Pest Risk Analysis (PRA) of Cucurbits in Bangladesh

Strengthening Phytosanitary Capacity in Bangladesh Project

Plant Quarantine Wing

Department of Agricultural Extension

Khamarbari, Farmgate, Dhaka-1205

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Strengthening Phytosanitary Capacity in Bangladesh Project
Plant Quarantine Wing
Department of Agricultural Extension
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Pest Risk Analysis (PRA) of Cucurbits in Bangladesh

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FORWARD

The Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW), Department of Agricultural Extension (DAE), Ministry of Agriculture conducted the study for the "**Pest Risk Analysis (PRA) of Cucurbits in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and Development Technical Consultants Pvt. Limited (DTCL) on 14 January 2016. The PRA study is a four-month assignment commencing from 20 April 2016 under the SPCB-DAE.

The overall objectives of this Pest Risk Analysis are to identify the pests and/or pathways of quarantine concern for a specified area of cucurbits and evaluate their risk, to identify endangered areas, and if appropriate, to identify risk management options. To carry out the PRA study, the consulting firm conducted field investigations in 68 upazila under 24 major cucurbit growing districts of Bangladesh. The study covered the interview 6800 cucurbit growers; 24 FGDs each of which conducted in one district; conducted 55 KII and physical inspection and visits of the cucurbit fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of cucurbits.

The study findings evidenced that the 13 arthropod pests, 19 disease causing pathogen and 5 weeds likely to be associated with the cucurbits in Bangladesh. The study also revealed that a total number of 22 pest species of quarantine importance had been identified, of which 14 insect pests, one mite pest, one fungus, two bacteria, one nematode and two viral disease and one weed that could be introduced into Bangladesh through importation of commercially produced cucurbits. The consultant team also conducted the risk assessment for each quarantine pest individually based on the consequences and potential of introduction of each quarantine pest and a risk rating was estimated for each. Based on the risk assessment and risk rating, 21 quarantine pests were identified as high risk, one pest was identified as moderate risk rating. The findings also suggested the risk management options for the quarantine pests of cucurbits in line with the pre and post harvest management and phytosanitary measures.

The findings of the PRA study had been presented in the National Level Workshop organized by the SPCB-PQW of DAE. The concerned professionals represented from the country's reputed agricultural universities, research organizations and other relevant personnel from different organizations attended in the workshop. The online version of this report is available in the official website of DAE at www.dae.gov.bd

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

(Dr. Mohammad Ali)
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PREFACE

This report intends to respond to the requirement of the client according to the provision of contract agreement signed between Project Director of Strengthening Phytosanitary Capacity in Bangladesh (SPCB) and the Development Technical Consultants Pvt. Limited (DTCL) for **“Conducting Pest Risk Analysis (PRA) of Cucurbits in Bangladesh”** under Plant Quarantine Wing (PQW), Department of Agricultural Extension (DAE), Ministry of Agriculture (MOA), Government of the Peoples Republic of Bangladesh. The PRA study is a four-month assignment commencing from 20 April 2016 under the SPCB-DAE.

Consultancy services for **“Conducting Pest Risk Analysis (PRA) of Cucurbits in Bangladesh”** was provided by the Development Technical Consultants Pvt. Ltd. (DTCL), Bangladesh. The study team consists of five senior level experts including field and office level support staffs. The major objective of the study is to listing of major and minor pests of cucurbits, identification of pests likely to be associated with pathway, identification of potential for entry, establishment and spread, identification of potential economic and environmental impact, identification of control measures and potential impacts of such measures, assessment of potential loss by the pests, preparation of report on risk analysis of the pests following the relevant ISPMs and make recommendation.

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

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ACKNOWLEDGEMENTS

It is indeed a great honor for us that Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW) of Department of Agricultural Extension (DAE) has entrusted Development Technical Consultant Pvt. Ltd. (DTCL) to carry out the "**Conducting Pest Risk Analysis (PRA) of Cucurbits in Bangladesh"**. The Report has been prepared based on the past four months (January 2016 to May 2016) activities of the survey study in major 24 cucurbit growing districts of Bangladesh as well as on the review of secondary documents. In the process of working on the setting indicators and sampling as well as for revising the questionnaires for the field survey and data collection, monitoring and supervision, data analysis and report writing, we have enjoyed the support of SPCB-PQW. The principal author is Prof. Dr. Md. Razzab Ali, Team Leader with inputs from Prof. Dr. Md. Abdul Karim, Dr. M. M. Amir Hossain, Prof. Dr. M. Salahuddin M. Chowdhury and Dr. B. A. A. Mustafi of the PRA study team.

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

(Prof. Dr. Md. Razzab Ali)
Team Leader

ACRONYMS

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

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EXECUTIVE SUMMARY

The study "Pest Risk Analysis (PRA) of Cucurbits in Bangladesh" documents the pests of cucurbits vegetables available in Bangladesh and the risks associated with the import pathway of cucurbits from the exporting countries namely India, Japan, Thailand, Taiwan, China, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chile into Bangladesh.

The findings evidenced that the forty five pests of cucurbits were recorded in Bangladesh, of which 21 arthropod pests that included 12 insect pests and one mite pests; 19 disease causing pathogens and 5 weeds. The insect pests of cucurbits reported were cucurbit fruit fly (*Bactrocera cucurbitae*), oriental fruit fly (*Bactrocera dorsalis*), guava fruit fly (*Bactrocera zonata*), mango fruit fly (*Bactrocera tau),* lesser fruit fly (*Dacus ciliatus*), vegetable leaf miner (*Liriomyza sativae*), black cutworm (*Agrotis ipsilon*), cucumber moth (*Diaphania indica*), epilachna beetle (*Epilachna vigintioctopunctata, E. dodecastigma*), red pumpkin beetle (*Raphidopalpa foveicollis*), cucumber beetle (*Aulacophora indica*), green stink bug (*Nezara viridula*), melon thrips (*Thrips palmi*), cucurbit aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci* Genn.), cotton jassid (*Amrasca bigutula bigutula*), pink mealy bug (*Maconellicoccus hirsutus*) and mole cricket (*Gryllotalpa brachyptera*), whereas one mite pest of cucurbit was recorded in Bangladesh namely two-spotted spider mite (*Tetranychus urticae*). Among these insect pests of cucurbits, cucurbit fruit fly was more damaging than others. The cucurbit fruit fly was designated as major pest of all cucurbits with high infestation intensity, but all other insect and mite pests were reported as minor pests and caused damage with low infestation intensity.

A total number of 19 species of disease causing pathogens of cucurbits were reported in Bangladesh, among which 12 diseases were caused by fungi, 3 caused by bacteria, 2 caused by nematode and 2 diseases of cucurbits were caused by viruses. The incidences of fungal diseases of cucurbits reported in Bangladesh were powdery mildew (*Podosphaera xanthii*), downy mildew (*Pseudopernospora cubensis*), cercospora leaf spot (*Alternaria brassicae*), charcoal rot (*Macrophomina physiolina*), anthracnose (*Colletotrichum orbiculaum*), root rot, stem rot, damping off/ seed rot of cucurbits were caused by *Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp., gummosis of cucurbits (*Cladosporium cucumerinum*), gummy stem blight (*Didymella bryoniae*), fusarium wilt (*Fusarium oxysporum* f.sp. *cucumerinum*), and cottony soft rot (*Sclerotinia sclerotiorum*). Whereas, the incidences of bacterial diseases of cucurbits recorded in Bangladesh were angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*), bacterial wilt (*Erwinia catotovora*) and bacterial root rot (*Pectobacterium cartovorum*). The nemic diseases of cucurbits were root knot nematode (*Meloidogyne incognita*) and reniform nematode (*Totyenchus reniformis*). The viral diseases of cucurbits reported in Bangladesh were *Cucumber mosaic virus* (CMV) and *Squash mosaic virus*. Among these diseases, the angular leaf spot for cucumber, Fusarium wilt and root rot and damping off of seedlings were more damaging than others. But diseases were reported as minor diseases of cucurbits and caused damage with low infection intensity in Bangladesh.

A total number of 5 weeds were reported as the problem in the field of cucurbits in Bangladesh. The incidences of weeds in the field of cucurbits and foliages as reported by the farmers were bermuda grass (*Cynodon dactylon*), nut sedge (*Cyperus esculentus*), pigweed (*Amaranthus acanthochiton*), spiny pigweed (*Amaranthus spinosus*), Parthenium weed (*Parthenium hysterophorus*). The parthenium weed (*Parthenium hysterophorus*) was recorded and found in some restricted areas of Bangladesh such as Rajshahi, Natore, Pabna, Kustia, Jessore districts. These districts are nearly attached with the Western border

of Bangladesh and Eastern border of West Bengal of India. It was also reported that the Parthenium weed might be entered into Bangladesh through cross boundary pathway from India by the transportation system of border trading. As a newly introduced weed, though Parthenium caused damage with low infestation intensity, but it could cause severe damage and spread to other areas, if not controlled properly. Other four weeds were reported as minor weeds with low infestation intensity in cucurbit fields.

Information on pests associated with cucurbits in the exporting countries- India, Japan, Thailand, Taiwan, China, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chile reveal that pests of quarantine importance exist. The study also revealed 22 pest species of quarantine importance that included 14 insect pests, one mite pest, 6 disease causing pathogens including one fungus, two bacteria, one nematode, and two viruses; and one weed. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced cucurbits. Pests of quarantine importance included insect pests namely silver leaf whitefly (*Bemisia tabaci B biotype*), cotton mealy bug (*Phenacoccus solenopsis*), alfalfa thrips (*Frankliniella occidentalis*), lesser fruit fly (*Dacus ciliates*), Malaysian fruit fly (*Bactrocera latifrons*), Medditeranean fruit fly (*Ceratitis capitata*), Quensland fruit fly (*Bactrocera tryoni*), tomato leaf miner (*Liriomyza bryoniae*), Serpentine leaf miner (*Liriomyza trifolii*), pea leaf miner (*Liriomyza huidobrensis*), green looper caterpillar (*Chrysodeixis eriosoma*), cucumber moth (*Diaphania indica*), cucumber worm (*Diaphania nitidalis*), and cucumber beetle (*Diabrotica undecimpunctata*). The quarantine mite pest of cucurbits for Bangladesh is red spider mite (*Tetranychus evansi*). On the other hand, and one mite pest named for Bangladesh is red spider mite (*Tetranychus evansi*).

The quarantine pathogens of cucurbits included six (6) disease causing pathogens have been identified as quarantine pests of cucurbits for Bangladesh. Among these, one quarantine fungus named Phytopthora root rot (*Phytophthora megasperma*); two quarantine bacteria namely Cucurbit bacterial wilt (*Erwinia tracheiphila),* Bacterial fruit blotch (*Acidovorax citrulli*); one species of nematode namely sting nematode (*Belonolaimus longicaudatus*); two viruses namely *Cucumber yellow stunting disorder virus, Zucchini yellow mosaic virus*. The quarantine weed for Bangladesh included *Parthenium hysterophorus* L. (Parthenium weed).

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 22 quarantine pests associated with the pathway risk assessed. Out of 22 potential hazard organisms, 21 quarantine pests were identified with high risk potential, and one namely *Belonolaimus longicaudatus* was identified with moderate risk potential. These mean that these pests pose unacceptable phytosanitary risk to Bangladesh's agriculture. Visual inspection at ports-of-entry for high risk potential pests is insufficient to safeguard Bangladesh's cucurbit industry and specific phytosanitary measures are strongly recommended. While for moderate risk potential pest, specific phytosanitary measures may be necessary to reduce pest risk.

CHAPTER 1

RISK ANALYSIS BACKGROUND AND PROCESS

1.1. Background

Pest risk analysis provides the rationale for phytosanitary measures for a specified PRA area. It evaluates scientific evidence to determine whether an organism is a pest. If so, the analysis evaluates the probability of introduction and spread of the pest and the magnitude of potential economic consequences in a defined area, using biological or other scientific and economic evidence. If the risk is deemed unacceptable, the analysis may continue by suggesting management options that can reduce the risk to an acceptable level. Subsequently, pest risk management options may be used to establish phytosanitary regulations. For some organisms, it is known beforehand that they are pests, but for others, the question of whether or not they are pests should initially be resolved.

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

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

Bangladesh is highly suitable for cucurbit production due to its favorable climatic, topography and other conditions like labour cost and relatively low capital investment in contrast with high value addition. The introduction of insect pests, plant diseases, weeds and other pest associated with the 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, weeds and other pests that were transported along with them. There are many instances of accidental introductions of insect pests and destructive 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. Instances may be cited of the introduction of grape *phylloxera (Phylloxera vitifolia*) from the U.S.A. to France which caused destruction of French vineyards; Mexican boll weevil (*Anthonomus grandis)* whose original home was in Mexico or Central America, round about 1892 entered the U.S.A. and later to various countries in the world, causing extensive damage to cotton; European corn borer (O*strinia nubilalis)* which reached North America probably through broom corn from Italy or Hungary and has since become a major pest there. Pink ball worm (*Pectinophora gossypiella*) considered to be one of the six most destructive insects of the world probably a native of India is now established as a highly destructive pest in nearly all cotton growing areas of the world. Downy mildew of grape (*Plasmopara viticola*) introduced in France from the U.S.A. was responsible for the destruction of grape vines till the discovery of Bordeaux mixture. Blight disease of chestnut (*Endothia parasitica*) introduced into the U.S.A. from Europe completely wiped out chestnut plants.

Due to imports of cucurbits with tropical and subtropical countries of the world, the possibility for introduction and establishment of quarantine pests along with the consignment of the commodity remains as threat. Therefore, the pathway risk analysis of cucurbits from exporting countries to Bangladesh is essential. In this context, the Pest Risk Analysis (PRA) of Cucurbits in Bangladesh is indispensable. Thus, the assignment on PRA of Ccurbits in Bangladesh was undertaken aiming to identify pests and/or pathways of quarantine concern for the cucurbits grown areas and evaluate their risk, to identify endangered areas, as well as to identify risk management options.

1.2. Scope of the Risk Analysis

The scope of this analysis is to findout the potential hazard organisms or diseases associated with cucurbits imported from different exporting countries such as India, China, Pakistan, Japan, Thailand, Taiwan, UAE, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chille (Plant Quarantine Wing of DAE, 2016). Risk in this context is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.

1.3. Objective of the PRA study

The overall objective of a Pest Risk Analysis by the SPCB Project is to support National Plant Protection Organization (NPPO) to identify pests and/or pathways of quarantine pests to be associated with the commodity which brings along with them a certain risk of the introduction of diseases and pests that are harmful to agriculture. The consulting Firm is required to identify the pests, pathway/s, evaluate their risk, endangered areas, and risk management options etc.

The **Specific Objectives** of the recruitment of a Pest Risk Analysis Consulting Firm are:

- Listing of major and minor pests mentioning plant parts affected
- Listing of regulated pests
- Identification and categorization of pests likely to be associated with a pathway
- Identification of potentials for entry, establishment and spread of regulated pests
- Identification of probability of survival during transport or storage & transfer of hosts
- Identification of probability of pest surviving existing pest management procedures
- Identification of availability of suitable hosts, alternate hosts and vectors in the PRA areas
- Identification of potential economic and environmental impacts
- Assessment of potential loss by the pests
- Identification of management options/system approach for control of regulated pests
- Preparation of report on risk analysis of the pests following the relevant ISPMs

1.4. Methodology for data collection

1.4.1. Introduction

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

1.4.2. Major Activities for data collection

Field survey

The study survey was conducted with the direct interview of cucurbits growers in 24 major cucurbit growing districts of Bangladesh for quantitative data aiming to identify insect pests, diseases, weeds and other pests, their status, damane severity, and management options; quarantine pests with their entry, establishment, risk and their management. The qualitative data were also collectected through focus group discussions (FGD) with cucurbit growers and through key informant interviews (KII) with extension personnel at field and headquarer level, Plant Quarantine Centres at Sea and land port, officials of Ministry of Agriculture, Entomologist and Plant Pathologist of Bangladesh Agricultural Research Institute (BARI), Agricultural Universities.

Secondary data collection and review

The current PRA related secondary data were collected and gathered from secondary sources such as journals, books, proceedings, CD-ROM (CABI) search, internet browsing especially through websits of CAB International, EPPO Bulletin and others. The documents were then critically reviewed, synthesized in relation to identify the quarantine pests of cucurbits available in the cucurbits exporting counties namely India, Japan, Thailand, Taiwan, China, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chile as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

Listing of pests of cucurbits

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

1.4.3. PRA location and study sampling

The survey study sas conducted in the 24 major cucurbit growing districts of Bangladesh as selected by the client Project Director, Stenghthening Phytosanitary Capacity in Bangladesh (SPCB) under Plant Quarantine Wing (PQW), DAE, Bangladesh. A total 68 upazilas were selected under the 24 sampled distrcts, where 10 agricultural blocks were covered under each upazilla and 10 cucurbit farmers were interviewed in each block through pre-tested questionnaire. Thus, a total of 6800 growers/farmers were interviewed from all of 24 sampled districts. The focus group discussion (FGD) meeting was also conducted for each of 24 sampled districts with the participation of at least 10 cucurbit farmers aiming to gather qualitative data. Besides, one officer designated as Additional Deputy Director (Plant Protection) for each district had also been interviewed through semi-structured key informant interview (KII) checklist. The district and upazila wise distribution of respondents is given below:

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

SN	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII
1	Norshingdi	Sadar	10	100	1	1
		Shibpur	10	100		
		Raipura	10	100		
		Monohordi	10	100		
		Belabo	10	100		
2	Manikgonj	Singair	10	100	1	1
		Saturia	10	100		
		Sadar	10	100		
3	Gazipur	Kaligonj	10	100	1	1
		Kapasia	10	100		
		Sadar	10	100		
		Kaliakoir	10	100		
4	Narayangonj	Soangaon	10	100	1	1
		Araihazar	10	100		
5	Comilla	Chandina	10	100	1	1
		Daudkandi	10	100		
		Burichong	10	100		
		Barura	10	100		
		Debiddar	10	100		
		Sadar South	10	100		
6	Chandpur	Sadar	10	100	1	1
		Hajigonj	10	100		
7	Lakshmipur	Sadar	10	100	1	1
8	Mymensingh	Fulpur	10	100	1	1
		Haluaghat	10	100		
9	Kishorgonj	Hosenpur	10	100	1	1
		Pakundia	10	100		
10	Tangail	Modhupur	10	100	1	1
		Ghatail	10	100		
		Dhanbari	10	100		
11	Sherpur	Sadar	10	100	1	1
		Nalitabari	10	100		
12	Chittagong	Potia	10	100	1	1
		Shitakunda	10	100		
		Mirershorai,	10	100		
		Fatikchari	10	100		
13	Bogra	Sadar	10	100	1	1
		Gabtoli	10	100		
		Shibgonj	10	100		
		Shajhanpur	10	100		
14	Pabna	Iswardi	10	100	1	1
		Atghoria	10	100		
15	Rajshahi	Poba	10	100	1	1
		Puthia	10	100		
		Durgapur	10	100		
16	Natore	Sadar	10	100	1	1
		Baghatipara	10	100		
17	Kustia	Sadar	10	100	1	1

SN	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII
		Doulatpur	10	100		
18	Jessore	Bagarpara	10	100	1	1
		Chougacha	10	100		
		Sadar	10	100		
		Keshobpur	10	100		
19	Chuadanga	Sadar	10	100	1	1
		Alamdanga	10	100		
20	Jhenidah	Kaligonj	10	100	1	1
		Court Chandpur	10	100		
		Shoilokupa	10	100		
		Harinakunda	10	100		
21	Magura	Sadar	10	100	1	1
		Mohammadpur	10	100		
22	Barisal	Uzirpur	10	100	1	1
		Babugonj	10	100		
23	Bhola	Sadar	10	100	1	1
		Daulotkhan	10	100		
24	Dhaka	Savar	10	100	1	1
		Dhamrai	10	100		
		Keranigonj	10	100		
Total=24		**68**	**680**	**6800**	**24**	**24**

1.4.4. Development of data collection tools

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

Field survey questionnaire: For quantitative analysis, the field survey was conducted in 24 major cucurbit growing districts of Bangladesh through face to face interview with 6800 cucurbit farmers using a set of pre-designed and pre-tested questionnaire (**Appendix-1)** encompassing the relevant study indicators.

Focus Group Discussion (FGD): For qualitative analysis, 24 FGD meetings were organized considering one FGD for each sampled districts with the participantion of at least 10 cucurbit farmers for each. The FGD meetings were conducted using pre-designed FGD guidelines (**Appendix-2**).

Key Informant Interview (KII): The key informant interviews were conducted with the extension personnel at field and headquarer level of DAE, officials of Plant Quarantine Centres at Sea and land ports; officials of Ministry of Agriculture; Entomologist and Plant Pathologist of BARI, Agricultural Universities, and importers and exporters. A total of 55 key personnel were interviewed using a semi-structured KII Checklist (**Appendix 3-6)** encompassing the qualitative issues of the study.

Field visit/physical observation: In addition, the expert team of the study physically visited the sampled districts of the study area aiming to observe the physical status of the insect pests, diseases and other associated pest problems in field condition**.**

1.4.6. Pests of cucurbits recorded in Bangladesh

The study for "Conducting Pest Risk Analysis (PRA) of Cucurbits in Bangladesh" was done in 24 major cucurbit growing districts of Bangladesh. From the field survey and review of sectondary documents, the precise findings of the study in-line with the presence of insect and mite pests, diseases and weed pests have been presented below:

1.4.6.1. Insect and mite pests of cucurbits

A total number of 21 arthropod pests of cucurbits of which 20 insect pests and 1 mite pest were reported in Bangladesh.

The incidences of insect pests of cucurbits recorded in Bangladesh were cucurbit fruitfly (*Bactrocera cucurbitae*), oriental fruitfly (*Bactrocera dorsalis*), guava fruitfly (*Bactrocera zonata*), mango fruit fly (*Bactrocera tau),* lesser fruit fly (*Dacus ciliates*), vegetable leaf miner (*Liriomyza sativae*), black cutworm (*Agrotis ipsilon*), cucumber moth (*Diaphania indica*), epilachna beetle (*Epilachna vigintioctopunctata*), epilachna beetle (*E. dodecastigma*), red pumpkin beetle (*Raphidopalpa foveicollis*), cucumber beetle (*Aulacophora indica*), green stink bug (*Nezara viridula*), melon thrips (*Thrips palmi*), cucurbit aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci* Genn.), cotton jassid (*Amrasca bigutula bigutula*), pink mealybug (*Maconellicoccus hirsutus*) and mole cricket (*Gryllotalpa brachyptera*), whereas one mite pest of cucurbit was recorded in Bangladesh named two-spotted spider mite (*Tetranychus urticae*) (Table 2).

Among these insect and mite pests of cucurbits, cucurbit fruit fly was more damaging than other arthropod pests. The cucurbit fruit fly was designated as major pest of all cucurnits and caused damage with high infestation intensity. The pest status of all other insect and mite pests was minor significance and caused low level of infestation. Usually Bangladesh's farmers always used chemical insecticides and acaricides through which these pests were suppressed in every season.

