roots. While the adult weevil does consume plant foliage, they feed for several months on the roots of the plant (Jetter and Godfrey, 2009).

7.3.A.2.3. Hosts

A total of 270 different plant species, including citrus, sugarcane, avocado, cassava, vegetables, potatoes, strawberries, woody field-grown ornamentals, sweet potatoes, papaya, guava, mahogany, containerized ornamentals, and non-cultivated wild plants, are attacked by *D. abbreviatus* (Thomas *et al.,* 2019).

7.3.A.2.4. Distribution

Florida, Puerto Rico, Jamaica, the Dominican Republic, and the lower Antilles are all home to D. abbreviatus. It was thought to solely be an issue in central Florida at the time it was introduced to Florida. The southern two-thirds of the state are currently thought to have a problem with it (Thomas *et al.,* 2019).

North America: USA (Peck *et al.,* 2014).

7.3.A.2.5. Hazard identification conclusion

Considering the facts that *D. abbreviatus* -

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of *Citrus* plants, as well as important pest for sugarcane, avocado, cassava, potato, guava, papaya, mahogany etc. (Thomas *et al.,* 2019).
- It is a serious pest of USA from where a large number of citruses are imported to Bangladesh.
- It can establish in Bangladesh through imports of the fruits and plant materials. It has capability to cause direct and indirect economic and ecological damage to citrus.
- *D. abbreviatus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.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 • This pest is only found in USA region (EPPO, 2022). **b. Possibility of survival of this pest during transport, storage and transfer? – No**. • There is no data about the survival of this pest during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,** • Infected citrus plant soil and plant parts can introduce *D. abbreviatus* into Bangladesh. Adults don't travel very far in the air after emerging from the ground. Therefore, long-distance weevil distribution occurs through the transportation of contaminated soil and containerized plants that may include all weevil life stages. Additionally, soil residues on cars may contain larval contamination. Therefore, it is not recommended to enter Bangladesh from the USA. If fruit from the United States is imported along with infested leaves (egg infection), this could be dangerous (Jetter and Godfrey, 2009). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • The primary hosts of *D. abbreviatus* are *Citrus* spp. Here, the host plant is widely dispersed in Bangladesh, as are alternate hosts including sugarcane, avocado, cassava, potato, guava, papaya, mahogany, etc. Therefore, there is a good chance that this virus will spread to Bangladesh (Thomas *et al.*, 2019). • 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

7.3.A.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 major pest of **Citrus**. Therefore, it is a high risk, if fruits and plant material are imported from USA, there is possibility to establish the pest in Bangladesh (Thomas *et al.*, 2019). **b. Economic Impact and Yield Loss**	**Yes and**

• It is estimated that *D. abbreviatus* causes about 70 million dollars in damage annually in Florida. Estimates show the weevil infests more than 100,000 acres of citrus (Thomas *et al.*, 2019). **c. Environmental Impact** • Using of synthetic insecticide to control *D. abbreviatus* is harmful for soil and environment.	**High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.A.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

7.3.A.2.9. Risk Management Measures

- Chemical controls using chlorinated hydrocarbons against *D. abbreviatus* were successful. Neem oil, neem leaf extract, and other botanicals are helpful in controlling D. abbreviates by preventing egg laying on leaves and lowering egg viability. A wide range of substances, including ants, parasitic wasps, at least one virus, *Bacillus thuringiensis*, and a fungus adulticide, are being researched as potential biological pest treatments for the weevil. To tackle the pest, irrigation water in affected crops in Florida is released with the nematode *Steinernema riobravis* (Jetter and Godfrey, 2009).

7.3.A.2.10. References

EPPO, 2022. EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Jetter, K. M. and K. Godfrey. (2009). Diaprepes root weevil, a new California pest, will raise costs for pest control and trigger quarantines. California Agriculture 63:3 121-6.

Peck, S.B., Thomas, M.C. and Turnbow, J.R.H. (2014). The diversity and distributions of the beetles (Insecta: Coleoptera) of the Guadeloupe Archipelago (Grande-Terre, Basse-Terre, La Désirade, Marie-Galante, Les Saintes, and Petite-Terre), Lesser Antilles. Insecta Mundi 0352, 1–156.

Thomas, J., Weissling, J.E., Peña, R.M., Giblin, D. and Knapp, J.J.L. (2019). Diaprepes root weevil. University of Florida. https://entnemdept.ufl.edu/creatures/citrus/diaprepes_root_weevil.htm

7.3.A.3.	African citrus psyllid, *Trioza erytreae*

7.3.A.3.1. Hazard identification

Preferred Common names: African citrus psyllid
Scientific name: *Trioza erytreae* (Del Guercio)
Synonyms: *Aleurodes erytreae* Del Guercio
Spanioza eritreae Del Guercio
Spanioza erythreae Del Guercio
Spanioza erytreae Del Guercio
Spanioza merwei
Trioza citri Laing
Trioza erythreae Del Guercio
Trioza merwei Pettey

Taxonomic tree
- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Uniramia
        - Class: Insecta
          - Order: Hemiptera
            - Suborder: Sternorrhyncha
              - Family: Triozidae
                - Genus: Trioza
                  - Species: *Trioza erytreae*

EPPO Code: TRIZER. This pest has been included in EPPO A2 list: No. 46

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

7.3.A.3.2. Biology

The eggs and first-instar nymphs are particularly vulnerable to dry weather and high heat (temperatures above 32°). Green & Catling (1971) used the maximum saturation deficit as an accurate predictor of the regional spread of *T. erytreae* based on this climatic profile and the mortality of the psyllid. It thrives in cool, humid climates where citrus growth flushes tend to last longer.

Although there are usually more female than male insect in the field, the sex ratio varies. Pre-oviposition lasts between three and seven days, but without young foliage, this time period is significantly lengthened, and longevity is also increased. Two to four times a day, there is mating, and the eggs may start to hatch right away. The sharp tip on the eggs is assumed to be in charge of preserving a good internal water relationship since it is used to pierce through the leaf epidermis. In the absence of males, females remain fertile for 11–16 days. Maximum egg production happens around the midpoint of the female's lifespan, which is typically 17–50 days. Up to 2000 eggs may be laid by each female. The lengths of both these periods are inversely proportional to mean temperature and directly related to the nutritional value of the leaves. Nymph development (five instars) takes place during the incubation period, which lasts 5–17 days, while the incubation period itself lasts 17–47 days. Nymph development seems to require a temperature range of 10–12°C. There isn't a menopause. While van den Berg *et al.*,(1990) researched mating, fertility, and oviposition in *T. erytreae*, van den Berg *et al.*,(1991a) focused on the daily routines and habits of adults as well as egg hatching and moulting.

Under natural circumstances, *T. erytreae* transmits "*Candidatus* Liberibacter africanus" to areas of Africa, Arabia, and various islands in the Indian Ocean (McClean & Oberholzer, 1965; Gottwall, 2010). Additionally, it has been demonstrated that *T. erytreae* can spread *Candidatus* Liberibacter asiaticus and *Candidatus* Liberibacter americanus (Ajene *et al.*, 2020; Gottwall, 2010).

7.3.A.3.3. Hosts

T. erytreae is confined to Rutaceae, occurring on wild and ornamental hosts (*Clausena anisata*, *Vepris lanceolata*) and on Citrus, especially lemons (*C. limon*) and limes (*C. aurantiifolia*). Within the EPPO region, the host species are generally confined to countries surrounding the Mediterranean Sea. The main hosts of interest are fruit trees: *Calodendrum capense, Casimiroa edulis, Choisya ternata, Citroncirus, Citrus aurantiifolia, Citrus australasica, Citrus deliciosa, Citrus jambhiri, Citrus limon, Citrus maxima,* ***Citrus medica,*** *Citrus paradisi, Citrus reticulata, Citrus sinensis, Citrus tangerina, Citrus trifoliata, Citrus unshiu, Citrus volkameriana, Citrus x nobilis, Citrus, Clausena anisata, Fortunella, Murraya koenigii, Murraya paniculata, Rutaceae, Vepris lanceolata, Vepris nobilis, Vepris, Zanthoxylum asiaticum, Zanthoxylum sp., x Citrofortunella microcarpa*.

7.3.A.3.4. Distribution

T. erytreae was found throughout Sub-Saharan Africa, Saudi Arabia, Yemen, as well as the islands of St. Helena, Mauritius, Reunion, and Madagascar until the 1990s. This psyllid invaded Madeira and the Canary Islands in Macaronesia in 1994 and 2002, respectively (West Palaearctic). *T. erytreae* arrived on the continent of Europe in 2014, moving from Galicia in northwest Spain to Lisbon in Portugal.

The *T. erytreae* individuals discovered in Europe (Madeira, Canary Islands, and Galicia) are thought to have a similar haplotype and most likely come from South Africa, while the idea of a Kenyan origin cannot be ruled out, according to a recent study (Ajene *et al.*, 2020).

T. erytreae has a wider geographic range than *Candidatus* Liberibacter africanus, the causal agent of the citrus huanglongbing (HLB) disease that was first linked to this vector. This is because the vector is found in Portugal and Spain in Europe and Congo, Sudan, and Zambia in Africa, where *Candidatus* Liberibacter africanus has not yet been identified.

EPPO Region: Portugal (mainland, Madeira), Spain (mainland, Islas Canárias)

Africa: Angola, Cameroon, Comoros, Congo, Democratic republic of the, Eritrea, Eswatini, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Malawi, Mauritius, Reunion, Rwanda, Saint Helena, Sao Tome & Principe, **South Africa**, Sudan, Tanzania, Uganda, Zambia, Zimbabwe

Asia: Saudi Arabia, Yemen

7.3.A.3.5. Hazard identification conclusion

Considering the facts that *T. erytreae* -

- is not known to be present in Bangladesh [CABI, 2023; EPPO, 2022]
- Like the other vector of citrus greening (*Diaphorina citri*), *T. erytreae* is listed as an A1 quarantine pest by EPPO (OEPP/EPPO, 1988) and is also a quarantine pest for CPPC and OIRSA.
- In Asian countries where the Asian form of citrus huanglongbing (greening) disease is present, its presence could facilitate spread and considerably add to the difficulties of huanglongbing control.

- It would probably also be easy to develop and propagate in Mediterranean-climate citrus-growing nations. Although biological control may be feasible, there is no assurance that it will be able to keep populations at a level low enough to stop the spread of huanglongbing. In addition to aiding in the spread of citrus huanglongbing disease, psyllids themselves have a high potential for harm.
- It is a serious pest of South Africa from where large number of citrus fruits are imported to Bangladesh.
- It can establish in Bangladesh through imports of the citrus. It has capability to cause direct and indirect economic and ecological damage to many valuable fruits.
- *T. erytreae* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.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 • Until the 1990s, *T. erytreae* was present in Sub-Saharan Africa, Saudi Arabi and the Yemen and on the islands of St. Helena, Mauritius, Reunion and Madagascar. In 1994 and 2002, this psyllid invaded Madeira and the Canary Islands, respectively, in Macaronesia (West Palaearctic). In 2014, *T. erytreae* reached mainland Europe, where it spread from Galicia (northwestern Spain) to Lisbon in Portugal. • A recent study has suggested that the *T. erytreae* individuals found in Europe (Madeira, Canary Islands and Galicia) have a similar haplotype and most likely originated from South Africa, although the possibility of a Kenyan origin cannot be excluded (Ajene *et al.,* 2020). **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • *T. erytreae* thrives in warm and humid climates. It prefers temperatures between 20 and 30 degrees Celsius, which is typical of many citrus-growing regions around the world. The pest's eggs and nymphs (immature stages) are often found on the underside of young, flush leaves where the microclimate is humid and relatively stable. • However, *T. erytreae* can survive in cooler conditions. For example, it has been found in regions of Spain where winter temperatures can dip below 10 degrees Celsius. In such conditions, the pest's activity and reproduction may slow down or cease, but it can become active again when temperatures rise. • Females remain fertile for 11-16 days in the absence of males, and maximum egg production occurs towards the middle of their life span, which normally lasts 17-50 days. There are an incubation period of 6-15 days and nymphal development (five instars) takes 17-43 days, both periods being inversely related to mean temperature and directly related to nutritional value of the leaves.	**Yes and Moderate**

• 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? - No,** • *T. erytreae* can spread locally by natural means of dispersal, over distances of up to 1.5 km (van den Berg & Deacon, 1988). Eggs and nymphs may be carried over longer distances on citrus material (budwood, grafted trees, rootstock seedlings). Both adults and nymphs can acquire the causal agent of huanglongbing, but only adults can transmit it (McClean 1974; Moll and van Vuuren 1977). The illegal introduction of plant material can lead to the introduction of the disease or the vector. Adults can survive for up to 12 days on recently harvested lemon fruits at 13.5 ± 2ºC, 85.4 ± 10% RH, under an L14 hours: D10 hours photoperiod (Urbaneja-Bernat *et al.,* 2020). Introduction on citrus fruits that have passed through packing house processes involving brushing, washing and the removal of stems and leaves is unlikely. But, it is not transmitted with citrus fruits. From South Africa, we only imported citrus fruit. So, there is no risk for this pest to enter into 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** • In regions where *T. erytreae* is present, it affects a wide variety of citrus plants, including oranges, lemons, limes, grapefruits, and various citrus hybrids. Although *Trioza erytreae* has not been reported in Bangladesh, but the country has various species of citrus plants that are cultivated in various regions of the country, particularly in the Sylhet Division, Chittagong Hill Tracts, and the northern regions and could potentially serve as hosts for the pest if it were to be introduced in the future. • In terms of climate, *Trioza erytreae* generally thrives in warm and humid climates, which are typical of many citrus-growing regions around the world, including Bangladesh. The country's subtropical monsoon climate, characterized by high temperature and humidity, especially during the monsoon season, could potentially support the survival and proliferation of this pest if it were to be introduced. • 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

7.3.A.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. • These hosts primarily belong to the citrus family and include numerous commercially important species. Therefore, it is a high risk, if plant and plant material are imported from South Africa there is possibility to establish the pest in Bangladesh. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits for Bangladesh. **b. Economic Impact and Yield Loss** • *T. erytreae* results principally from its role as a vector of huanglongbing, the most damaging citrus disease in the world (Gottwald, 2010). Heavy infestations with *T. erytreae* also cause severe leaf distortion, the development of conspicuous pits on the leaf surface and the development of sooty mold on the excreted honeydew. **c. Environmental Impact** • Experience in areas to which *T. erytreae* already has spread or into which it has recently been introduced suggests that the eradication of this species is almost impossible (Cocuzza *et al.,* 2017). • Biological control may be possible, at least on islands, but there is no guarantee that it could keep populations at sufficiently low levels to prevent transmission of huanglongbing.	**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

7.3.A.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

7.3.A.3.9. Risk Management Measures

- Considering the severity of huanglongbing, EPPO has recommended to prohibit the importation of citrus plants for planting and cut branches or buds of citrus from areas or countries where citrus huanglongbing (or either of its vectors) are present.
- It is also forbidden to import fruit from third countries with their peduncles and leaves.
- In disease free countries as those of the Mediterranean area, awareness, monitoring, surveillance, pest risk assessment, quarantine measures and action plans are advised (Duran-Vila *et al.*, 2014; Siverio *et al.*, 2017).
- Procedures for official control with the aim of detecting, containing and eradicating huanglongbing and its vectors are provided in the EPPO Standard PM 9/27 (EPPO, 2020).

7.3.A.3.10. References

Ajene IJ, Khami FM, van Asch B, Pietersen G, Seid N, Rwomushana I, Ombura FLO, Momanyi G, Finyange P, Rasowo BA, Tanga CM, Mohammed S, Ekesi S (2020) Distribution of *Candidatus* Liberibacter species in Eastern Africa, and the first report of *Candidatus* Liberibacter asiaticus in Kenya. Scientific Reports 10, 3919 https://doi.org/10.1038/s41598-020-60712-0

EPPO (2020) PM 9/27 (1) '*Candidatus* Liberibacter' species that are casual agents of Huanglongbing disease of citrus and their vectors: procedures for official control. EPPO Bulletin, 50, 122-141.

Gottwald TR (2010) Current epidemiological understanding of citrus huanglongbing. Annual Review of Phytopathology, 48, 119-139.

Green GC, Catling HD (1971) Weather-induced mortality of the citrus psylla *Trioza erytreae*, a vector of greening virus, in some citrus-producing areas of South Africa. Agricultural Meteorology 8, 305-317.

McClean APD, Oberholzer PCJ (1965) Citrus psylla, a vector of the greening disease of sweet orange. South African Journal of Agricultural Science 8, 297-298.

Urbaneja-Bernat P, Hernández-Suárez E, Urbaneja A, Tena A (2020) Preventive measures to limit the spread of *Trioza erytreae* (Del Guercio) (Hemiptera: Psyllidae) in mainland Europe. Journal of Applied Entomology. https://doi.org/10.1111/jen.12771

Van den Berg MA (1990) The citrus psylla, *Trioza erytreae*: a review. Agriculture, Ecosystems and Environment 30, 171-194.

7.3.A.4.	Mediterranean fruit fly/Medfly, *Ceratitis capitate*

7.3.A.4.1. Hazard identification

Preferred Common names: Mediterranean fruit fly/Medfly
Scientific name: *Ceratitis capitate*

Synonyms: *Ceratitis citriperda* MacLeay
Ceratitis hispanica De Brême
Pardalaspis asparagi Bezzi
Tephritis capitata Wiedemann

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Tephritidae

Genus: Ceratitis
Species: *Ceratitis capitata*

EPPO Code: ANOLCN. This pest has been included in EPPO A2 list: No. 105

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

7.3.A.4.2. Biology

Eggs are placed beneath the host fruit's skin, following the general life cycle of other *Ceratitis* species that infest fruits. Within the fruit, three larval stages grow and consume plant tissue. When fully developed, the larva of the third instar leaves the fruit, burrows into the ground, and pupates inside a puparium. The puparium will release the adult fly. According to Carey *et al.*, (2008), adult Ceratitis capitata flies have an average lifespan of 11 weeks for males and 9 weeks for females, while some can live even longer. Between 3 and 6 days following the adult emergence, females begin laying eggs in fruit (Manrakhan & Lux, 2006). The larval period lasts between 5 and 21 days between 30°C and 15°C (Duyck & Quilici, 2002). At 30°C to 15°C, the pupal stage lasts for 8–35 days. At 25°C, it can complete its entire life cycle in around 32 days (Vargas *et al.,* 1984). According to Diamantidis *et al.*, (2009), *C. capitata* populations have evolved to adopt various life history strategies (in terms of longevity, reproductive maturity, and fecundity) in response to altering environmental factors. According to the environmental circumstances and local bioclimate conditions, resistance to the effects of climate stress (such as cold and heat, desiccation, and malnutrition), demography, population fluctuations, and number of annual generations also vary (Nyamukondiwa *et al.,* 2013; Weldon *et al.,* 2018).

7.3.A.4.3. Hosts

The larvae of the highly polyphagous *C. capitata* species grow in a broad variety of unrelated fruits. More than 350 different confirmed hosts from 70 different plant families have been reported from all over the world. It is also connected to numerous additional plant species, the host status of which is uncertain. A comprehensive list of hosts with thorough references may be found in the USDA Compendium of Fruit Fly Host Information (CoFFHI) (Liquido *et al.*, 2020).