Table-2: Insect and mite pests of cucurbits in Bangladesh, their status, plant parts affected and infestation severity

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity
A. Insect pests							
1	Cucurbit fruitfly	*Bactrocera cucurbitae*	Tephritidae	Diptera	Fruit	Major	High
2	Oriental fruitfly	*Bactrocera dorsalis*	Tephritidae	Diptera	Fruit	Minor	Low
3	Guava fruitfly	*Bactrocera zonata*	Tephritidae	Diptera	Fruit	Minor	Low
4	Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	Fruit	Minor	Low
5	Lesser fruitly	*Dacus ciliates*	Tephritidae	Diptera	Fruit	Minor	Low
6	Vegetable leaf miner	*Liriomyza sativae*	Agromyzidae	Diptera	Leaf	Minor	Low
7	Black cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Seedling	Minor	Low
8	Cucumber moth	*Diaphania indica*	Crambidae	Lepidoptera	Leaf, twig, fruit	Minor	Low
9	Epilachna beetle	*Epilachna vigintioctopunctata*	Coccinellidae	Coleoptera	Leaf, twig	Minor	Low
10	Epilachna beetle	*E. dodecastigma*	Coccinellidae	Coleoptera	Leaf, twig	Minor	Low
11	Red pumpkin beetle	*Raphidopalpa foveicollis*	Chrysomeliae	Coleoptera	Leaf, root, vine	Minor	Low
12	Cucumber beetle	*Aulacophora indica*	Chrysomelidae	Coleoptera	Leaf	Minor	Low
13	Green stink bug	*Nezara viridula*	Pentatomidae	Hemiptera	Leaf, twig, vine	Minor	Low
14	Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Leaf, fruit	Minor	Low
16	Cucurbit aphid	*Aphis gossypii*	Aphididae	Homoptera	Leaf, twig, flower, fruit, vine	Minor	Low
17	Whitefly	*Bemisia tabaci* Genn.	Aleurodidae	Homoptera	Leaf, twig, flower, fruit, vine	Minor	Low
18	Cotton jassid	*Amrasca bigutula bigutula*	Cicadellidae	Hemiptera	Leaf, twig, flower, vine	Minor	Low
19	Pink mealybug	*Maconellicoccus hirsutus*	Pseudococcidae	Homoptera	Leaf, twig, flower, fruit, vine	Minor	Low
20	Mole cricket	*Gryllotalpa brachyptera*	Gryllotalpidae	Orthoptera	Seedling	Minor	Low
B. Mite pest							
21	Two-spotted spider mite	*Tetranychus urticae* Kock	Tetranichidae	Acarina	Leaf, twig,flower, vine	Minor	Low

Some pictures of insect and mite Pests cucurbits are presented below:

Plate-1: Cucurbit fruit fly and its infestation on cucumbers

Plate-2: Thrips and its infestation on cucurbit leaf

Plate-3: Whitefly on underside of leaf (left), infested leaves with chlorosis (right)

Plate-4: Adult epilachna beetle on leaf (left) and severely damaged leaf by grubs (right)

Plate-5: Adult red pumpkin beetle on leaf (left), and severely damaged leaves (right)

Plate-6: Adult stink bugs on twig (left) and sucking sap from stem (right)

Plate-7: Aphids on leaf (left), cucumber mosaic virus (mid) and leaf curling (right)

Plate-8: Jassid on leaf

Plate-9: Leaf miner damaged cucurbit leaves

1.4.6.2. Diseases of cucurbits recorded in Bangladesh

A total number of 19 species of disease causing pathogens of cucurbits were reported in Bangladesh, among which 12 diseases were caused by fungi, 3 caused by bacteria, 2 caused by nematode and 2 diseases of cucurbits were caused by viruses.

The incidences of fungal diseases of cucurbits reported in Bangladesh were powdery mildew (*Podosphaera xanthii*), downey mildew (*Pseudopernospora cubensis*), cercospora leaf spot

(*Alternaria brassicae*), chacoal rot (*Macrophomina physiolina*), anthracnose (*Colletotrichum orbiculaum*), root rot, stem rot, damping off/ seed rot of cucurbits were caused by *Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp., gummosis of cucurbits (*Cladosporium cucumerinum*), gummy stem blight (*Didymella bryoniae*), fusarium wilt (*Fusarium oxysporum* f.sp. *cucumerinum*), and cottony soft rot (*Sclerotinia sclerotiorum*) (Table 3).

The incidences of bacterial diseases of cucurbits recorded in Bangladesh were angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*), bacterial wilt (*Erwinia catotovora*) and bacterial root rot (*Pectobacterium cartovorum*). The nemic diseases of cucurbits were root knot nematode (*Meloidogyne incognita*) and reniform nematode (*Totyenchus* reniformis). The viral diseases of cucurbits reported in Bangladesh were *Cucumber mosaic virus* (CMV) and *Squash mosaic virus* (Table 3).

Among these diseases, the angular leaf spot for cucumber, fusarium wilt and root rot and damping off of seedlings were more damaging than others. But diseases were reported as minor diseases of cucurbits and caused damage with low infection intensity in Bangladesh. Most of cases, the damage severity was controlled by the farmers through routine application of fungicides and other pesticides in the field of cucurbits.

1.4.6.3. Weeds of cucurbits recorded in Bangladesh

A total number of 5 weeds were reported as the problem in the field of cucurbits in Bangladesh. The incidences of weeds in the field of cucurbits were bermuda grass (*Cynodon dactylon*), nutsedge (*Cyperus esculentus*), pigweed (*Amaranthus acanthochiton*), spiny pigweed (*Amaranthus spinosus*), and parthenium weed (*Parthenium hysterophorus*) (Table 4). The parthenium weed (*Parthenium hysterophorus*) was recorded and found only in some restricted areas of Bangladesh namely Rajshahi, Natore, Pabna, Kustia, Jessore districts. These districts are nearly attached with the Western border of Bangladesh and Eastern border of West Bengall of India. It was also reported that the parthenium weed might be entered into Bangladesh through cross boundary pathway from India by the transportation system of border trading.

Among the five weeds, the Parthenium grows in the whole season. As a newly introduced weed, though parthenium caused damage with low infestation intensity, but it could cause severe damage and spread to other areas, if not controlled properly. Other four weeds were reported as minor weeds with low infestation intensity in the field cucurbits. Basically Bangladeshi farmers controlled these weeds by weeding during intercultural operations of the field, thus these weeds remain as controlled condition except Parthenium.

Table-3: Diseases of cucurbits in Bangladesh, their status, plant parts affected and infestation severity

Sl. No.	Common name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity
Causal organism: Fungi							
1	Powdery mildew	*Podosphaera xanthii*	Erysiphaceae	Erysiphales	Leaf, vine, fruit	Minor	Low
2	Downey mildew	*Pseudopernospora cubensis*	Peronosporaceae	Peronosporales	Leaf, vine, fruit	Minor	Low
3	Cercospora leaf spot	*Alternaria brassicae*	Pleosporaceae	Pleosporales	Leaf, fruit	Minor	Low
4	Charcoal rot	*Macrophomina physiolina*	Botryosphaeriaceae	Botryosphaeriales	Stem, vine	Minor	Low
5	Anthracnose	*Colletotrichum orbiculaum*	Glomerellaceae	Glomerellales	Stem, vine, leaf, fruit	Minor	Low
6	Root-stem rot/ damping off/ seed rot	*Pythium* spp.	Pythiaceae	Pythiales	Root, stem/ vine, seedling, seed	Minor	Low
7		*Fusarium* spp.	Nectriaceae	Sordariomycetes		Minor	Low
8		*Rhizoctonia* spp.	Ceratobasidiaceae	Cantharellales		Minor	Low
9	Gumosis	*Cladosporium cucumerinum*	Davidiellaceae	Capnodiales	Vine, fruit	Minor	Low
10	Gummy stem blight	*Didymella bryoniae*	Incertae sedis	Pleosporales	Vine, fruit	Minor	Low
11	Fusarium wilt	*Fusarium oxysporum* f.sp. *cucumerinum*	Nectriaceae	Hypocreales	Root, vine, fruit	Minor	Low
12	Cottony soft rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales	Fruit, stem	Minor	Low
Causal organism: Bacteria							
13	Angular leaf spot	*Pseudomonas syringae* pv. *lachrymans*	Pseudomonadaceae	Pseudomonadales	Leaf	Minor	Low
14	Bacterial wilt	*Erwinia catotovora*	Enterobacteriaceae	Enterobacteriales	Root, stem	Minor	Low
15	Bacterial root rot	*Pectobacterium cartovorum*	Enterobacteriaceae	Enterobacteriales	Root, stem	Minor	Low
Causal organism: Nematode							
16	Root knot nematode	*Meloidogyne incognita*	Heteroderidae	Tylenchida	Root	Minor	Low
17	Reniform nematode	*Rotylenchulus reniformis*	Hoplolaimidae	Tylenchida	Root	Minor	Low
Virus							
18	Cucumber mosaic virus	*Cucumber mosaic virus*	Bromoviridae	Unassigned (+ve)ssRNA	Leaf, fruit	Minor	Low
19	Squash mosaic virus	*Squash mosaic virus*	Secoviridae	Picornavirales	Leaf, fruit	Minor	Low

Table-4: Weeds of cucurbits in Bangladesh, their status, plant stage affected and infestation severity

Sl. No.	Common name	Scientific name	Family	Order	Plant stage affected	Pest status	Infestation severity
1	Bermuda grass	*Cynodon dactylon*	Poacegae	Poales	Seedling-Vegetative	Minor	Low
2	Nutsedge	*Cyperus esculentus*	Cyperaceae	Poales		Minor	Low
3	Pigweed	*Amaranthus acanthochiton*	Amaranthaceae	Caryophyllales	Seedling-Vegetative	Minor	Low
4	Spiny pigweed	*Amaranthus spinosus*	Amaranthaceae	Caryophyllales	Seedling-Vegetative	Minor	Low
5	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Recorded in limited areas	Minor	Medium

Some pictures of diseases of cucurbits are presented below;

Plate-10: Powdery mildew on leaf (left) and damaged cucurbit field (right)

Plate -11: Downy mildew damaged leaf at initial stage (left) and severe stage (right)

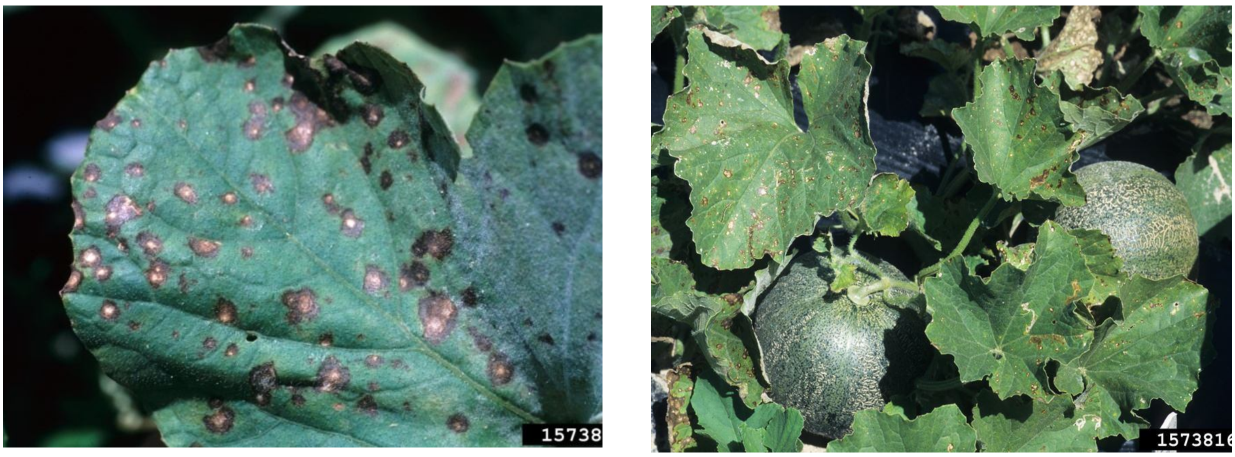


Plate-12: Cercospora leaf spot on cucurbit leaves

Plate-13: Anthracnose damaged fruit (left) and leaf (right)

Plate-14: Bacterial wilt at early stage (left) and severed at later stage (right)

Plate-15: Angular leaf spot of cucurbit

Plate- 7: Fruit rot of cucurbit

Plate-16: Fusarium wilted cucurbit field (left) and damaged vine (right)

Plate -17: Gummy ooze out from stem (left) and damaged vine (right)

Plate-18: Aphid transmitted CMV (left), curled leaf (mid) and infected fruits (right)

1.4.6.4. Management options for cucurbit pests in Bangladesh

Insect and mite pest management: The most effective and commonly practiced management options against the insect pests of cucurbits were spraying of insecticides in the field. But pheromone traps and poison bait traps were used especially for controlling fruit flies in the field. Irrigation was done for controlling soil dewelling insect namely cutwom and removal of harmful insects and infested fruits and parts of plants was also done. It was also reported that Integrated Pest Managemend (IPM) was also followed for controlling insect pests of cucurbits. Few cases, especially for thrips and aphid sticky trap was used as well as hand picking was done for controlling epilachna beetle.

Disease management: The most effective and commonly practiced management options against the diseases of cucurbits were spraying of fungicides in the field, seed treatment with fungicides for preventing seed borne diseases, and removal of diseased plants or parts of plants. Other management practices for controlling diseases of cucurbits were removal of weeds and spraying of insecticides in the cucurbit fields for disease transmitting vector control.

Weed management: The most effective and commonly practiced management options for weeds in the field of cucurbits were removal of weeds during land preparations and weeding during intercultural operations. Other options were earthing up at the base of plants, irringaiton and use of herbicides.

1.5. Pathway Risk Analysis Process and Methodology

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

1.5.1. Undertaking of Pest Risk Analysis (PRA)

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

PRA STAGE 1: INITIATION

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

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

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

PRA STAGE 2: PEST RISK ASSESSMENT

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

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

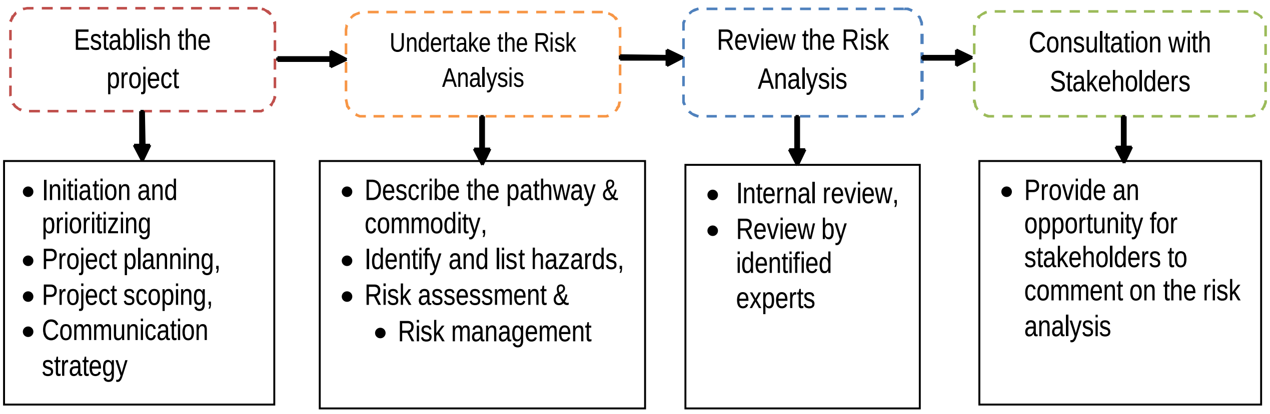
In most cases, these steps were applied sequentially in a PRA but it is not essential to follow a particular sequence. Pest risk assessment needs to be only as complex as is technically justified by the circumstances. This standard allows a specific PRA to be judged against the principles of necessity,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

PRA STAGE 3: PEST RISK MANAGEMENT

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

The following briefly describes the Biosecurity process and methodology for undertaking pathway risk analyses. The risk analysis process leading to the final risk analysis document is summarized in Figure 1 below:

Figure-1: A summary of the risk analysis development process



1.6. Pathway Description

1.6.1. Import pathways of cucurbits

For the purpose of this risk analysis, cucurbits are presumed to be from anywhere in exporting countries such as India, Japan, Thailand, Taiwan, China, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chille.

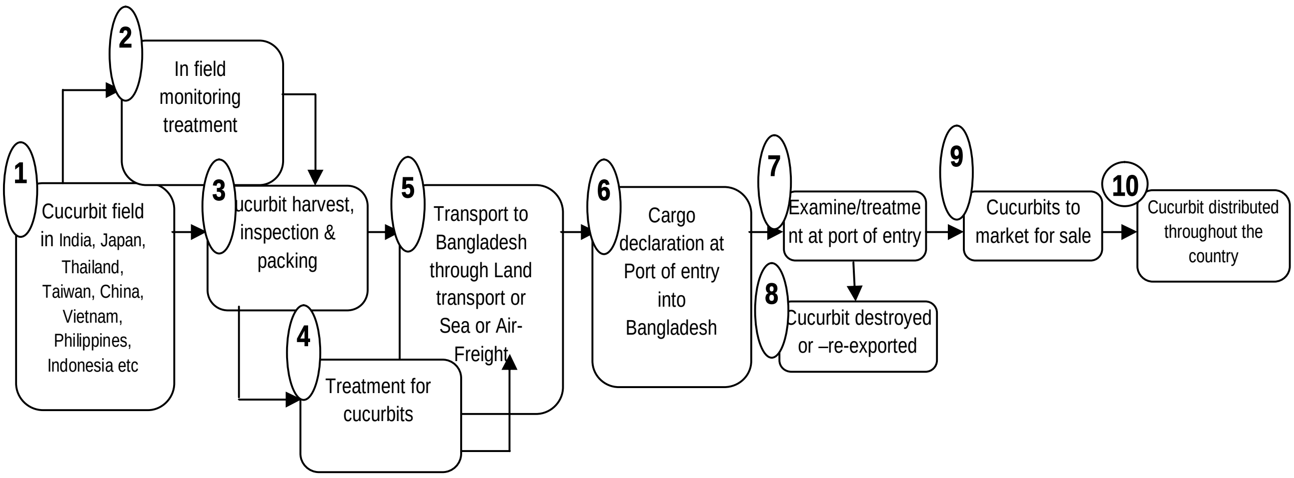
To comply with existing Bangladesh import requirements for cucurbits, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests (insect & mite pests, diseases, weeds or any othe pests) are not associated with the product. Commodity would then be sea or land or air freighted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

1.5.2. Description

- Cucurbits in India, Japan, Thailand, Taiwan, China, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chille are being grown in the field, either as a single crop or beside other field or horticultural crops.

- Monitoring of the insect & mite pests, diseases, weeds and any other pests of cucurbits is undertaken, with appropriate controls applied.
- cucurbits are being harvested, inspected and the best quality cucurbits washed, pre-treated and packed in boxes.
- Post harvest disinfestations including fumigation or cold disinfestations are being undertaken either before or during transport of the cucurbits to Bangladesh.
- Transport to Bangladesh is by air or sea or land port.
- Each shipment must be accompanied by the appropriate certification, e.g. a phytosanitary certificate attesting to identity the cucurbits, any treatments completed, or other information required to help mitigate risks.
- Cucurbits are examined at the border to ensure compliance.
- Any cucurbit not complying with Bangladesh biosecurity requirements (e.g. found harboring pest organisms) are either treated re-shipped or destroyed.
- Cucurbits are stored before being distributed to market for sale.
- Dealers and sellers of cucurbits stock and these are bought to users and or farmers within the local area these are sold in.The linear pathway diagram of import risk of cucurbits is furnished below:

Figure-2: Linear Pathway Diagram

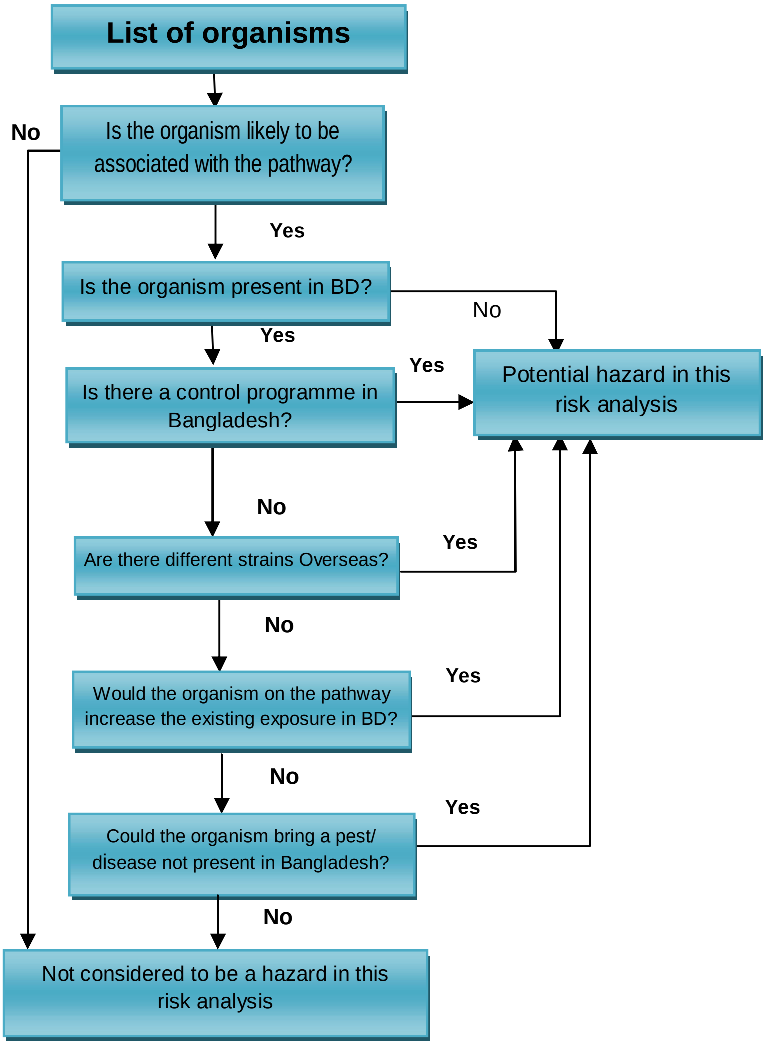


1.7. Hazard Identification

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

This list is further refined and species removed or added to the list depending on the strength of the association and the information available about its biology and life cycle. Each pest or pathogen is assessed mainly on its biological characteristics and its likely interaction with the Bangladesh environment and climate. Hitch-hiker organisms sometimes associated with a commodity, but which do not feed on it or specifically depend on that commodity in some other way 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 Figure 3.

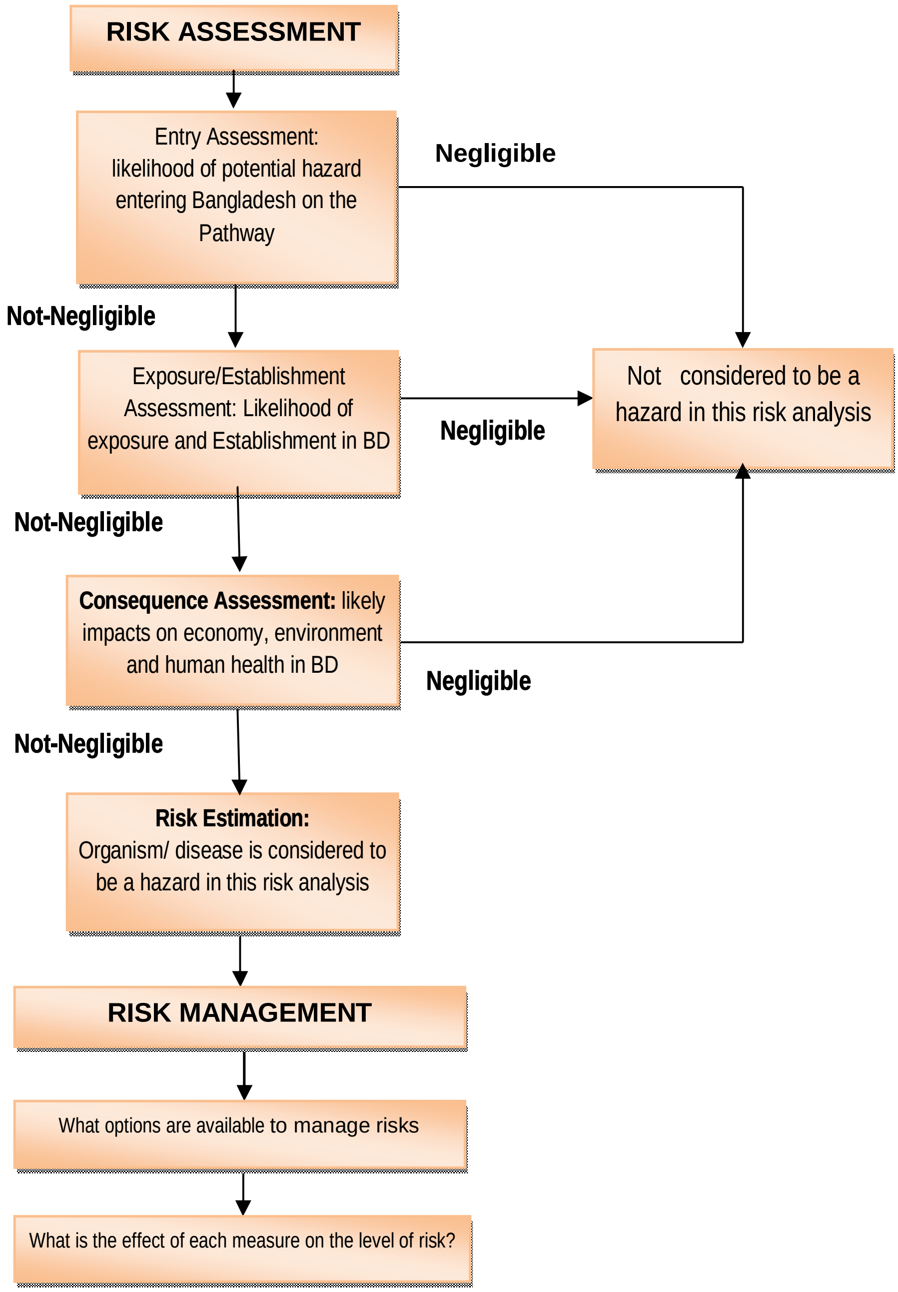
Figure-3: Diagrammatic representation of hazard identification



1.8. Risk Assessment of Potential Hazards

Risk assessment is the evaluation of the likelihood of entry, exposure and establishment of a potential hazard, and the environmental, economic, human and animal health consequences of the entry within Bangladesh. The aim of risk assessment is to identify hazards which present an unacceptable level of risk, for which risk management measures are required. Descriptors are used in assessing the likelihood of entry, exposure and establishment, and the economic, environmental, social and human health consequences. The approach taken in this Risk Analysis is to assume the commodity is imported without any risk management. In this risk analysis hazards have been grouped where appropriate to avoid unnecessary duplication of effort in the assessment stage of the project. Diagrammatic representation of risk assessment and risk management is shown in Figure 4.

Figure 4: Diagramatic representation of the process followed for risk assessment and management



1.9. Assessment of Uncertainties

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

1.10. Analysis of Measures to Mitigate Biosecurity Risks

Risk management in the context of risk analysis is the process of identifying measures to effectively manage the risks posed by the hazard(s) associated with the commodity or organisms under consideration.

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

The uncertainty noted in the assessments of economic consequences and probability of introduction should also be considered and included in the consideration of risk management options. Where there is significant uncertainty, a precautionary approach may be adopted. However, the measures selected must nevertheless be based on a risk assessment that takes account of the available scientific information. In these circumstances the measures should be reviewed as soon as additional information becomes available. It is not acceptable to simply conclude that, because there is significant uncertainty, measures selected on the basis of a precautionary approach. The rationale for selecting measures must be made apparent.

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

1.11. Risk Evaluation

If the risk estimate determined in the risk assessment is significant, measures can be justified.

1.12. 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. While there are currently six established pathways (India, China, Pakistan, Japan, Thailand, Taiwan, UAE, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile) for cucurbit fruits and seeds coming 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.

1.13. Review and Consultation

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

CHAPTER 2

IMPORT RISK ANALYSIS

2.1. Introduction

This chapter provides information on the commodity that is relevant to the analysis of biosecurity risks and common to all organisms or diseases potentially associated with the cucurbits. 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 Banladesh.

2.2. Commodity Description

2.2.1. Introduction

Cucurbits belong to the family ***Cucurbitaceae*** and consist of about 118 genera and 825 species, according to the last taxonomic treatment of Jeffrey (1990). Cucurbits are present in both the New and Old World and are among the most important plant families that supply human with edible products and useful fibers. Cucurbits are divided into five sub-families: Fevilleae, Melothrieae, Cucurbitaceae, Sicyoideae, and Cyclanthereae.

The plants in this family are grown around the tropics and in temperate areas, where those with edible fruits were among the earliest cultivated plants both in the Old and New Worlds. The Cucurbitaceae family ranks among the highest of plant families for number and percentage of species used as human food.

2.2.2. History

The greatest controversy among gourd lore concerns the bottle gourd or calabash, *Lagenaria siceraria*, which is also called the Pre-Columbian gourd. This is one of the plants that was used for containers in both the Old and New World before Columbus discovered America. Records of the fruits come from Peru (7000 B.C.), Thailand (7000 B.C.), Mexico (2700 B.C.), and Egypt (2500 B.C.), even though the genus *Lagenaria* is native to Africa! Some authors have used the bottle gourd as evidence that there was pre-Columbian cultural exchange. However, experiments have shown that dried, sealed bottle gourds can float for as long as two years in seawater without killing the seeds; it is likely that bottle gourds floated between the continents and were picked up in the New World and adopted for uses there. Interestingly, in western Africa (e.g., Nigeria), certain tribes use the gourd in an annual fishing festival in which the gourds are floated on the water. One fruit making a successful trans-Atlantic voyage to the coast of Brazil from Africa would have been sufficient to establish the plant in the New World.

2.2.3. Cucurbits in Bangladesh

Bangladesh has a long history of growing some cucurbits which include water melon, muskmelon as dessert crops, cucumber as salad and bitter gourd, snake gourd, bottle gourd, ash gourd, sponge gourd, ribbed gourd as vegetables. Bottle gourd is primarily a winter vegetable but now days it is available also in summer. Pumpkins are grown round the year. They are grown in homestead for family consumption as well as in larger plots for commercial purpose. The total acreage under cucurbits is about 81,720 ha while the total production is around 308,096 MT in Bangladesh (BBS, 2011).

Different cucurbits are grown in Bangladesh, among which, the sweet gourd, bottle gourd, ridge gourd, ribbed gourd, snake gourd, cucumber, ash gourd, pointed gourd, bitter gourd, teasle gourd/kakrol, water melon are widely cultivated in Bangladesh. The list of major cucurbits and some of them are briefly described below:

Table-5: List of cucurbit vegetables grown in Bangladesh

Name of vegetables	Scientific name	Family
Sweet gourd	*Cucurbita moschasta*	*Cucurbitaceae*
Bottle gourd	*Lagenaria siceraria*	*Cucurbitaceae*
Ridge gourd	*Luffa acutangula*	*Cucurbitaceae*
Ribbed gourd	*Luffa cylindrical*	*Cucurbitaceae*
Snake gourd	*Trichosanthes anguina*	*Cucurbitaceae*
Cucumber	*Cucumis sativus*	*Cucurbitaceae*
Ash gourd	*Benincasa hispida*	*Cucurbitaceae*
Pointed gourd	*Trichosanthes dioica*	*Cucurbitaceae*
Bitter gourd	*Momordica charantia*	*Cucurbitaceae*
Teasle gourd/Kakrol	*Momordica dioica*	*Cucurbitaceae*
Water melon	*Cucumis melo*	*Cucurbitaceae*

Source: *Rashid (2002)*

2.2.4. Morphological characteristics

An excellent example of a plant family with many useful species is the gourd family, the Cucurbitaceous. Anyone can easily learn to recognize cultivated members of this family by observing several conspicuous features.

a) Vines, usually annuals, with five-lobed or palatably divided leaves having long petioles; leaves alternately arranged on the stem.
b) Spring-like tendrils.
c) Male (staminate) and female (pistillate) flowers (unisexual flowers) on a single plant (**monoecious**).
d) Flowers with five fused petals and five stamens (male) or an inferior ovary (female).
e) Fruits large and fleshy, usually with a hard outer covering (a special type of berry termed a **pepo**).
f) Seeds attached to the ovary wall (**parietal placentation**) and not to the center.
g) Many large, fairly flat seeds in which the embryo has two very large cotyledons.

Although most cucurbits have a tough "skin," i.e., a hard exocarp, some have a much thinner skin, so that they are perishable, such as the chayote (*Sechium*) of Middle America and certain squashes. Chayote grows as a large perennial vine, usually on trellises.

2.2.5. Classification of cucurbits

The most important cultivated genera are

- *Cucurbita* - squash, pumpkin, zucchini, some gourds
- *Lagenaria* - mostly inedible gourds
- *Citrullus* - watermelon (*C. lanatus*, *C. colocynthis*) and others
- *Cucumis* - cucumber (*C. sativus*), various melons

Luffa - the common name is also luffa, sometimes spelled loofah (when fully ripened, two species of this fibrous fruit are the source of the loofah scrubbing sponge)

(a) Squash and Pumpkins - *Cucurbita* sp.

Cucurbita or yellow flowered cucurbit is considered to be one of the most morphologicaly variable genera in the entire plant kingdom (Robinson ***et al***., 1976). The 22 wild and five cultivated species are extremely diverse in fruit color, size, and shape. The cultivated species are reproductively isolated from each other by genetic barriers and can be identified using morphological characteristics (Whitaker & Bemis, 1964; Whitaker & Bemis, 1975; Nee, 1990). The constant and relatively high chromosome number ($2n = 40$) as well as the complex isozyme pattern suggest an allopolyploid origin for the genus (Singh, 1979; Kirkpatrick ***et al***., 1985).

Archaeological records of the New World suggest that ***Cucurbita*** was one of the first plant to be domesticated (Nee, 1990). ***Cucurbita***-corn-bean complex formed the nutritional basis for pre-Columbian civilizations in the Western Hemisphere (Whitaker & Bemis, 1975). One of the first species to be domesticated in the New World was ***C. pepo***. Cultivation by the inhabitants of Guila Naquitz cave dated between 10,000 to 8,000 before present (BP), predating corn and beans by more than 4,000 years (Smith, 1997).

The origin and early spread of all ***Cucurbita*** species was in the Americas**.** ***Cucurbita ficifolia*** was the most widespread cultivated species with a native range in the mountains from Mexico to northern Chile and Argentina (Whitaker & Bemis, 1975; Wilson ***et al***., 1992). ***Cucurbita maxima*** was the only cultivated species with a native range restricted to South America, in the warm temperate areas of Uruguay and Argentina. ***Cucurbita moschata*** was native to the low lands of tropical and sub-tropical America (Mexico and South America), ***C. argyrosperma*** to the pacific coast ranging from Mexico to Nicaragua, and ***C. pepo*** to the high elevations of Mexico and northern Central America (Nee, 1990; Wilson ***et al***., 1992). Also, ***C. moshata*** was unique in being spread in two distinct native areas, a major one in Mexico and a minor one in the northern South America (Whitaker & Bemis, 1975).

The cultivated species of ***Cucurbita*** can be divided into mesophytic annuals (***C. maxima***, ***C. argyrosperma***, ***C. moschata***, and ***C. pepo***) or mesophytic perennial (***C. ficifolia***) (Whitaker & Bemis, 1964). Three species have defined ancestors. ***Cucurbita andreana*** Naud., a weedy species, is the ancestor of ***C. maxima***; ***C. sororia*** Bailey is the ancestor of ***C. argyrosperma*** (Nee, 1990); and ***C. fraterna*** Bailey and/or ***C. texana*** (Scheele) Gray are the possible ancestors of ***C. pepo*** (Decker, 1988; Nee, 1990). Allozyme analysis showed an independent domestication of ***C. pepo*** in the eastern United States and in Mexico, from divergent populations of the original and respective wild progenitors ***C. fraterna*** and ***C. texana*** (Decker-Walters, 1990). The high level of gene flow between ***C. texana*** and ***C. pepo*** in field experiments suggested a long-term of interspecific hybridizations and confirmed ***C. texana*** as ancestor of ***C. pepo*** (Kirkpatrick & Wilson, 1988).

Genetic diversity studies indicated that cultivated species belong to different genetic groups. A dendrogram of 21 ***Cucurbita*** species constructed from data using 93 phenotypic characters grouped cultivated species in five different groups (Whitaker & Bemis, 1975). Chloroplast DNA diversity analysis also placed cultivated species in different groups, being ***C. pepo*** in two sub-groups: one with ***C. texana*** and another with ***C. fraterna*** (Wilson ***et al***., 1992). Among cultivated species, ***C. moshata*** was the most variable and closely related species and nearest the common ancestor of the genus, because of the high interspecific compatibility (Whitaker & Bemis, 1975). Isozyme study showed high allelic diversity in *C. pepo* and ***C. moschata***. ***Cucurbita pepo*** shares a common ancestor with ***C. moschata*** and ***C. argyrosperma***, but not with ***C. maxima*** (Decker-Walters ***et al***., 1990).

(b) Cucumber - *Cucumis sativus*

According to a recent comprehensive biosystematic monograph of Kirkbride (1993), the genus ***Cucumis*** includes 32 annual and perennial species divided in to two very distinct groups defined by geographic origin and chromosome number (African $2n$ = 24 and Asiatic group $2n$ = 14 chromosomes). The African group includes melon (***C. melo***) and the Asiatic group includes cucumber (***C. sativus***) and its probable ancestor ***C. sativus*** var. *hardwickii* (Royle) or simply ***C. hardwickii*** (Perl-Treves & Galun, 1985). Studies based on isozymes, chloroplast DNA and restriction fragment length polymorphism supported the distinction between melon and cucumber (Perl-Treves & Galun, 1985; Perl-Treves ***et al***., 1985).

Cucumber originated in India about 3,000 years ago and was soon cultivated in the South and East of the Himalayas, forming the Asiatic group (Kroon ***et al***., 1979; Ramachandran & Narayan, 1985). From India, cucumber was brought to Greece and Italy and later to China.

Records confirmed cucumber cultivation in France in the 9th century, England in the 14th century and in North America by the mid-16th century (Swiader ***et al.***, 1992).

(c) Melon - *Cucumis melo*

The African group (melon group) has 30 species divided into six subgroups (Kirkbride, 1993). Melon and other $2n = 24$ species were originally distributed across a large part of Africa and Middle East up to Pakistan and South Arabia. However, some species also occurred in the Asiatic group range (Kroon ***et al.***, 1979; Ramachandran & Narayan, 1985). This is the case of ***C. hystrix*** Chakr, which is the only $2n = 24$ native to Asia. This species is of particular interest because of morphological and biochemical characteristics similar to ***C. sativus*** and chromosome number equal to ***C. melo***, indicating a possible bridge between the two species (Chen & Adelberg, 2000).

(d) Watermelon - *Citrullus lanatus*

The genus ***Citrullus*** consists of eight species and sub-species. Watermelon, the only cultivated species of the genus, is a diploid with 22 chromosomes ($2n = 22$) (Mallick & Masui, 1986). The watermelon ancestor is the bitter-fruit form of ***C. vulgaris*** Schrader. (Mohr,1986). Watermelon originated in Africa and India (Mallick & Masui, 1986). Watermelon is an important crop in warmer parts of Russia and other parts of Asia Minor, the Near East, China and Japan. In the New World, cultivation began in Massachusetts as early as 1629 (Mohr, 1986). Watermelon was brought to America by Spanish and quickly became very popular crop (Robinson & Decker-Walters, 1997).

(e) Bottle gourd - *Lagenaria siceraria*

A total of six species have been recognized as belonging to the genus ***Lagenaria*** or white flowered gourds. One is the domesticated monoecious species ***L. siceraria*** while five of them are wild perennial, dioecious forms from Africa and Madagascar. The basic haploid chromosome number in the genus is 11 ($2n = 22$) (Sing, 1990). Bottlegourd was domesticated in Asia and at the same time indigenous to Africa (Whitaker & Davis, 1962). Tropical Africa remains as the primary gene pool for this species (Sing, 1990).

(f) Loofah - ***Luffa* spp.**

The genus ***Luffa*** is comprised of seven species, four well-differentiated species from the Old World (***L. echinata*** Roxb*,* ***L. acutangula, L. aegyptiaca****,* and ***L. graveolens*** Roxb.) and three species from the New World (***L. quinquefida*** (Hook. & Arn.) Seem*,* ***L. operculata*** (L.) Cogn*,* and ***L. astorii*** Svens.) (Heiser & Schilling 1990). All species have 26 chromosomes ($2n = 26$) (Dutt & Roy, 1990; Heiser & Schilling, 1990). The early spread of the genus ***Luffa*** was in the New and Old World, but both cultivated species originated in India (Heiser & Schilling, 1990).

Cytological and hybridization studies suggest a close relationship between the two cultivated species (***L. aegyptiaca*** and ***L. acutangula***) and their derivation from either *L. graveolens* or an unidentified common ancestor (Dutt & Roy, 1990). While Old World species are well differentiated from each other and from the American species, the American species are rather similar to each other. ***Luffa aegyptiaca*** is the most extensively cultivated species (Heiser & Schilling, 1990).

2.2.6. Cultivation

Cultivation of typical garden cucurbits is familiar to most people. Seeds are planted in the spring, the plant grows vigorously in warm and hot weather with plenty of water, and flowers form in summer to produce fruits in summer or early fall before frost. In many forms, the first-formed flowers on a plant are staminate (male), and this is why they never form a fruit. Several weeks later the pistillate (female) flowers form, and enough male flowers present so that the pollen can be transferred by a bee to a female flower. In the genus *Cucurbita*, the commonly cultivated species are not able to cross with each other, so one can plant a cultivar from each of the four species without fear of developing hybrid seeds---seeds collected from a fruit should produce the same type of fruit in the next generation.

2.2.7. Climatic requirements

The climate of Bangladesh is favorable for growing most of the vegetable crops specially cucurbits. Cucurbits grow best in summer weather when days and nights are consistently warm. Traditionally, cucurbit crops need a fair amount of space to sprawl and twine; however, there are now dwarf and bush types of cucurbits that are well suited to small spaces. It is also possible to train traditional vines to vertical structures to save space.

Cucurbits need full sun and well-drained soil in order to thrive. Before planting, add organic matter for best results. If your soil is particularly heavy, you can add peat or rotted manure. All cucurbits require low nitrogen and high potassium for fruit development. It is always best to take a soil sample before fertilizing. Be careful not to over fertilize with nitrogen. This encourage a healthy vine but stunt fruit development. Provide one inch of water per week, delivered slowly and in the early morning. Follow specific planting instructions for varieties that grow best in your area.

2.2.8. Cucurbit imports from exporting countries into Bangladesh

Cucurbit seed imports

According to the record provided by the Plant Quarantine Wing (PQW) of Department of Agricultural Extension (DAE), Bangladesh imports cucurbit seeds from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile (DAE, 2016). The seeds of different cucurbits types are being imported from these exporting countries through Air Freight. The imported cucurbits are snake gourd, bitter gourd, cucumber, bottle gourd, ash gourd, sweet gourd, sponge gourd, ridge gourd, melon, water melon and squash. The year-wise amount of dirrent cucurbit seeds imported during 2010/11 to 2014/15 has been presented in Table 6.

Table-6: Year wise cucurbit seed imported in Bangladesh during 2010-11 to 2014-15

Type of cucurbit seed	Year-wise quantity of seed import (M/T)					Country from import
	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011	
Snake gourd	4.150	3.546	3.025	3.380	3.346	India, China, Taiwan, Thailand, Japan, Philippines, Vietnam Indonesia, Australia, U.S.A, France, Germany, Italy, Netherlands, Belgium Brazil, Chile
Bitter gourd	1.745	1.632	1.576	1.305	1.291	
Cucumber	9.451	8.690	7.375	5.868	4.694	
Bottle gourd	1.795	1.950	1.603	1.856	1.670	
Ash gourd	1.775	1.675	1.495	1.153	1.037	
Sweet gourd	2.700	2.577	2.275	0.353	0.317	
Sponge gourd	1.350	1.257	1.314	0.558	0.502	
Ridge gourd	1.675	1.563	1.125	0.988	0.889	
Melon	0.245	0.345	0.012	-	-	
Water melon	10.945	12.127	11.461	7.784	-	
Squash	0.975	0.876	0.925	0.617	0.556	

2.2.9. Cucurbit fruit imports

According to the record provided by the Plant Quarantine Wing (PQW) of Department of Agricultural Extension (DAE), Bangladesh imports cucurbit fruits mainly from Pakistan, Thailand, UAE, and Australia (DAE, 2016). The imported cucurbits are melon, squash and other cucurbits. The year-wise amount of dirrent cucurbit seeds imported during 2010/11 to 2014/15 has been presented in Table 7.

Table-7: Year wise cucurbit fruits imported in Bangladesh during 2010-11 to 2014-15

Type of cucurbits	Year-wise quantity fruit import (M/T)					Country from export
	2014-2015	2013- 2014	2012-2013	2011-2012	2010-2011	
Melon	02.82	01.65	03.46	02.86	2.16	Thailand, Pakistan, UAE, Australia
Squash	01.75	02.05	02.90	01.24	0.93	
Others	296.71	242.75	281.21	265.75	234.77	

Source: DAE (2016)

2.2.10. Uses of cucurbits

In the Old and New World there was early use of dried pepos for other purposes. Of course, the warty gourds have been used as decorations, and the bitter meat of gourds has been used for medicines and fish poisons. But the large gourds of *Lagenaria* in particular became popular around the world as containers, e.g., as vessels for carrying water or other liquids, as dippers, as objects to conceal male genitalia, or as places to mix brews, such as tea (e.g., mat). In addition, many peoples have used gourds as parts of musical instruments because the dry fruits have good resonant properties when used with strings or as horns or percussion instruments, such as rattles, scrapers, marimbas, and drums. Many tribes carve and decorate gourds for the home or ceremonies, including ceremonial masks. The calabash pipe, ala Sherlock Holmes, and many native pipes and hookahs have been fashioned from the necks of gourds.

The earliest records of human use of edible cucurbits have come from Mexico; caches of seeds of squashes have been found from habitations older than 9000 years, and certainly by 5000 B.C. In the New World, squashes and pumpkins were used as a major food crop (planted) by native peoples and became a major part of the diet of the Pilgrims, apparently a prominent food at the first Thanks giving feast and all subsequent ones. *Cucurbita* fruits have yellow or orange flesh, which is rich in carotenoids, the compounds humans need to make vitamin A and our visual pigment rhodopsin.

Finds in Egyptian tombs have revealed that sweet (sugar-bearing) cucurbits were being eaten by sophisticated cultures in the Old World during early times. Seeds of melons (*Cucumis* and *Citrullus*) found in these tombs suggest that the pharaohs were serving these fruits at their meals. Moreover, melons and cucumbers are found throughout Africa, so they were probably important early food crops of African peasants. Today the food markets of Africa have many forms of these cucurbits, as well as the New World species.