Major hosts: *Annona cherimola* (cherimoya); *Citrus aurantiifolia, Citrus aurantium, Citrus clementina, Citrus deliciosa, Citrus latifolia, Citrus limon, Citrus lumia, Citrus maxima, Citrus medica, Citrus paradisi, Citrus reshni, Citrus reticulata, Citrus sinensis, Citrus trifoliata, Citrus unshiu, Capsicum annuum* (bell pepper); *Coffea; Ficus carica* (common fig); *Malus domestica* (apple); *Prunus* (stone fruit); *Prunus salicina* (Japanese plum); *Citrus; Psidium guajava* (guava) *and Theobroma cacao* (cocoa).
Minor hosts: *Averrhoa bilimbi* (bilimbi); *Averrhoa carambola* (carambola); *Capsicum frutescens* (chilli); *Carica papaya* (pawpaw)*; Cinnamomum verum* (cinnamon); *Citrus aurantiifolia* (lime); *Citrus aurantium* (sour orange); *Citrus limetta* (sweet lemon tree); *Citrus limon* (lemon); *Cucumis* (melons, cucuimbers, gerkins); *Mangifera indica* (mango); *Punica granatum* (pomegranate); *Solanum lycopersicum* (tomato); *Solanum melongena* (aubergine) *and Ziziphus jujuba* (common jujube).

7.3.A.4.4. Distribution

According to De Meyer *et al.* (2004), *Ceratitis capitata* originates in Sub-Saharan Africa, most likely in Eastern or Southern Africa. It is widespread in dry, hot areas but appears to be less common in wetter, cooler climates. It originated in Africa and has since spread to many regions of the globe, first to the Mediterranean Basin and then to Latin America, Australia, and Hawaii. All of the islands in the western Indian Ocean also introduce it. See Ruiz-Arce *et al.* for a recent global phylogeography based on mitochondrial DNA (2020). *C. capitata* is frequently found in

California (US), however systematic eradication activities are conducted there. Papadopoulos *et al.* (2013) questioned the notion that populations are completely eliminated and argued that hardly perceptible populations are established and resurface frequently. Additionally, there are sporadic data from a number of nations beyond the defined range.

EPPO Region: Albania, Algeria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, France, Germany, Greece, Israel, Italy, Jordan, Malta, Montenegro, Morocco, Portugal, Romania, Russia, Serbia, Slovenia, Spain, Switzerland, Tunisia, Türkiye, Ukraine.

Africa: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Comoros, Congo, Congo, Democratic republic of the, Cote d'Ivoire, **Egypt**, Eritrea, Eswatini, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Saint Helena, Sao Tome & Principe, Senegal, Seychelles, **South Africa,** Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

Asia: Iran, Iraq, Israel, Jordan, Lebanon, Saudi Arabia, Syria, Yemen.

North America: United States of America (Hawaii).

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

South America: Argentina, Bolivia, **Brazil**, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela.

Oceania: Australia (Western Australia).

7.3.A.4.5. Hazard identification conclusion

Considering the facts that *C. capitata* -

- is not known to be present in Bangladesh [CABI, 2020; EPPO, 2021]
- *C. capitata* is a highly invasive species. It has a high dispersive ability, a very large host range and a tolerance of both natural and cultivated habitats over a comparatively wide temperature range. It has a high economic impact, affecting production, control costs and market access. It has successfully established in many parts of the world, often as a result of multiple introductions (Malacrida *et al.*, 2007).
- will be potentially economic important to Bangladesh because it is a major pest of several crops like tea, citrus, orchids, mango, papawa etc. which are also important crops in our country.
- The degree of polyphagy of *C. capitataits* numerous economically important hostplants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- *C. capitata* is an important pest in Africa and has spread to almost every other continent to become the single most important pest species in the family. It is highly polyphagous and causes damage to a very wide range of unrelated fruit crops. In Mediterranean countries, it is particularly damaging on citrus and peaches. It also transmits fruit-rotting fungi (Cayol *et al.*, 1994).
- *C. capitata* is a quarantine pest for Bangladesh and considered to be a potential hazard organism in this risk analysis.

7.3.A.4.6. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.1.4 – 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 • Original from tropical Africa, *C. capitata* widely spread to the Mediterranean Basin, Southern Europe and most tropical and subtropical regions throughout the world (Malacrida *et al.*, 2007; EPPO, 2013). This species was also reported to be present in countries neighboring to Romania, such as Serbia (Glavendekic *et al.*, 2005), Hungary (Bodor *et al.*, 2011) and Bulgaria (Staneva, 2006). The extensive studies found in recent literature, that evaluated the potential of the geographic distribution of *C. capitata* in climate-based scenarios, estimated that it poses great abilities to penetrate into zones with wide climatic regimes, outside of its current distribution in Europe (Baini *et al.*, 2009; Vera *et al.*, 2002, De Meyer *et al.*, 2008). This species is native to both the Ethiopian and Palearctic regions, and introduced populations have since been discovered in all of the biogeographic regions. The pest already established in many countries from where a varietal fruit are imported every year. These countries are Jordan (EPPO, 2014; CABI/EPPO, 2015); Lebanon (EPPO, 2014; CABI/EPPO, 2015); Saudi Arabia (EPPO, 2014; CABI/EPPO, 2015); Syria (Ali et. al., 2015); Turkey (Fimiani,1989); Cameroon (EPPO, 2014; CABI/EPPO, 2015); Congo (EPPO, 2014; CABI/EPPO, 2015); Egypt (EPPO, 2014; CABI/EPPO, 2015) etc. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • The eggs of *C. capitata* are laid below the skin of the host fruit. They hatch within 2-4 days (up to 16-18 days in cool weather) and the larvae feed for another 6-11 days (at 13-28°C). Pupariation is in the soil under the host plant, the adults emerge after 6-11 days (24-26°C; longer in cool conditions) (Christenson and Foote, 1960), and after adult emergence, ovarian development at 25°C takes 5 days (Duyck and Quilici, 2002). The thermal constant for development from egg to adult is 260°D (Duyck and Quilici, 2002). Christenson and Foote (1960) report that adult C. capitata live for up to 2 months (field-caged). The transport, storage and transfer duration of fruits is about 20 days and the storage temperature for fruits is about 15-200C in our country, so the duration and as well as the storage condition is favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • 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. Private individuals who successfully smuggle fruit are likely to discard it when they discover that it is rotten. This method of introduction has been suggested to account for the discovery of at least one fly in a trap in California every year (Foote *et al.*, 1993), although this notion has been strongly criticized by others that suggest the presence of a barely detectable, establish population (Papadopoulos *et al.*, 2013). Transportation of fresh fruit by air (either commercially, or incidentally by	**Yes and High**

travelers) has greatly increased the risk of accidental introduction of this species into other parts of the world, and strong efforts are made to prevent its spread. (Copeland, *et al.*, 2002; Dekker and Messing, 2005; Thomas, *et al.*, 2001). • Natural Dispersal: The majority of mark-release-recapture studies on dispersal of *C. capitata* obtain recaptures no more than 1 km from the release site, although these results may represent limitations of the trapping array. There is evidence that *C. capitata* can fly at least 20 km (Fletcher, 1989). • Movement in Trade: The transport of infested fruits is the major means of movement and dispersal to previously uninfested areas. Some host fruits are only infested when ripe, and this has been the basis for an 'infestation-free quarantine procedure' for avocados exported from Hawaii to mainland USA. This was recently called into question when fruits still on the tree were found to be infested (Liquido *et al.*, 1995). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *C. capitata* is an extremely polyphagous species, more than 350 cultivated and wild fruit and vegetable species having been recorded as host plants for it (Thomas *et al.*, 2001). Among these, the fruit crops of high commercial importance as plums *(Prunus* spp.*)*, peaches *(P. persica)*, apricots *(P. armeniaca)*, cherries *(P. cerasi)*, apples *(Malus domestica)*, pears *(Pyrus communis)*, mandarins *(Citrus reticulata)*, oranges *(Citrus sinensis)*, lemons *(Citrus limon)*, grapefruits *(Citrus paradisi)*, Zara lebu *(C. medica)*, figs *(Ficus carica)*, persimmon *(Diospyros kaki)*, jujube *(Ziziphus jujuba)*, *Psidium guajava (*guava*)*, kiwifruits *(Actinidia deliciosa)*, *Capsicum frutescens (*chilli*)*; *Carica papaya (*pawpaw*)*, *Mangifera indica (*mango*)*; *Punica granatum (*pomegranate*)*; *Solanum lycopersicum (*tomato*)*; *Solanum melongena (*aubergine*)* are also included. • Host range of *C. capitata* are very common in Bangladesh. • *C. capitata* lives in Mediterranean climates, which tends to coincide with where Citrus is grown). Although it is able to tolerate low temperatures, its northward expansion in Europe appears to have been prevented by the cold winters. The lower developmental temperature for larvae is 10.2°C (Duyck & Quilici, 2002). Adult activity is reduced or suspended at higher temperatures around 30°C, when the flies seek out cooler areas (Cayol, 1996). In the absence of behavioural thermoregulation, the lower and upper temperatures that permit coordinated movement of adults are within the range of 5.4–6.6°C and 42.4–43.0°C, respectively. • So, the climatic requirements for growth and development of *C. capitata*, is more or less similar with the climatic condition of Bangladesh.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.3.A.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. • *C. capitata* is an extremely polyphagous species, more than 350 cultivated and wild fruit and vegetable species having been recorded as host plants for it (Thomas *et al.*, 2001). Among these, the fruit crops of high commercial importance as plums *(Prunus spp.),* lemons *(Citrus limon),* Zara lebu *(C. medica),* figs *(Ficus carica),* persimmon *(Diospyros kaki)*, jujube *(Ziziphus jujuba), Psidium guajava (*guava*), Capsicum frutescens (*chilli*); Carica papaya (*pawpaw*), Mangifera indica (*mango*); Punica granatum (*pomegranate*); Solanum lycopersicum (*tomato*); Solanum melongena (*aubergine*)* are also included. • If the pest establishes establish in Bangladesh, it will be a fairly serious pest of several important fruits for Bangladesh. **b. Economic Impact and Yield Loss** • *C. capitata* is an important pest in Africa and has spread to almost every other continent to become the single most important pest species in its family. It is highly polyphagous and causes damage to a very wide range of unrelated fruit crops. In Mediterranean countries, it is particularly damaging to citrus and peach. It may also transmit fruit-rotting fungi (Cayol *et al.*, 1994). • Damage to fruit crops is frequently high and may reach 100% (Fimiani, 1989; Fischer-Colbrie and Busch-Petersen, 1989). In Central America, losses to coffee crops were estimated at 5-15% and the berries matured earlier and fell to the ground with reduced quality (Enkerlin *et al.*, 1989). As in areas where the fly is endemic, in outbreak conditions the economic impacts include reduced production, increased control costs and lost markets. • Fruit-growers and their governments around the world spend millions of dollars a year trying to control this pest and prevent it from spreading to new locations. ("Common Pests of Summer Fruit in Western Australia", 2003; International Atomic Energy Agency, 2003; Mau and Kessing, 1992). • Serious economic damage is caused by this insect in Tunisia; in mixed fruit cultivation crop losses can be from 80 to 100% (Jerraya, 2003). Citrus is the most affected host crop, with direct annual losses attributed to *C. capitata* of up to 38% of annual income from Tunisian citrusproduction (Driouchi, 1990; Lebdi Grissa, 2010). **c. Environmental Impact** • No impact of *C. capitata* on the natural environment or on other species has been observed, although the decline in populations of *Ceratitis catoirii* on Mauritius and Réunion may be due in part to competition from *C. capitata* (Duyck *et al.*, 2006). • Moreover, use of this chemical insecticide for controlling the pest may harm to the environment and destroying the natural control system in the field. • The social impact on fruit growers and their families caused by the presence or introduction of *C. capitata* is severe, mostly through reduced or lost	**Yes and High**

income and increased costs of control. As a recognized and serious quarantine pest, loss of markets to producers in outbreak areas is also often severe.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.A.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 – High

7.3.A.4.9. Risk Management Measures

- Avoid importation of infested fruits from those countries, where this pest is available.
- Consignments of fruits from countries where *C. capitata* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae.
- EPPO recommends (OEPP/EPPO, 1990) that fruits of Citrus or Prunus should have been treated by an appropriate method, e.g. in transit by cold treatment (e.g. 10, 11, 12, 14, 15 days at 0.0, 0.6, 1.1, 1.7 or 2.2°C, respectively,) or, for certain types of fruits, by vapour heat (e.g. keeping at 44°C for 8 h) (USDA, 1994), forced hot-air (Armstrong *et al.*, 1995) or hot water treatment (Sharp & Picho-Martinez, 1989).
- Ethylene dibromide was previously widely used as a fumigant but is now generally withdrawn because of its carcinogenicity; methyl bromide is less satisfactory, damaging many fruits and reducing their shelf-life, although treatment schedules are available for specific cases (e.g. 32 g/m^3 for 2-4 h; USDA, 1994).
- Irradiation has been proposed as disinfestation method (Ohta *et al.*, 1989).
- A combination of methyl bromide fumigation and cold treatment is also recommended against *C. capitata*.
- Wrapping fruits in shrinkwrap film has been investigated as a possible method of disinfesting fruits (Jang, 1990).

7.3.A.4.10. References

Armstrong, J.W.; Hu, B.K.S.; Brown, S.A. (1995) Single-temperature forced hot-air quarantine treatment to control fruit flies (Diptera: Tephritidae) in papaya. J. Econo. Entomo. 88, 678-682.

Carey JR, Papadopoulos NK, Muller HG, Katsoyannos BI, Kouloussis NA, Wang JL, Wachter K, Yu W & Liedo P (2008) Age structure changes and extraordinary lifespan in wild medfly populations. Aging cell 7, 426-437.

De Meyer M, Copeland RS, Wharton RA & McPheron BA (2004) On the geographical origin of the medfly, *Ceratitis capitata* (Wiedemann). Proceedings 6th International Symposium on Fruit Flies of Economic Importance (Stellenbosch, South Africa), 45-53.

Diamantidis AD, Papadopoulos NT, Nakas CT, Wu S, Müller HG & Carey JR (2009) Life history evolution in a globally invading tephritid: patterns of survival and reproduction in medflies from six world regions. Biological Journal of the Linnean Society 97, 106-117.

Duyck PF & Quilici S (2002) Survival and development of different life stages of three *Ceratitis* spp. (Diptera: Tephritidae) reared at five constant temperatures. Bulletin of Entomological Research 92, 461-469.

Jang, E.B. (1990) Fruit fly disinfestation of tropical fruits using semipermeable shrinkwrap film. Acta Horticulturae No. 269, 453-458.

Liquido NJ, McQuate GT, Hanlin MA & Suiter KA (2020) Host plants of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), Version 4.0. Available online at: USDA Compendium of Fruit Fly Host Information (CoFFHI), Edition 4.0. https://coffhi.cphst.org/

Manrakhan A & Lux SA (2006) Contribution of natural food sources to reproductive behavior, fecundity and longevity of *Ceratitis cosyra*, *C. fasciventris* and *C. capitata* (Diptera: Tephritidae). Bulletin of Entomological Research 96, 259-268.

Nyamukondiwa C, Weldon CW, Chown SL, le Roux PC & Terblanche JS (2013) Thermal biology, population fluctuations and implications of temperature extremes for the management of two globally significant insect pests. Journal of Insect Physiology 59, 1199-1211.

Ohta, A.T.; Kaneshiro, K.Y.; Kurihara, J.S.; Kanegawa, K.M.; Nagamine, L.R. (1989) Gamma radiation and cold treatments for the disinfestation of the Mediterranean fruit fly in California-grown oranges and lemons. Pacific Science 43, 17-26.

Papadopoulos NT, Plant RE & Carey JR (2013) From trickle to flood: the large-scale, cryptic invasión of California by tropical fruit flies. Proceedings of the Royal Society B Biological Sciences 280, 20131466

Sharp JL, Picho-Martinez H, 1989. Hot-water quarantine treatment to control fruit flies in mangoes imported into the United States from Peru. J. Econo. Entomol., 83(5):1940-1943 (/isc/abstract/19911154790)

USDA (1994) Treatment manual. USDA/APHIS, Frederick, USA.

Vargas RI, Miyashita D & Nishida T (1984) Life-history and demographic parameters of three laboratory-reared Tephritids (Diptera: Tephritidae). Annals of the Entomological Society of America 77, 651-656.

Weldon CW, Nyamukondiwa C, Karsten M, Chown SL & Terblanche JS (2018) Geographic variation and plasticity in climate stress resistance among southern African populations of *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae). Scientific Reports 8, 9849.

7.3.A.5.	Queensland fruit fly, *Bactrocera tryoni*

7.3.A.5.1. 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]

7.3.A.5.2. Biology

The general life cycle is as like 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.

7.3.A.5.3. 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 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, Citrus aurantiifolia* (lime), *Citrus aurantium* (sour orange), *Citrus limetta (sweet lemon tree), Citrus limon (lemon), Citrus maxima (pummelo), Citrus medica* (citron), 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 is potential hosts.

7.3.A.5.4. 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.

7.3.A.5.5. 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.

7.3.A.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	

• 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. **d. 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 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,** • 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*	**Yes and High**

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 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

7.3.A.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: 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 establish 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).	**Yes and High**

• 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 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). • **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

7.3.A.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 – High

7.3.A.5.9. 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 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.

7.3.A.5.10. References

Allwood AJ, Leblanc L, 1997. Losses caused by fruit flies (Diptera: Tephritidae) in seven Pacific Island countries. Management of fruit flies in the Pacific, *ACIAR Proceedings Series* **76** 208-211.

Christenson, L.D.; Foote, R.H. (1960) Biology of fruit flies. *Annual Review of Entomology* **5**, 171-175.

Clarke AR (2019). Biology and Management of Bactrocera and Related Fruit Flies. CAB International, Wallingford, xiv+254pp

Clarke AR, Powell KS, Weldon CW & Taylor PW (2011). The ecology of *Bactrocera tryoni* (Diptera: Tephritidae): what do we know to assist pest management? *Annals of Applied Biology* **158**: 26-54.

Dominiak BC & Mapson R (2017). Revised distribution of *Bactrocera tryoni* in eastern Australia and effect on possible incursions of Mediterranean fruit fly: development of Australia's eastern trading block. *Journal of Economic Entomology*. **110**: 2459-2465.

EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Dehnen-Schmutz K, Di Serio F, Gonthier P, Jacques MA, Jaques Miret JA, Justesen AF, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke HH, Van der Werf W, Vicent Civera A, Yuen J, Zappalà L, Bali EM, Papadopoulos N, Papanastassiou S, Czwienczek E & MacLeod A (2020). Pest categorization of non-EU Tephritidae. *EFSA Journal*. **18**: 5931, 62pp. https://doi.org/10.2903/j.efsa.2020.5931

EPPO, 2022. EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

FAO (2009) Annex 5 Irradiation treatment for *Bactrocera tryoni*. Rome, IPPC, FAO. https://assets.ippc.int/static/media/files/publication/en/2016/06/PT_05_2009_En_2016-04-22_PostCPM11_InkAm.pdf

FAO (2015) Annex 16 Cold treatment for *Bactrocera tryoni* on Citrus sinensis. Rome, IPPC, FAO. https://assets.ippc.int/static/media/files/publication/en/2016/06/PT_17_2015_En_2016-05-27_PostCPM11_InkAm.pdf

Fitt GP (1986). The roles of adult and larval specialisations in limiting the occurrence of five species of Dacus in cultivated fruits. *Oecologia* 69, 101-109.