2.2.11. Pests of cucurbits

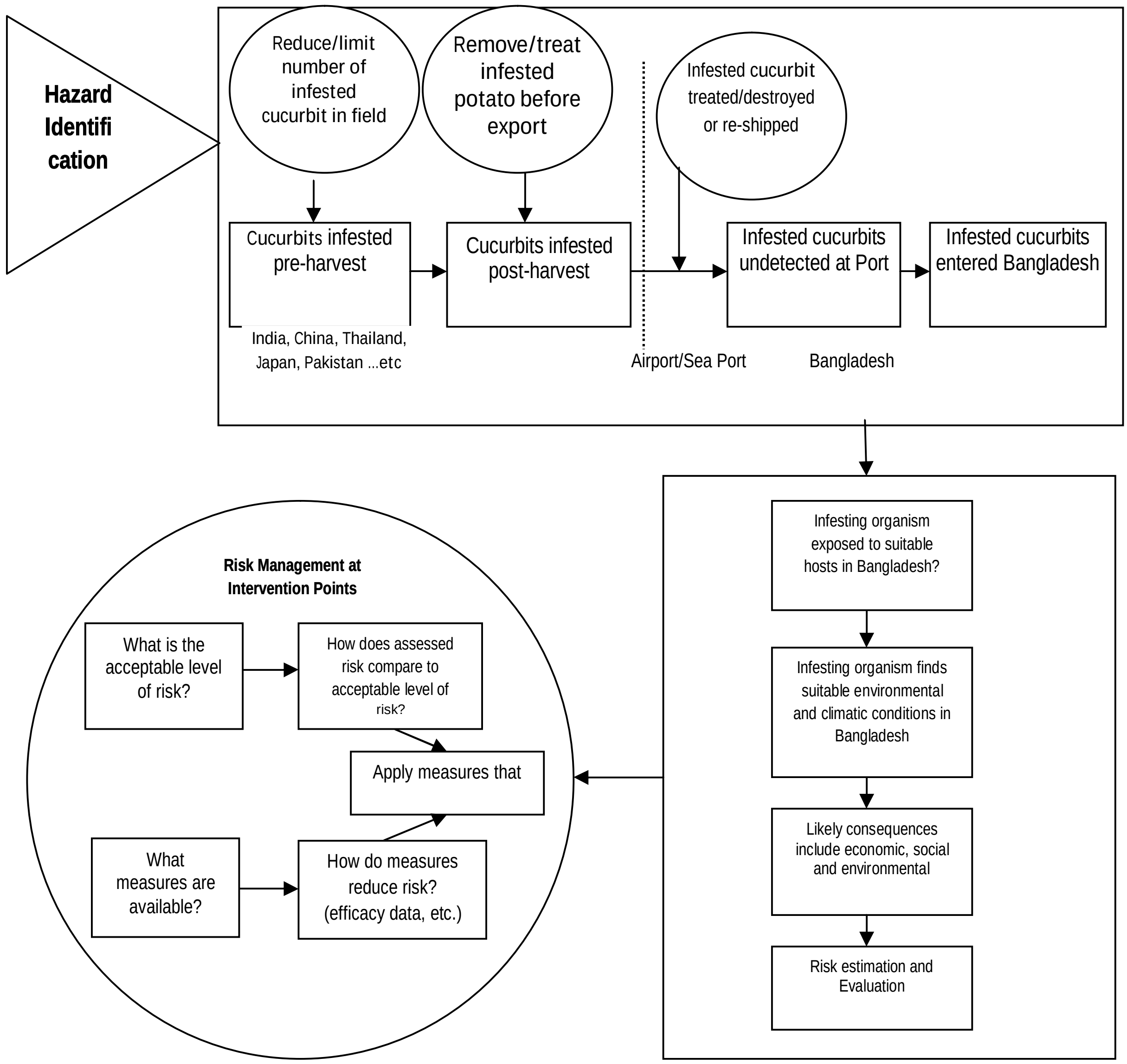
Insect pests: Several insect pests attack cucurbits. The major insect pests of cucurbits in Bangladesh are fruit fly, epilachna beetle, pumpkin beetle, flea beetle, pentatomid bug, jassid, thrips, whitefly, leaf miner, fruit borer etc.

Diseases: The diseases of cucurbits commonly found in Bangladesh are powdery mildew, gummy stem blight, *Cucumber mosaic virus,* anthracnose, cercospora leaf spot, angular leaf spot, wilt, fruit rot, root-knot, foot/root rot, ring spot virus, soft rot, seed rot, downy mildew etc.

2.3. Description of the Proposed Import Pathway

For the purpose of this risk analysis, cucurbits are presumed to be from anywhere in India, China, Pakistan, Japan, Thailand, Taiwan, UAE, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile (DAE, 2016). To comply with existing Bangladesh import requirements for cucurbits, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests are not associated with the product. Cucurbits would then be sea or air freighted to Bangladesh where it go to a holding facility before being distributed to dealers, distributors, markets, sellers and farmers for cultivation and uses of the imported cucurbits. The proposed import pathway of cucurbits indicating how the risk analysis process applied at the pathway level is given below:

Figure-5: Proposed import pathway of cucurbits



2.4. Exporting Countries-General Climate

2.4.1. India-General Climate

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

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

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

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

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

2.4.2. Thailand-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 climate, a hot, humid climate with all months above 18°C (WeatherOnline, 2015c).

2.4.3. China-General Climate

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

The northeast experiences hot and dry summers and bitterly cold harsh winters, with temperatures known to reach as low as -20°C (-4°F). The north and central region has almost continual rainfall, temperate summers reaching 26°C (79°F) and cool winters when temperatures reach 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.

2.4.4. Japan-General Climate

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

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

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

2.4.5. Pakistan-General Climate

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

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

Pakistan has four seasons: a cool, dry winter from December through February; a hot, dry spring from March through May; the summer rainy season, or southwest monsoon period, from June through September; and the retreating monsoon period of October and

November. The onset and duration of these seasons vary somewhat according to location. http://en.wikipedia.org/wiki/Climate_of_Pakistan

2.4.6. Taiwan-General Climate

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

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

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

2.4.7. Indonesia-General Climate

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

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

2.4.8. Vietnam-General Climate

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

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

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

2.4.9. Philippines-General Climate

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

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

2.4.10. United Arab Emirates-General Climtae

The climate of the UAE generally is very hot and dry. The hottest months are July and August, when average maximum temperatures reach above 40 °C (104.0 °F) on the coastal plain. In the Al Hajar al Gharbi Mountains, temperatures are considerably cooler, a result of increased altitude. Average minimum temperatures in January and February are between 10 and 14 °C (50.0 and 57.2 °F). During the late summer months, a humid southeastern wind known as the sharqi makes the coastal region especially unpleasant. The average annual rainfall in the coastal area is fewer than 120 mm (4.7 in), but in some mountainous areas annual rainfall often reaches 350 mm (13.8 in). Rain in the coastal region falls in short, torrential bursts during the summer months, sometimes resulting in floods in ordinarily dry wadi beds. The region is prone to occasional, violent dust storm, which can severely reduce visibility. The Jebel Jais mountain cluster in Ras al Khaimah has experienced snow only twice since records began.

2.4.11. Australia-General Climate

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

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

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

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

[http://www.weatheronline.co.uk/reports/climate/Australia.htm]

2.4.12. *The Netherlands-General Climate*

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

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

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

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

2.4.13. Germany-General Climate

Germany's climate is moderate and has generally no longer periods of cold or hot weather. Northwestern and coastal Germany have a maritime influenced climate which is characterized by warm summers and mild cloudy winters. During January, the coldest month, the average temperature is about 1.5°C in the north and about -2°C in the south. In July, the warmest month, it is cooler in the north than in the south. The northern coastal region has July temperatures averaging between 16°C and 18°C; at some locations in the south, the average is almost 20°C or even slightly higher.

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

2.4.14. Belgium-General Climate

Belgium has a temperate maritime climate influenced by the North Sea and Atlantic Ocean, with cool summers and moderate winters. Since the country is small there is little variation in climate from region to region, although the marine influences are less inland. Rainfall is distributed throughout the year with a dryer period from April to September. Especially in fall and winter strong Atlantic low-pressure systems can bring gales and uncomfortable weather. Sometimes easterly winds can cause a more continantal type of weather, warm and dry in the summer, but cold and clear in the winter with temperatures sometimes far below zero.

Belgium is a flat country and has often breezy conditions, although more in the winter than in the summer, and more among the coastal areas than inland. In the eastern regions hills cause a cooler and wetter climate with more rainfall and sometimes heavy snowfall in the winter.

2.4.15.Italy-General Climate

With its hot, dry summers and cool, wet winters, **Italy** experiences a mediterranean climate. Winters in Italy are cool and humid in the north and the mountainous zone. Sometimes cold air from northern Europe can spread south into Italy; bring snow to most mountains, while the coasts are kept warm by the high sea temperatures. Storms like the Mistral can bring snow and gales, sometimes even in southern districts of Italy.

The summer can be quite **hot** in Italy, mainly in the south of the peninsula, with high nocturnal temperatures of usually 28-33°C, but sometimes even 40°C. Thunderstorms are quite common especially in the northern areas. The meditteranean climate in Italy has often local variations. Surrounded by warm seas and with mountains close by, the coast always has a breeze; mountain areas are usually cooler with clear sunny skies, but sometimes local showers or thunderstorms in the afternoon. Hot air rising from the sea can cause heavy **Thunderstorms** especially in early fall, but these bring often the only summer rain that rapidly evaporates. In spring and fall, the Sirocco, a warm wind from Africa, raises the temperature of the peninsula. In The summer these Winds can bring very hot, unpleasant weather, sometimes even up to the northern districts of Italy.

2.4.16. France-General Climate

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

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

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

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

2.4.17. United States of America-General Climate

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

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

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

2.4.18. Brazil-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.

2.4.19. Chile-General Climate

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

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

2.5. Bangladesh-General Climate

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

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

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

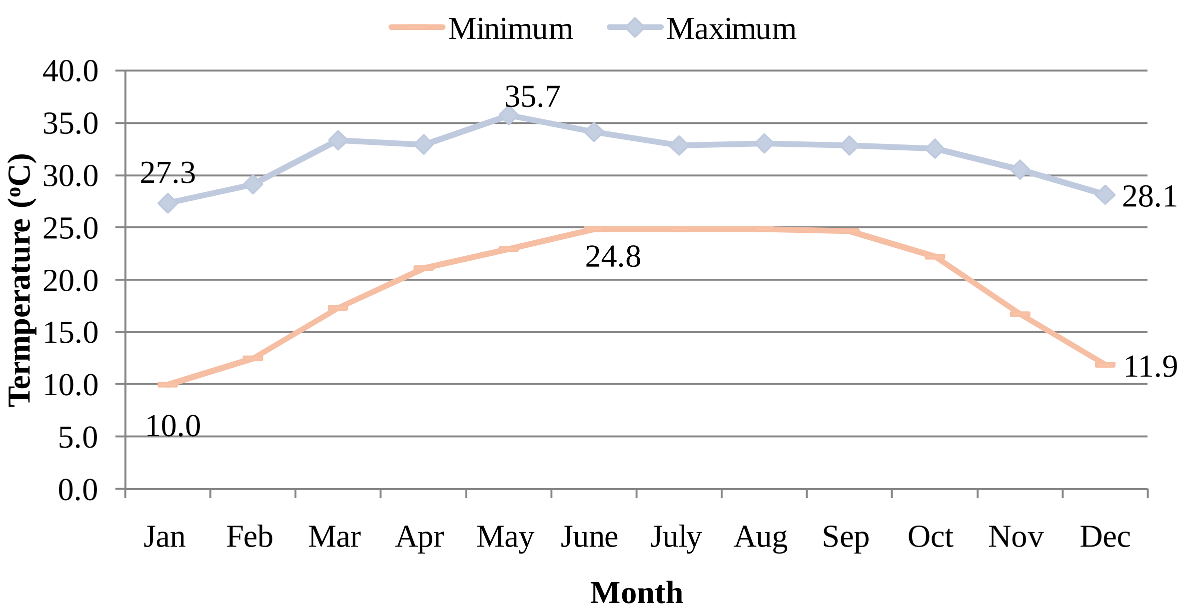


Figure -6: Monthly distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

Köppen climate classification

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

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

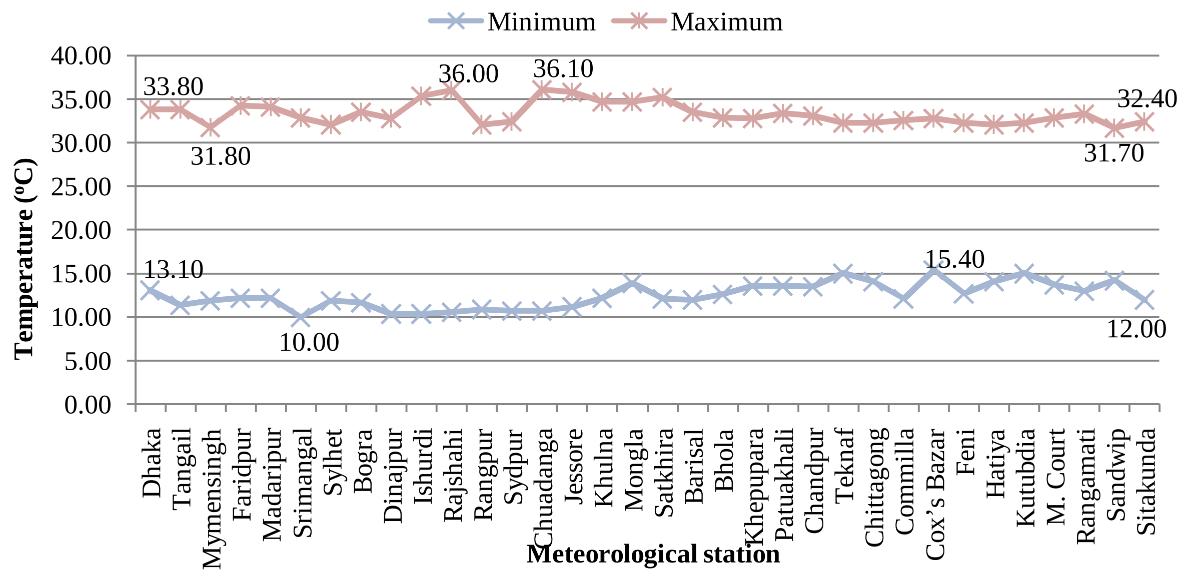


Figure -7: Location-wise distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

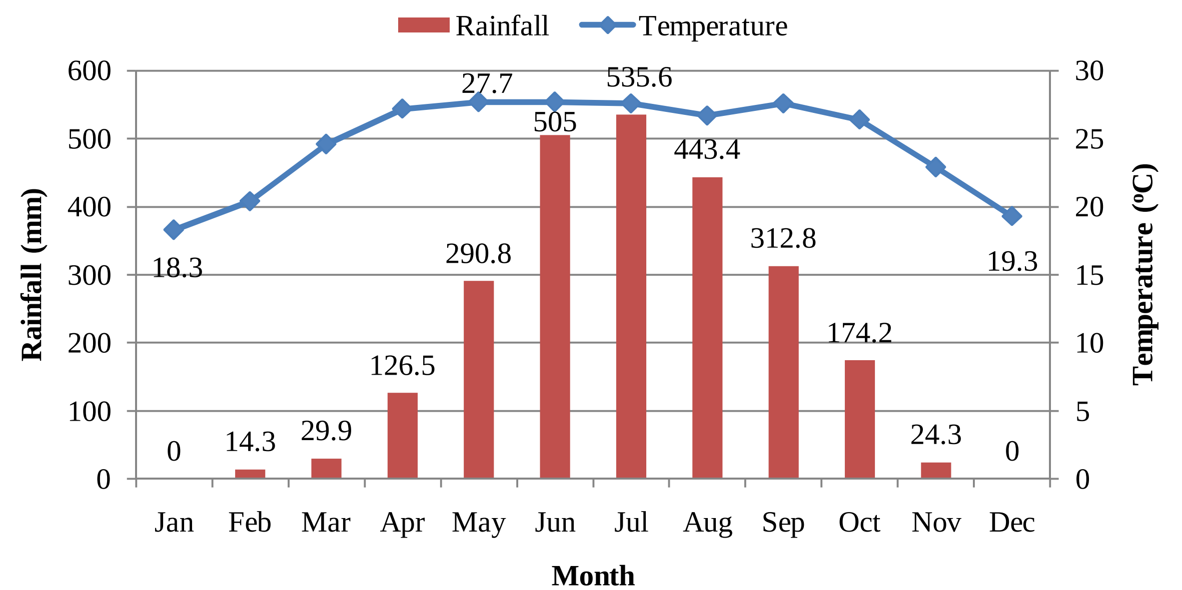


Figure-8: Average monthly Temperature and Rainfall for Bangladesh from 1960-1990

Source: World Bank Group (2015)

CHAPTER 3

HAZARD IDENTIFICATION

3.1. Introduction

This chapter outlines the potential hazards associated with cucurbits in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile, 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 cucurbits found India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile*.* The Plant Quarantine Wing of the Department of Agricultural Extension (DAE) in Bangladesh list for pests of cucurbits from these exporting countries was used as its basis, with various species added or excluded after considerations of association. This original list was later refined to include only those organisms directly associated with cucurbits and found to be present in these exporting countries. Some hitch-hiker pests are included in the pest analyses where entry and establishment of a species into the country would cause potential economic, environmental or health consequences. The following a list of those organisms assessed and discarded as likely hazards based on biology, and lack of association with the commodity. Then all potential hazards and individual pest risk assessments and recommend measures where required.

3.2. Potential Hazard Groups

Pests and pathogens can be grouped in two main ways regarding their association with the commodity. Under their taxonomic category, i.e. Lepidoptera, Coleoptera, Acari, Fungi etc, or within the trophic role they play in their association, and what structures or part of the flower plants they attack, e.g. surface feeder, seed feeder, pathogen. In this risk analysis hazard organisms are grouped according to their general taxonomic category. Where a genus contains more than one species, information on all species is contained within one pest risk assessment. If organisms that are hitch hikers or vectors this is noted in the individual pest risk assessment.

The following categories are used are as follows:

Insect pests
Mite pests
Fungi
Bacteria
Nematode
Virus
Weeds

3.3. Pests and Pathogens of cucurbits in exporting countries

The most common pests and pathogens affecting cucurbits found in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile are shown in the following Table below. Among which several pests were identified as quarantine pests likely to be imported with unmitigated shipments of cucurbits, possibly requiring phytosanitary measures to mitigate risk. Further analysis of these quarantine pests have been done in the following chapter with recommendation of phytosanitary measures.

Table-6: Pests likely to be associated with cucurbits in the exporting countries, but not in Bangladesh

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect pests					
1	Western flower thrips	*Frankliniella occidentalis*	India, Thailand, China, Japan, Sri Lanka	Flower, stem, leaf	CABI/EPPO, 1999; EPPO, 2014
2	Chrysanthemum leaf miner	*Liriomyza trifolii*	India, China, Japan, Taiwan	Leaf, stem, flower	EPPO, 2014; CABI/EPPO, 1997; Minkenberg (1988
3	Pea leaf miner	*Liriomyza huidobrensis*	India, Thailand, Japan, Taiwan	Leaf, stem, flower	CABI/EPPO, 2002; EPPO, 2014
4	Cotton leaf worm	*Spodoptera littoralis*	Japan, Pakistan, Indonesia	Stem, leaf, flower	CIE, 1967; CABI/EPPO, 1997; OEPP/EPPO, 1981
5	Carnation tortrix moth	*Cacoecimorpha pronubana*	Japan, Turkey, Azerbaijan	Leaf, stem, flower	Carter, 1984; EPPO, 2014; CABI/EPPO, 2014
6	Red tiger moth	*Amsacta lactinea*	India, China, Thailan, Malaysia	Leaf, stem, flower	CABI, 2011; BAPHIQ, 2007; TARI, 2009
7	Japanese rose beetle	*Popilla japonica*	India, China, Japan	Leaf, cutting, flower	CABI, 2004; EPPO, 2014; EPPO, 2016; CIE, 1978
8	Tapioca scale insect	*Aonidomytilus albus*	India, China, Thailand, Malaysia,	Leaf, stem, cutting, flower	EPPO, 2014; Tao, 1999; Sankaran et al., 1984
Mite pest					
9	Red spider mite	*Tetranychus evansi*	Japan, Taiwan	Leaf, stem, cutting, flower	CABI, 2015; EPPO, 2016
Disease causing organisms					
Fungi					
10	Phytopthora root rot	*Phytophthora megasperma*	Japan, Philippines	Leaf, stem, cutting,	CABI, 2006;
Bacterial					
11	Bacterial stem crack of carnation	*Burkholderia caryophylli*	India, China, Japan	Leaf, stem, cutting, flower	EPPO/CABI, 1996
Nematode					
12	Golden cyst nematode	*Globodera rostochiensis*	India, Japan, Pakistan, Sri Lanka	Tuber, bulb, corm	EPPO, 1997; CABI, 2007
13	Pale cyst nematode	*Globodera pallid*	India, Japan, Pakistan, Sri Lanka	Tuber, bulb, corm	EPPO, 1997; CABI, 2007

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
14	Stem and bulb nematode	*Ditylenchus dipsaci*	India, Japan, Pakistan, Sri Lanka	Tuber, bulb, corm	EPPO, 1997; CABI, 2007
15	Stem and bulb nematode	*Ditylenchus destructor*	India, Japan, Pakistan, Sri Lanka	Tuber, bulb, corm	EPPO, 1997; CABI, 2007
Virus and viroid					
16	Chrysanthemum stem necrosis virus	*Chrysanthemum stem necrosis tospovirus*	Netherlands, Brazil	Seed, leaf,cutting, flower	EPPO, 2006; CABI, 2007
17	Tobacco ringspot virus	*Tobacco ringspot nepovirus*	India, China, Japan	Seed, leaf, cutting, flower	EPPO, 2006
18	Stunt of chrysanthemum	Chrysanthemum stunt viroid	India, China, Japan	Seed, leaf, cutting, flower	CABI, 2007
Weeds					
19	Parthenium weed	*Parthenium hysterophorus*	India	Seed, equipment	

References

BAPHIQ. 2007. Pests list of *Oncidium sp*. in Taiwan. *In* E. Y. B. Bureau of Animal and Plant Health Inspection and Quarantine Council of Agriculture, ed.

CABI (2004). *Crop Protection Compendium*. http://www.cabicompendium.org/ (9 June 2005).

CABI, (2006): Crop Protection Compendium, CD-ROM Search: 2006 Edition. Commonwealth Agricultural Bureau International (CABI). Wallingford, UK.

CABI. 2011. Crop Protection Compendium. Commonwealth Agricultural Bureau International (CABI). http://www.cabi.org/cpc/. (Archived at PERAL).

CABI/EPPO , 1999. *Frankliniella occidentalis*. [Distribution map]. Distribution Maps of Plant Pests, December (1st revision). Wallingford, UK: CAB International, Map 538.

CABI/EPPO, 1997. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 1997. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 2014. *Cacoecimorpha pronubana*. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 340 (1st revision).

Carter DJ, 1984. Pest Lepidoptera of Europe with special reference to the British Isles. Dordrecht, Netherlands: Dr. W. Junk.

CIE (1967a) *Distribution Maps of Pests, Series A* No. 232. CAB International, Wallingford, UK.

CIE (1978) *Distribution Maps of Pests, Series A* No. 16 (revised). CAB International, Wallingford, UK.

EPPO (2016). Report of a Pest Risk Analysis for *Tetranychus evansi.* European and Mediterranean Plant Protection Organization.

https://www.eppo.int/QUARANTINE/Alert.../Tetranychus_evansi.doc

EPPO, 2006. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2016. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO/CABI (1996). *Burkholderia caryophylli*. In: *Quarantine pests for Europe*. 2nd edition (Ed. by Smith, I.M., McNamara, D.G., Scott, P.R., Holderness, M.). CAB INTERNATIONAL, Wallingford, UK.

EPPO/CABI (2002) *Amauromyza maculosa*, *Liriomyza sativae*, *Liriomyza trifolii*. In: *Quarantine pests for Europe*. 2nd edition (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB INTERNATIONAL, Wallingford, UK.

Minkenberg, O.P.J.M. (1988) Dispersal of *Liriomyza trifolii*. *Bulletin OEPP/EPPO Bulletin* **18**, 173-182.

OEPP/EPPO (1981) Data sheets on quarantine organisms No. 120, *Spodoptera littoralis*. *Bulletin OEPP/EPPO Bulletin* 11 (1).

Sankaran T, Nagaraja H, Narasimham AU, 1984. On some South Indian armoured scales and their natural enemies. Proceedings of the 10th International Symposium of Central European Entomofaunistics, Budapest, 15-20 August 1983, 409-411.

Tao C, 1999. List of Coccoidea (Homoptera) of China. Taichung, Taiwan: Taiwan Agricultural Research Institute, Wufeng, 1-176.

TARI. 2009. Pest List. Taiwan Agricultural Research Institute

3. 4. Organism Interception on Commodity from Existing Pathways

In the past, there was no previous pest risk assessment on cucurbits from any of the exporting countries including the India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile. As reported by the Plant Quarantine Wing (PQW) under Department of Agricultural Extension (DAE), Bangladesh, during inspection in port of entry of cucurbits from these exporting counties, not a pest had been intercepted yet today on the commodity imported into Bangladesh.