Heather, N.W.; Corcoran, R.J.; Banos, C. (1991) Disinfestation of mangoes with gamma irradiation against two Australian fruit flies (Diptera: Tephritidae). *Journal of Economic Entomology* **84**: 1304-1307.

Leblanc L, Vueti ET, Drew RAI & Allwood AJ (2012). Host plant records for fruit flies (Diptera: Tephritidae: Dacini) in the Pacific Islands. *Proceedings of the Hawaiian Entomological Society*. **44**: 11-53.

Meats A & Fitt GP (1987). Survival of repeated frosts by the Queensland fruit fly, *Dacus tryoni*: experiments in laboratory simulated climates with either step or ramp fluctuations of temperature. *Entomologia Experimentalis et Applicata*. **45**: 9-16.

Meats A, Edgerton JE, 2008. Short- and long-range dispersal of the Queensland fruit fly, *Bactrocera tryoni* and its relevance to invasive potential, sterile insect technique and surveillance trapping. *Australian Journal of Experimental Agriculture,* 48(9):1237-1245. http://www.publish.csiro.au/nid/72.htm

Meats, A.; Fitt, G.P. (1987) Survival of repeated frosts by the Queensland fruit fly, *Dacus tryoni*: experiments in laboratory simulated climates with either step or ramp fluctuations of temperature. *Entomologia Experimentalis et Applicata* **45**, 9-16.

Sutherst RW, Collyer BS, Yonow T, 2000. The vulnerability of Australian horticulture to the Queensland fruit fly, *Bactrocera (Dacus) tryoni*, under climate change. *Australian Journal of Agricultural Research,* **51**(4): 467-480.

USDA (2021) United States Department of Agriculture Treatment Manual. https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf [accessed on 2021-04-23]

Vijaysegaran S, 1997. Fruit fly research and development in tropical Asia. ACIAR Proceedings Series, **76**: 21-29.

White IM, Elson-Harris MM, 1994. Fruit Flies of Economic Significance. Their Identification and Bionomics. Wallingford, UK: CAB International.

Yonow T, Zalucki MP, Sutherst RW, Dominiak BC, Maywald GF, Maelzer DA & Kriticos DJ (2004). Modelling the population dynamics of the Queensland fruit fly, *Bactrocera (Dacus) tryoni*: a cohort-based approach incorporating the effects of weather. *Ecological Modelling*. **173**: 9-30.

7.3.A.6.	South African citrus thrips, *Scirtothrips aurantii*

7.3.A.6.1. Hazard identification

Preferred Common names: South African citrus thrips
Scientific name: *Scirtothrips aurantii*
Synonyms: *Scirtothrips acaciae Moulton*

Taxonomic tree

- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Arthropoda
      - Subphylum: Hexapoda
        - Class: Insecta
          - Order: Thysanoptera
            - Family: Thripidae
              - Genus: Scirtothrips
                - Species: *Scirtothrips aurantii*

EPPO Code: SCITAU. This pest has been included in EPPO A1 list: No. 221

Bangladesh status: Not present in Bangladesh [EPPO, 2021]

7.3.A.6.2. Biology

Scirtothrips females insert their eggs into young and soft tissues of leaves, stems and fruit using their distinctive saw-like ovipositor. After having hatched these thrips go through four developmental stages (EPPO, 2005; CABI, 2017): two actively feeding immature instars (first and second instar larva), two non-feeding immature instars (prepupa and pupa) and the feeding adults. Both, adults and larvae feed on epidermal and occasionally even palisade cells of young leaves or on young fruit often still concealed under the calyx (Milne and Manicom, 1978); they do not feed on mature leaves. Upon completion of the second instar, larvae seek refuge, usually on the ground in leaf litter, where they pupate. Very occasionally pupae can be found beneath the calyx of fruits, however, as only the youngest fruits are attacked *S. aurantii* rarely occur on harvested fruits. Breeding is almost continuous, with no diapause, although development is slower in colder seasons due to cooler weather and diminishing food supply. The life cycle of *S. aurantii* can be completed within 18 days in summer to 44 days in winter, respectively (Gilbert and Bedford, 1998). In South Africa, more than nine generations per year are known to occur in citrus and mangoes. Adults are probably dispersed downwind, but observations in South Africa have suggested that early-season infestations in citrus orchards develop mainly from thrips that have overwintered within each orchard, rather than from adults flying in from wild plants (Gilbert and Samways, 2018). Later in the season (November and December), wild hosts probably assume greater importance as a source of the pest. Citrus trees close to windbreaks made of host plants (e.g. Grevillea trees which harbour *S. aurantii*) had more severe fruit scarring than citrus trees close to non-host windbreaks (e.g. Pinus or Casuarina trees) (Grout and Richards, 1990a; Dubois and Quilici, 1999).

7.3.A.6.3. Hosts

Although usually considered to be associated with Citrus, especially oranges (*C. sinensis*) in southern Africa, *S. aurantii* is highly polyphagous and has been found on more than 70 plant species in a wide range of different plant families. Its native hosts are probably Acacia and Combretum trees, but it has also been found on a range of crops that are not only botanically unrelated but differ widely in form, including amaranth, asparagus, banana, cashew, castor bean, cotton, mango, peanut, and grapevine (Freebairn, 2008). However, the occurrence of adults feeding on a plant does not necessarily constitute this plant as a true host (EFSA, 2018). Reports based on records of adults alone do not provide conclusive evidence of the suitability of a plant, to allow reproduction and sustain development of all life stages of S. aurantii. The following host list provides plant species where both larvae and adults of S. aurantii have been found, suggesting that they are true hosts.

Host list: *Acacia, Arachis hypogaea, Asparagus, Bauhinia galpinii, Caesalpinia pulcherrima, Calliandra calothyrsus , Citroncirus, Citrus latifolia, Citrus limon, Citrus paradisi, Citrus reticulata, Citrus sinensis, Citrus trifoliata, Citrus , Combretum, Dichrostachys cinerea, Diospyros kaki, Fortunella, Fragaria x ananassa, Gloriosa superba, Gossypium, Grevillea robusta, Kalanchoe blossfeldiana, Kalanchoe delagoensis, Kalanchoe pinnata, Leucaena leucocephala, Macadamia integrifolia, Mangifera indica, Mucuna coriacea subsp. irritans, Musa x paradisiaca, Persea americana, Pithecellobium dulce, Punica granatum, Ricinus communis, Rubus idaeus, Rubus, Senegalia polyacantha subsp. campylacantha, Vaccinium, Vachellia karroo, Vitis vinifera, x Citrofortunella microcarpa.*

7.3.A.6.4. Distribution

S. aurantii is native to Africa

EPPO Region: Portugal (mainland), Spain (mainland)

Africa: Angola, Cote d'Ivoire, Egypt, Eswatini, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Nigeria, Reunion, South Africa, Sudan, Tanzania, Uganda, Zimbabwe

Asia: Yemen

Oceania: Australia (New South Wales, Queensland)

7.3.A.6.5. Hazard identification conclusion

Considering the facts that *S. aurantii* -

- is not known to be present in Bangladesh [EPPO, 2021]
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically fruits: *Citrus limon* (Lemon)*; Citrus paradisi* (Grapefruit), *Citrus reticulata* (Mandarin Orange), *Citrus sinensis* (Sweet Orange*), Citrus medica* (Zara lebu) are also infested.
- It is a serious pest of Australia, Egypt, South Africa from where a large number of fruits are imported to Bangladesh.
- *S. aurantii* is a very polyphagous species. It could be introduced with plants for planting, cut flowers or cut foliage. Its occurrence in citrus-growing areas with a subtropical or Mediterranean climate suggests that *S. aurantii* could probably establish on citrus in Southern Europe and the Mediterranean area. It is a damaging pest on citrus and requires specific control that may challenge current IPM practices. Mango and avocado are also cultivated in the EPPO region and may be at risk if *S. aurantii* was introduced.
- *S. aurantii* is mainly present in Africa, where it is a damaging pest of citrus, requiring insecticide treatments. Its importance has also increased on mangoes, where insecticide treatments are applied, and concerns have also been raised for banana and tea. Since its present range includes areas with tropical, subtropical and Mediterranean climates, any such area elsewhere in the world, growing its four main hosts, could be at risk.
- *S. aurantii* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.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? - Yes • This pest has been established in many countries including Australia, Spain, Portugal, Egypt, South Africa (EPPO 2023). A huge amount of citrus was imported in Bangladesh from **Australia,** Egypt, South Africa, etc. (DAE, 2022). In Australia, Egypt and South Africa *S. aurantii* is very common pest. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Scirtothrips females insert their eggs into young and soft tissues of leaves, stems and fruit using their distinctive saw-like ovipositor. Both, adults and larvae feed on epidermal and occasionally even palisade cells of young leaves or on young fruit often still concealed under the calyx (Milne and Manicom, 1978). The life cycle of *S. aurantii* can be completed within 18 days in summer to 44 days in winter, respectively (Gilbert and Bedford, 1998). 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	**Yes and High**

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 potential of *S. aurantii* for natural spread is relatively limited. In international trade, *S. aurantii* could be carried on plants for planting (on young leaves or in the growing medium attached) as well as on cut flowers or cut foliage, but in fact interceptions are relatively rare (EFSA, 2018; Vierbergen *et al.,* 2010). Nevertheless, it has been introduced to Australia and more recently to Spain. Unlike other Thysanoptera, *Scirtothrips* sp. seem to require access to soft green tissues, except when pupating in leaf litter and soil. So only seedlings, green fruits or cuttings with young growing leaf buds are liable to carry these pests. EFSA (2018) considers that *S. aurantii* is unlikely to be associated with mature fruit as they do not feed or oviposit on mature fruit. • There is no direct evidence that *S. aurantii* has been dispersed beyond its natural range by human activity (except possibly to African islands such as Cape Verde, Mauritius and Réunion). *S. aurantii* is not likely to be transported on traded fruit, which limits the risk of introduction. It could however, be carried on plants for planting.*S. aurantii* has been declared to be a quarantine pest for the following Regional Plant Protection Organizations: APPPC, EPPO, OIRSA, PPPO. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *S. aurantii* is highly polyphagous and has been found on more than 70 plant species in a wide range of different plant families. Its native hosts are probably Acacia and Combretum trees, but it has also been found on a range of crops that are not only botanically unrelated but differ widely in form, including **citrus, amaranth**, asparagus, **banana**, **cashew**, castor bean, **cotton**, **mango**, peanut, and grapevine (Freebairn, 2008). However, the occurrence of adults feeding on a plant does not necessarily constitute this plant as a true host (EFSA, 2018). • 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

7.3.A.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.	

• It is an important pest of many cultivated plants including most characteristically fruits: **Citrus**, *Citrus limon* (lemon), *Citrus medica* (Zara) *Citrus sinensis* (sweet orange), *Camellia sinensis* (tea), *Gossypium* (cotton), **mangoes** (*Mangifera indica*), etc. Therefore, it is a high risk, if fruits and plant material are imported from Australia, South Africa and Egypt; there is possibility to establish 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** • At least ten species of *Scirtothrips* are known as pests of various crops in different parts of the tropics, but most of them have restricted geographic ranges and breed on specific tropical host plants, such as *S. kenyensis* which damages tea and coffee in Eastern Africa (Moritz *et al.*, 2013), or *S. manihoti* which causes serious leaf distortion of cassava in Central and South America (Mound and zur Strassen, 2001). *Scirtothrips* species are particularly associated with plants that grow in warm, dry conditions; they are usually more abundant on terminal shoots rather than within the canopy of a tree. Along with *S. citri* and *S. dorsalis, S. aurantii* is, as a pest of citrus, one of the most important *Scirtothrips* sp. for international agriculture. • In South Africa and Zimbabwe, *S. aurantii* causes reduction in citrus yields due to serious damage to young leaves and reduces the proportion of export quality fruits. It is a most serious pest at low altitudes (Hill, 1983). It is not generally regarded as harmful to citrus crops further north in Africa, although this might be due to less intensive cultivation practices. Damage to tea plants has been reported from plantations in Malawi (Rattan, 1992), and *S. aurantii* is the primary cause of banana fruit spotting in Yemen (Nasseh and Mughni, 1990). *S. aurantii* is also considered as a pest in mango (Grové *et al.*, 2000a) and avocado (Bara and Laing, 2019). • In Australia, *S. aurantii* is not considered as a crop pest (Garms *et al.*, 2013; Rafter *et al.*, 2013) as it is mainly recorded on the weed *Bryophyllum delagoense*. **c. Environmental Impact** • *S. aurantii* is a very polyphagous species. It could be introduced with plants for planting, cut flowers or cut foliage. Its occurrence in citrus-growing areas with a subtropical or Mediterranean climate suggests that *S. aurantii* could probably establish on citrus in Southern Europe and the Mediterranean area. It is a damaging pest on citrus and requires specific control that may challenge current IPM practices. • Managing this pathogen might require the use of insecticides or other chemical control measures. These can have broader environmental impacts, such as effects on non-target organisms in the ecosystem or potential contamination of water resources. • The pest might affect not only cultivated citrus but also wild species, potentially impacting local biodiversity.	**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

7.3.A.6.8. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table-7.6.3 – 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

7.3.A.6.9. Risk Management Measures

- Importation of Citrus plants for planting is prohibited or restricted in many EPPO countries to prevent introduction of important pests. However, *S. aurantii* could be introduced with other plant species, as it is very polyphagous, and adults may be found on plants on which they may not complete their full life cycle. To prevent introduction of the pest, plants for planting should either be dormant (i.e., without leaves and fruit) with no growing medium attached or come from a pest-free area or a pest-free place of production. An insecticide treatment before shipping may also be an option.
- Measures for cut flowers/foliage may not be justified as the risk of transfer to host plants at destination is limited.

7.3.A.6.10. References

Bara GT, Laing MD (2019) Determination of the natural host status of avocado fruit to pestiferous thrips (Thysanoptera: Thripidae) in KwaZulu-Natal, South Africa. African Entomology 27(1), 245-253 https://doi.org/10.4001/003.027.0245

CABI (2017) CABI Datasheet report for *Scirtothrips aurantii* (South African citrus thrips). Available at: https://www.cabi.org/isc/datasheet/49061

Dubois B, Quilici S (1999) Etude préliminaire de l'évolution des populations de *Scirtothrips aurantii* Faure sur vigne à l'île de la Réunion. Fruits 54(1), 67-78. Available at: https://revues.cirad.fr/index.php/fruits/article/view/35648

EFSA PLH Panel (EFSA Panel on Plant Health) Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Gregoire J-C, Jaques Miret JA, Navarro MN, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van der Werf W, West J, Winter S, Gardi C, MacLeod A (2018) Scientific Opinion on the pest categorisation of *Scirtothrips aurantii*. EFSA Journal 16(3), 5188, 21 pp. https://doi.org/10.2903/j.efsa.2018.5188

EPPO (2005) Diagnostics. *Scirtothrips aurantii, Scirtothrips citri, Scirtothrips dorsalis.* EPPO Standard PM 7/56 (1). EPPO Bulletin 35(2), 353-356. Available from https://gd.eppo.int/standards/PM7/

Freebairn C (2008) South African citrus thrips in Australia – identity, pest status and control. Final Report: CT03022, Horticultural Australia Ltd., 202 pp.

Garms BW, Mound LA, Schellhorn NA (2013) Polyphagy in the Australian population of South African citrus thrips (*Scirtothrips aurantii* Faure). Australian Journal of Entomology 52, 282-289.

Gilbert MJ, Bedford ECG (1998) Citrus thrips. Scirtothrips aurantii Faure. In: Citrus pests in the Republic of South Africa, 2nd revised edition (Ed. by Bedford ECG, van den Berg MA, de Villiers EA). Institute for Tropical and Subtropical Crops, Nelspruit, South Africa, pp. 164-170.

Gilbert MJ, Samways MJ (2018) Mature larval dispersal and adult emergence of the economically significant pest, *Scirtothrips aurantii* Faure (Thysanoptera: Thripidae), in commercial citrus. Journal of Insect Science 18(2), 32. https://doi.org/10.1093/jisesa/iey028
Grout TG, Richards GI (1990a) The influence of windbreak species on citrus thrips (Thysanoptera: Thripidae) populations and their damage to South African citrus orchards. Journal of the Entomological Society of Southern Africa 53, 151-157.
Grové T, Giliomee JH, Pringle KL (2000a) Seasonal abundance of different stages of the citrus thrips, *Scirtothrips aurantii*, on two mango cultivars in South Africa. Phytoparasitica 28, 43-53.
Hill DS (1983) Agricultural insect pests of the tropics and their control. Cambridge University Press, Cambridge, UK. 758pp.
Milne DL, Manicom BQ (1978) Feeding apparatus of the South African citrus thrips *Scirtothrips aurantii* Faure. Citrus and Subtropical Fruit Journal 535, 6-11.
Moritz G, Brandt S, Triapitsyn S, Subramanian S (2013) Identification and information tools for pest thrips in East Africa. CBIT Publishing, Queensland. Available at: http://thripsnet.zoologie.uni-halle.de/key-server-neu/data/03030c05-030b-4107-880b-0a0a0702060d/media/Html/index.html
Mound LA, zur Strassen R (2001) The genus Scirtothrips (Thysanoptera: Thripidae) in Mexico: a critique of the review by Johansen & Mojica-Guzmán (1998). Folia Entomológica Mexicana 40, 133-142.
Nasseh OM, Mughni AAA (1990) Efficacy of chemical and natural insecticides for suppression of *Scirtothrips aurantii* (Faure) (Thripidae - Thysanoptera) causing banana fruit spotting disease in the Yemen Arab Republic. In: Proceedings, Integrated Pest Management in Tropical and Subtropical Cropping Systems, Frankfurt, 1990, pp. 749-756. Deutsche Landwirtschaftsgesellschaft, Frankfurt am Main, Germany.
Rafter MA, Walter GH (2013) Mate recognition in the South African citrus thrips *Scirtothrips aurantii* (Faure) and cross-mating tests with populations from Australia and South Africa. Journal of Insect Behaviour 26, 780-795. https://doi.org/10.1007/s10905-013-9391-7
Rattan PS (1992) Thrips (*Scirtothrips aurantii*), synthetic pyrethroid insecticides and alternatives. Quarterly Newsletter, Tea Research Foundation of Central Africa 106, 9-11.
Vierbergen G, Kucharczyk H, Kirk WDJ (2010) A key to the second instar larvae of the Thripidae of the Western Palaearctic region (Thysanoptera). Tijdschrift voor Entomologie 153(1), 99-160. https://doi.org/10.1163/22119434-900000294

7.3.A.7.	California citrus thrips, *Scirtothrips citri*

7.3.A.7.1. Hazard identification

Preferred Common names: California citrus thrips
Scientific name: *Scirtothrips citri* (Moulton, 1909)
Synonyms: *Euthrips citri* Moulton, 1909
Scirtothrips clivicola Hood, 1957

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Order: Thysanoptera
Family: Thripidae
Genus: Scirtothrips
Species: *Scirtothrips citri*

EPPO Code: SCITCI. This pest has been included in EPPO A1 list: No. 222

Bangladesh status: Not present in Bangladesh [EPPO, 2022]

7.3.A.7.2. Biology

Scirtothrips citri has a short life cycle and high fecundity. Each adult female lays about 25 eggs embedded in the new leaf tissue or young fruit. *Scirtothrips* have four developmental stages: two actively feeding immature instars (first and second instar larva), two non-feeding immature instars (prepupa and pupa) and the feeding adults. *S. citri* adults can live as long as 25-30 days under warm conditions and could live longer under cooler conditions, but do not develop below 14°C. Citrus thrips can produce 8-12 generations per year. In California, overwintering eggs from the previous season hatch in March as the new leaf flush begins (Grafton-Cardwell *et al.*, 2020). Larvae feed actively on tender leaves and fruit, especially under the sepals of young fruit. The pre-pupal and pupal phase is spent in cracks in the bark of trees or on the ground. The lifecycle can be completed in 2-3 weeks during summer.