3.5. Other Risk Characteristics of the Commodity

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

3.5.1 Unlisted Pests

These include pests that are not yet identified. With a trend towards decreasing use of chemical products in agriculture and further reliance on Integrated Pest Management strategies it is assumed that new 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.

3.5.2 Symptomless Micro-organisms

Pests such as microbes and fungi infect cucurbits 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 cucurbits after arrival making it difficult to distinguish the origin of saprobes and pathogens without adequate identification. Consumers tend to throw away moulded cucurbits rather than take it to a diagnostic laboratory so there is little data on post entry appearance of “invisible organisms”.

3.6 Assumptions and Uncertainties

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

There is a major uncertainty concern regarding the prevalence of above mentioned high and moderate rated insect pests, diseases and weed of cucurbits in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile and other countries of cucurbit export.

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 cucurbits in the importing countries, and preferably, any information on incidence level in pests infested cucurbits consignments or lots would be valuable.

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

3.7. Assumptions and Uncertainties around hazard biology

- The species of mealybug (*Pseudococcus* spp.) are the well known hitch-hiker species, and has been associated with cucurbits in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile. Currently there are no data demonstrating this association between this hitch-hiker pest and the pathway imported from these countries into Bangladesh. Interception data rather than biological information would be required to clarify this issue.
- The biology of insects that have been reared in the laboratory for several generations is often different to wild counterparts established in greenhouses or in field conditions (Mangan & Hallman 1998). Aspects such as life cycle, preovipositional 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 behaviour in the colonised 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 colonising 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.

3.8. Assumption and Uncertainties around the Inspection Produre

- There are distinct temperature requirements for optimum development and reproduction for the different biotype of pests like *Bemisia tabci B biotype* (Silver leaf whitefly). Therefore, the molecular data on race detection of the insect pests rather than occurrence of biological information would be required to clarify this issue.

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

- An assumption is made around the time the fresh cucurbits take to get from the field in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile to Bangladesh ready for wholesale if it is transported by Landport or Sea shipment.

3.10. Assumption around Commodity Growon 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 cucurbit 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 4

REVIEW OF MANAGEMENT OPTIONS

4.1. Introduction

The following assessment of pre- and post-harvest practices reflects the current systems approach for risk management employed for commercially produced cucurbits. It is proposed that these practices combined with specific post-harvest treatment (such as fumigation and other requirements e.g. phytosanitary inspection) are used to manage the risks to importing countries posed by regulated organisms associated with the importation of cucurbits from exporting countries. The management options for different insect and mite pests as well as diseases of cucurbit crops have been reviewed and presented below:

4.2. Insect and Mite Pest Management of Cucurbits

Cucurbits (cucumber, pumpkin, snake gourd, bottle gourd, ridge gourd, sponge gourd, pointed gourd, bitter gourd, melon, watermelon, pointed gourd, squash etc) are the most common vegetables grown in Bangladesh. Although there are a large variety of cucurbits most have a few very important pests in common such as cucubit fruit flies, epilachna beetles, redpumpkin beetles, green stink bugs, aphids, whiteflies, and mites. The timing of control tactics is critical for many of these pests-miss the window and the crop can be severely affected. Some growers choose to spray weekly thinking this lead to good control, but not only does this lead instead to wasted resources and ineffective controls, excessive sprays also lead to secondary pest outbreaks and the development of resistance by pests to some chemical controls.

The key to any successful pest management program is to develop a regular scouting plan to gain information on insect pest populations that is used to determine if insecticide applications are needed. Monitoring can consist of sampling groups of 10 plants which are randomly selected at different locations in a field. Samples should be distributed throughout the field so that plants near the edges and middle of the field are examined. In recent years there has been a great increase in new control technologies available to growers, this makes management of insect pests in cucurbits an ongoing process. The new insecticides generally act against a narrower range of pest species than the older, broadspectrum materials. Therefore, it is critical to properly identify the pest to be controlled and to determine its potential for damage. The only way to obtain this information is through routine scouting. The purpose of this guide is to serve as a reference for insect pest identification and for general management guidelines.

4.2.1. Cucurbit fruit fly

The cucurbit fruit fly *Bactrocera cucurbitae* can attack about 16 different types of cucurbit crops. Although the rate of attack varies among the crop, infestation reduced both the yield and quality of the cucurbit fruits. Yield losses due to fruit fly infestation vary from 19.19 to 69.96 percent in different fruits and vegetables (Kabir *et al.* 1991) and the damage caused by fruit fly is the most serious in melon which may be up to 100 percent (Atwal 1993).

Management

Due to its nature of infestation, it is very difficult to control the pest. A cluster method have been developed and suggested by Kapoor (1993) to control these pests. Among all these methods, the chemical control method is still popular to the Bangladeshi farmers because of its quick and visible results.Approaches of IPM are the thought to be the best and very effective in many countries of the world as well as in Bangladesh, to control vegetable pests. In the contemporary usage, IPM is not limited to deal with pesticides and management; in fact IPM has a holistic approach to crop production based on sound ecological understanding and in this sense, IPM could even be termed as Eco-friendly pest management. “IPM targets changing of the farmer’s practices toward growing a healthy crop and increasing the farm output and farmers income on a sustainable basis while improving the environment and community health”.

Fruit fly is the most damaging pest of cucurbits and considered as an important obstacle for economic production of these crops. The uses of alternatives to toxic chemicals for the management of cucurbit fruit fly are as follows:

Management of fruit fly by bagging: This method has been tried with the use of colorless polythene bags having a few holes made with an ordinary pin (Narayer and Batra, 1960). Aktaruzzamn *et al.* (1999) reported that the mean of all stages of fruit fly infestation was significantly lower (5.53%), where bagging of fruits at 3 days after anthesis was made and retained for 5 days.

Management of fruit fly by cultural & mechanical control: Several authors highly advocated hand picking of infested fruits to reduce fruit fly damage on cucurbit vegetables. Nasiruddin & Karim (1992) recommended collection and destruction of infested fruits with larvae inside for reducing fruits fly population on snake gourd. Mitchell and Soul (1990) reported that this practice is widely used in USA for suppressing Mediterranean fruit fly *Ceratitis capitata*. Atwal (1993) suggested such mechanical control measures in farmer’s fields as normal practice for effective control against this pest in India. Several authors recommended field sanitation for suppression of fruit fly population in many countries (Agarwal *et al.* 1987; Mitchell and Saul 1990; Smith 1992).

Management of fruit fly by indigenous bait traps: A poison-bait gave good control of fruit flies (Steiner *et al.* 1998). An experiment was conducted by Nasiruddin and karim (1992) on the evaluation of potential control measure for fruit fly, *Bactrocera* (Dacus) *cucurbitae*, in snake gourd. They observed that fruit fly infestation rates in snake gourd fruits in bait trap treatment plot was 4.9% against 22.5% infested fruits in the control plot which differed significantly ($P<0.05$; Table 4) . They also observed that 78.4% reduction of fruit infestation over the infestation rate in the control

Comparative effectiveness of pheromone dispensers and bait traps: Fruit fly capture in pheromone dispensers and the bait trap differed significantly. Cuelure, methyl eugenol and naled captured significantly more fruit flies (269) than any other treatment. Catches in mashed sweet gourd and methyl eugenol and naled were the lowest, 86 and 18, respectively. The noteworthy feature of the mashed sweet gourd trap was that it captured both male (25) and female (61) fruit flies, indicating its biological impact in the management of cucurbit fruit fly. On the contrary, all the pheromone traps captured only males (Aktaruzzamn *et al.*, 1999).

Pheromone and indigenous bait trap for fruit fly control: Aktaruzzamn *et al.* (1999) reported that the fruit fly capture can create a negative impact on fruit infestation. The higher the fruit fly capture the lesser was the fruit infestation and higher was the yield. The pheromone traps captured the highest number of flies, more then 20 times higher than that captured in indigenous mashed sweet gourd traps, and effected 5 times less fruit infestation than the untreated fields. The mashed sweet gourd baits, although captured lower number of fruit flies than the pheromone traps, significantly lessened fruit infestation and produced 35% more yield than the untreated control plot. Cucumber yields in pheromone and sweet gourd baited fields were comparable (Aktaruzzamn *et al.*, 1999).

4.2.1. Aphids

Aphids of many species can be found in a cucurbit field, but the most destructive species present are the melon and green peach. Aphids are small, soft-bodied insects that vary in color from pale yellow to red to green to black, depending on the species (with one species capable of having several colors), the host plant, and time of season. Direct-feeding damage by aphids is rarely severe enough to kill plants. They pierce plant tissue with needlelike mouthparts, which may result in blossom shed or curling or stunting of new growth. They also produce a sticky material called honeydew that is a substrate for the sooty mold fungus, if the honey dew gets on the fruit it is difficult to remove making the fruit unmarketable. **Melon aphids** (*Aphis gossypii*) are pear-shaped and vary from yellow to green to darker colors, but always have dark colored cornicles (slender tailpipe-like appendages, red arrows). The **green peach aphid** *(Myzus persicae)* is pear shaped and is pale yellow to green with its cornicles also being green. Adult females give birth to live young, called nymphs. Although slightly smaller than adults, nymphs are similar in color and shape (Gerald Brust, 2009).

Melon aphid (also known as cotton aphid) has a very wide host range. At least 50 host plants are known in Maryland. Among cucurbits, it can be a serious pest on watermelons, cucumbers, and cantaloupes, and to a lesser degree squash and pumpkin. The green peach aphid also has a wide host range and moves into melon fields in large numbers from surrounding vegetation, carrying viruses as it moves and feeds from one plant to another.

Both aphids feed on the underside of leaves, or on the growing tips, sucking nutrients from the plant. The foliage may become chlorotic and die prematurely. The end result of feeding by these aphids is loss of vigor, stunting, or at times even death of the plant. Most importantly both aphids transmit potyviruses, and while there are several other aphid species that also are capable of vectoring viruses, melon and green peach aphids are very proficient at it. The watermelon mosaic virus, zucchini yellow mosaic virus and papaya ringspot virus are transmitted by these aphids despite numerous applications of insecticides because the viruses can be transmitted within seconds of the aphid landing on a plant.

Management

Aphids are ubiquitous in the summer and find cucurbit fields. To slow down the numbers that land on plants silver reflective mulches have been used successfully to repel aphids from plants, thus reducing or delaying virus transmission by two to four weeks compared with no mulch or black plastic mulch (Gerald Brust, 2009).

Biological control can have a significant impact on reducing aphid populations, but cannot stop virus transmission, so be sure to evaluate predator and parasite populations when making treatment decisions.

Biological Control: Naturally-occurring populations of the convergent lady beetle, *Hippodamia convergens,* may provide effective control throughout the summer. Do not purchase these predators as releases of this beetle are not effective because very few remain in the field following release. Other general predators, such as lacewing and syrphid larvae, and parasitic wasps, including *Aphidius*, *Diaeretiella*, and *Aphelinus* species, also attack aphids. You can maintain natural enemy numbers by not applying weekly or calendar-based insecticide applications.

Chemical Controls: Treatment is only needed to reduce large aphid populations and no or very few natural enemies are present. Chemical controls DO NOT stop virus transmission. Organic chemical controls include insecticidal soaps and horticultural oils as well as *Beauveria bassiana*, an insect fungal disease that attack and kill aphids. The *B. bassiana* must be applied 3 times on a 5-7 day schedule to be effective. Reduced risk chemicals include pymetrozine (Fulfill) imidacloprid (Admire) or thiamethoxam (Platinum or Actara). Other chemical controls include endosulfan (Thionex).

4.2.2. Whiteflies

Whiteflies consist of several species (Silver leaf whitefly *Bemisia argentifolii,* Greenhouse whitefly and common whitefly). Although the silver leaf whitefly and other whitefly species are found in Maryland, they are only an occasional problem on cucurbits. The silverleaf whitefly is small, about inch long and whitish yellow. The head is broad at the antennae and narrow toward the mouthparts. The wings are held roof-like at about a 45-degree angle, whereas other whiteflies usually hold the wings nearly flat over the body. As a result, the silverleaf whitefly appears more slender than other common whiteflies. The eggs are whitish to light beige. The nymphal stage appears glassy to opaque yellow. Its body is flattened and scale-like. The pupa or fourth nymphal instars are somewhat darker beige-yellow and opaque. This pest feeds on many different kinds of plants. The most common hosts in Maryland include poinsettia, tomato, squash, cucumbers, and melons. Silverleaf whiteflies damage plants directly and indirectly. Direct damage results from their feeding activity, which involves them sucking plant sap. Both the adults and nymphs contribute to direct damage. Chlorotic (yellow) spots sometimes appear at the feeding sites on leaves. Heavy infestations cause leaf wilting. In addition, as they feed they excrete honeydew (a sugary substance), which sooty mold fungi grow on. The resulting dark splotches on the leaves may reduce photosynthesis and other physiological functions of the plant. Indirect damage results from their activity as disease vectors. The silverleaf whitefly carries and spreads several important viral diseases of tomatoes, lettuce and melons in the southeastern United States, but does not vector these viruses to any great extent to Maryland vegetable crops (Gerald Brust, 2009).

Management

Whiteflies should not become a problem in most fields, but occasionally their populations can increase to such levels that they begin to directly damage the plant. If sooty mold is found on many plants or fruit an insecticide application is needed. This should only occur rarely and in the latter part of the season. Chemicals that work for aphids also work for whitefly (Gerald Brust, 2009).

4.2.3. Spotted cucumber beetles

The spotted cucumber beetles are one of the most damaging pests on cucurbits, such as squash, cucumber, cantaloupe and pumpkin. The larvae can damage roots while the overwintering generation can transmit bacterial wilt disease.

Striped cucumber beetles (SCB) are about 1/5 to 1/4 inch long, have black abdomens, with yellow and black stripes on their backs. The three black stripes have distinct straight edges. Larvae are approximately 3/8 inch long, have white worm-like bodies with brown heads and three tiny pairs of legs. SCB orange-yellow eggs are laid near the base of host plants. The slender white larva grows to about 1/3 inch long and is dark on each end. There is one generation per year.

SCBs overwinter as unmated adults in bordering vegetation, plant debris, woodlots and fence rows and are active in the spring when temperatures reach 55 to 65o F. SCBs feed on alternate host plants until cucurbit plants appear in vegetable fields. They feed on pollen, petals and leaves of ow, apple, hawthorn, goldenrod, and aster. As soon as cucurbits, the preferred hosts, come up or are transplanted, the beetles move to these plants to start feeding and mating, for Maryland this can be anytime from late-April through mid-May. In a few days, the female lays eggs in the soil at the base of a cucurbit. The eggs hatch in about 10 days. The larvae work their way to the plant roots where they feed for the next 2 to 6 weeks, sometimes causing damage. The mature larvae pupate in the soil. The adults emerge in 7 to 10 days. These beetles spend the rest of the summer feeding in cucurbit flowers (Gerald Brust, 2009).

Spotted cucumber beetles do not vector bacterial wilt disease but can spread squash mosaic virus. (Also known as the southern corn rootworm), are 1/4 inch long, yellow-green with 12 black spots on their backs. Spotted cucumber beetles are polyphagous during the larval and adult stages, both feed on multiple host plants. The larvae are commonly known as rootworms because they feed on roots of corn, peanuts, small grains and grasses. Adult spotted cucumber beetles feed on the pollen, petals and leaves of more than 200 alternate host plants. Adult spotted cucumber beetles overwinter in southern states and migrate into northern states in June and July, appearing two to four weeks later than striped cucumber beetles. Adults are strong fliers and disperse rapidly from field to field during summer. Spotted cucumber beetles produce two or three generations in a growing season.

Direct feeding by either cucumber beetle adult can kill or severely stunt young plants by feeding on stems and cotyledons or on fruit, but most importantly adult striped cucumber beetles can vector bacterial wilt disease of cucumber, cantaloupe, and squash and to a lesser extent pumpkins. Although feeding damage by adult beetles is less serious to plants that are large and already leafed out, feeding on fruits can result in scarring and decreases the marketability and storage life of the crop. Spotted cucumber beetle feeding can vector mosaic viruses, although this is not very common in Maryland cucurbit fields (Gerald Brust, 2009).

Bacterial Wilt Transmitted by Striped Cucumber beetles: The bacterium that causes bacterial wilt (*Erwinia tracheiphila*) overwinters only in the gut of some of the striped cucumber beetles (between 1-10% of the population may contain the bacteria). When beetles become active in the spring and begin feeding, they spread the bacterium through their feces. Feeding damage on young leaves or cotyledons can open entry points for the pathogen. Bacteria in the feces of the beetle enter the feeding wounds via moisture, i.e., rain, overhead irrigation or even heavy dew. Once inside the plant, the bacterium multiplies in the vascular system, producing blockages that cause the leaves to wilt. This wilting can take place 2-5 weeks after the plant has become infected. The best chance for infection is when there are large numbers of beetles feeding and defecating on small plants, usually in the early part of the season. Beetles are attracted to infected plants and can pick up the bacterium and move it to healthy plants. The first symptom of bacterial wilt on cucumber and muskmelon is a distinct flagging of lateral and individual leaves. There usually is no feeding damage on wilted leaves. Soon, adjacent leaves wilt and finally the entire plant wilts and dies. Nothing can be done to save an infected plant. The only way to avoid bacterial wilt is to prevent large numbers of beetles from feeding on small plants. Fruit produced on a wilting plant usually is not marketable. One way to determine if bacterial wilt has infected a plant is to cut the stem and squeeze both cut ends. Asticky sap ooze from the water conducting tissues of the stem. If you push the cut ends of the stem together and slowly pull them apart, you sometimes able to see a stringing effect if bacteria are present (Gerald Brust, 2009).

Management

Begin SCB control as soon as seedlings emerge. Early treatment is essential for beetle management in commercial muskmelon or cucumber fields. A single post-transplant soil drench with Admire or Platinum often can provide 3-4 weeks of control. If beetle numbers remain high or no neonicotinoid drench was used applications of foliar insecticides are necessary to protect muskmelon plants from beetle feeding and transmission of bacterial wilt. There is usually a peak in beetle activity each spring that lasts two to four weeks. This is the most important time to control beetles. Because watermelon is not susceptible to the wilt disease, protection is necessary only when plants are small and beetle populations are high. Seedlings of cantaloupe and cucumber need to be protected until the plants reach the 5-true-leaf stage or beyond. Protecting older plants generally does not reduce plant death due to bacterial wilt or direct feeding, but blossom or fruit feeding and excessive defoliation on more mature plants may delay growth, reduce yields or render fruit unmarketable. Crop rotation to a distant field (>½ mile away) can help minimize the size of the beetle population. Simply rotating to new ground within a field, or to an adjacent field, is not effective due to the mobility of the beetle. Floating row covers can also be used to exclude the beetles from the plants, but must be removed by bloom to allow bees to pollinate the crop.

Chemical controls: There are no good organic insecticides available that control beetles, although a rotenone-pyrethrum combination is the best choice. Reduced risk pesticides such as the neonicotinoids previously discussed when drenched can give protection for 3-4+ weeks, which is often as much protection as necessary. Foliar treatments consist of pyrethroids (Asana, Brigade, Warrior) applied only when plants are small and beetle populations average more than 1 per plant (Gerald Brust, 2009).

4.2.4. Squash bug

The **squash bug**, *Anasa tristis* is one of the most common and severe pests of cucurbits, especially squash and pumpkins. Adults are 5/8 inch long dark brown or gray with the edges of the abdomen having orange and brown stripes. Eggs are 1/16 inch long and are a yellowish brown to bronze color. Eggs are laid on the underside of leaves in groups of about twelve usually in a characteristic V shape pattern following the leaf veins. Eggs take 1-2 weeks to hatch. Adult females continuously lay eggs until midsummer; this extended egg laying period results in all stages being present during much of the summer. Nymphs are 3/16 to 1/2 inch in length. Young nymphs have a red head and legs with a green abdomen; however as the nymphs age the red color turns to black. Late instar nymphs turn a greenish-gray in color with black appendages. Young nymphs are gregarious and feed together in groups. Nymphs require five to six weeks to mature into adults. Squash bugs spend most of their time around the base and stems of the plants and on the undersides of leaves. Only squash bug adults can overwinter, nymphs cannot.

Adult squash bugs begin to move into fields in late May and early June. Squash bugs damage plants by removing sap with their sucking mouthparts and causing leaves to wilt and collapse. The foliage is the primary site of feeding but the fruit is also fed upon. Squash bugs secret highly toxic saliva into the plant as they feed. Young plants and infested leaves on older plants may be killed. Plants that are heavily fed upon can have leaves turn yellow around the leaf margin. These yellow areas become necrotic over time with the yellowing progressing into the leaf and the leaf eventually wilting, this is sometimes called “anasa” wilt. The amount of damage occurring on a plant is directly proportional to the density of squash bugs. Squash bugs are the vectors of a newly recognized disease of cucurbit crops, **Yellow Vine Decline**. Watermelon and pumpkins are susceptible to this disease. The bacteria that cause this disease are injected into the plant when squash bugs feed. The disease results in yellowing, wilting and death of the plant. Early infection by the bacteria can result in severe yield loss (Gerald Brust, 2009).

Management

This insect can be very difficult to control if populations are allowed to build. Early detection of adult squash bugs is very important since they are difficult to kill and can cause considerable damage. Timing is the key to successful squash bug control. Because Yellow Vine Decline has not been found as yet in Maryland, growers should use insecticides to control squash bugs when 2 overwintering adults are observed feeding on small plants (< 5 leaves) or if two egg masses are found per plant when plants are larger. Sprays for adults should be directed at the base of the plant (down in the plastic hole) as this increase control.

Chemical controls: There are no organic or reduced risk chemical controls that work well on squash bugs. Pyrethroids (Asana, Warrior & Brigade) control squash bugs best if used on small instars and before populations build.

Biological control: *Trichopoda pennipes* is a parasitic fly about the size of a house fly that can be found sitting on squash plants in search of prey. It has a bright orange abdomen, velvety black head and thorax, and a fringe of short black hairs on the hind legs. The wings of male flies have a dark spot. The tip of the abdomen of female flies is black. They can be seen throughout the production period of squash and pumpkins. These Tachinid flies primarily parasitize squash bug and southern green stinkbug. Eggs are laid on the underside of the thorax or abdomen of the squash bug, but they can occur on almost any body part. Many eggs may be laid on the same host (blue arrows), but only one larva survive in each bug. The young larva that hatches from the egg bores directly into the host body. The maggot feeds on the body fluids of the host for about two weeks, during which time it increases to a size almost equal to that of the body cavity of its host. When it has completed its development, the third instar maggot emerges from the bug between the posterior abdominal segments. The bug dies after emergence of the fly, not from the feeding, but from the mechanical injury to its body. Adult flies feed on nectar, especially from plants such as wild carrot (Queen Anne's lace) and meadowsweet (*Spiraea salicifolia*). The rate of parasitism can be as high as 95% on squash bug, but because the bugs continue to feed after parasitization, *T. pennipes* usually not prevent crop damage. However, if parasitized early in squash bug development the reproductive organs of the host bug begin to atrophy when the parasitoid reaches the second instar, so pest population increase reduced. The fly is most effective when it parasitizes nymphs because 50% of the nymphs die before becoming adults and 65% of the remaining population that become adults die before laying eggs. At this time, however, this parasitoid is not reliable enough to consistently prevent damage (Gerald Brust, 2009).

4.2.5. Seed corn maggot

The **seed corn maggot**, *Delia platura*, is an occasional pest of many vegetable crops including cucurbits. They cause the most damage in early spring to newly emerging seedlings or new transplants, especially if wet, cold conditions are present.