7.3.A.7.3. Hosts

Scirtothrips citri (Moulton), also commonly known as 'Citrus thrips' but not to be confused with 'South African citrus thrips' (*Scirtothrips aurantii* Faure) is primarily a pest of Citrus and blueberries. S. citri has a broad host range: overall, S. citri has been found on over 50 plant species. However, many are likely to not be hosts on which the life cycle can be completed. Its native host plant is possibly one or more species of Quercus (Bailey, 1964), or more likely Rhus laurina (Morse, 1995). The main hosts of interest are fruit trees: *Adenostoma fasciculatum, Carya illinoinensis, Citroncirus, Citrus aurantiifolia, Citrus clementina, Citrus limon, Citrus medica, Citrus paradisi, Citrus reticulata, Citrus sinensis, Citrus trifoliata, Citrus unshiu, Citrus, Coffea arabica, Dahlia imperialis, Fortunella, Gossypium hirsutum, Larrea tridentata, Magnolia tripetala, Magnolia, Mangifera indica, Medicago sativa, Myrtus, Phoenix dactylifera, Prosopis, Quercus, Rhizophora mangle, Rhus laurina, Rosa, Salix, Schinus molle, Simmondsia chinensis, Umbellularia californica, Vaccinium corymbosum, Vaccinium hybrids, Vitis vinifera, x Citrofortunella microcarpa*

7.3.A.7.4. Distribution

Scirtothrips citri is found in warm climates that are ranging from tropical to arid conditions. It is known to be found in North America in the USA and Mexico. There are some uncertainties on the distribution outside of North America.

EPPO region: Israel.

North America: Mexico, USA (EPPO, 2022)).

Asia: China, India, Iran, Thailand (Unreliable present)

7.3.A.7.5. Hazard identification conclusion

Considering the facts that *S. citri* -

- 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: *Citrus limon (*Lemon); *Citrus medica* (Zara), *Citrus paradisi* (Grapefruit), *Citrus reticulata* (Mandarin Orange), *Citrus sinensis* (Sweet Orange), *Citrus unshiu* (Satsuma Orange), *Coffea arabica* (Arabica Coffee),

Gossypium hirsutum (Upland Cotton), *Mangifera indica* (Mango), *Medicago sativa* (Alfalfa), *Phoenix dactylifera* (Date Palm), *Rosa* (Rose), etc.

- It is a serious pest of USA from where a large number of fruits including citrus are imported to Bangladesh.
- *S. citri* is a very polyphagous species. It could be introduced with host plants for planting, cut foliage or cut flowers. The occurrence of *S. citri* in citrus-growing areas with a subtropical or Mediterranean climate suggests that it could probably establish on citrus in Southern Europe and the Mediterranean area. *S. citri* is a damaging pest of citrus and blueberry and requires specific control that may challenge current IPM practices.
- 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.
- *S. citri* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.7.6. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.7.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years? - Yes • This pest has been established in many North American and European countries. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • *S. citri* adults can live as long as 25-30 days under warm conditions and could live longer under cooler conditions, but do not develop below 14°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,** • Up to December 2017, there is one record of an EU interception of *S. citri* in the Europhyt database. It relates to an interception in 2003 in the UK on a consignment of Festuca pratensis seeds (plants for planting not yet planted) coming from Thailand. This is considered an unusual interception given that *S. citri* feeds on actively growing leaf and fruit tissues rather than grass seed. More likely pathways for *S. citri* would be: o plants for planting, on either young leaves or fruit (all stages), or in the associated soil/litter (prepupae and pupae), o cut flowers with young leaves or fruit (all stages),	**Yes and High**

○ fruit, most likely on young fruit (all developmental stages). Very unlikely on mature commercial fruit. • Current EU legislation prohibits the import of plants of Citrus, Fortunella, Poncirus and their hybrids, other than fruit and seeds from third countries. Therefore, pathways 1 and 2 can be considered as closed for citrus. For other hosts, the number of plant species that could provide a pathway via plants for planting or cut flowers is uncertain because of the lack of sound data supporting the status of plants reported as hosts (Morse, 1995; CABI, 2017). • Nevertheless, *S. citri* is potentially highly polyphagous and the current measures aimed at the import of plants for planting in a dormant stage (no young foliage or fruits present) with no soil/growing medium/debris attached decreases the likelihood of *S. citri* being carried with imports of host plants. • The third pathway is considered unlikely as *S. citri* does not feed on mature commercial fruit. Eurostat trade data do not discriminate between species of plants for planting. Fortunately, the Netherlands NPPO kindly provided EFSA with detailed trade inspection data regarding plants for planting from 2012 to 2014. This information show that a number of genera reported to be hosts of *S. citri* were imported into the EU as plants for planting from China, Thailand and USA over the period 2012–2014, indicating that potential pathways exist for the entry of *S. citri*. • The potential for *Scirtothrips* spp. to spread naturally is relatively limited (EPPO, 2017). Although *S. citri* adults actively fly they do not move long distances between hosts (Moreno *et al.*, 1984; UC, 1991). Long distance international spread is most likely via trade in plants or plant parts in a nondormant stage (i.e., with actively growing leaf flush and/or young fruit). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • A range of plant species reported as hosts to *S. citri* occurs in the EU. For example, cultivated fruit such as ***Citrus* spp,** *Vitis* sp. and ***Mangifera indica***, as well as on ornamental plants, e.g., ***Rosa* spp**., *Phoenix* spp., and wild plants, e.g., *Vaccinium* sp., *Quercus* spp. and *Abies* spp. However, from these plant species, *S. citri* has reached pest status only in highbush blueberries (*V. corymbosum*) in California and in citrus in south-western USA (UC, 1991; Haviland *et al.*, 2009; Dreistadt *et al.*, 2011) and Asia (Bhagat *et al.*, 1999; Sharma, 2007). • The Koppen–Geiger classification of climatic regions (Peel *et al.*, 2007) in North America where *S. citri* occurs, includes regions that are also found in Europe where citrus and Vaccinium are grown. We assume establishment in these areas would be possible outdoors. Moreover, given the polyphagy of this thrips, its establishment under protected cultivation might also possible further north in Europe. • 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	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	

7.3.A.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. • It is an important pest of many cultivated plants including most characteristically fruits: *Citrus limon (*Lemon); *Citrus medica* (Zara), *Citrus paradisi* (Grapefruit), *Citrus reticulata* (Mandarin Orange), *Citrus sinensis* (Sweet Orange), *Citrus unshiu* (Satsuma Orange), *Coffea arabica* (Arabica Coffee), *Gossypium hirsutum* (Upland Cotton), *Mangifera indica* (Mango), *Medicago sativa* (Alfalfa), *Phoenix dactylifera* (Date Palm), *Rosa* (Rose), etc. Therefore, it is a high risk, if fruits and plant material are imported from USA, China, India there is possibility to establishthe 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** • *Scirtothrips citri* feeding and oviposition in citrus does not reduce yields but can produce unacceptable cosmetic damage which may affect the marketability of fruit, at least for fresh consumption. The cosmetic damage is caused by feeding which punctures plant tissues and drains the contents of cells causing their cell walls to collapse (Lewis, (1973). Such damage in citrus often results in a conspicuous ring of scarred tissue around the apex of young fruits (Parker *et al.*, 1995; Mound and Kibby, 1998). • Oviposition damage (oviposition scars) on fruit may be a problem in early harvested citrus fruit only. Most economic damage to fruits occurs from petal fall until the fruit are about 4 cm in diameter. Damage is greatest on fruit on the outside of the canopy (UC, 1991; EPPO, 2017). • Damage in blueberry consists of curling and abnormal growth of new leaves, as well as scarring of new twigs, which would lead to lower fruit set the following year. However, fruit quality is not affected in this case (Haviland *et al.*, 2009; Haviland, 2014). • The type of damage caused by *S. citri* in North America could be expected in the EU. **c. Environmental Impact** • *S. citri* is a very polyphagous species. It could be introduced with plants for planting, cut flowers or cut foliage. Its occurrence in citrus-growing areas with a subtropical or Mediterranean climate suggests that *S. citri* could probably establish on citrus in Southern Europe and the Mediterranean area. It is a damaging pest on citrus and requires specific control that may challenge current IPM practices. • Managing this pathogen might require the use of insecticides or other chemical control measures. These can have broader environmental impacts,	**Yes and High**

such as effects on non-target organisms in the ecosystem or potential contamination of water resources. • The pest might affect not only cultivated citrus but also wild species, potentially impacting local biodiversity.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.A.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

7.3.A.7.9. Risk Management Measures

- Importation of citrus plants for planting is prohibited or restricted in many EPPO countries to prevent introduction of important pests. However, *S. citri* could be introduced with other plant species, as it is very polyphagous, and adults may be found on plants on which they may not complete their full life cycle. To prevent introduction of the pest, plants for planting should either be dormant (i.e., without leaves) with no growing medium attached or come from a pest-free area or a pest-free place of production. An insecticide treatment before shipping may also be an option.
- Measures for cut flowers/foliage may not be justified as the risk of transfer to host plants at destination is limited.

7.3.A.7.10. References

Bhagat KC, Nehru RK and Koul VK, 1999. Sap feeding pests of citrus in Jammu. Insect Environment, 5, 123. Available online: https://www.cabdirect.org/cabdirect/abstract/20001107657

CABI, 2017. *Scirtothrips citri* (California citrus thrips) Datasheeet 49063, Crop Protection Compendium. Last modified 11 October 2017. Available online: https://www.cabi.org/isc/datasheet/49063

Dreistadt SH, Phillips PA and O'Donnell CA, 2011. Pest notes: Thrips. UC ANR Publication 7429. IPM Education and Publications, University of California Statewide IPM Program. Available online: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7429.html

EPPO (European and Mediterranean Plant Protection Organization), 2017. EPPO Global Database. Available online: https://gd.eppo.int

Haviland DR, Rill SM and Morse JG, 2009. Southern highbush blueberries are a new host for *Scirtothrips citri* (Thysanoptera: Thripidae) in California. Florida Entomologist, 92, 147–149.

Haviland DR. 2014. University of California Pest Management Guidelines. Blueberry. Citrus thrips. Available online: http://ipm.ucanr.edu/PMG/r57300111.html [Accessed: 13 December 2017]
Lewis T, 1973. Thrips - their biology, ecology and economic importance. Academic Press, London. 349 pp.
Moreno DS, Gregory WA and Tanigoshi LK, 1984. Flight response of *Aphytis melinus* (Hymenoptera: Aphelinidae) and *Scirtothrips citri* (Thysanoptera: Thripidae) to trap color, size, and shape. Environmental Entomology, 13, 935–940.
Morse JG, 1995. Prospects for IPM of citrus thrips in California. In: Parker BL, Skinner M and Lewis T (eds.). Thrips biology and management, Proceedings of the 1993 International Conference on Thysanoptera: Towards understanding thrips management. September 28–30 1993, Burlington, Vermont. pp. 371–379.
Mound LA and Kibby G, 1998. Thysanoptera, an identification guide, 2nd Edition. CABI, Wallingford.
Parker BL, Skinner M and Lewis T (eds.)., 1995. Thrips biology and management, Proceedings of the 1993 International Conference on Thysanoptera: towards understanding thrips management. September 28–30 1993, Burlington, Vermont. Plenum, London.
Peel MC, Finlayson BL and McMahon TA, 2007. Updated world map of the Koppen-Geiger climate classification. Hydrology and Earth System Sciences, 11, 1633–1644.
Sharma DR, 2007. Activity and control of citrus thrips, *Scirtothrips citri* (Moulton) on kinnow. Agricultural Research Journal, 44, 59–62.
UC (University of California), 1991. Integrated Pest Management for Citrus. 2nd Edition. University of California. Statewide Integrated Pest Management Project. Division of Agriculture and Natural Resources. Publication 3303. Oakland, CA (USA), 144 pp.

7.3.A.8.	Citrus rust mite, *Phyllocoptruta oleivora*

7.3.A.8.1. Hazard identification

Preferred Common names: Citrus rust mite
Scientific name: *Phyllocoptruta oleivora* (Ashmead)

Synonyms: *Eriophyes oleivorus*
Phyllocoptes oleivorus
Phyllocoptrata oleivorus
Typhlodromus oleivorus

Taxonomic tree
Domain: Eukaryota
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Chelicerata
Class: Arachnida
Family: Eriophyidae
Genus: *Phyllocoptruta*
Species: *Phyllocoptruta oleivora*

EPPO Code: PHYUOL.

7.3.A.8.2. Biology

The citrus rust mite is yellow, fusiform, dorsally flattened, and very little (approximately 0.15 mm long). Over the course of her 20-day existence, a female lays 20 to 30 eggs. The semi-translucent, smooth, spherical eggs are placed in clusters in divots on the ventral surfaces of leaves and fruits. Nymphal development takes 2 to 11 days to finish after the egg period of 3 days. In the summer, the life cycle lasts 7 to 10 days, but it takes 14 days in the winter (Qureshi and Stansly, 2019).

7.3.A.8.3. Hosts

Phyllocoptruta oleivora is found on all varieties of citrus (Rutaceae). It also feeds on other rutaceous hosts such as tabog, *Swinglea glutinosa* (Blanco) Merr, and kumquats, *Fortunella* spp. (Vacante and Gerson 2012).

7.3.A.8.4. Distribution

Phyllocoptruta oleivora is thought to have originated in Southeast Asia. It is a tropical species present in all citrus growing areas of the world where humidity is high. Regions where the mite represents a major pest of citrus include the Middle East (Georgia, Israel, and Turkey), South Africa, Australia, USA, and southern Asia (Japan and China) (Tropea and Lillo 2018). In the USA, *Phyllocoptruta oleivora* is found throughout Florida and on the Coastal Intermediate region of California (Hoy 2011).

Africa: Egypt (EPPO 2022).

Asia: China, India, Thailand, Philippines, Malaysia, Vietnam, Japan (EPPO 2022).

North America: USA, Mexico (EPPO 2022).

South America: Argentina, Brazil (EPPO 2022).

Oceania: Australia, New Zealand (EPPO 2022).

Europe: Italy (EPPO 2022).

7.3.A.8.5. Hazard identification conclusion

Considering the facts that *P. oleivora* -

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of *Citrus* plants.
- It is a serious pest of China, India, Thailand, USA, Egypt, Australia and Brazil from where a large number of citruses are imported to Bangladesh.
- The major risk is from the importation of infested plant parts by human.
- It can establish in Bangladesh through imports of the fruits and plant materials. It has capability to cause direct and indirect economic and ecological damage to citrus.
- *P. oleivora* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.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? - No **b. Possibility of survival of this pest during transport, storage and transfer? – No**	**Yes and Moderate**

• There is no data about the survival of this pest during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes** • *P. oleivora* can enter Bangladesh through citrus plant materials including fruits and leaves. Although it exists in India, there is another natural route (by wind) for people to enter Bangladesh from the surrounding nations. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *Citrus* spp. is the main hosts of *P. oleivora*. Here the host plant is well distributed in Bangladesh. So, there will be highly possibility to establish this pathogen in Bangladesh. • 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

7.3.A.8.7. Determine the <u>Consequence</u> 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. • It is a major pest of **Citrus**. Therefore, it is a high risk, if fruits and plant material are imported from Australia, China, India, USA, Egypt, Brazil, there is possibility to establish the pest in Bangladesh. **b. Economic Impact and Yield Loss** • It can reduce size, weight and quality of fruit, juice content, and increase fruit drop. • In many other countries across the world, including Argentina, Australia, China, Egypt, and the United States, *P. oleivora* has been identified as a severe citrus pest. In fact, it is now present in the mostcitrus-growing regions worldwide. Numerous studies have been conducted on infestation and damage (Yang *et al.*, 1994). **c. Environmental Impact** • Using of synthetic miticide to control *P. oleivora* is harmful for 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

7.3.A.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 – High

7.3.A.8.9. Risk Management Measures

Successful natural enemies against *P. oleivora* include *Amblyseius victoriensis*, *Hirsutella thompsonii*, *Tydeus* sp., *Agistemus exsertus*, etc. (CABI, 2021). To avoid conditions of water stress and the ensuing flare-up, water wisely, especially during the summer. Spray 1000–1500 litres of water per hectare with monocrotophos 36 SL 1.5 L or dicofol 18.5 EC 1.0 L.

7.3.A.8.10. References

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

EPPO, 2022. EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Hoy MA. 2011. Agricultural Acarology: Introduction to Integrated Mite Management. CRC Press, Boca Raton, Florida, 430.

Qureshi, J.A. and Stansly, P.A. (2019). Rust mites, spider mites, and other phytophagous mites. ENY-603. https://edis.ifas.ufl.edu/cg002. Accessed 8 Nov 2019.

Tropea, G.G. and Lillo, D.E. (2018). Geographic distribution of *Phyllocoptruta oleivora* in the Mediterranean Basin, with particular emphasis on Italy. Systematic and Applied Acarology 23: 1021-1023.

Vacante, V. and Gerson, U. (2012). Acari, pp. 88–108. **In:** Vacante V, and Gerson U. Integrated control of citrus pests in the Mediterranean region. Bentham Science Publishers, Sharjah, UAE.

Yang, Y., Allen, J.C., Knapp, J.L. and Stansly, P.A. (1994). Citrus rust mite (Acari: Eriophyidae) damage effects on 'Hamlin' orange fruit growth and drop. Environmental Entomology, 23(2):244-247.

7.3.A.9.	Citrus bud mite, *Aceria sheldoni*

7.3.A.9.1. Hazard identification

Preferred Common names: Citrus bud mite
Scientific name: *Aceria sheldoni* (Ashmead)

Synonyms: *Eriophyes sheldoni*

Taxonomic tree

Domain: Eukaryota
Kingdom: Animalia

Phylum: Arthropoda
Subphylum: Chelicerata
Class: Arachnida
Family: Eriophyidae
Genus: *Aceria*
Species: *Aceria sheldoni*

EPPO Code: ACEISH. It is listed as A1 pest in Bahrain, Uzbekistan, Georgia and Canada in 2003, 2008, 2018 and 1992, respectively. Egypt listed this pest as A2 listed pest in 2018.

7.3.A.9.2. Biology

The citrus bud mite is a tiny, yellowish, or pinkish insect that can grow up to 0.16 mm in length. The 50 eggs that a female can lay will hatch in 2 to 5 days. Although it is active all year round, each generation can last up to 10 days in the summer and up to 20 days in the winter. Before attaining adulthood, the animal goes through four pre-imaginal instars.

7.3.A.9.3. Hosts

Citrus spp. is the main hosts of *A. sheldoni* (EPPO, 2022).

7.3.A.9.4. Distribution

Africa: Egypt, South Africa (EPPO 2022).
Asia: India, Indonesia, Saudi Arabia (EPPO 2022).
North America: USA (EPPO 2022).
South America: Argentina, Brazil (EPPO 2022).
Oceania: Australia, New Zealand (EPPO 2022).
Europe: Italy, Greece, Spain (EPPO 2022).

7.3.A.9.5. Hazard identification conclusion

Considering the facts that *A. sheldoni* -

- is not known to be present in Bangladesh (EPPO 2022).
- potentially economic important to Bangladesh because it is an important pest of *Citrus* plants.
- It is a serious pest of India, USA, Egypt, South Africa,Australia and Brazil from where large number of citruses are imported to Bangladesh.
- The major risk is from the importation of infested plant parts by human.
- It can establish in Bangladesh through imports of the fruits and plant materials. It has capability to cause direct and indirect economic and ecological damage to citrus.
- *A. sheldoni* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.9.6. Determine <u>likelihood of pest establishing</u> in Bangladesh via this pathway

Table 7.9.1 – 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	**Yes and**

b. Possibility of survival of this pest during transport, storage, and transfer? – No • There is no data about the survival of this pest during transport, storage and transfer. Mostly it can dispersal through wind (CABI, 2021). **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes** • *A. sheldoni* can be entered into Bangladesh through the fruits and plant parts of infected citrus. Another pathway is natural (by wind) to enter Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *Citrus* spp. is the main hosts of *A. sheldoni*. Here the host plant is well distributed in Bangladesh. So, there will be highly possibility to establish this pathogen in Bangladesh. • The climate of Bangladesh is similar to places it is established.	**Moderate**
• 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

7.3.A.9.7. Determine the <u>Consequence</u> 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. • It is a major pest of **Citrus**. Therefore, it is a high risk, if fruits and plant material are imported from Australia, China, South Africa, USA, Egypt, Brazil, there is possibility to establish the pest in Bangladesh. **b. Economic Impact and Yield Loss** • It can reduce size, weight and quality of fruit, juice content, and increase fruit drop (CABI, 2021). **c. Environmental Impact** • Using of synthetic miticide to control *A. sheldoni* is harmful for 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

7.3.A.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

7.3.A.9.9. Risk Management Measures

Narrow-range oil is applied annually to control citrus bud mite numbers (Hare *et al.*, 1999). Numerous predatory mites have been linked to the citrus bud mite, but because they are shielded inside the buds, none seem to have an impact on the pest's populations or harm.

7.3.A.9.10. References

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Hare, J.D., Rakha, M. and Phillips, P.A. (1990). Citrus Bud Mite (Acari: Eriophyidae): an Economic Pest of California Lemons? Journal of Economic Entomology, Volume 92, Issue 3, 1 June 1999, Pages 663–675.

7.3.A.10.	Lewis spider mite, *Eotetranychus lewisi*

7.3.A.10.1. Hazard identification

Preferred Common names: Lewis spider mite
Scientific name: *Eotetranychus lewisi* (McGregor)

Synonyms: *Tetranychus lewisi* (McGregor)

Taxonomic tree

Domain: Eukaryota
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Chelicerata
Order: Acarida
Class: Arachnida
Family: Tetranychidae
Genus: *Eotetranychus*
Species: *Eotetranychus lewisi*

EPPO Code: EOTELE. EPPO A1 list no. 205 and EU Annex designation II/A1.

7.3.A.10.2. Biology

The biology and life table of *E. lewisi* were assessed (19°C, 45% R.H., and 12:12 L.D.) under laboratory circumstances. Between 16.24 and 16.56 days, the mean immature phase (from egg to adult) duration did not significantly differ between the Blanco, Abridor and Tejón cultivars (Miño *et al.*, 2022).

E. lewisi has a five-stage life cycle, similar to other tetranychid species: egg, larva, protonymph, deutonymph, and adult. Citrus mites lay their eggs in depressions on the fruit's surface and feed on the growing fruit; they rarely harm the leaves. According to estimates using the Lactin and linear models, *E. lewisi*'s lower development temperature threshold from egg to adult is 8.3 or 9.0°C, respectively. The same authors state that 28.2°C is the upper development threshold. Deutonymphs are the stage that can withstand cold temperatures the best, with estimated thresholds of 2.5 or 3.4°C, respectively. The protonymph stage is the most heat-tolerant, with a higher growth threshold of 31.5°C. On poinsettia leaves, development from egg to adult takes 19 days at 16°C and falls linearly with temperature to at least eight days at 26°C. The larval, protonymphal, and deutonymphal stages persisted for 1.8, 1.4, and 2.3 days, respectively, at 26°C, while egg hatching took an average of 2.5 days. The time between egg deposition and female emergence when *E. lewisi* was raised on delicate lemon leaves at temperatures ranging from 17 to 23°C was twelve days. The average time between each step was six days for egg incubation, two days for the larval stage, two days for the protonymph stage, and a further two days for the deutonymph stage. Male development was two days shorter than female development. According to Ahmed *et al.* (2014), the male citrus tree's life cycle from egg to adult lasts an average of 12 days, whereas the female's cycle lasts 14.5 days.

7.3.A.10.3. Hosts

About 69 herbaceous and woody plant species from 26 distinct families of plants have been found to harbour *E. lewisi*. Castor oil plant, poinsettia, strawberry, cotton, orange, fig, lemon, papaya, olive, peach, and vine are cultivated plants that could serve as hosts. Weeds like nightshade and several tree species, like acacias, pines, and aspens, are examples of wild hosts.

7.3.A.10.4. Distribution

Africa: South Africa (Vacante, 2010).

Asia: Iran, Japan, Philippines (Beyzavi *et al.*, 2013).

North America: Mexico, USA (Baker and Tuttle, 1994).

7.3.A.10.5. Hazard identification conclusion

Considering the facts that *E. lewisi* -

- is not known to be present in Bangladesh (EPPO, 2022).
- potentially economic important to Bangladesh because it is an important pest of *Citrus* plants. And among the alternative hosts of *E. lewisi* cotton, strawberry, orange, papaya, olive, peach etc. are also well distributed in Bangladesh.
- It is a serious pest of South Africa and USA from where large number of citruses are imported to Bangladesh.
- The major risk is from the importation of infested plant parts by human.
- It can establish in Bangladesh through imports of the fruits and plant materials. It has capability to cause direct and indirect economic and ecological damage to citrus.
- *E. lewisi* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.A.10.6. Determine likelihood of pest establishing in Bangladesh via this pathway

Table 7.3.A.10.1 – Which of these descriptions best fit of this pest?

<table>
<tr><th>Description</th><th>Establishment Potential</th></tr>
<tr><td>a. Has this pest been established in several new countries in recent years? - No
• There was no data about this.
b. Possibility of survival of this pest during transport, storage and transfer? – Yes
• Mite can survive up to about 19 days under the calyx of fruit at the time of transportation, storage and transfer.
c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes
• E. lewisi can be entered into Bangladesh through the fruits and plant parts of infected citrus. Another pathway is natural (by wind) to enter into Bangladesh.
d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes
• Citrus spp. is the main hosts of E. lewisi. Here the host plant is well distributed in Bangladesh. So, there will be highly possibility to establish this pathogen in Bangladesh.
• The climate of Bangladesh is similar to places it is established.</td><td>Yes and Moderate</td></tr>
<tr><td>• Not as above or below</td><td>Moderate</td></tr>
<tr><td>• This pest has not established in new countries in recent years, and
• The pathway does not 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</td><td>Low</td></tr>
</table>

7.3.A.10.7. Determine the Consequence establishment of this pest in Bangladesh-

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

<table>
<tr><th>Description</th><th>Consequence potential</th></tr>
<tr><td>a. Is this a serious pest of Bangladesh? - Yes.
• It is a major pest of Citrus. Therefore, it is a high risk, if fruits and plant material are imported from South Africa and USA, there is possibility to establish the pest in Bangladesh.
b. Economic Impact and Yield Loss
• It can reduce size, weight and quality of fruit, juice content, and increase fruit drop (CABI, 2021).
c. Environmental Impact
• Using of synthetic miticide to control E. lewisi is harmful for soil and environment.</td><td>Yes and Moderate</td></tr>
</table>

• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.A.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

7.3.A.10.9. Risk Management Measures

Citrus bud mite populations are controlled with yearly applications of narrow-range oil (Hare *et al.*, 1999). Numerous predatory mites have been linked to the citrus bud mite, but because they are shielded inside the buds, none seem to have an impact on the pest's populations or harm. Immersion in hot water is helpful against *E. lewisi*.

7.3.A.10.10. References

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T. and Ahmed, S. (2014). Pest Risk Analysis (PRA) of Citrus under Strengthening Phytosanitary Capacity in Bangladesh Project (SPCB), DAE, Strengthening Phytosanitary Capacity in Bangladesh Project, Department of Agricultural Extension, Kharmarbhari, Farmgate, Dhaka-1215.

Baker, E.W. and Tuttle, D.M. (1994). **In:** A guide to the spider mites (Tetranychidae) of the United States, pp. 171-172. Indira Publishing House, West Bloomfield, USA.

Beyzavi, G., Ueckermann, E.A., Faraji, F. and Ostovan, H. (2013). A catalog of Iranian prostigmatic mites of superfamilies Raphignathoidea & Tetranychoidea (Acari). Persian Journal of Acarology, 2: 389-474.

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Hare, J.D., Rakha, M. and Phillips, P.A. (1990). Citrus Bud Mite (Acari: Eriophyidae): an Economic Pest of California Lemons? Journal of Economic Entomology, Volume 92, Issue 3, 1 June 1999, Pages 663–675.

Miño, C., Santana, R., León, O., Colmenárez, Y., Villa-Murillo, A. and Vásquez, C. (2022). Biology and life table of *Eotetranychus lewisi* (Acari: Tetranycidae) on Prunus persica cultivars from the Ecuadorian Andean region, International Journal of Acarology, 48:3, 275-278, DOI: 10.1080/01647954.2022.2060305

Vacante, V. (2010). Review of the phytophagous mites collected on citrus in the world. Acarologia 50(2), 221-241.

7.3.B. DISEASE CAUSING PATHOGEN: BACTERIA

7.3.B.11.	Citrus variegated chlorosis, *Xylella fastidiosa* subsp. *pauca*

7.3.B.11.1. Hazard identification

Preferred Common names: Citrus variegated chlorosis
Scientific name: *Xylella fastidiosa* subsp. *pauca*

Taxonomic tree
Domain: Eukaryota
Kingdom: Bacteria
Phylum: Proteobactria
Class: Gammaproteobacteria
Order: Xanthomonadales
Family: Xanthomonadaceae
Genus: *Xylella*
Species: *Xylella fastidiosa* subsp. *pauca*

EPPO Code: XYLEFP, Listed in EPPO A2 list and pest number is 166.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.3.B.11.2. Biology

A rod-shaped, xylem-limited, fastidious Gram-negative bacteria with rippling cell walls is known as *X. fastidiosa*. It is 0.1-0.5 1–5 m in size, strictly aerobic (microaerophilic), non-flagellate, and does not produce spores. In scanning and electron microscopy, thread-like strands (fimbriae) adhering to the polar ends of bacterial cells can be seen. These most likely play a role in bacterial adhesion and 'twitching' movement (Meng *et al.*, 2005).

7.3.B.11.3. Hosts

The current list of host plant species for *X. fastidiosa* includes 359 plant species (including hybrids) from 204 genera and 75 different botanical families, according to the European Food Safety Authority (2016).
According to Coletta-Filho *et al.* (2016), the main hosts are grapevine, almonds, lucerne, blackberries, peaches, plums, apricots, citrus, peaches, coffee, oak, elm, plane, mulberry, and olives.
The alternate hosts for the *X. fastidiosa* pathogen include maple, silk tree, pepper vine, wild oat, quick grass, bermuda grass, crab grass, Japanese millet, wild strawberry, ivy, and daylilies, among others (Olmo *et al.*, 2017).

7.3.B.11.4. Distribution

North America: Costa Rica, USA (EPPO 2022).

South America: Argentina, Brazil, Ecuador (Tolocka *et al.*, 2017).

Europe: France, Italy, Spain (EPPO 2022).

7.3.B.11.5. Hazard identification conclusion

Considering the facts that *X. fastidiosa* subsp. *pauca* -

- is not known to be present in Bangladesh (EPPO, 2022).

- potentially economic important to Bangladesh because it is an important pest of *Citrus*, peach, mulberry, blackberry and olive.
- It is not found at the countries from where large number of citruses are imported to Bangladesh.
- The major risk is from the importation of fruit containing hyphae/spores, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail.
- It cannot establish in Bangladesh through imports of the fruits. But it has capability to cause direct and indirect economic and ecological damage to citrus.
- *X. fastidiosa* subsp. *pauca* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.B.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? - Yes • In 2013, *X. fastidiosa* was discovered in Europe and seriously harmed Italian Puglian olive orchards. It was also found in a great deal of other host plants, mostly ornamentals. The bacterium was discovered in decorative plants on the island of Corsica in 2015. The *X. fastidiosa* subspecies that was found in France (subsp. *multiplex*) differed from that found in Italy (clustered in a clade that was most closely related to subsp. *pauca*) (Elbeaino *et al.*, 2014a). **b. Possibility of survival of this pest during transport, storage and transfer? – No** • On a local scale, *X. fastidiosa* is disseminated by its vectors. Additionally, vectors may be transported across international borders on grapevine, peach, or other plant fruits or plants. When grapefruit clusters were tested as a source of acquisition for feeding vectors, no transmission by an effective vector occurred (Purcell and Saunders, 1995). **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No** • Bangladesh does not import any plant materials from the countries where *X. fastidiosa* subsp. *pauca* present. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *Citrus* spp. is the main hosts of *X. fastidiosa* subsp. *pauca.* Where the host plant is well distributed in Bangladesh. So, there will be highly possibility to establish this pathogen in Bangladesh. • 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	

7.3.B.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? - No. • Though, it is an important pest of **Citrus** and grasses. But Bangladesh does not import any fruits and plant materials from the countries where this pest already present. **b. Economic Impact and Yield Loss** • In 2005, due to the infestation of *X. fastidiosa* subsp. *pauca* in citrus, it caused major losses in Brazil and Argentina. • By contrast, phony disease of peach does not kill trees or cause dieback, but it does significantly reduce the size and number of fruits. **c. Environmental Impact** • No ecological changes have been documented. • No quantitatively documented impacts on biodiversity have been reported (European Food Safety Authority, 2015).	**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

7.3.B.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 – Low

7.3.B.11.9. Risk Management Measures

It should be forbidden or strongly limited to import citrus fruits and plant materials from nations where *X. fastidiosa* subsp. *pauca* is present. If imported planting material is used, it must be kept in post-entry quarantine for two years and proven to be pest-free. Vector-free plants and fruits should be imported, maybe with the help of a suitable treatment. According to Goheen *et al.* (1973), a temperature treatment that kills the bacteria (45°C for at least 3 hours) may be useful as a phytosanitary measure.

7.3.B.11.10. References

Coletta-Filho, H.D., Francisco, C.S., Lopes, J.R.S., Oliveira, A.F. and Silva, L.F.O. (2016). First report of olive leaf scorch in Brazil, associated with *Xylella fastidiosa* subsp. *pauca*. Phytopathologia Mediterranea, 55(1):130-135.

Elbeaino, T., Valentini, F., Kubaa, R.A., Moubarak, P., Yaseen, T. and Digiaro, M. (2014). Multilocus sequence typing of *Xylella fastidiosa* isolated from olive affected by "olive quick decline syndrome" in Italy. Phytopathologia Mediterranea, 53(3):533-542.

EPPO, 2022. EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

European Food Safety Authority. (2015). Scientific opinion on the risks to plant health posed by *Xylella fastidiosa* in the EU territory, with the identification and evaluation of risk reduction options. EFSA Journal, 13(1):3989. http://www.efsa.europa.eu/en/efsajournal/doc/3989.pdf

European Food Safety Authority. (2016). Update of a database of host plants of *Xylella fastidiosa*: 20 November 2015. EFSA Journal, 14(2):4378. http://www.efsa.europa.eu/en/efsajournal/pub/4378

Goheen, A.C., Nyland, G. and Lowe, S.K. (1973). Association of a rickettsia like organism with Pierce's disease of grapevines and alfalfa dwarf and heat therapy of the disease in grapevines. Phytopathology, 63(3):341-345.

Meng, Y.Z., Li, Y.X. and Galvani, C.D. (2005). Upstream migration of *Xylella fastidiosa* via pilus-driven twitching motility. Journal of Bacteriology, 187:5560-5567.

Olmo, D., Nieto, A., Adrover, F., Urbano, A., Beidas, O., Juan, A., Marco-Noales, E., López, M. M., Navarro, I., Monterde, A., Montes-Borrego, M., Navas-Cortés, J.A. and Landa, B.B., 2017. First detection of *Xylella fastidiosa* infecting cherry (*Prunus avium*) and Polygala myrtifolia plants, in Mallorca Island, Spain.Plant Disease, 101(10) 1820.

Purcell, A.H. and Saunders, S. (1995). Harvested grape clusters as inoculum for Pierce's disease. Plant Disease, 79(2):190-192.

Tolocka, P.A., Mattio, M.F., Paccioretti, M.A., Otero, M.L., Roca, M.E., Guzman, F.A. and Haelterman, R.M. (2017). *Xylella fastidiosa* subsp. *pauca* ST69 in olive in Argentina. Journal of Plant Pathology. 99 (3), 803.

7.3.B.12.	Stubborn disease of citrus, *Spiroplasma citri*

7.3.B.12.1. Hazard identification

Preferred Common names: Stubborn disease of citrus
Scientific name: *Spiroplasma citri* (Saglio *et al.*, 1973)

Taxonomic tree
Domain: Eukaryota
Kingdom: Bacteria
Phylum: Mycoplasmatota
Class: Mollicutes
Order: Mycoplasmatales
Family: Xanthomonadaceae
Genus: *Spiroplasma*
Species: *Spiroplasma citri*

EPPO Code: SPIRCI, EU annex designation: II/A2.

Bangladesh status: Not present in Bangladesh [EPPO 2022]

7.3.B.12.2. Biology

In citrus, spiroplasm grows best in hot temperatures (28–32°C) and may not manifest any obvious symptoms in lower temps. Annual plants that have been infected experimentally are quickly killed at temperatures exceeding 30°C, although they might not exhibit symptoms at lower temperatures as well (Oldfield, 1988).