The seed corn maggot overwinters as pupae in the soil. In early spring, the adults emerge; mate within 2-3 days and lay eggs in soil with abundant decaying organic matter and/or on seeds or transplants within the fields. Adults, which resemble small houseflies, are dark gray, with wings that overlap their bodies when at rest. Eggs hatch in 2-4 days in temperatures as low as 50o F. Maggots are yellowish-white, about ¼ inch in length, legless, and very tough-skinned with head-ends that are wedge-shaped and tail ends that are flattened. There are three generations in Maryland. The first generation causes almost all the crop damage. Seedlings are most susceptible to seed corn maggots during a wet, cold spring in which plant growth is slowed. Seedcorn maggot eggs are laid 1-2 inches below the soil surface in tilled ground that is high in organic matter or they can be laid in the root ball of a transplant. When eggs hatch maggots attack the transplants and drill into the seedling's stem. What is seen above ground are transplants suddenly wilting. If the stem of the transplant is split open when the wilting is first observed maggots found within the stem if SCM are responsible (Gerald Brust, 2009).

Management

Once seed corn maggot damage is noticed-wilted plants, it is too late to apply control procedures. Thus, economic thresholds are not useful and all management options are preventative. Preventive measures only be necessary if transplants are placed in fields that have large amounts of organic matter tilled in or soil temperatures that are cool (> 68^{o}F) and remain cool and damp. Once soil temperatures are above 70^{o}F at a 4-inch depth, SCM adults lay few eggs. Most severe infestations of SCM in transplanted fields are due to SCM that oviposit directly into transplants. This can be seen in fields that have been fumigated and yet still have SCM damage.

Chemical control: There are few chemicals that are registered that give control of SCM. Seed treatments give poor control of maggots of transplants. Cultural methods are the best management program for this pest.

4.2.6. Cucumber worms

Cucumber worms (*Diaphania nitidalis*) are a tropical moth pest and only an occasional pest of melons. Melon worms may also occasionally be found in cucurbit fields but as these pests usually confine their feeding to the foliage they are a minor problem. Eggs are laid principally on the buds, flowers, and other actively growing portions of the plant. Hatching occurs in about 4-days. There are five instars and larval development takes 2-weeks. Young larvae are nearly white in color with numerous dark gray or black spots. The dark spots are lost in last instar resulting in the larva being a dark copper color. Moths have the central portion of both the front and hind wings as a semi-transparent yellow with an iridescent purplish reflection. The wings are dark brown with a tannish-yellow central area. Summer squash are the most preferred host. Pumpkin is a moderate host, while cucumber, cantaloupe and watermelon are rarely attacked. When about half grown, pickleworms bore into sides of fruit and continue to feed causing internal damage. Both young and old fruits are attacked, but they prefer young fruit before the rind has hardened (Gerald Brust, 2009).

Management

Chemical treatment should rarely be necessary for control of this pest, however if there is a late planting of summer squash growers should watch for any feeding damage at the growing tip of vines. Organic chemicals consist only of Entrust. Reduced risk chemicals include SpinTor, Spinatoram, Intrepid and Avaunt. Other chemicals include pyrethroids (Brigade, Asana, Warrior), and Lannate (Gerald Brust, 2009).

4.2.7. Rindworms/Cucumber moth

Rindworms (*Diaphania indica*) is a catch-all term for a complex of melon–surface feeding pests that sporadically become a problem in all cucurbits, but especially in watermelon, pumpkin and cantaloupe. This complex can consist of cucumber beetle adults or larvae, wireworms and caterpillar pests such as beet armyworm and others that feed on the surface or just into the rind. This causes scarring and a more rapid break down of the fruit all of which make the fruit less marketable. These pests usually appear in the latter part of the season a few weeks before and after harvest begins. Melons should be watched closely for any surface feeding on the rind. Fruit should be turned over and the area in contact with the ground examined for wireworm or cucumber beetle larvae feeding (Gerald Brust, 2009).

Management

The most difficult to control pests are the wireworm and cucumber beetle larval pests as their feeding is difficult to detect unless the fruit is turned and even more difficult to control as it is not easy to reach the pests with chemical insecticides. Wireworm and cucumber beetle larvae come to the surface to feed on melon rinds when the ground is moist from the surface down. Melons sitting on plastic (not organic mulch) not be fed upon from below. If feeding scars are found on fruit chemicals used for striped cucumber beetle control (Brigade, Asana, Warrior) or beet army worm (Synapse, Avaunt, Intrepid, SpinTor, Radiant or the organic pesticide Entrust) can be used. Large volumes of water (100-150 gallons/acre) are needed to ensure that the pesticide spray covers the entire fruit (Gerald Brust, 2009).

4.2.8. Thrips

Thrips are generally a problem early in the season when plants are drought stressed. Thrips are tiny (1/16 inch), slender insects that vary in color from yellow or orange (most common color) to dark brown or black. Thrips overwinter in plant debris or on weeds such as winter annuals found in or near fields. In the spring they can be found on the undersides of leaves producing silver flecking near the large leaf veins. They are more likely to be found on leaves of cucurbits early in the season when these leaves have pine pollen or other types of tree pollen on them. Pine pollen, as well as other tree pollen is quite commonly found on plants in the field in the spring. Thrips then feed on this pollen. These early season thrips populations rarely result in any problems unless plants become drought stressed. There are two larval stages and a pupal stage. Thrips have only the left mandible and use this mouthpart to punch a hole or scrape the leaf surface of the plant disrupting cells and feeding on the cell contents (Gerald Brust, 2009).

4.2.9. Twospotted spider mites

Twospotted spider mites (*Tetranychus urticae* (TSSM*)* are very small, 1/80 - 1/60 inch long, with 2 spots on their back pests that are a problem usually in July and August during hot dry weather. Mites are most problematic on watermelon and cucumber, less so on cantaloupe and rarely pose a problem on squash or pumpkin. Mites overwinter in leaf debris in and around fields. In spring, the reddish mites feed on weed hosts, such as chickweed, clovers, and some grasses. Females find their way into fields by climbing to the top of their feeding site and releasing a long string of silk from their abdomen that catches a breeze and they become airborne. Because they have such a wide host range, wherever they land they can usually start to feed. Females can lay 50-100 spherical eggs. Unfertilized eggs turn into males, and fertilized ones turn into females. The life cycle of the mites can be as short as 5-7 days in the summer. Mite infestations usually start on the field edge and move towards the center over time. Hot, dry weather conditions favor rapid development of TSSM adults, nymphs and eggs eggs, increases feeding of nymphs and adults, and decreases the abundance of pathogenic fungi. Dusty conditions also favor mite activity. Both nymph and adult mites feed by piercing the cell walls of the leaf and sucking out the juices. Twospotted spider mite damage appears as a yellow discoloration or a mottled sand blasted appearance on leaves, which can take on a bronze, then brown color (Gerald Brust, 2009).

Management

During hot, dry conditions that continue for several weeks, fields should be checked closely, especially along borders and near grassy areas. The underside of several crown leaves should be checked for mite activity as these leaves are a prime site for mite development. A 10X hand lens can be used to identify mites. Also, leaves can be shaken over a piece of paper, and the dislodged mites can be seen crawling about. If mites are found along the border of a field, the whole field should be checked for the presence of mites. An exact threshold for mites has not been developed. If there are only a few mites along the field borders with little mite activity in the interior of the field, then a treatment is not necessary, or just the border around the field may be treated. If there are mites found in scattered areas throughout the field and there is webbing found on the undersides of leaves, then a treatment is necessary. Natural enemies help control and reduce mite populations under most circumstances and therefore, insecticide applications should be kept to a minimum. Natural enemies, however, can be overwhelmed by mite reproduction during hot, dry weather (Gerald Brust, 2009).

Chemical controls: Organic controls include soaps and oils (moderate to poor results) as well as *Beauveria bassiana*, an insect fungal disease that attack and kill mites. The *B. bassiana* (Botanigard, Naturalis) must be applied 3 times on a 5-7 day schedule to be effective. If mite populations are large the organic controls give moderate to poor results at best. There are several reduced risk chemicals available for mite control in cucurbits: Acramite and Agri-mek. These other pesticides control two spotted spider mites: Oberon, Danitol, and if populations are not large bifenthrin (Brigade) (Gerald Brust, 2009).

4.3. Disease Management of Cucurbits

4.3.1. Bacterial Wilt

Erwinia tracheiphila is the bacterium responsible for bacterial wilt and replicates only in the xylem; wilt appears initially on leaves and then on one or more runners on a plant; look for vascular browning in the xylem by cutting at the grown level (crown of plant).

Management

Cultural Practices: Beetles aggregate on preferred varieties (due to cucurbitacins levels); this feature makes use of a susceptible variety as a trap crop.

Chemical Control: Imidacloprid (Admire) is the preferred material for striped beetle control, but others are registered.

4.3.2. Angular Leaf Spot

Pseudomonas syringae pv. *lachrymans* bacterium is the responsible for causing this disease. Young spots are water-soaked and older spots may have holes in center; spots are usually limited by the main veins of leaves; circular water-soaked and then sunken spots appear on fruit.

Management

Cultural Practices: Use pathogen-free seed and rotate out of cucurbits for 2 years.

Chemical Control: Use copper or a mixture of copper (**Group M1**) plus maneb (**Group M3**); discontinue sprays during extended rain-free periods.

4.3.3. Phytophthora Blight

Phytophthora capsici is the responsible for causing this disease. The blight phase starts in lower areas of fields with saturated soils; yeast-like growth may start on underside of fruit and spread to topside.

Cultural Practices: Management is critical; organism survives in the soil for many seasons; rotate at least 3 years out of susceptible crops (pepper, tomato, all cucurbits); avoid planting in fields with a history of standing water; provide adequate drainage by sub-soiling and disking in spray alleys during the season; provide means for water to exist fields away from surrounding susceptible crops.

Chemical Control: Acrobat (**Group 15**) tank mixed with a protectant fungicide labeled for the cucurbit of interest (chlorothalonil, maneb or mancozeb, **Groups M5 and M3**) may provide some suppression of the disease.

4.3.4. Downy Mildew

Pseudoperonospora cubensis fungus is the responsible for causing this disease.Chlorotic spots appear on the upper leaf surface and purplish or gray spores form on these spots on the lower leaf surface.

Management

Chemical Control using Acrobat (**Group 13**) tank mixed with a protectant labeled for the cucurbit of interest (chlorothalonil, maneb or mancozeb, **Groups M5**, and **M3**) and alternated with Ridomil Gold Bravo or Ridomil Gold Copper (**Group 4**) or Gavel (**Group 22**) (only labeled on C, M SS, W) and use Bravo and maneb in alternate weeks; or consider Aliette (**Group 33**) or Phostrol or ProPhyt (**Group 33**), combined or alternated with a protectant fungicide.

4.3.5. Powdery Mildew

Podosphaera xanthii (formerly *Sphaerotheca fuliginea*) and *Erysiphe cichoracearum* produces white powdery colonies on upper and lower leaf surfaces, on stems and petioles.

Management

Cultural Practices: Choose PM tolerant varieties for cucurbit of interest if available.

Chemical Control: Management of chemicals use for control is critical; use mix protectant fungicides (**Group M5, M3, M1** or other chemicals (chlorothalonil, maneb, mancozeb, copper, oil, sulfur, etc.) with a strobilurin (**Group 11**); or with demethylation inhibitors (**Group 3**) or thiophanate-methyl (**Group 1**) and follow alternation protocol. If resistance to Quadris occurs in the area, you must use a fungicide from different fungicide group.

4.3.6. Gummy Stem Blight and Black Rot

Didymella bryoniae fungus is the responsible for causing this disease. Leaf symptoms are infrequent unless plants are infected during a wet growing season; lesions if they develop are circular and may have black pepper-like specks which are pycnidia; pycnidia also occur on lower stems and on fruit; fruit lesions may be water soaked and purplish in color before turning black; field infections often appear as a dry"petrified wood" beige semi-circular lesion with pycnidia.

Management

Cultural Practices: Use fungicide-treated seed, as organism is seedborne; rotate two years out of all cucurbits.

Chemical Control: Bravo (**Group 5**) used alone or combined with Topsin M (**Group 1**) reduce chance for resistance from developing.

4.3.7. White Mold

Sclerotinia sclerotiorum fungus is the responsible for causing this disease. Look for white, cottony growth on stems and especially fruit; raisin-shaped black sclerotia appear within this growth.

Management

Cultural Practices: Rotate 3 or more years out of susceptible crops, choosing crops like sweet corn and grass cover crops.

Chemical Control: For farms with short rotations, consider the biological product Contans for incorporation into the soil prior to planting.

4.3.8. Fusarium Crown and Fruit Rot

Fusarium solani f. sp. *cucurbitae* fungus is the responsible for causing this disease. Crown of plant may be girdled and the dark brown decayed area covered with white or pinkish colored fungal mycelium; tan or white circular lesions appear on side of fruit touching the ground.

Management

Cultural Practices: A soilborne fungus that survives in the soil for at least 2 years; rotation out of cucurbits for 3 years.

Chemical Control: None available

4.3.9. Alternaria Leaf Spot or Blight

Alternaria cucumerina fungus is the responsible for causing this disease.Lesions first appear on the older crown leaves as circular brown spots; as lesions expand they develop concentric rings; more common on muskmelon than pumpkin or winter and summer squash.

Management

Cultural Practices: Follow a 2-year rotation out of all cucurbits.

Chemical Control: Can be controlled with most protectant fungicides (**Groups M5, M3 and M1**) and used in alternation with strobilurins (**Group 11**) fungicides.

4.3.10. Anthracnose

Colletotrichum orbiculare fungus is the responsible for causing this disease.More likely to occur on muskmelon, watermelon and cucumber. Appears as tan or brown oval lesions on upper leaf surface; raised acervuli (often salmon-colored) with hair-like setae (whiskers); lesions with fruiting bodies also appear on fruit.

Management

Cultural Practices: Use disease-free seed; follow a 2-year rotation out of cucurbits. Be mindful under moist conditions and high humidity for 24 hrs.

Chemical Control: Apply Bravo (**Group M5**) alone or in combination with Topsin M (**Group 1**) in alternation with **Group 11** fungicides (Quadris and Cabrio). If resistance to Quadris occurs in the area, you must use a fungicide from different fungicide group.

Scab

Cladosporium cucumerinum fungus is the responsible for causing this disease. Young lesions are water soaked but when older turn tan with a yellow halo and eventually crack and fall out; fruit lesions vary as cavity or erumpent lesions on fleshy fruit (summer squash) or sunken dry and corky lesions on hard fruit (pumpkins and winter squash.

Management

Cultural Practices: Use disease-free seed; follow a crop rotation out of cucurbits for 2 years.

Chemical Control: Control is achieved with protectant fungicides like Bravo (**Group M5**) and is especially needed during cool and wet springs and summers.

References

Compendium of Cucurbit Diseases. 1996. Ed. T. A. Zitter, D. L. Hopkins, and C. E. Thomas. APS Press, St. Paul, MN. 87pp.

Pumpkin Production Guide. 2003. Ed. D. Riggs, NRAES, Ithaca, NY. 152pp.

Vegetable MD online web site: http://vegetablemdonline.ppath.cornell.edu for selected fact sheets, news articles (ie. Occurrence of Strobilurin Resistance and Impact on Managing Powdery mildew of Cucurbits), and images.

Fungicide Resistance Action Committee site for **Fungicide Groups** used in this paper. http://www.frac.info/publications/FRACCODE_sept2002.pdf

Gerald Brust, 2009. Cucurbit Pest Management. University of Maryland Extension, USA. https://www.extension.umd.edu/sites/default/files/_docs/articles/CucurbitPestManagement.pdf

4.4. Phytosanitary measures

4.4.1. Post-Harvest Procedures

The procedure is to sorting/grading to remove damaged/overripe/infested/infected cucurbits. The grading process is likely to remove flowers showing obvious signs of fungal and bacterial disease as well as the presence of aphids, mealybugs, scale insects, caterpillars etc .

4.4.2. Visual Inspection

Visual inspection of flowers occurs at several points during the routine production and post-harvest pathway for flowers and foliage. These include:

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

A visual inspection at multiple points of the pathway provides opportunities to remove infested/infected flowers and is considered an appropriate risk management option for regulated organisms such as aphids, mealybugs and scale insects as they are easily detected on the surface of cucurbits.

4.4.3. Application of phytosanitary measures

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

- Surveillance for pest freedom;

- Testing prior to export for regulated pests which cannot be readily detected by inspection (e.g. viruses on propagating material);
- Specific pre-shipment pest control activities to be undertaken by the supply contracting party;
- The application of a pre-shipment treatment;
- Inspection of the export consignment;
- Treatment on arrival in Bangladesh.

4.4.4. General conditions for cucurbits

- Cucurbits include fresh fruits intended for consumption and not for planting. For the purposes of this standard cucurbits excludes roots or viable seeds.
- Only inert/synthetic material may be used for the protection, packaging and shipping materials of cucurbits and branches.
- Cucurbits and branches shall not be shipped or contained in free-standing water.

4.4.5. Pre-shipment requirements

Inspection of the consignment: Bangladesh requires that the NPPO of the country of origin sample and inspect the consignment according to official procedures for all the visually detectable regulated pests specified by Plant Quarantine Wing (PQW) of the Departemnt of Agiculture Extension of Bangladesh.

Treatment of the consignment

The PQW of Bangladesh requires that the NPPO of the country of origin ensure that the cucurbits from which the cucurbits were collected, have been treated as specified by PQW of Bangladesh.

Documentation

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

4.4.6. Phytosanitary certification

A completed phytosanitary certificate issued by the NPPO of the country of origin must accompany all cucurbits exported to Bangladesh.

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

The cucurbits have:

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

AND, ONE OR MORE OF THE FOLLOWING;

ii) been sourced from a pest free area that is, as verified by pest surveillance methods (in accordance with the International Standards for Phytosanitary Measures; Requirements for the Establishment of Pest Free Areas, IPPC, FAO, Publication 4, 1996), free from a regulated pest(s).
iii) been sourced from a pest free place of production that is, as verified by pest surveillance methods (in accordance with the International Standards for Phytosanitary Measures; Requirements for the Establishment of Pest Free Places of Production and Pest Free Production Sites, IPPC, FAO, Publication 10, 1996), free from a regulated pest(s).

AND;

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

4.4.7. Additional declarations to the phytosanitary certificate

If satisfied that the pre-shipment activities have been undertaken, the NPPO of the country of origin must confirm this by providing the following additional declarations to the phytosanitary certificate:

"The cucurbits in this consignment have been:

- inspected according to appropriate official procedures and are considered to be free from the regulated pests specified by Plant Quarantine Wing under Department of Agriculture of Bangladesh, and to conform with Banglasesh's current phytosanitary requirements".

AND,

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

4.4.8. Transit requirements

The cucurbits must be packed and shipped in a manner to prevent infestation and/or contamination by regulated pests.

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

4.4.9. Inspection on arrival in Bangladesh

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

4.4.10. Testing for regulated pests

PQW of DAE of Bangladesh may, on the specific request of the Director, PQW, test the consignment for regulated pests.

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

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

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

Actions for the interception/detection of regulated non-plant pests in accordance with the actions required by the relevant government department.

4.4.12. 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 given.

4.4.13. Feedback on non-compliance

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

CHAPTER 5

POTENTIAL HAZARD ORGANISM: RISK ANALYSIS

5.1. Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding the cucurbits imported from any exporting countries of India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil and Chile into Bangladesh.

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

5.2.1. Pests of cucurbits in the world

The pests associated with fresh cucurbits and seeds 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.

Fifty one species of pests were recorded for cucurbits in the world of which 17 species were insect pests and 2 species were mite pests; the species of disease causing fungi were 11, bacteria 4, nematode 4, and virus & viroids were 5. On the other hand, 8 species of weeds for cucurbits were recorded in the world.

Among Table 9 depicted the lists of pests associated with the cucurbits that also occur in India, China, Thailand, Japan and Bangladesh and the absence or presence of these pests in Bangladesh. Based on Table 9, any pest that meets all above criteria selected for further risk assessment (Table 10)

5.2.2. Quaratine pests of cucurbits for Bangladesh

Twenty two (22) species of quarantine pests of cucurbits for Bangladesh were identified those were present in India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile, but not in Bangladesh. Among these 22 species of quarantine pests, 14 were insect pests, 1 species was mite pest, 1 fungus, 2 bacteria, one nematode species, two viruses and weed was one species (Table 10).

The quarantine insect pests are silver leaf whitefly (*Bemisia tabaci B biotype*), cotton mealy bug (*Phenacoccus solenopsis*), alfalfa thrips (*Frankliniella occidentalis*), lesser fruit fly (*Dacus ciliates*), Malaysian fruit fly (*Bactrocera latifrons*), Meditteranean fruit fly (*Ceratitis capitata*), Quensland fruit fly (*Bactrocera tryoni*), tomato leaf miner (*Liriomyza bryoniae*), Serpentine leaf miner (*Liriomyza trifolii*), pea leaf miner (*Liriomyza huidobrensis*), green looper caterpillar (*Chrysodeixis eriosoma*), cucumber moth (*Diaphania indica*), cucumber worm (*Diaphania nitidalis*), and cucumber beetle (*Diabrotica undecimpunctata*). The quarantine mite pest of cucurbits for Bangladesh is red spider mite (*Tetranychus evansi*) (Table 10).

On the other hand, six (6) disease causing pathogens have been identified as quarantine pests of cutcucurbits for Bangladesh. Among these, one quarantine fungus named Phytopthora root rot (*Phytophthora megasperma*); two quarantine bacteria namely Cucurbit bacterial wilt (*Erwinia tracheiphila),* Bacterial fruit blotch (*Acidovorax citrulli*); one species of nematode namely sting nematode (*Belonolaimus longicaudatus*); two viruses namely *Cucumber yellow stunting disorder virus, Zucchini yellow mosaic virus*. One species of quarantine weed has been identified Bangladesh named Parthenium weed (*Parthenium hysterophorus*) (Table 10).