S. citri creates pleomorphic cells without walls that have the distinctive spiral shape. Helixes can be made with a minimum feasible length of 2.0 x 0.1–0.2 m. The helices can move by rotating or flexing. Some strains lack both motility and helicity. One of the extremely rare plant pathogenic mollicutes that have been cultured is *S. citri*. For further information on biochemical assays, cultured behaviour, and morphology, see Bradbury (1991).

7.3.B.12.3. Hosts

The primary hosts for this bacterium are *Citrus* spp. and horse radish (Alar *et al.*, 2020; Mello *et al.*, 2008). There are various alternate hosts, such as Johnson grass, foxglove, cruciferous crops, amaranthus, and wild radish (Sertkaya, 2002). In addition, according to Nejat *et al.* (2011), *S. citri* inhabits or is connected with a number of host plants, including zinnia, horned violet, sesame, radish, European pear, peach, sweet cherry, rice, turnip, Chinese cabbage, cabbage, cauliflower, black mustard, etc.

7.3.B.12.4. Distribution

Africa: Egypt, Libya, Morocco, Sudan (CABI, 2021).

Asia: Israel, Malaysia, Oman, Pakistan, Saudi Arabia, United Arab Emirates (CABI, 2021)

North America: USA, Mexico (CABI, 2021).

Europe: France, Italy, Spain, Turkey (CABI, 2021).

Oceania: New Zealand (CABI, 2021).

7.3.B.12.5. Hazard identification conclusion

Considering the facts that *S. citri* -

- is not known to be present in Bangladesh (EPPO, 2022).
- potentially economic important to Bangladesh because it is an important pest of *Citrus*. It can survive in radish, cabbage, cauliflower, rice, mustard, sesame, zinnia, sweet cherry etc.
- It is found at the countries (Egypt, USA and Pakistan) from where a large number of citruses are imported to Bangladesh.
- The theoretical possibility exists that infective vectors may be carried on citrus plants, the insects concerned are actively mobile and do not preferentially feed on citrus, so the risk seems minor.
- It can establish in Bangladesh through imports of the fruits and plant materials. And it has capability to cause direct and indirect economic and ecological damage to citrus.
- *S. citri* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.B.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	Establish ment 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? – No** • Natural transmission by leafhoppers will carry *S. citri* over local distances. International spread would be more likely to occur in infected budwood. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes** • Bangladesh imported citrus fruits and plant materials from the countries (Egypt, USA and Pakistan) where *S. citri* present. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *S. citri*'s primary hosts are *Citrus* spp. In addition, *S. citri* has other related hosts that are widely cultivated in Bangladesh, including zinnia, sesame, radish, European pear, peach, sweet cherry, rice, turnip, Chinese cabbage, cabbage, cauliflower, and black mustard. Therefore, there is a good chance that this virus will spread to Bangladesh. • 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 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

7.3.B.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? - Yes. • Nevertheless, it is a significant citrus pest. Agricultural crops (rice, mustard, cabbage, cauliflower, radish, sesame, sweet cherry, etc.) that were commonly grown in Bangladesh are among its large variety of related hosts. Therefore, if the insect enters Bangladesh, it will pose a significant pest problem for Bangladesh.	**Yes and High**

b. Economic Impact and Yield Loss • Citrus is susceptible to the dangerous disease Stubborn, which can significantly lower the yield's quality and quantity in hot, dry weather. • The principal hosts in California (USA) are orange, grapefruit, and tangelo trees, with an estimated 5–10% of trees being afflicted. • Although *S. citri* naturally infects a variety of other hosts, these do not appear to be affected economically. Their primary importance would be as *S. citri* reservoirs for citrus infection. The brittle root of horseradish is only anecdotally interesting (EPPO, 2022). **c. Environmental Impact** • No ecological changes have been documented.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.B.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 – High

7.3.B.12.9. Risk Management Measures

Citrus fruits and plant materials from nations with *S. citri* should not be imported or should only be imported with rigorous restrictions. The only feasible way to prevent reinfection during the early years of orchard development is to produce healthy budwood. In the vicinity of orchards, trap plants should be planted (Gumpf, 1988).

7.3.B.12.10. References

Bradbury, J.F. (1991). *Spiroplasma citri*. CMI Descriptions of Fungi and Bacteria, No. 1046. Wallingford, UK: CAB International.

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

Çağlar, B.K., Satar, G., Baloğlu, S., Drais, M.I., Djelouah, K. (2020). Detection of *Spiroplasma citri* from citrus trees in Turkey by molecular techniques. Mediterranean Agricultural Sciences, 33(1) 37-42.

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/
Gumpf, D.J. (1988). Stubborn diseases of citrus caused by *Spiroplasma citri*. **In:** Maramorosch K, Raychaudhuri SP, eds. Mycoplasma Diseases of Crops. Basic and Applied Aspects. New York, USA: Springer-Verlag, 327-342.
Mello, A.F.S., Yokomi, R.K., Melcher, U., Chen, J.C.C. and Fletcher, J. (2010). Citrus stubborn severity is associated with *Spiroplasma citri* titer but not with bacterial genotype. Plant Disease, 94(1) 75-82.
Nejat, N., Vadamalai, G., Sijam, K. and Dickinson, M. (2011). First report of *Spiroplasma citri* (-induced) associated with periwinkle lethal yellows in Southeast Asia. Plant Disease, 95(10):1312. http://apsjournals.apsnet.org/loi/pdis
Oldfield, G.N. (1988). Ecological associations of *Spiroplasma citri* with insects, plants and other plant mycoplasmas in the western United States. **In:** Maramorosch K, Raychaudhuri SP, eds. Mycoplasma Diseases of Crops. Basic and Applied Aspects. New York, USA: Springer-Verlag, 175-191.
Saglio, P., L'Hospital, M., LaflFche, D., Dupont, G., Bové, J.M., Tully, J.G. and Freundt, E.A. (1973). *Spiroplasma citri* gen. and sp. n.: a mycoplasma-like organism associated with stubborn disease of citrus. International Journal of Systematic Bacteriology, 23:191-204.
Sertkaya, G. (2002). Johnsongrass (*Sorghum halepense* (L.) Pers.) as a host of citrus stubborn diseases (*Spiroplasma citri* Saglio *et al.*) in the Eastern Mediterranean Region of Turkey. **In:** Proceedings of the 12th EWRS Symposium Wageningen 2002, Papendal, Arnhem, The Netherlands, 24-27 June 2002, [ed. by Laar, H. H. van der]. Doorwerth, Netherlands: European Weed Research Society. 66-67.

7.3.C. DISEASE CAUSING PATHOGEN: VIRUS

7.3.C.13.	Citrus exocortis virus, *Citrus exocortis viroid*

7.3.C.13.1. Hazard identification

Preferred Common names: Citrus exocortis virus
Scientific name: *Citrus exocortis viroid*

Taxonomic tree
Domain: Eukaryota
Kingdom: Viruses and viroids
Category: Viroids
Family: Pospiviroidae
Genus: *Pospiviroid*
Species: *Citrus exocortis viroid*

EPPO Code: CEVD00. Bahrain, Jordan and United Kingdom were listed this pest in their A1 list in 2003, 2013 and 2020, respectively. Argentina and IAPSC were listed this pest in their A2 list in 2019 and 1989, respectively. Mexico listed as quarantine pest in 2018 and Switzerland listed as regulated non-quarantine pest in 2019 (EPPO, 2022).

Bangladesh status: Not present in Bangladesh [EPPO, 2022]

7.3.C.13.2. Biology

Citrus exocortis viroid is transmitted through seed and propagative materials of plants (Singh *et al.*, 2009).

7.3.C.13.3. Hosts

Citrus spp. is the main host for this virous (Dang *et al.*, 2021). There are some alternative hosts which includes- turnip rape, jessamine, carrot, tomato, potato, French marigold, grapevine etc. (Shu *et al.*, 2010).

7.3.C.13.4. Distribution

Africa: Egypt, Libya, Morocco, Sudan, South Africa (CABI, 2021).

Asia: Israel, Malaysia, Oman, Pakistan, India, Saudi Arabia, United Arab Emirates, Turkey, China, Thailand, Indonesia, Philippines, Japan (CABI, 2021)

North America: USA, Mexico, Cabnada (CABI, 2021).

South America: Argentina, Brazil, Chile (CABI, 2021).

Europe: France, Italy, Spain, Germany, Netherlands, Greece (CABI, 2021).

Oceania: Australia, New Zealand (CABI, 2021).

7.3.C.13.5. Hazard identification conclusion

Considering the facts that Citrus exocortis virus -

- is not known to be present in Bangladesh (CABI, 2021).
- potentially economic important to Bangladesh because it is an important pest of *Citrus*. It can survive in tomato, potato, turnip rape, jessamine, carrot etc.
- It is found at the countries (Brazil, China, India, Egypt, South Africa, Thailand, Australia, USA and Pakistan) from where a large number of citruses are imported to Bangladesh.
- This virus is transmitted through seeds and propagating materials so there will be possibility to enter into Bangladesh at the time of citrus fruit import.
- It can establish in Bangladesh through imports of the fruits and plant materials. And it has capability to cause direct and indirect economic damage to citrus.
- Citrus exocortis virus is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.C.13.6. Determine <u>likelihood of pest establishing</u> in Bangladesh via this pathway

Table 7.13.1 – 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** • Citrus exocortis virus can survival into the seed of citrus at the time of transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes**	**Yes and Moderate**

• Bangladesh imported citrus fruits and plant materials from the countries (Brazil, China, India, Egypt, South Africa, Thailand, Australia, USA and Pakistan) where Citrus exocortis virus present. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • The primary hosts of the Citrus exocortis virus include *Citrus* spp. In addition, Bangladesh has a good distribution of the alternate related hosts (tomato, potato, turnip rape, jessamine, carrot, etc.) of the Citrus exocortis virus. Therefore, there is a good chance that this virus will spread to Bangladesh. • 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

7.3.C.13.7. Determine the <u>Consequence</u> 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. • Though, it is an important pest of **Citrus**. And its associated host range is wide including agricultural crops (tomato, potato, turnip rape, jessamine, carrot etc.) which were widely present in Bangladesh. So, if the pest inserts into Bangladesh, then it will be the serious pest for Bangladesh. **b. Economic Impact and Yield Loss** • In Belize, CEV-infected budwood was brought into the country and propagated on Carrizo citrange rootstock, which is susceptible to CEV. • The costs of maintaining a block planted with CEV-infected budwood and a grove planted with the same variety on Carrizo citrange rootstock under the same owner/management system were then compared. 225 trees were planted per hectare in each of the blocks. In comparison to the block propagated with viroid-free budwood, the block created with CEV-infected budwood had a total loss of US$ 5147 per hectare after 8 years (Roistacher *et al.*, 1997). **c. Environmental Impact** • No ecological changes have been documented.	**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

7.3.C.13.8. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.13.3 – 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

7.3.C.13.9. Risk Management Measures

As long as CEV is designated as a target graft transmissible disease to be eradicated from mother trees, clean stock and certification programmes effectively suppress viroids. It is important to take precautions to avoid spreading known CEV-contaminated bud sources onto vulnerable rootstocks. It is important to take precautions to sterilise equipment before trimming or cutting another plant since CEV can easily mechanically transmitted on infected knives and cutting tools. Cutting tools should be sterilised using sodium hypochlorite or similar sterilant that has been shown to successfully inactivate viroids. Only Poncirus trifoliata and hybrids made up of *P. trifoliata*, limes, lemons, and citrons are symptomatic hosts, even though other *Citrus* species are susceptible to CEV. To establish a trifoliate-type rootstock with tolerance for CEV, intergeneric somatic hybrids between red tangerine (*C. reticulata*) and *P. trifoliata* have been created in China (Guo *et al.*, 2002).

7.3.C.13.10. References

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

Dang, T., Huang, A., Bodaghi, S., Tan, S., Tian, T., Posis, K., McGuire, B., McRoberts, N. and Vidalakis, G. (2021). First report of citrus leaf blotch virus infecting bearss lime tree in California. Plant Disease. 104(11): 3088-3089.

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Guo, W.W., Cheng, Y.J. and Deng, X.X. (2002). Regeneration and molecular characterization of intergeneric somatic hybrids between *Citrus reticulata* and *Poncirus trifoliata*. Plant Cell Reports. 20(9):829-834.

Roistacher, C.N., Canton, H. and Reddy, P.S. (1997). The economics of living with citrus viroids in Belize. Proceedings of the 13th Conference International Organization of Citrus Virologists, 369-374.

Shu, J., Wang, G. P., Xu, W. X. and Hong, N. (2010). First report of Citrus exocortis viroid from grapevine in China. Plant Disease, 94(8) 1071.

Singh, R.P., Dilworth, A.D. and Ao, X. (2009). Citrus exocortis viroid transmission through commercially-distributed seeds of Impatiens and Verbena plants. Eur. J. Plant Pathol. 124: 691–694 (2009). https://doi.org/10.1007/s10658-009-9440-4

7.3.C.14.	**Indian citrus ringspot virus, *Indian citrus ringspot virus***

7.3.C.14.1. Hazard identification

Preferred Common names: Indian citrus ringspot virus
Scientific name: *Indian citrus ringspot virus*

Taxonomic tree
Domain: Virus
Group: Positive sense ssRNA viruses
Group: RNA viruses
Order: Tymovirales
Family: Alphaflexiviridae
Genus: *Mandarivirus*
Species: *Indian citrus ringspot virus*

EPPO Code: ICRSV0. Argentina was listed this pest in their A1 list in 2019 and Mexico listed as quarantine pest in 2018 (EPPO, 2022).

Bangladesh status: Not present in Bangladesh [EPPO, 2022]

7.3.C.14.2. Biology

The virus comprises particles with cross banding that are about 650 nm 15 nm in size. A 34 kDa coat protein and 7560 nucleotides of single-stranded RNA are both present in the particles. The six open-reading frames (ORFs) in the genomic RNA are potential proteins that are 187.3, 25, 12, 6.4, 34, and 23 kDa in size, respectively. The function of ORF 6 is unknown, while ORFs 1, 2, 3, and 4 make up the triple-gene block and ORFs 5, 6, and 7 encode the capsid protein, respectively. Particles can be seen in the cytoplasm of parenchyma cells in thin leaf sections (Rustici *et al.*, 2000, 2002).

7.3.C.14.3. Hosts

Citrus spp. is the main host for this virous (Rustici *et al.*, 2000).

7.3.C.14.4. Distribution

Asia: India, Pakistan (CABI, 2021)

7.3.C.14.5. Hazard identification conclusion

Considering the facts that Indian citrus ringspot virus -

- is not known to be present in Bangladesh (CABI, 2021).
- potentially economic important to Bangladesh because it is an important pest of *Citrus*.
- It is found in India and Pakistan from where a large number of citruses are imported to Bangladesh.
- This virus is transmitted through seeds and propagating materials so there will be possibility to enter into Bangladesh at the time of citrus fruit import.
- It can establish in Bangladesh through imports of the fruits and plant materials. And it has capability to cause direct and indirect economic damage to citrus.
- Indian citrus ringspot virus is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.3.C.14.6. 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. 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** • Citrus exocortis virus can survival into the seed of citrus at the time of transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes** • Bangladesh imported citrus fruits and plant materials from India and Pakistan where Indian citrus ringspot virus present. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *Citrus* spp. is the main hosts of Indian citrus ringspot virus. So, there will be highly possibility to establish this pathogen in Bangladesh. • 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 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

7.3.C.14.7. 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. • Though, it is an important pest of **Citrus**. And the required climate is same for growth of this pest as it is established in neighboring countries like India and Pakistan. So, if the pest inserts into Bangladesh, then it will be the serious pest for Bangladesh. **b. Economic Impact and Yield Loss** • The number and weight of Kinnow mandarin (*Citrus nobilis* x *Citrus deliciosa*) plant fruits were reduced by 45 and 55%, respectively, after ICRSV infection. Fruit width, weight, length, granulation index, and juice content all decreased by 11.59, 13.75, 38.88, 22.00, and 15.25%, respectively, while shape index, peel, rag, and peel thickness all increased by 2.32, 10.23, 32.41, and 50%, respectively. According to Lore *et al.*	**Yes and High**

(2001), infected fruits had lower levels of total soluble solids (12.96%), ascorbic acid (9.09%), and reducing sugars (10.90%) but higher levels of acidity (56.69%). **c. Environmental Impact** • No ecological changes have been documented.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.3.C.14.8. Calculating the Risk of this Pest via this pathway for Bangladesh

Establishment Potential X Consequence Potential = Risk

Table 7.14.3 – 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

7.3.C.14.9. Risk Management Measures

By subjecting infected Kinnow mandarin (*Citrus nobilis* x *Citrus deliciosa*) bud-sticks to dry heat for 30 minutes or more at 50°C or for 120 minutes at 45°C, the virus was destroyed. For the effective and efficient control of ICRSV, the creation, multiplication, and distribution of such virus-free plants are advised (Singh *et al.*, 2006).

7.3.C.14.10. References

CABI. (2021). Crop Production Compendium. *Spiroplasma citri*. https://www.cabi.org/cpc/datasheet/50977

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

Lore, J.S., Cheema, S.S. and Thind, S.K. (2001). Effect of citrus ring spot disease on yield and fruit quality of Kinnow. Journal of Research, Punjab Agricultural University, 38(1/2):23-26.

Rustici, G., Accotto, G.P., Noris, E., Masenga, V., Luisoni, E. and Milne, R.G. (2000). Indian citrus ringspot virus: a proposed new species with some affinities to potex-, carla-, fovea- and allexiviruses. Archives of Virology, 145(9):1895-1908.

Rustici, G., Milne, R.G. and Accotto, G.P. (2002). Nucleotide sequence, genome organisation and phylogenetic analysis of Indian citrus ringspot virus. Archives of Virology, 147(11):2215-2224

Singh, B., Sharma, S., Rani, G., Zaidi, A.A., Hallan, V., Virk, G.S. and Nagpal, A. (2006). In vitro production of Indian citrus ringspot virus-free plants of Kinnow mandarin (*Citrus nobilis* Lour × *C. deliciosa* Tenora) by nucellar embryo culture. Plant Pathology Journal (Faisalabad), 5(3):274-282.

7.D. 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 citrus pathway to Bangladesh from Bhutan, India, China, Brazil, Egypt, Pakistan, South Africa, USA, Thailand, Myanmar, Australia and other exporting countries, out 15 potential hazard organisms, 12 hazard organisms were identified with high-risk potential, 1 moderate and 1 low were identified with low-risk potential. Besides, 1 hazard organism was identified as uncertainly due to lack of information.