Table-9: Pests associated with cucurbits in the world and identification of quarantine organisms

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
Arthropod pests							
A. Insect pests							
1	Cucurbit fruitfly	*Bactrocera cucurbitae*	Tephritidae	Diptera	Yes	No	CABI/EPPO, 2003; EPPO, 2014
2	Oriental fruitfly	*Bactrocera dorsalis*	Tephritidae	Diptera	Yes	No	EPPO, 2014; CABI/EPPO, 2013; Leblanc et al., 2013a
3	Guava fruitfly	*Bactrocera zonata*	Tephritidae	Diptera	Yes	No	Kapoor, 1993; EPPO, 2014; CABI/EPPO, 2013
4	Mango fruit fly	*Bactrocera tau*	Tephritidae	Diptera	Yes	No	Akhtaruzzaman *et al., 1999*
5	Lesser fruitly	*Dacus ciliates*	Tephritidae	Diptera	No	Yes	CABI/EPPO, 2002; EPPO, 2014
6	Malaysian fruit fly	*Bactrocera latifrons*	Tephritidae	Diptera	No	Yes	EPPO, 2015
7	Meditteranean fruit fly	*Ceratitis capitata*	Tephritidae	Diptera	No	Yes	CABI, 2007; Cayol & Causse, 1993; Kapoor, 1989
8	Quensland fruit fly	*Bactrocera tryoni*	Tephritidae	Diptera	No	Yes	IIE, 1991; Maelzer, 1990; Bateman, 1982
9	Vegetable leaf miner	*Liriomyza sativae*	Agromyzidae	Diptera	Yes	No	Santosh & Bhuiya, 2014
10	Tomato leaf miner	*Liriomyza bryoniae*	Agromyzidae	Diptera	No	Yes	EPPO, 2016; CABI/EPPO, 1997; CABI, 2007
11	Serpentine leaf miner	*Liriomyza trifolii*	Agromyzidae	Diptera	No	Yes	CABI/EPPO, 1997; EPPO, 2014
12	Pea leaf miner	*Liriomyza huidobrensis*	Agromyzidae	Diptera	No	Yes	CABI/EPPO, 2002; EPPO, 2014
13	Black cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Yes	No	Alam & Ahmad, 1975; Islam et al., 1991; APPPC, 1987
14	Cucumber moth	*Diaphania indica*	Crambidae	Lepidoptera	No	Yes	Ke *et al.,* 1986
15	Cucumber worm	*Diaphania nitidalis*	Crambidae	Lepidoptera	No	Yes	IIE, 1993; EPPO, 2014
16	Green looper caterpillar	*Chrysodeixis eriosoma*	Noctuidae	Lepidoptera	No	Yes	EPPO, 2014; Saha & Saharia, 1983; Waterhouse, 1993
17	Epilachna beetle	*Epilachna vigintioctopunctata*	Coccinellidae	Coleoptera	Yes	No	Ahad, 2003
18	Epilachna beetle	*E. dodecastigma*	Coccinellidae	Coleoptera	Yes	No	Ahad, 2003
19	Red pumpkin beetle	*Raphidopalpa foveicollis*	Chrysomeliae	Coleoptera	Yes	No	Ahad, 2003
20	Cucumber beetle	*Diabrotica undecimpunctata*	Chrysomeliae	Coleoptera	No	Yes	OEPP/EPPO, 1999; EPPO, 2014
21	Green stink bug	*Nezara viridula*	Pentatomidae	Hemiptera	Yes	No	Ohno & Alam, 1992; CABI/EPPO, 1998;APPPC, 1987
22	Melon thrips	*Thrips palmi*	Thripidae	Thysanoptera	Yes	No	CABI/EPPO, 1998; CABI & EPPO, 1998; EPPO, 2014
23	Alfalfa thrips	*Frankliniella occidentalis*	Thripidae	Thysanoptera	No	Yes	CABI/EPPO, 1999; EPPO, 2014
24	Cucurbit aphid	*Aphis gossypii*	Aphididae	Homoptera	Yes	No	Ahad, 2003; APPPC, 1987

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
25	Whitefly	*Bemisia tabaci* Genn.	Aleurodidae	Homoptera	Yes	No	CABI/EPPO, 1999; EPPO, 2014
26	Silver leaf whitefly	*Bemisia tabaci B biotype*	Aleurodidae	Homoptera	No	Yes	EPPO, 2014; CABI/EPPO, 1999
27	Cotton jassid	*Amrasca bigutula bigutula*	Cicadellidae	Homoptera	Yes	No	AVRDC, 2001
28	Pink mealybug	*Maconellicoccus hirsutus*	Pseudococcidae	Homoptera	Yes	No	EPPO, 2014; CABI/EPPO, 2015
29	Cotton mealy bug	*Phenacoccus solenopsis*	Pseudococcidae	Homoptera	No	Yes	CABI/EPPO, 2012; EPPO
30	Mole cricket	*Gryllotalpa brachyptera*	Gryllotalpidae	Orthoptera	Yes	No	www.en.wikipedia.org
B. Mite pest							
31	Two-spotted spider mite	*Tetranychus urticae* Kock	Tetranichidae	Acarina	Yes	No	Mir, 1990; IIE, 1996
32	Red spider mite	*Tetranychus evansi*	Tetranichidae	Acarina	No	Yes	CABI, 2015; EPPO, 2016
Diseases							
Causal organism: Fungi							
33	Powdery mildew	*Podosphaera xanthii*	Erysiphaceae	Erysiphales	Yes	No	Ashrafuzzaman (1991)
34	Downey mildew	*Pseudopernospora cubensis*	Peronosporaceae	Peronosporales	Yes	No	Ashrafuzzaman (1991)
35	Cercospora leaf spot	*Alternaria brassicae*	Pleosporaceae	Pleosporales	Yes	No	Ashrafuzzaman (1991)
36	Chacoal rot	*Macrophomina physiolina*	Botryosphaeriaceae	Botryosphaeriales	Yes	No	Ashrafuzzaman (1991)
37	Anthracnose	*Colletotrichum orbiculaum*	Glomerellaceae	Glomerellales	Yes	No	Ashrafuzzaman (1991)
38	Root-stem rot/ damping off/ seed rot	*Pythium* spp.	Pythiaceae	Pythiales	Yes	No	Ashrafuzzaman (1991)
39		*Fusarium* spp.	Nectriaceae	Sordariomycetes	Yes	No	Ashrafuzzaman (1991)
40		*Rhizoctonia* spp.	Ceratobasidiaceae	Cantharellales	Yes	No	Ashrafuzzaman (1991)
41	Gumosis	*Cladosporium cucumerinum*	Davidiellaceae	Capnodiales	Yes	No	Ashrafuzzaman (1991)
42	Gummy stem blight	*Didymella bryoniae*	Incertae sedis	Pleosporales	Yes	No	Ashrafuzzaman (1991)
43	Fusarium wilt	*Fusarium oxysporum* f.sp. *cucumerinum*	Nectriaceae	Hypocreales	Yes	No	Ashrafuzzaman (1991)
44	Cottony soft rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales	Yes	No	Ashrafuzzaman (1991)
45	Phytopthora root rot	*Phytophthora megasperma*	Pythiaceae	Pythiales	No	Yes	CABI, 2006;
Causal organism: Bacteria							
46	Angular leaf spot	*Pseudomonas syringae* pv. *lachrymans*	Pseudomonadaceae	Pseudomonadales	Yes	No	Ashrafuzzaman (1991)
47	Bacterial wilt	*Erwinia catotovora*	Enterobacteriaceae	Enterobacteriales	Yes	No	Ashrafuzzaman (1991)
48	Cucurbit bacterial wilt	*Erwinia tracheiphila*	Enterobacteriaceae	Enterobacteriales	No	Yes	CABI, 2016; CABI, 2007
49	Bacterial root rot	*Pectobacterium cartovorum*	Enterobacteriaceae	Enterobacteriales	Yes	No	Ashrafuzzaman (1991)
50	Bacterial fruit blotch	*Acidovorax citrulli*	Comamonadaceae	Burkholderiales	No	Yes	CABI/EPPO, 2011; EPPO, 2014

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
Causal organism: Nematode							
51	Root knot nematode	*Meloidogyne incognita*	Heteroderidae	Tylenchida	Yes	No	Ashrafuzzaman (1991)
52	Reniform nematode	*Rotylenchulus reniformis*	Hoplolaimidae	Tylenchida	Yes	No	Ashrafuzzaman (1991)
53	Sting nematode	*Belonolaimus longicaudatus*	Belonolaimidae	Tylenchida	No	Yes	CABI/EPPO, 2003
Virus							
54	Cucumber mosaic virus	*Cucumber mosaic virus*	Bromoviridae	Unassigned (+ve)ssRNA	Yes	No	Ashrafuzzaman (1991)
55	Squash mosaic virus	*Squash mosaic virus*	Secoviridae	Picornavirales	Yes	No	Ashrafuzzaman (1991)
56	Cucumber yellow stunting disorder virus	*Cucumber yellow stunting disorder virus*	Closteroviridae	Group: RNA viruses	No	Yes	CABI/EPPO, 2004; EPPO, 2014; CABI, 2007
57	Zucchini yellow mosaic virus	*Zucchini yellow mosaic virus*	Potyviridae	Group: RNA viruses	No	Yes	CABI/EPPO, 2003; EPPO, 2014
Weed							
58	Bermuda grass	*Cynodon dactylon*	Poacegae	Poales	Yes	No	-
59	Nutsedge	*Cyperus esculentus*	Cyperaceae	Poales	Yes	No	-
60	Pigweed	*Amaranthus acanthochiton*	Amaranthaceae	Caryophyllales	Yes	No	-
61	Spiny pigweed	*Amaranthus spinosus*	Amaranthaceae	Caryophyllales	Yes	No	-
62	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	Yes (limited areas)	Yes	Shabbir 2006; Shabbir et al. 2011; Anwar et al. 2012

Table-10: Quarantine pests for Bangladesh likely to be associated with cucurbits imported from flower exporting countries selected for further analysis

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect pests					
1	Silver leaf whitefly	*Bemisia tabaci B biotype*	India, China, Japan, Pakistan, Philippines, Thailand, Italy, USA, Indonesia, Australia	Stem, leaf, flower, fruits	EPPO, 2014; CABI/EPPO, 1999
2	Cotton mealy bug	*Phenacoccus solenopsis*	India, China, Thailand, Japan, Taiwan, Australia, Brazil, USA	Leaf, stem, fruits	CABI/EPPO, 2012; EPPO, 2014; Muniappan, 2009
3	Alfalfa thrips	*Frankliniella occidentalis*	India, Thailand, China, Japan, Sri Lanka	Flower, stem, leaf	CABI/EPPO, 1999; EPPO, 2014
4	Lesser fruit fly	*Dacus ciliates*	India, Pakistan, Bangladesh (reported but not confirmed)	Fruit	CABI/EPPO, 2002; EPPO, 2014
5	Malaysian fruit fly	*Bactrocera latifrons*	India, China, Japan, Malaysia	Fruit, stem	EPPO, 2015
6	Meditteranean fruit fly	*Ceratitis capitata*	India, Afganistan, France, Germany, Italy, Australia	Fruit	CABI, 2007; Cayol & Causse, 1993; Kapoor, 1989
7	Quensland fruit fly	*Bactrocera tryoni*	Australia, USA, Chile	Fruit	IIE, 1991; Maelzer, 1990; Bateman, 1982
8	Tomato leaf miner	*Liriomyza bryoniae*	Japan, Taiwan, Italy, France, Germany, USA	Leaf, fruit, flower	EPPO, 2016; CABI/EPPO, 1997; CABI, 2007
9	Serpentine leaf miner	*Liriomyza trifolii*	India, China, Japan, Taiwan	Leaf, stem, flower, fruits	EPPO, 2014; CABI/EPPO, 1997; Minkenberg (1988
10	Pea leaf miner	*Liriomyza huidobrensis*	India, Thailand, Japan, Taiwan	Leaf, stem, flower, fruits	CABI/EPPO, 2002; EPPO, 2014
11	Green looper caterpillar	*Chrysodeixis eriosoma*	China, India, Japan, Thailand, USA, Australia	Leaf, fruits	EPPO, 2014; Rogers et al., 1997
12	Cucumber moth	*Diaphania indica*	Japan, Turkey, Azerbaijan	Leaf, stem, fruits	Vamsree *et al.*, 2005; EPPO, 2014; Ke *et al.*, 1988
13	Cucumber worm	*Diaphania nitidalis*	India, China, Japan, Philippines, Thailand, Taiwan, Vietnam, USA	Leaf, stem, fruits	Vamsree *et al.*, 2005; EPPO, 2014; Ke *et al.*, 1988
14	Cucumber beetle	*Diabrotica undecimpunctata*	USA	Leaf, stem, flower	OEPP/EPPO, 1999; EPPO, 2014

Mite pest					
15	Red spider mite	*Tetranychus evansi*	Japan, Taiwan, USA, Brazil, France, Italy	Leaf, stem, cutting, flower	CABI, 2015; EPPO, 2016
Disease causing organisms					
Fungi					
16	Phytopthora root rot	*Phytophthora megasperma*	Japan, Philippines, Italy, France, Australia	Leaf, stem, cutting,	CABI, 2006;
Bacterial					
17	Cucurbit bacterial wilt	*Erwinia tracheiphila*	China, Japan, Thailand, Taiwan, USA	Stem, fruits, seed	CABI, 2016; CABI, 2007
18	Bacterial fruit blotch	*Acidovorax citrulli*	China, Japan, Thailand, Taiwan, USA, Brazil, Australia	Stem, fruits, seed	CABI/EPPO, 2011; EPPO, 2014
Nematode					
19	Sting nematode	*Belonolaimus longicaudatus*	Pakistan, USA	Root, stem	CABI/EPPO, 2003
Virus					
20	Cucumber yellow stunting disorder virus	*Cucumber yellow stunting disorder virus*	UAE, KSA, USA, France	Seed, leaf, stem, fruits	CABI/EPPO, 2004; EPPO, 2014; CABI, 2007
21	Zucchini yellow mosaic virus	*Zucchini yellow mosaic virus*	India, China, Japan, Pakistsan, Taiwan, France, Germany, Italy, USA, Brazil, Australia	Seed, leaf, cutting, flower	CABI/EPPO, 2003; EPPO, 2014
Weeds					
22	Parthenium weed	*Parthenium hysterophorus*	Bangladesh (restricted areas), India, China, Bhutan, Japan, Pakistan, Australia, Brazil	Whole season of the crops	Shabbir 2006; Shabbir et al. 2011; Anwar et al. 2012

References

Ahad, M. A. 2003. *Trinojatiyo Fashaler Balai Bebosthapana* (In Bengali): Pest Management in Graminicious Crops. Bangla Academy, Dhaka, Bangladesh.

Akhtaruzzaman M, Alam MZ, Sardar MA, 1999. Identification and distribution of fruit flies infesting cucurbits in Bangladesh. Bangladesh Journal of Entomology, 9(1/2):93-101; 12 ref.

Alam MZ, Ahmad A, 1975. Control of cutworm in potato. Bangladesh Horticulture, 3(1):51

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).

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).

Ashrafuzzaman, H. (1991). A Text Book of Plant Pathology, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

AVRDC. 2001. AVRDC International Cooperators' Fact Sheets, Asian Vegetable Research and Development Center, Thailand.

CABI, 1997. *Aulacophora foveicollis.* . [Distribution map]. Distribution Maps of Plant Pests, Wallingford, UK: CAB International, 1997 No. June pp. Map 570

CABI , EPPO , 1998. *Thrips palmi*. [Distribution map]. Distribution Maps of Plant Pests, December (2nd revision). Wallingford, UK: CAB International, Map 480.

CABI/EPPO, 1998. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 1998. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 1998. Nezara viridula. Distribution Maps of Plant Pests. Map No. 27, 2nd revision. Wallingford, UK: CAB International.

CABI/EPPO, 1999. *Bemisia tabaci*. [Distribution map]. Distribution Maps of Plant Pests, June (1st revision). Wallingford, UK: CAB International, Map 284.

CABI/EPPO, 2002. *Dacus ciliatus*. Distribution Maps of Plant Pests, No. 323. Wallingford, UK: CAB International.

CABI/EPPO, 2003. Bactrocera cucurbitae. Distribution Maps of Plant Pests, No. 64. Wallingford, UK: CAB International.

CABI/EPPO, 2013. Bactrocera dorsalis. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 109 (4th revision).

CABI/EPPO, 2015. *Maconellicoccus hirsutus*. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 100 (4th revision).

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

CIE (1967a) *Distribution Maps of Pests, Series A* No. 232. CAB International, Wallingford, UK.

CIE (1978) *Distribution Maps of Pests, Series A* No. 16 (revised). CAB International, Wallingford, UK.

EPPO (2016). Report of a Pest Risk Analysis for *Tetranychus evansi.* European and Mediterranean Plant Protection Organization. https://www.eppo.int/QUARANTINE/Alert.../Tetranychus_evansi.doc

EPPO (2016). Data Sheets on Quarantine Pests: *Dacus ciliatus.* European and Mediterranean Plant Protection Organization. https://www.eppo.int/QUARANTINE/data_sheets/insects/DACUCI_ds.pdfIIE, 1993. Distribution Maps of Plant Pests, No. 15. Wallingford, UK: CAB International.

IIE, 1996. Distribution maps of pests, No. 562. Wallingford, UK: CAB International.

Islam MN, Nessa Z, Karim MA, 1991. Management of the potato cutworm, Agrotis ipsilon (Hfn.) (Lepidoptera: Noctuidae) with insecticides other than the organochlorinated hydrocarbon insecticides. Bangladesh Journal of Zoology, 19(2):173-177

Islam W, Ahmed KN, Nargis A, 1987. An investigation on the insect pests of Bengal gram (*Cicer arietinum* L.). Bangladesh Journal of Scientific and Industrial Research, 22(1-4):175-179

Kapoor VC, 1993. Indian Fruit Flies (Insecta: Diptera: Tephritidae). New Delhi, India; Oxford, UK: IBH Publishing Company.

Ke, L. D., Li, Z. Q., Xu, L. X. and Zheng, Q. F. 1986. A brief report of a study on *Diaphania indica. Zhejiang Agricultural Science.* 3:139-142.

Leblanc L, Hossain MA, Khan SA, San Jose M, Rubinoff D, 2013. A preliminary survey of the fruit flies (Diptera: Tephritidae: Dacinae) of Bangladesh. Proceedings of the Hawaiian Entomological Society, 45:51-58.

Mir AA, 1990. Problem of red spider mites in tea and its remedies. Pamphlet - Bangladesh Tea Research Institute, No. 13:12 pp.

Ohno K, Alam MZ, 1992. Hereditary basis of adult color polymorphism in the southern green stink bug, *Nezara viridula* Linne (Heteroptera: Pentatomidae). Applied Entomology and Zoology, 27(1):133-139.

Santosh Mazumdar, Bhuiya BA, 2014. Vegetable leafminers (Diptera: Agromyzidae) and their plant hosts in Bangladesh. Journal of Threatened Taxa, 6(6):5894-5899. http://www.threatenedtaxa.org/showAbstract.asp

5.3. Potential Hazard Organisms: Risk Analyses

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

ARTHROPOD: INSECT PESTS

5.3.1.	Silver leaf whitefly, ***Bemisia tabaci (B biotype)*** **(Gennadius, 1889)**

5.3.1.1. Hazard identification

Scientific Name: *Bemisia tabaci (B biotype) (*Gennadius, 1889)

Synonyms:

Bemisia argentifolii Bellows,
Perring, Gill & Hendrick, 1994
Bemisia tabaci B

Common names: Silver whitefly,
Poinsettia whitefly;
Tobacco whitefly, B biotype

Taxonomic tree

Domain: Eukaryota
- Kingdom: Metazoa
  - Phylum: Arthropoda
    - Subphylum: Uniramia
      - Class: Insecta
        - Order: Hemiptera
          - Suborder: Sternorrhyncha
            - Superfamily: Aleyrodoidea
              - Family: Aleyrodidae
                - Genus: *Bemisia*
                  - Species: *Bemisia tabaci* (*B biotype*)

EPPO Code: BEMIAR. This pest has been included in EPPO A2 list: No. 178

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI/EPPO, 1999]

5.3.1.2. Biology

Eggs are laid usually in circular groups, on the underside of leaves, with the broad end touching the surface and the long axis perpendicular to the leaf. They are anchored by a pedicel which is inserted into a fine slit made by the female in the tissues, and not into stomata, as in the case of many other aleyrodids. Eggs are whitish when first laid but gradually turn brown. Hatching occurs after 5-9 days at 30°C but, like many other developmental rates, this depends very much on host species, temperature and humidity.

On hatching, the first instar, or "crawler", is flat, oval and scale-like. This first instar is the only larval stage of this insect which is mobile. It moves from the egg site to a suitable feeding location on the lower surface of the leaf where its legs are lost in the ensueing moult and the larva becomes sessile. It does not therefore move again throughout the remaining nymphal stages. The first three nymphal stages last 2-4 days each (this could however vary with temperature). The fourth nymphal stage is called the 'puparium', and is about 0.7 mm long and lasts about 6 days; it is within the latter period of this stage that the metamorphosis to adult occurs. The adult emerges through a "T"-shaped rupture in the skin of the puparium and spreads its wings for several minutes before beginning to powder itself with a waxy secretion from glands on the abdomen. Copulation begins 12-20 h after emergence and takes place several times throughout the life of the adult. The life span of the female could extend to 60 days. The life of the male is generally much shorter, being between 9 and 17 days. Each female lays up to 160 eggs during her lifetime, although the B biotype has been shown to lay twice as many, and each group of eggs is laid in an arc around the female. Eleven to fifteen generations can occur within one year.

5.3.1.3. Hosts

B. tabaci was mainly known as a pest of field crops in tropical and subtropical countries: cassava *(Manihot esculenta)*, cotton *(Gossypium)*, sweet potatoes *(Ipomoea batatas)*, tobacco *(Nicotiana)* and tomatoes *(Lycopersicon esculentum)*. Its host plant range within any particular region was small, yet *B. tabaci* had a composite range of around 300 plant species within 63 families (Mound & Halsey, 1978). With the evolution of the highly polyphagous B biotype, *B. tabaci* has now become a pest of glasshouse crops in many parts of the world, especially Capsicum, **courgettes *(Cucurbita pepo)***, **cucumbers *(Cucumis sativus)***, Hibiscus, Gerbera, Gloxinia, lettuces (*Lactuca sativa*), poinsettia (*Euphorbia pulcherrima*) and tomatoes (*Lycopersicon esculentum*). *B. tabaci* moves readily from one host species to another and is estimated as having a host range of around 600 species (Asteraceae, Brassicaceae, Convolvulaceae, **Cucurbitaceae**, Euphorbiaceae, Fabaceae, Malvaceae, Solanaceae, etc.).

5.3.1.4. Distribution

- ***EPPO region**:* Present and widespread in the field in Algeria, Cyprus, France (South), Greece, Israel, Italy, Libya, Portugal, Spain, Turkey and Ukraine (CABI & EPPO, 1999; EPPO, 2014).
- ***Asia**:* Afghanistan, Bhutan, China *(*He et al., 2008), Cyprus, Hong Kong, Israel, India (Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Jammu and Kashmir, Kerala, Karnataka, Maharashtra, Meghalaya, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal) *(*CABI & EPPO, 1999; EPPO, 2014), Indonesia, Iran, Iraq, Japan, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Thailand, Yemen. The B biotype has been recorded in Cyprus, India, Israel, Japan and Yemen.
- **Africa:** Algeria, Angola, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Morocco, Mozambique, Nigeria *(*Brown et al., 1995a; EPPO, 2014; CABI/Bedford et al., 1994a).
- **North America:** Bermuda, Canada, Mexico, USA. The *B biotype* is confirmed in Mexico and USA (southern states, Hawaii, New York).
- **Central America and Caribbean:** Antigua and Barbuda, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, Trinidad and Tobago. The B biotype has been recorded in Central America and the Caribbean Basin.
- **South America:** Argentina, Brazill.
- **Oceania:** Australia, Fiji, New Zealand, Papua New Guinea, Samoa, Solomon Islands, Tuvalu. The B biotype is present in Australia.
- EU: Present.