The overall pest risk potential ratings of 15 quarantine pests of citrus 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	Citrus longhorn beetle	*Anoplophora chinensis*	Cerambycidae	Coleoptera	High
2	Citrus weevil	*Diaprepes abbreviates*	Curculionidae	Coleoptera	High
3	African citrus psyllid	*Trioza erytreae*	Triozidae	Homoptera	High
4	Mediterranean fruit fly/Medfly	*Ceratitis capitate*	Tephritidae	Diptera	High
5	Queensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	High
6	South African citrus thrips	*Scirtothrips aurantia*	Thripidae	Thysanoptera	High
7	California Citrus thrips	*Scirtothrips citri*	Thripidae	Thysanoptera	High
Mite					
8	Citrus rust mite	*Phyllocoptruta oleivora*	Eriophyidae	Acarina	High
9	Citrus bud mite	*Aceria Sheldon*	Eriophyidae	Acarina	High
10	Lewis spider mite	*Eotetranychus lewisi*	Tetranychidae	Acarina	Moderate
Fungi					
11	Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales	Uncertain
Bacteria					
12	Citrus variegated chlorosis	*Xylella fastidiosa* subsp. *Pauca*	Xanthomonadaceae	Xanthomonadales	Low
13	Citrus stubborn	*Spiroplasma citri*	Mycoplasmataceae	Mycoplasmatales	High
Virus					
14	Citrus exocortis	*Citrus exocortis viroid*	Pospiviroidae	Incertae sedis	High
15	Indian citrus ringspot virus	*Indian citrus ringspot virus*	Alphaflexiviridae	Tymovirales	High

7.4. Uncertainty

The quarantine pest species those remain uncertainty as potential hazards due to lack of their detail information. Such uncertain species was Greasy spot (*Mycosphaerella citri*). 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.	Greasy spot	*Mycosphaerella citri*	Mycosphaerellaceae	Capnodiales

7.5. 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 citrus cultivation, the focus of this assessment lies on three significant pests: the citrus leaf miner, Citrus thrips and citrus canker. These pests, while not native to the region, have the potential to cause substantial harm to citrus 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 citrus 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.

7.5.1.	Citrus leaf miner, *Phyllocnistis citrella*

7.5.1.1 Hazard identification

Preferred Common names: Citrus leaf miner
Scientific name: *Phyllocnistis citrella* Stainton

Synonyms: *Lithocolletis citricola*
Phyllocnistis citricola Shiraki

Taxonomic tree

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

Order: Lepidoptera
Family: Gracillariidae
Genus: Phyllocnistis
Species: *Phyllocnistis citrella*

EPPO Code: PHYNCI.

Bangladesh status: Present in Bangladesh [EPPO 2022]

7.5.1.2. Biology

P. citrella larvae usually mine the under surface of a leaf, but attack both surfaces in heavy infestations, and occasionally fruit. The serpentine mine has a silvery appearance and reaches a length of 50-100 mm. Young leaves are attacked and mines can cause leaf curl. Up to 20 mines per leaf have been recorded on elephant lemon in India. There are four larval instars including a pre-pupal stage when the larva does not feed. Development time is 5-20 days. Pupation takes place within the mine, near the leaf margin, under a slight curl of the leaf. Pupation takes 6-22 days. *P. citrella* adults emerge at dawn and are active in the morning. They also fly at dusk and by night. Continuously brooded, up to 13 generations have been reported in a year in India and Egypt, 7 in a year in Tuscany, Italy.

7.5.1.3. Hosts

A list of reported and potential hosts is given by Heppner (1993). A pest of citrus, *P. citrella* also attacks other Rutaceae. *Citrus*, *Citrus aurantium* (sour orange), *Citrus sinensis* (sweet orange), *Citrus reticulata* (mandarin), Citrus medica (zara), *Citrus maxima* (pummelo), *Citrus limonia* (mandarin lime) are the main host of the insect.

7.5.1.4. Distribution

Originally an Asiatic species, *P. citrella* was discovered in Florida, USA, in 1993 and has since spread throughout the state. It was found in the Mediterranean basin in 1994 where it has since spread rapidly. It is also spreading in Central and South America and has been reported from southern Africa and West Africa.

In addition to the records on the map, *P. citrella* has been identified in Lebanon, Libya, Mozambique, Brazil and Colombia (J LaSalle, IIE, UK, personal communication, 1997). It has also been identified in Oman (T Pittaway, CABI, Wallingford, UK, personal communication, 1996) and Zimbabwe (DJL Agassiz, IIE, UK, personal communication, 1997).

Africa: Algeria; Egypt; Nigeria; South Africa; Tanzania (EPPO, 2022)

Asia: Bangladesh (UK, CAB International 1986); Bhutan, China; India; Indonesia; Japan, Malaysia; Myanmar; Nepal; Pakistan; Sri Lanka; Thailand; United Arab Emirates; Vietnam (EPPO, 2022)

Europe: Croatia, Cyprus, France, Greece, Spain, Sweden (UK, CAB International 1986)

North America: Mexico, United States (UK, CAB International 1986)

South America: Argentina, Brazil, Chile, Colombia, Peru (UK, CAB International 1986)

Oceania: Australia (UK, CAB International 1986)

7.5.1.5. Hazard identification conclusion

Considering the facts that *P. citrella* -

- is present in Bangladesh [UK, CAB International 1986]

- *P. citrella* is a major pest of citrus, found in virtually all major citrus-producing areas. Heavy infestations can hinder the growth of newly planted trees or reduce fruit production of mature trees. Larval feeding reduces the photosynthetic capacity of leaves and increases the susceptibility of leaves to citrus bacterial canker, *Xanthomonas axonopodis* pv. *citri* (Gottwald *et al.,* 2007; Hall *et al.,* 2010)
- *P. citrella* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.5.1.6. 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
a. Has this pest been established in several new countries in recent years? - Yes • The citrus leaf miner is native to eastern and southern Asia and is now widely distributed where citrus is grown in Asia, Papua New Guinea, Australia, northern and central Africa, and Florida in the United States of America. It has been linked to the severity of citrus canker (*Xanthomonas axonopodis* pv. *citri*), a serious disease of citrus. **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Larval development time is 5-20 days. Pupation takes 6-22 days. P. citrella adults emerge at dawn and are active in the morning. They also fly at dusk and by night. Continuously brooded, up to 13 generations have been reported in a year in India and Egypt, 7 in a year in Tuscany, Italy. • 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 planting materials containing adults. *P. citrella* has been intercepted in citrus fruits in international trade (USDA, 1988; SPC, 1989). **d. Are the host(s) of this fairly common in the importing countries and the climate is similar to places it is established? – Yes** • A pest of citrus, *P. citrella* also attacks other Rutaceae. *Citrus, Citrus aurantium (sour orange), Citrus sinensis (sweet orange), Citrus reticulata (mandarin), Citrus medica (zara), Citrus maxima (pummelo), Citrus limonia (mandarin lime)* are the main host of the insect.	**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	Low

• Its host(s) are not common in Bangladesh and climate is not similar to places it is established	

7.5.1.7. 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 **citrus**. 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** • *P. citrella* is a major pest of citrus, found in virtually all major citrus-producing areas. Heavy infestations can hinder the growth of newly planted trees or reduce fruit production of mature trees. Larval feeding reduces the photosynthetic capacity of leaves and increases the susceptibility of leaves to citrus bacterial canker, *Xanthomonas axonopodis* pv. *citri* (Gottwald *et al.*, 2007; Hall *et al.*, 2010) • Originating in the Far East, *P. citrella* spread rapidly to other citrus-growing areas during the 1990s. Damage to young trees can be severe and populations can increase dramatically under heavy pesticide regimes such as those currently practiced in Florida (USA) for control of a separate pest and vector of citrus greening disease, the Asian citrus psyllid *Diaphorina citri*. The location of larvae inside the mine protects the insects from most topical sprays. • Huang and Li (1989) considered the economic threshold of *P. citrella* to be 0.74 larvae per susceptible (tender) leaf. If the percentage of damaged area in susceptible leaves is below 20% there will be no negative impact on growth, development or yield of citrus fruit. However, a major concern of producers of high-quality fresh fruit for export markets is the increased susceptibility of leaves damaged by the leafminer to infection by citrus canker disease. Loss of access to international markets due to phytosanitary controls is a major economic impact related to leafminer damage. **c. Environmental Impact** • Wide range of insecticides were used against *P. citrella.* So, indiscriminate uses of these insecticide play negative impact on the environment. • Effectively controlling citrus leaf miner using chemicals is difficult because larvae are protected by their mines and pupae are protected by their pupal chambers. Insecticides, such as organophosphates, carbamates, and pyrethroids, also disrupt the activity of natural enemies. Such disruption can lead to outbreaks of other pests (e.g., scales and mites).	**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

7.5.1.8. 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

7.5.1.9. 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 the symptom. Zhang *et al.* (1994) outlined a programme using cultural practices, with the possibility of releasing parasitoids and predators when necessary, with carefully timed applications of Bacillus thuringiensis. Mating disruption should provide an excellent management option if the pheromone dispensers become widely available to growers, especially when combined with biological control and minimal chemical control.

7.5.1.10. References

Heppner JB, 1993. Citrus leafminer, *Phyllocnistis citrella*, in Florida (Lepidoptera: Gracillariidae: Phyllocnistinae). Tropical Lepidoptera, 4(1):49-64.

UK, CAB International, 1986. *Phyllocnistis citrella.* [Distribution map]. In: Distribution Maps of Plant Pests, Wallingford, UK: CAB International. Map 274 (Revised). DOI:10.1079/DMPP/20056600274

Hall DG, Gottwald TR, Bock CH, 2010. Exacerbation of citrus canker by citrus leafminer Phyllocnistis citrella in Florida. Florida Entomologist, 93(4):558-566. http://www.fcla.edu/FlaEnt/

Gottwald TR, Bassanezi RB, Amorim L, Bergamin Filho A, 2007. Spatial pattern analysis of citrus canker-infected plantings in São Paulo, Brazil, and augmentation of infection elicited by the Asian leafminer. Phytopathology, 97(6):674-683.

Huang M, Li S, 1989. The damage and economic threshold of citrus leafminer *Phyllocnistis citrella* (Stainton) in citrus. In: Studies on the Integrated Management of Citrus Insect Pests. Academic Bood and Periodical Press. Beijing. [Chinese, English abstract]

7.5.2	Citrus thrips, *Scirtothrips dorsalis* (Hood, 1919)

7.5.2.1. Hazard identification

Preferred Common names: Citrus thrips

Scientific name: *Scirtothrips dorsalis* (Hood, 1919)

Synonyms: *Anaphothrips andreae* (Karny, 1925)

Heliothrips minutissimus (Bagnall, 1919)

Neophysopus fragariae (Girault, 1927)

Scirtothrips dorsalis var. padmae (Ramakrishna, 1942)

Taxonomic tree

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Arthropoda

Sub-phylum: Uniramia

Class: Insecta

Order: Thysanoptera

Family: Thripidae

Genus: *Scirtothrips*

Species: *Scirtothrips dorsalis*

EPPO Code: SCITDO.

Bangladesh status: Present in Bangladesh (Ahmed *et al.*, 2019)

7.5.2.2. Biology

The egg usually has an oval shape, is pale to yellowish, narrows anteriorly, and is incubated for 4-6 days. The first instar larva is translucent, with a short body and larger legs, short, inflated antennae, a bent and short mouth cone, and seven segmented, cylindrical antennae. Sclerotization is diffuse, and the head and thorax have reticulation. The larva's second instar has larger, cylindrical, seven-segmented antennae, a longer mouth cone, three-segmented maxillary palpi, longer body setae than the first instar, and reticulate skin on the head and thorax. The pupa is dark yellow, with red eyes and ocelli. Its wing buds are lengthy, and its antennae are short and reflected over its head. Female pupae have a bigger, pointed abdomen, while male pupae are smaller and have a blunt abdomen. Backward-curving antennas cross the head. Adults are nearly white upon emergence, becoming yellowish later; abdominal tergites have a median dark patch; tergites and sternites have a dark antecostal ridge; pair III of ocellar setae is located between posterior ocelli; two pairs of median post-ocular setae are present; pronotum has four pairs of posteromarginal setae; major setae are 25-30 m long; metanotum medially has sternites with numerous microtrichia, more than two full rows medially; forewing first vein with three setae distally, second vein with two setae, posteromarginal cilia straight; tergal microtrichial fields with three discal setae, VIII and IX with microtrichia; Male on tergite IX without a drepanae (CABI, 2021).

7.5.2.3. Hosts

S. dorsalis is polyphagous and has been recorded feeding and breeding on more than 100 plant species in 40 families.

Major hosts of *S. dorsalis* are okra, onion, garlic, cashew nut, groundnut, asparagus, beetroot, tea, bell pepper, chilli, *Citrus* spp., marrow, garden dahlia, longan tree, persimmon, Strawberry, soyabean, cotton, sunflower, rubber, sweet potato, hyacinth bean, mango, sensitive plant, mulberry tree, rambutan, tobacco, passion fruit, common bean, peach, pomegranate, pears, blackberry, tomato, water apple, tamarind, mung bean, grapevine, sweetcorn, jujube etc. (Affandi *et al.*, 2019).

7.5.2.4. Distribution

Africa: South Africa (EPPO, 2022)

Asia: Bangladesh (Biswas, 2014), China, India, Indonesia, Japan, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand (Kumar and Rachana, 2021)

Europe: Netherlands, Spain, United Kingdom (IPPC, 2009)

North America: Mexico, United States (Seebens *et al.*, 2017)

South America: Brazil (Dias-Pini *et al.*, 2018)

Oceania: Australia (Mound and Palmer, 1981)

7.5.2.5. Hazard identification conclusion

Considering the facts that *S. dorsalis* -

- is present in Bangladesh (Ahmed *et al.*, 2019)
- The fruit and plant materials of citrus containing eggs and larvae of this pest is the main risk of introducing *S. dorsalis*. It represents a risk to citrus-growing regions like Italy, France, Germany, Greece, Switzerland, Sweden, Denmark, Bahrain and United Arab Emirates where it has not been reported or is not widespread.
- *S. dorsalis* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.5.2.6. Determine <u>likelihood of pest establishing</u> in importing countries via this pathway

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

Description	**Establish ment Potential**
a. Has this pest been established in several new countries in recent years? - Yes • One of the most significant citrus pests, *S. dorsalis*, is common in most nations that grow citrus. From Vietnam and China, it is introduced to Taiwan and Japan (Dickey *et al.*, 2015a). • One of the most significant citrus diseases, *S. dorsalis,* is common in the majority of citrus-growing nations. It is brought from Vietnam and China to Taiwan and Japan (Dickey *et al.*, 2015a). • Blueberries in Michoacán provided the first evidence of *S. dorsalis* in Mexico (Ortiz *et al.*, 2020). • *S. dorsalis* was discovered in Californian blueberries in 2021. This pest has been spotted there since 2015, when it was also discovered to be a problem for roses. • In Turkey, where samples were taken from blueberries growing in Adana, *S. dorsalis* was discovered for the first time in 2020 (Atakan and Pehlivan, 2021). **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Human activities played a major role in the spread of *S. dorsalis* via the movement of contaminated propagative materials.	**Yes and High**

• Long distance non-human mediated travel is possible and probably results with the assistance of wind (Kumar *et al.*, 2014). **c. Does the pathway appear good for this pest to enter importing countries and establish? - Yes,** • Fruits and plant materials containing eggs and adults of *S. dorsalis* are the important pathway to enter the importing countries. **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. dorsalis* is the most serious insect pest of *Citrus* spp. and have various alternative hosts to establish. • *S. dorsalis* preferred temperate and warmer climatic condition for its growth and survival (Seal *et al.*, 2010). 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

7.5.2.7. Determine the <u>Consequence</u> 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 importing countries? - Yes. • It is an important pest of ***Citrus* spp.** 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 citrus in that country/ies. **b. Economic Impact and Yield Loss** • Significant plant disease or host plant death caused by thrips vector viruses is found to increase difficulties in addition to damage from thrips eating. In order to reliably assess pest populations and enable the timely application of treatments, much work has been put into designing sampling plans. Research has examined the effectiveness of control methods, particularly insecticides and natural enemies, highlighting the necessity to manage this pest to reduce financial losses. **c. Environmental Impact** • Wide range of insecticides were used against *S. dorsalis.* So, indiscriminate uses of these pesticides 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

7.5.2.8. 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 – High

7.5.2.9. Risk Management Measures

Strict phytosanitary procedures are required to stop S. dorsalis from unintentionally spreading to new locations. Long-distance unintentional spread into new places is facilitated by the movement of live plants with S. dorsalis infestations. For instance, visual detection of S. dorsalis life phases by quarantine personnel is exceedingly problematic because all life stages are very small and difficult to locate. Because thrips adults and larvae exhibit thigmotaxis and hide in cracks, it is more difficult to find them. Thrips eggs are placed inside leaf tissue.

7.5.2.10. References

Affandi, Medina, C.R., Velasco, L.R.I., Javier, P.A., Depositario, D.P.T., Mansyah, E. and Hardiyanto. (2019). Population dynamic of *Scirtothrips dorsalis* Hood (thysanopetera: Thripidae) on mango and associated weeds under low and intensive agricultural practices. AGRIVITA, Journal of Agricultural Science. 41 (3), 575-585.

Ahmed, H.U., Latif, M.A., Huq, M.F., Mia, A.T., Latif, M.A., Rahman, M.A. and Ahmed, S. (2019). Developing pest list of plants and plant products in Bangladesh. Strengthening phytosanitary capacity in Bangladesh project. Plant Quarantine Wing. Department of Agricultural Extension. Khamarbari, Farmgate, Dhaka-1215.

Atakan, E. and Pehlivan, S. (2021). First report of the chilli thrips, *Scirtothrips dorsalis* Hood 1919 (Thysanoptera: Thripidae), in Turkey. Turkish Journal of Zoology, 45(2) 156-160.

Biswas, G.C. (2014). Insect pests of groundnut (*Arachis hypogaea* L.), nature of damage and succession with the crop stages. Bangladesh Journal of Agricultural Research. 39 (2), 273-282.

CABI. (2021). *Bactrocera dorsalis*. [Distribution map]. **In:** Distribution Maps of Plant Pests, Wallingford, UK:

Dias-Pini, N.S., Lima, M.G.A., Lima, E.F.B., Maciel, G.P.S. and Duarte, P.M. (2018). *Scirtothrips dorsalis* (Thysanoptera: Thripidae): a newly introduced polyphagous pest in northeastern Brazil. Neotropical Entomology. 47 (5), 725-728.

Dickey, A.M., Kumar, V., Hoddle, M.S., Funderburk, J.E., Morgan, J.K., Jara-Cavieres, A., Shatters, R.G. Jr., Osborne, L.S. and McKenzie, C.L. (2015). The *Scirtothrips dorsalis* complex: endemism and invasion in a global pest. PLoS ONE, 10(4) e0123747.

EPPO. (2022). EPPO Global database. In: EPPO Global database, Paris, France: EPPO. 1 pp. https://gd.eppo.int/

IPPC. (2009). *Scirtothrips dorsalis*. **In:** IPPC Official Pest Report, Rome, Italy: FAO. https://www.ippc.int/IPP/En/default.jsp

Kumar, P.S. and Rachana, R.R. (2021). *Scirtothrips dorsalis* (Thysanoptera: Thripidae) is a pest of celery, *Apium graveolens* (Apiales: Apiaceae): first report and diagnostic characters. Journal of Integrated Pest Management. 12 (46), DOI:10.1093/jipm/pmab039

Kumar, V., Kakkar, G., Seal, D.R., McKenzie, C.L., Colee, J. and Osborne, L.S. (2014). Temporal and spatial distribution of an invasive thrips species *Scirtothrips dorsalis* (Thysanoptera: Thripidae). Crop Protection, 5580-90.

Mound, L.A. and Palmer, J.M. (1981). Identification, distribution and host-plants of the pest species of *Scirtothrips* (Thysanoptera: Thripidae). Bulletin of Entomological Research. 71 (3), 467-479.

Ortiz, J.A., Infante, F., Rodriguez, D. and Toledo-Hernandez, R.A. (2020). Discovery of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in blueberry fields, Michoacán Mexico. Florida Entomologist, 103(3) 408-410.

Seal, D.R., Kalssen, W. and Kumar, V. (2010). Biological parameters of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on selected hosts. Florida Entomologist, 39(5) 1389-1398.

Seebens, H., Blackburn, T.M., Dyer, E.E., Genovesi, P., Hulme, P.E., Jeschke, J.M., Pagad, S., Pyšek, P., Winter, M., Arianoutsou, M., Bacher, S., Blasius, B., Brundu, G., Capinha, C., Celesti-Grapow, L., Dawson, W., Dullinger, S., Fuentes, N., Jäger, H., Kartesz, J., Kenis, M., Kreft, H., Kühn, I., Lenzner, B., Liebhold, A. and Mosena, A. (2017). No saturation in the accumulation of alien species worldwide. Nat. Comm. 8(2): 14435.

Behlau, F., Belasque, J., Jr., Leite, R.P., Jr., Bergamin-Filho, A., Gottwald, T.R., Graham, J.H., Scandelai, L.H.M., Primiano, I.V., Bassanezi, R.B. and Ayres, A.J. (2021a). Relative contribution of windbreak, copper sprays, and leafminer control for citrus canker management and prevention of crop loss in sweet orange trees. Plant Disease, 105(8) 2097-2105.

Ference, C.M., Gochez, A.M., Behlau, F., Wang, N., Graham, J.H. and Jones, J.B. (2018). Recent advances in the understanding of *Xanthomonas citri* ssp. *citri* pathogenesis and citrus canker disease management. Molecular Plant Pathology, 19(6) 1302-1318.

Goto, M. (1992). Citrus canker. **In:** Plant Diseases of International Importance, Vol. III, Diseases of Fruit Crops, [ed. by Kumar, J., Chaube, H.S., Singh, U.S., Mukhopadhyay, A.N.]. Englewood Cliffs, USA: Prentice Hall. 170-208.

Leduc, A., Traoré, Y.N., Boyer, K., Magne, M., Grygiel, P., Juhasz, C.C., Boyer, C., Guerin, F., Wonni, I., Ouedraogo, L., Vernière, C., Ravigné, V. and Pruvost, O. (2015). Bridgehead invasion of a monomorphic plant pathogenic bacterium: *Xanthomonas citri* pv. *citri*, an emerging citrus pathogen in Mali and Burkina Faso. Environmental Microbiology, 17(11) 4429-4442.

Li, W.B., Song, Q.J., Brlansky, R.H. and Hartung, J.S. (2007). Genetic diversity of citrus bacterial canker pathogens preserved in herbarium specimens. Proceedings of the National Academy of Sciences of the United States of America. 104 (47), 18427-18432.

Lin, H.C., Feng, C.Y., Chang, Y.A. and Chang, H. (2012). Molecular typing and genetic characterization of pathogenic variants of *Xanthomonas axonopodis* pv. *citri* in Taiwan. Journal of Phytopathology. 160 (9), 475-483.

Mirzaee, M.R. (2015). Citrus bacterial canker pustules are associated with leafminer galleries in Iran. Journal of Plant Pathology, 97(1) 213.

Paola, R., Mariana, M., Raquel, d-C. and Mercedes, P. (2013). Characterization of *Xanthomonas citri* sbsp. Strains. citrus, the causative agent of citrus cancer. (Caracterización de cepas de Xanthomonas citri sbsp. citri, agente causal del cancro cítrico). Agrociencia. 17 (2), 64-74.

Ray, J.D., Taylor, R.K., Griffin, R.L., James, R.S., Dale, C., Ximines, A. and Jones, L.M., (2017). Confirmation of *Xanthomonas citri* subsp. *citri* causing citrus canker in Timor-Leste. Australasian Plant Disease Notes. 12 (1), 44.

Savitha, A.S., Ajithkumar, K., Palaiah, P. and Ramesh, G. (2016). Integrated management of citrus canker caused by a *Xnthomonas axonopodis* pv. *citri (*Hasse) in acid lime (Citrus auruntifolia). Pest Management in Horticultural Ecosystems. 22 (2), 189-192.

Schaad, N.W., Postnikova, E., Lacy, G.H., Sechler, A., Agarkova, I., Stromberg, P.E., Stromberg, V.K. and Vidaver, A.K. (2005). Reclassification of *Xanthomonas campestris* pv. *citri* (ex Hasse 1915) Dye 1978 forms A, B/C/D, and E as *X. smithii* subsp. *citri* (ex Hasse) sp. nov. nom. rev. comb. nov., *X. fuscans* subsp. *aurantifolii* (ex Gabriel 1989) sp. nov. nom. rev. comb. nov., and *X. alfalfae* subsp. *citrumelo* (ex Riker and Jones) Gabriel *et al.*, 1989 sp. nov. nom. rev. comb. nov.;

X. campestris pv. *malvacearum* (ex Smith 1901) Dye 1978 as *X. smithii* subsp. smithii nov. comb. nov. nom. nov.; *X. campestris* pv. *alfalfae* (ex Riker and Jones, 1935) Dye 1978 as *X. alfalfae* subsp. *alfalfae* (ex Riker *et al.*, 1935) sp. nov. nom. rev.; and "var. fuscans" of *X. campestris* pv. *phaseoli* (ex Smith, 1987) Dye 1978 as *X. fuscans* subsp. *fuscans* sp. *nov*. Systematic and Applied Microbiology, 28(6) 494-518.

7.5.3	Citrus canker, *Xanthomonas axonopodis* pv. *citri* (Hasse)

7.5.3.1. Hazard identification

Preferred Common names: Citrus canker
Scientific name: *Xanthomonas axonopodis* pv. *citri* (Hasse)
Synonyms: *Bacillus citri* (Hasse) Holland
Bacterium citri (Hasse) Doidge
Phytomonas citri (Hasse) Bergey *et al.*
Pseudomonas citri Hasse
Xanthomonas axonopodis pv. *aurantifolii* Vauterin *et al.*
Xanthomonas axonopodis pv. *citri* (ex Hasse) Vauterin *et al.*
Xanthomonas campestris pv. *aurantifolii* Gabriel *et al.*
Xanthomonas campestris pv. *citri* (Hasse) Dye
Xanthomonas citri Gabriel *et al.*
Xanthomonas citri f.sp. *aurantifolia* Namekata & Oliveira
Xanthomonas citri ssp. *citri* Schaad *et al.*
Xanthomonas fuscans ssp. *aurantifolii* Schaad *et al.*

Taxonomic tree
Domain: Eukaryota
Kingdom: Bacteria
Phylum: Proteobacteria
Class: Gammaproteobacteria
Order: Xanthomonadales
Family: Xanthomonadaceae
Genus: *Xanthomonas*
Species: *Xanthomonas axonopodis pv. citri*

EPPO Code: XANTCI.

Bangladesh status: Present in Bangladesh (Vernière *et al.*, 2013)

7.5.3.2. Biology

Xanthomonas axonopodis pv. *citri* is a Gram-negative, straight, rod-shaped bacterium measuring 1.5-2.0 x 0.5-0.75 µm. It is motile by means of a single, polar flagellum. Colonies are formed on nutrient agar plates containing glucose and are creamy-yellow with copious slime. The yellow pigment is xanthomonadin. Catalase is positive, but Kovacs' oxidase is negative or weak; nitrate reduction is negative (Schaad *et al.*, 2005).

7.5.3.3. Hosts

Major hosts of *Xanthomonas axonopodis* pv. *citri* are *Citrus* spp., mango, Trifoliate orange, Australian desert lime etc. (Ray *et al.*, 2017).

7.5.3.4. Distribution

Asia: Bangladesh, Afghanistan, China, India, Indonesia, Japan, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Thailand, United Arab Emirates (Savitha *et al.*, 2016)

Europe: Italy, Netherlands (Li *et al.*, 2007)

North America: Mexico, United States (Lin *et al.*, 2012)

South America: Argentina, Brazil (Paola *et al.*, 2013)

Oceania: Australia, New Zealand (Lin *et al.*, 2012)

7.5.3.5. Hazard identification conclusion

Considering the facts that *X. axonopodis* pv. *citri* -

- is present in Bangladesh (Vernière *et al.*, 2013)
- The fruit and plant materials of citrus containing latent of this bacterium is the main risk of introducing *X. axonopodis* pv. *citri*. It represents a risk to citrus-growing regions like United Kingdom, France, Germany, Greece, Switzerland, Sweden, Denmark and Bahrain where it has not been reported or is not widespread.
- *X. axonopodis* pv. *citri* is a **regulated non-quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.5.3.6. Determine <u>likelihood of pest establishing</u> in importing countries 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 • *X. axonopodis* pv. *citri* is one of the most important citrus diseases and widespread in most citrus-growing countries. It is a perennial disease which probably originated from Asia (Vernière *et al.*, 2014). Human activities have played a major role in the spread of *X. axonopodis* pv. *citri* strains via the movement of contaminated propagative materials (Leduc *et al.*, 2015). **b. Possibility of survival of this pest during transport, storage and transfer? – Yes** • Human activities played a major role in the spread of *X. axonopodis* pv. *citri* strains via the movement of contaminated propagative materials (Leduc *et al.*, 2015). • Association of bacterial canker pustules with leafminer (*Phyllocnistis citrella*) tunnels was reported in Yemen, India and Iran (Mirzaee, 2015).	**Yes and High**

However, the insect is less likely to act as vector of the pathogen as leafminer control has no effect on reducing citrus canker (Behlau *et al.*, 2021a). **c. Does the pathway appear good for this pest to enter importing countries and establish? - Yes,** • Fruits and plant materials containing strain of *X. axonopodis* pv. *citri* (which were not visual) are the important pathway to enter into the importing countries. **d. Are the host(s) of this fairly common in the importing countries and the climate is similar to places it is established? – Yes** • *X. axonopodis* pv. *citri* is the most serious insect pest of *Citrus* spp. and another alternative host of this pest is not recorded (Ference *et al.*, 2018). • *X. axonopodis* pv. *citri* preferred all kind of climatic condition for its growth and survival. 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

7.5.3.7. Determine the <u>Consequence</u> 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 importing countries? - Yes. • It is an important pest of ***Citrus* spp.** 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 citrus in that country/ies. **b. Economic Impact and Yield Loss** • Citrus canker losses are generally caused by defoliation, early fruit abscission, and imperfect fruit. Young, vulnerable trees frequently have practically all of their fruits and foliage infected. In highly diseased young trees, growth and attainment of full size may be delayed. The estimate of loss has not fully shown the impact of the condition. Investigating the potential risk of citrus canker spreading across continents via lesions on marketable fruits is necessary. Financial losses result from decreased crop yields, an increase in pesticide use, and market loss as a result of regulatory restrictions. **c. Environmental Impact** • Wide range of insecticides were used against *X. axonopodis* pv. *citri*. So, indiscriminate uses of these pesticides 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

7.5.3.8. 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

7.5.3.9. Risk Management Measures

The first crucial step in the control of citrus canker is the adoption of nursery plants free of the disease. Establishing windbreaks around citrus crops helps control the illness. Angular branches with canker lesions can be pruned to remove over-seasoning inoculum. Large-scale citrus tree destruction and the introduction of stringent international plant quarantine restrictions against the virus are just two of the major efforts that have been undertaken to eradicate the illness (Goto, 1992).

7.5.3.10. References

Behlau, F., Belasque, J., Jr., Leite, R.P., Jr., Bergamin-Filho, A., Gottwald, T.R., Graham, J.H., Scandelai, L.H.M., Primiano, I.V., Bassanezi, R.B. and Ayres, A.J. (2021a). Relative contribution of windbreak, copper sprays, and leafminer control for citrus canker management and prevention of crop loss in sweet orange trees. Plant Disease, 105(8) 2097-2105.

Ference, C.M., Gochez, A.M., Behlau, F., Wang, N., Graham, J.H. and Jones, J.B. (2018). Recent advances in the understanding of *Xanthomonas citri* ssp. *citri* pathogenesis and citrus canker disease management. Molecular Plant Pathology, 19(6) 1302-1318.

Goto, M. (1992). Citrus canker. **In:** Plant Diseases of International Importance, Vol. III, Diseases of Fruit Crops, [ed. by Kumar, J., Chaube, H.S., Singh, U.S., Mukhopadhyay, A.N.]. Englewood Cliffs, USA: Prentice Hall. 170-208.

Leduc, A., Traoré, Y.N., Boyer, K., Magne, M., Grygiel, P., Juhasz, C.C., Boyer, C., Guerin, F., Wonni, I., Ouedraogo, L., Vernière, C., Ravigné, V. and Pruvost, O. (2015). Bridgehead invasion of a monomorphic plant pathogenic bacterium: *Xanthomonas citri* pv. *citri*, an emerging citrus pathogen in Mali and Burkina Faso. Environmental Microbiology, 17(11) 4429-4442.

Li, W.B., Song, Q.J., Brlansky, R.H. and Hartung, J.S. (2007). Genetic diversity of citrus bacterial canker pathogens preserved in herbarium specimens. Proceedings of the National Academy of Sciences of the United States of America. 104 (47), 18427-18432.

Lin, H.C., Feng, C.Y., Chang, Y.A. and Chang, H. (2012). Molecular typing and genetic characterization of pathogenic variants of *Xanthomonas axonopodis* pv. *citri* in Taiwan. Journal of Phytopathology. 160 (9), 475-483.

Mirzaee, M.R. (2015). Citrus bacterial canker pustules are associated with leafminer galleries in Iran. Journal of Plant Pathology, 97(1) 213.

Paola, R., Mariana, M., Raquel, d-C. and Mercedes, P. (2013). Characterization of *Xanthomonas citri* sbsp. Strains. citrus, the causative agent of citrus cancer. (Caracterización de cepas de Xanthomonas citri sbsp. citri, agente causal del cancro cítrico). Agrociencia. 17 (2), 64-74.

Ray, J.D., Taylor, R.K., Griffin, R.L., James, R.S., Dale, C., Ximines, A. and Jones, L.M., (2017). Confirmation of *Xanthomonas citri* subsp. *citri* causing citrus canker in Timor-Leste. Australasian Plant Disease Notes. 12 (1), 44.

Savitha, A.S., Ajithkumar, K., Palaiah, P. and Ramesh, G. (2016). Integrated management of citrus canker caused by a *Xnthomonas axonopodis* pv. *citri (*Hasse) in acid lime (Citrus auruntifolia). Pest Management in Horticultural Ecosystems. 22 (2), 189-192.

Schaad, N.W., Postnikova, E., Lacy, G.H., Sechler, A., Agarkova, I., Stromberg, P.E., Stromberg, V.K. and Vidaver, A.K. (2005). Reclassification of *Xanthomonas campestris* pv. *citri* (ex Hasse 1915) Dye 1978 forms A, B/C/D, and E as *X. smithii* subsp. *citri* (ex Hasse) sp. nov. nom. rev. comb. nov., *X. fuscans* subsp. *aurantifolii* (ex Gabriel 1989) sp. nov. nom. rev. comb. nov., and *X. alfalfae* subsp. *citrumelo* (ex Riker and Jones) Gabriel *et al.*, 1989 sp. nov. nom. rev. comb. nov.; *X. campestris* pv. *malvacearum* (ex Smith 1901) Dye 1978 as *X. smithii* subsp. smithii nov. comb. nov. nom. nov.; *X. campestris* pv. *alfalfae* (ex Riker and Jones, 1935) Dye 1978 as *X. alfalfae* subsp. *alfalfae* (ex Riker *et al.*, 1935) sp. nov. nom. rev.; and "var. fuscans" of *X. campestris* pv. *phaseoli* (ex Smith, 1987) Dye 1978 as *X. fuscans* subsp. *fuscans* sp. *nov*. Systematic and Applied Microbiology, 28(6) 494-518.

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 citrus from exporting countries such as India, China, Thailand, Bhutan, South Africa, Egypt, Brazil and Australia, or any other countries of citrus 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:

8.1.1. Pre-harvest Management Options

The in-field, pest management practices for the production of mangoes are in brief:

- Pre-flowering pesticide treatments for arthropods, fungi and other pathogenic micro-organisms those causing damage above threshold levels;
- Post-flowering and fruit pesticide treatments above threshold levels for specific pests such as lemon butterfly, thrips, leaf miner, mealy bug, stem borer, and anthracnose, die-back, black spot, sooty mold, powdery mildew, fruit rot, stem-end-rot, etc.;
- Use of Bordeaux-paste 10 percent on pruning wounds of gummosis infected trunk is effective to reduce the gummosis disease in the orchard;
- Copper fungicide sprays (oxychloride, hydroxide, or oxide) must be administered against scab and canker diseases as soon as the blooms begin to appear and continued until the fruit has reached a size of around 50 percent;
- Specific acaricide such as propargite and bio-neem plus should be sprayed in the field against red spider mite;
- Fruit bagging is effective to reduce fruit fly infestation, black spot, fruit rot and anthracnose disease infection;
- 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 must be selected for the management of citrus canker (*Xanthomonas campestris* pv. *citri*);
- Annual flooding of orchards along with nematicides to kill the nematodes that causing diseases;
- 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 citrus 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

Citrus fruits including *Citrus medica* (Zara/Colombo Lebu varieties) should be routinely graded and washed. The procedure is as follows:

1. Washing of harvested fruits with clean water mixed with 2.3% sodium ortho-phenylphenate and drying (likely to remove external arthropods and pathogens);
2. Sorting and grading to remove damaged, overripe, infested, or infected fruits from the harvested fruit lot. The grading process is likely to remove fruit showing obvious signs of fungal and bacterial disease;
3. Fruits are packed for disinfestation by irradiation in export cartons.
4. Monthly applications of copper oxychloride mixed with mancozeb are effective against the majority of post-harvest illnesses such as anthracnose, fruit rot, etc.

8.1.3. Visual Inspection

Visual inspection of fruit occurs at several points during the routine production and post-harvest pathway for citrus including *Citrus medica*. 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, thrips, and scale insects as they are easily detected on the surface of fruit.

8.1.4. Treatment for arthropods

The current pre- and post-harvest procedures are aimed at reducing regulated organism rather than removing all risk associated with citrus from exporting countries. Therefore, a treatment like vapour heat treatment (VHT) or irradiation is necessary to mitigate residual risk, especially from internally feeding arthropods such as fruit fly. Vietnam exports vapor heat treated dragon fruit to Japan (Vietnam Net/VNA, 2009) and irradiated dragon fruit to the USA. Irradiation is used to control regulatory insects in exported fresh commodities.

8.1.5. Phytosanitary Inspection and Certification

Importing country requires a phytosanitary certificate issued by respective authority of exporting country to accompany citrus 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,
    - 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 hitchhikers 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 citrus 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.