5.3.1.5. Hazard Identification Conclusion

Considering the facts that *Bemisia tabaci B biotype*-

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 1999];
- is potentially economic important to Bangladesh because it is an important pest of field crops and flowers in Asia including China, India, Thailand, **Japan**, Sri Lanka, Cyprus, Israel, Turkey, Lebanon, Philippines, Taiwan, [EPPO, 2014; CABI/EPPO, 1999] from where many vegetables, seeds, vegetable parts and flowers are imported to Bangladesh.
- EPPO (OEPP/EPPO, 1989) has listed *B. tabaci* as an A2 quarantine pest, and it is also a quarantine pest for CPPC. The risk to the EPPO region is primarily to the glasshouse industry in northern countries, and mainly concerns the B biotype (though it is difficult in practice to confirm this in specific cases). Since its recent introduction to several of these countries, the pest has proved particularly difficult to combat because of its polyphagy, its resistance to many insecticides and its disruption of biological control programmes (Della Giustina et al., 1989). Very few countries remain free from B. tabaci, illustrating the difficulty of preventing its movement in international trade.
- *Bemisia tabaci (B biotype)* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-1.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years-Yes**, • First reports of a newly evolved biotype of *B. tabaci*, the B biotype, appeared in the mid-1980s (Brown et al., 1995b). Commonly referred to as the silverleaf whitefly or poinsettia strain, the B biotype has been shown to be highly polyphagous and almost twice as fecund as previously recorded strains and has been documented as being a separate species, *B. argentifolii* (Bellows et al., 1994). • The B biotype has been recorded in Cyprus, **India,** Israel, **Japan** and Yemen (EPPO, 2014). • The presence of the B biotype has been confirmed in Cyprus, **France** (South) (Villevieille & Lecoq, 1992), Israel, **Italy**, Spain and in the glasshouse infestations of northern Europe (e.g. **Netherlands**). **b. Posibility of survival during transport, storage and transfer? Yes** • The cucurbit seeds and fruits are transported from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile to Bangladesh mainly by Airfreight, and or Landport. Therefore, the period of time taken for shipment through these transportation pathways from the exporting countries to Bangladesh is very short. Within this period the eggs and crawlers of whitefly can easily survive on fruit surfaces of cucurbits. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with high risk potential.	**YES and HIGH**

Description	Establishment Potential
c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes, • The cucurbits are imported into Bangladesh manily from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile. *B. tabaci* B biotype is a common problem in such countries. So, the pathway appear good for this pest to entire in Bangladesh. Adults of *B. tabaci* do not fly very efficiently but, once airborne, they can be transported quite large distances by the wind. All stages of the pest are liable to be carried on planting material and cucurbits of host species. The international trade in poinsettia is considered to have been a major means of dissemination within the EPPO region of the B biotype of *B. tabaci*. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?- Yes** • This pest can become establish in Bangladesh through imports of the vegetables, seeds, vegetable parts and flowers. *B. tabaci* was mainly known as a pest of field crops in tropical and subtropical countries. *B. tabaci* had a composite range of around 300 plant species within 63 families. *B. tabaci* moves readily from one host species to another and is estimated as having a host range of around 600 species (Asteraceae, Brassicaceae, Convolvulaceae, **Cucurbitaceae**, Euphorbiaceae, Fabaceae, Malvaceae, Solanaceae, etc.) which are mostly common in Bangladesh. • The development time of this insect from egg to adult may range from 15-70 days dependent upon temperature and plant host. Development occurs in temperatures ranging from 50 to 89.6^{o}F (10 to 32^{o}C). 80.6^{o}F (27^{o}C) appears to be the optimal temperature for development. Under control conditions on cotton, the pest completes its development in 17 days at 86^{o}F (30^{o}C) on the contentinal U.S. development from egg to adult under field conditions varies with the season; development variesfrom 25 to 50 days. Very little seasonal difference occurs in Hawaii. Overlapping whitefly generations occur throughout the year. • These climatic requirements for growth and development of *Bemisia tabaci* are more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.3.1.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Until recently, *B. tabaci* was mainly known as a pest of field crops in tropical and subtropical countries: cassava *(Manihot esculenta),* cotton *(Gossypium),* sweet potatoes *(Ipomoea batatas),* tobacco *(Nicotiana)* and tomatoes *(Lycopersicon esculentum).* Its host plant range within any particular region was small, yet *B. tabaci* had a composite range of around 300 plant species within 63 families (Mound & Halsey, 1978). With the evolution of the highly polyphagous **B biotype**, *B. tabaci* has now become a pest of glasshouse crops in many parts of the world, especially *Capsicum,* **courgettes *(Cucurbita pepo),* cucumbers *(Cucumis sativus)***, Hibiscus, Gerbera, Gloxinia, lettuces *(Lactuca sativa),* poinsettia *(Euphorbia pulcherrima)* and tomatoes *(Lycopersicon esculentum).* • *B. tabaci* has been known as a minor pest of cotton and other tropical or semi-tropical crops in the warmer parts of the world and, until recently, has been easily controlled by insecticides. In the southern states of the USA in 1991, however, it was estimated to have caused combined losses of 500 million USD to the winter vegetable crops (Perring et al., 1993) through feeding damage and plant virus transmission. *B. tabaci* is also a serious pest in glasshouses in North America and Europe. • The larvae of the B biotype of *B. tabaci* are unique in their ability to cause phytotoxic responses to many plant and crop species. These include a severe silvering of courgette leaves, white stems in pumpkin, white streaking in leafy brassica crops, uneven ripening of tomato fruits, reduced growth, yellowing and stem blanching in lettuce and kai choy (*Brassica campestris*) and yellow veining in carrots and Lonicera (Bedford et al., 1994a, 1994b). • *B. tabaci* B biotype is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries and the problems presented by its presence in vegetables, flowers and other crops, illustrate clearly the serious nature of this pest and the potential threat to thevegetables cucurbits as well as other crops in Bangladesh still free from the pest. • This is a fairly serious pest of several important vegetables, flower and other crops for Bangladesh. **b. Economic impact and yield loss** • The B biotype of *B. tabaci* can have a serious impact on the production of certain field crops as well as a wide range of protected horticultural crops. In the majority of cases, this is due to viruses that the whitefly transmits between susceptible crops or acquires from indigenous host reservoirs. • The B biotype is also able to induce a phytotoxic response from a number of plant species that could cause yield loss or reduced quality produce. This includes squash silver leaf (Bedford et al., 1994), pumpkin white stem (Costa and Brown, 1991), white streaking of cole crops	**Yes and High**

Description	Consequence potential
(Brown et al., 1992), reduced growth and stem blanching of kai choy (Costa et al., 1993) and uneven ripening of tomato (Maynard and Cantliffe, 1989). All of these can affect the yield and quality of a crop and thus its market value. • In 1991, the B biotype alone caused an estimated $500 million loss to the 1991 winter harvest in California, USA, mainly through virus damage. However, in other areas of the world where the B biotype has appeared, it is found alongside an indigenous non-B biotype, so it is extremely difficult to determine specific economic damage. For example, the B biotype is found alongside the K biotype in Pakistan where both biotypes transmit a disease of cotton, Cotton leaf curl virus. Around 2 million tonnes of cotton are grown in Pakistan and between 30 and 40% crop losses can be expected through whitefly-transmitted viruses based on figures in the mid 1990s. An estimate of 2.4 billion dollars damage was caused by the virus between 1993 and 1994 (Bhatti and Soomro 1996). In 1994, the cotton virus spread to India as did a whitefly-transmitted virus of tomato, Tomato leaf curl virus (Colvin et al. 2002), which caused a number of complete crop failures. This tomato virus was then reported to have spread to potato (Gard et al., 2001). Again the B biotype was present within the epidemics although indigenous biotypes G, H and I were also recorded from India, so specific damage attributed to B biotypes alone, could not be calculated. • Within Israel around the Mediterranean Basin, North Africa and on the Canary Islands the B biotype is present alongside the indigenous Q biotype. As seen in Pakistan, it is impossible to calculate the economic impact of the B biotype alone in these areas. The economic impact of more recent appearances of the B biotype within Africa, South and Central America and Australasia currently remains unknown. A European network for the exchange of research ideas into whitefly-related problems exists and can be accessed at www.whitefly.org (EWSN, 1999). **c. Environmental Impact** • The appearance of the B biotype within new areas is in most cases, the result of movement of infested plant material. The movement and establishment of B biotype populations through this route bring along the possibility of insecticide resistance genes. This invariably leads to an increase in the use of insecticides as whitefly control becomes increasingly more difficult. This in turn can produce an ever increasing spiral in the levels of insecticide resistance and insecticide use, having a direct impact on the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-1.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.1.9. Risk Management Measures

- Avoid importation of vegetables, cucurbits from countries, where this pest is available.
- In countries where *B. tabaci* biotype B is not already present, the enforcement of strict phytosanitary regulations as required for *B. tabaci*, may help to reduce the risk of this whitefly becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *B. tabaci*-listed viruses, now on the EPPO A1 or A2 quarantine lists, are present. These viruses are also transmitted by the B biotype.

5.3.1.10. References

Bedford I.D., Briddon R.W., Jones P., Alkaff N. and Markham P.G., 1994. Differentiation of three whitefly-transmitted geminiviruses from the Republic of Yemen. European Journal of Plant Pathology, 100(3-4):243-257.

Bedford, I.D.; Briddon, R.W.; Brown, J.K.; Rosell, R.C.and Markham, P.G. (1994a) Geminivirus transmission and biological characterisation of Bemisia tabaci (Gennadius) biotypes from different geographic regions. Annals of Applied Biology 125, 311-325.

Bellows, T.S.; Perring, T.M.; Gill, R.J. and Headrick, D.H. (1994) Description of a species of Bemisia (Homoptera: Aleyrodidae). Annals of the Entomological Society of America 87, 195-206.

Brown J.K., Coats S.A., Bedford I.D., Markham P.G., Bird J. and Frohlich D.R., 1995. Characterization and distribution of esterase electromorphs in the whitefly, Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae). Biochemical Genetics, 33(7/8):205-14; 22 ref.

Brown JK, Bird J, 1992. Whitefly-transmitted geminiviruses and associated disorders in the Americas and the Caribbean Basin. Plant Disease, 76(3):220-225.

Brown, J.K.; Frohlich, D.R.and Rosell, R.C. (1995b) The sweetpotato or silverleaf whiteflies. Biotypes of Bemisia tabaci or a species complex. Annual Review of Entomology 40, 511-534.

CABI , EPPO , 1999. *Bemisia tabaci* biotype B. [Distribution map]. Distribution Maps of Plant Pests, June. Wallingford, UK: CAB International, Map 591.

Costa HS, Brown JK, 1991. Variation in biological characteristics and esterase patterns among populations of *Bemisia tabaci*, and the association of one population with silverleaf symptom induction. Entomologia Experimentalis et Applicata, 61(3):211-219.

Costa HS, Ullman DE, Johnson MW, Tabashnik BE, 1993. Squash silverleaf symptoms induced by immature, but not adult, Bemisia tabaci. Phytopathology, 83(7):763-766.

Della Giustina, W.; Martinez, M.; Bertaux, F. (1989) *Bemisia tabaci*: le nouvel ennemi des cultures sous serres en Europe. Phytoma No. 406, 48-52.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EWSN, 1999. European Network On European Whiteflies, Their Associated Plant Pathogens And Disorders. (European Whitefly Studies Network). Commission of the European Communities Directorate-General for Agriculture DG VI - FII.3. World Wide Web page at http://www.whitefly.org

He Y.X., Huang J., Weng Q.Y. and Liang Z.S., 2008. Biochemical mechanisms of resistance to chlorpyrifos and dichlorvos in field populations of Bemisia tabaci (Gennadius) B-biotype. Acta Entomologica Sinica, 51(4):384-389. http://www.insect.org.cn

Maynard DN, Cantliffe DJ, 1989. Squash silverleaf and tomato irregular ripening: New vegetable disorders in Florida. Vegetable crops fact sheet VC-37, Florida cooperative extension service. University of Florida, Gainsville.

Mound, L.A. and Halsey, S.H. (1978) Whiteflies of the world, a systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History), London, UK

Perring, T.M.; Cooper, A.D.; Rodriguez, R.J.; Farrar, C.A.and Bellows, T.S. (1993) Identification of a whitefly species by genomic and behavioural studies. Science 259, 74-77.

Villevieille, M.and Lecoq, H. (1992) L'argenture de la courgette - Une maladie nouvelle en France, liée à un aleurode. Phytoma - La Défense des Végétaux, No. 440, 35-36.

Pest-2:	**Cotton mealybug, *Phenacoccus solenopsis* Tinsley**

5.3.2.1 Hazard Identification

Scientific Name: *Phenacoccus solenopsis* Tinsley

Synonyms: *Phenacoccus cevalliae* Cockerell 1902

Phenacoccus gossypiphilous Abbas et al. 2005; 2007; 2008

Common names: Solenopsis mealybug

Chile: soil mealybug

India: cotton mealy bug

Pakistan: cotton mealy bug

Taxonomic tree

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Arthropoda

Subphylum: Uniramia

Class: Insecta

Order: Hemiptera

Suborder: Sternorrhyncha

Superfamily: Coccoidea
Family: Pseudococcidae
Genus: *Phenacoccus*
Species: *Phenacoccus solenopsis*

EPPO Code: PENSO.

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

5.3.2.2. Biology

Females of this ovoviviparous, bisexual species have been reported as capable of producing from 150 to 600 eggs, protected within a waxy ovisac (Lu et al., 2008). Upon hatching, females undergo three immature stages prior to reaching adulthood, whereas males undergo first, second, prepupa and pupa stages prior to adulthood. The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This species is capable of producing multiple generations annually. The mealybugs feed on the plant by extracting sap from cells in the leaves or stems. The sap contains soluble sugars, phenols, proteins and other potential nutrients. Mealybug-infested leaves produce high quantities of sugars and proteins compared to the amounts produced in uninfested leaves (Jagadish et al., 2009a). Conversely, Jagadish et al. (2009a) reported a decline in the phenol content in infested sunflower plants. From studies on the influence of weather on population growth, Suresh and Kavitha (2008b) concluded that maximum temperature and sunshine hours had a positive influence, whereas relative humidity and rainfall had a negative influence on the mealybug.

5.3.2.3. Hosts

The solenopsis mealybug has been recorded on 202 host plant species that include field crops, ornamentals, trees and vegetables. In Pakistan, *P. solenopsis* obtained the status of a serious pest on a wide host range. In a field survey, Arif et al. (2009) identified the mealybug from 154 plant species, the majority of which belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and **Cucurbitaceae**. Significant economic damage was determined to occur on cotton [*Gossypium* spp.], brinjal [*Solanum melongena*], okra [*Abelmoschus esculentus*], tomato [*Solanum lycopersicum*], sesame [*Sesamum indicum*], sunflower [*Helianthus annuus*] and China rose [*Hibiscus rosa-sinensis*] (Sharma, 2007; Arif *et al.,* 2009; Jagadish *et al.,* 2009b). Several cultivated plants, as well as weeds, have been used as trap crops to suppress the population numbers in an area. In surveys of the insect fauna in the southwestern USA, this pseudococcid was recorded on several plant hosts ranging from silver nightshade [*Solanum elaeagnifolium*] (Goeden, 1971) to jojoba [*Simmondsia chinensis*] (Pinto and Frommer, 1980).

a. **Major hosts:** The main host of *Phenacoccus solenopsis includes Carrot (Daucus carotla) Mango (Mangifera indica), Sun flower (Helianthus annuus),* ***Water melon (Citrullus lanatus), Pumpkin (Cucurbita moschata), Bottle gourd (Lagenaria siceraria), Bitter gourd (Momordica charantia),*** *Cotton (Gossypium hirsutum), Sesame (Sesamum indicum), Betel pepper (Piper betle), Maize (Zea mays), Chilli (Capsicum frutescens), Tobbaco (Nicotiana tabacum), Tomato (Solanum lycopersicum), Brinjal (Solanum melongena), Potato (Solanum tuberosum), etc. Celery, lettuce, marigold, gypsophila (baby's breath), ornamental gourd, common bean, pea, onion, garlic etc.*

b. Minor hosts: The minor or other hosts of this pest include slender *amaranthus*, cashew nut, silkweed, date palm, Aster, gerbera, marigold, zinnia, spinach, faba bean, bell pepper, *petunia,* etc.

5.3.2.4. Distribution

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

- **EPPO region**: Cyprus, Malta, Netherlands (CABI/EPPO, 2012; EPPO, 2014).
- **Asia**: India (Prishanthini & Vinobaba, 2009; Tanwar *et al.,* 2007; Ghulam *et al.,* 2009; Nagrare *et al.,* 2009; CABI/EPPO, 2012; EPPO, 2014), China (Muniappan, 2009; CABI/EPPO, 2012; EPPO, 2014), Thailand, Japan, Sri Lanka, Taiwan, [CABI/EPPO, 2012; EPPO, 2014]
- **Africa**: Benin, Egypt, Ghana. Mali, Senegal (CABI/EPPO, 2012; EPPO, 2014)
- **North America**: Mexico, USA (Arizona, California, Colorado, Florida, Hawaii, Maryland, New York, Texas, Washington).
- **Central America and Caribbean**: Belize, Costa Rica, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Honduras, Nicaragua, Panama.
- **South America**: Argentina, Brazil (Bahia, Espirito Santo) Chile, Colombia, Ecuador.
- **Oceania**: Australia (CABI/EPPO, 2012; EPPO, 2014).

5.3.2.5. Hazard Identification Conclusion

Considering the facts that *P. solenopsis* -

- is not known to be present in Bangladesh [CABI/EPPO, 2012; EPPO, 2014];
- is potentially economic important to Bangladesh because it is an important pest of various vegetables and fruits in Asia including China, India, Thailand, Japan, Sri Lanka, Taiwan, [CABI/EPPO, 2012; EPPO, 2014] from where not only most of the vegetables and fruits but also planting matetials like seeds, nursery stocks of many vegetables are imported to Bangladesh.
- can become established in Bangladesh through imports of the vegetables and fruits. It has capability to cause direct economic and ecological damage to many valuable cultivated crops. The extraction of sap by the mealybug results in the leaves of the plant turning yellow and becoming crinkled or malformed, which leads to loss of plant vigour, foliage and fruit-drop, and potential death of the plant, if not treated. Phloem feeding affects the growing regions of the plant often resulting in bunched and stunted growth (Dhawan *et al.,* 2009b; Jagadish *et al.,* 2009a), with plants producing smaller fruit or flowers, which ultimately leads to a reduction in seed or fruit yields. Commercial trade involving infested plants may often be the cause for spread of the invasive species over vast distances. Movement of equipment from an infested area to a non-infested area may also be involved in the accidental spread of the mealybugs.
- *P. solenopsis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-2.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years?-Yes, • This pest has been established in many countries. P. solenopsis was discovered in 1898 by Tinsley (1898a) in New Mexico, USA. This mealybug was later reported to have spread to Arizona, California, Colorado, Mississippi, Washington D.C., and Texas, USA (McKenzie, 1967). Fuchs *et al.* (1991) discovered from their survey that the species had spread throughout the several cotton- [Gossypium spp.] growing areas of Texas by 1988 and also recorded the mealybug from 29 additional plant hosts. It was discovered to be infesting ornamentals in Nigeria (Akintola and Ande, 2009). Hodgson et al. (2008) inferred that the infestation in Nigeria may have originated from South America. This pest has been established in many asain countries including India, China, Japan, Thailand, Taiwan and many others country from where many vegetables are imported. **b. Posibility of survival during transport, storage and transfer? Yes** • The cucurbit seeds and fruits are transported from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile to Bangladesh mainly by Airfreight, and or Landport (particularly from India). Therefore, the period of time taken for shipment through these transportation pathways from the exporting countries to Bangladesh is very short. The period of development of *P. solenopsis* from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature (Jagadish et al., 2009a). Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with high risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Internationally, *P. solenopsis* is liable to be carried on any plants and plant parts like fruits, which are the main means of dispersal of this pest [EPPO, 2016]. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The solenopsis mealybug has been recorded on 202 host plant species that include field crops, ornamentals, trees and vegetables. Arif et al. (2009) identified the mealybug from 154 plant species, the majority of which belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. The main host of Phenacoccus solenopsis includes Carrot (Daucus carotla) Mango (Mangifera indica), Sun flower (Helianthus annuus), **Water melon (Citrullus lanatus), Pumpkin (Cucurbita moschata), Bottle gourd (Lagenaria siceraria), Bitter gourd (Momordica charantia),** Cotton (Gossypium hirsutum), Sesame (Sesamum indicum), Betel pepper (Piper betle), Maize (Zea mays), Chilli (Capsicum frutescens), Tobbaco	**YES and HIGH**

Description	Establishment Potential
(Nicotiana tabacum), Tomato (Solanum lycopersicum), Brinjal (Solanum melongena), Potato (Solanum tuberosum), etc. Celery, lettuce, marigold, gypsophila (baby's breath), ornamental gourd, common bean, pea, onion, garlic etc, which are mostly common in **Bangladesh**. • Females of this ovoviviparous, bisexual species have been reported as capable of producing from 150 to 600 eggs, protected within a waxy ovisac (Lu *et al.,* 2008). Upon hatching, females undergo three immature stages prior to reaching adulthood, whereas males undergo first, second, prepupa and pupa stages prior to adulthood. The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This species is capable of producing multiple generations annually. The mealybugs feed on the plant by extracting sap from cells in the leaves or stems. The sap contains soluble sugars, phenols, proteins and other potential nutrients. • These climatic requirements for growth and development of *P. solenopsis* are more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.3.2.7. Determine the Consequence establishment of this pest in Bangladesh-

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

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • The solenopsis mealybug has been recorded on 202 host plant species that include field crops, ornamentals, trees and vegetables. In Pakistan, *P. solenopsis* obtained the status of a serious pest on a wide host range. In a field survey, *Arif et al. (2009)* identified the mealybug from 154 plant species, the majority of which belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and **Cucurbitaceae**. • The main host of *Phenacoccus solenopsis includes Carrot (Daucus carotla) Mango (Mangifera indica), Sun flower (Helianthus annuus),* ***Water melon (Citrullus lanatus), Pumpkin (Cucurbita moschata), Bottle gourd (Lagenaria siceraria), Bitter gourd (Momordica charantia),*** *Cotton (Gossypium hirsutum), Sesame (Sesamum indicum), Betel pepper (Piper betle), Maize (Zea mays), Chilli (Capsicum frutescens), Tobbaco (Nicotiana tabacum), Tomato (Solanum lycopersicum), Brinjal (Solanum melongena), Potato (Solanum tuberosum), etc. Celery, lettuce, marigold, gypsophila (baby's breath), ornamental gourd, common bean, pea, onion, garlic etc.* • *Phenacoccus solenopsis* is of quarantine significance for Bangladesh.	**Yes and High**

Description	Consequence potential
Its introduction and rapid spread to many countries, and the problems presented by its presence in many vegetables and fruits and ornamental crops, illustrate clearly the serious nature of this pest and the potential threat to the vegetables as well as other crops in Bangladesh still free from the pest. • This is a fairly serious pest of several important vegetables, fruits and other crops for Bangladesh. **b. Economic impact and yield loss** • The solenopsis mealybug is an important plant pest worldwide (Williams and Granara de Willink, 1992; Hodgson et al., 2008). Mealybug feeding may cause the leaves to turn yellow and results in defoliation, reduced plant growth or plant death. The presence of the solenopsis mealybug has the potential to inflict significant damage to field crops (i.e. cotton [*Gossypium* spp.] and tobacco [*Nicotiana* spp.]) in all growing regions. This mealybug caused serious damage to cotton in Pakistan in 2005 (Saeed et al., 2007; Dhawan et al., 2009a,b) and India (Jhala et al., 2008; Bhosle et al., 2009). Also, it is a pest of commercial crops including a variety of vegetables, grapes [*Vitis vinifera*], jute [*Corchorus* spp.], mesta [*Hibiscus cannabinus*] and tobacco. • The significant damage to cotton caused by *P. solenopsis* can have significant impact on the economy of Pakistan. Economic crop losses of an estimated 14% occurred in Pakistan in 2005 and in Punjab, India in 2005-2006 and 2006-2007 (Anon., 2005; Hodgson et al., 2008; Dhawan et al., 2009a). In the 2005 growing season, this invasive pest was responsible for a 44% reduction in seed-cotton yields in Pakistan (Dhawan et al., 2009b). The intense attack by the mealybug on Bt cotton resulted in significant economic losses to growers in the Punjab region (Dutt, 2007). In 2007, the number of hectares committed to growing cotton increased over the previous year, but cotton production had a significant decline over the previous year (Dutt, 2007). Previous field crop losses in cotton have ranged from 30-80% in some regions of India (Nalwar et al., 2009). However, the grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. **c. Environmental Impact** • As a result of *P. solenopsis* dispersal, reproductive and survival capacity, this invasive pest has the potential to damage or kill native plant species that could result in their displacement by other more aggressive species. Wang et al. (2009) projected that *P. solenopsis* could infest regions within 17 provinces of China and posed a pest risk analysis value of 0.856 to the area. Dhawan et al. (2009a) inferred that meteorological parameters influenced the presence and population size of the mealybug, with humidity and rainfall producing a negative effect.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-2.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.2.9. Risk Management Measures

- Avoid importation of vegetables, fruits and other from countries, where this pest is available.
- Several countries have incorporated measures to inspect plant material from locations where the mealybug pest is known to occur. China has initiated a notice of inspection and quarantine for P. solenopsis (Ministry of Agriculture, 2009)
- The placing of sticky traps in the fields and around the borders is useful in early detection of the mealybugs into the area. Observations of the plant stems, leaves and flowers aid in detecting the white, waxy masses produced by P. solenopsis.
- A phytosanitary certificate may be required for importation of vegetables, fruits and other ornamental plants.

5.3.2.10 References

Anon, 2005. Weekly pest scouting reports. Lahore, Pakistan: Directorate General, Pest Warning and Quality Control of Pesticides.

Arif MI, Muhammad Rafiq, Abdul Ghaffar, 2009. Host plants of cotton mealybug (Phenacoccus solenopsis): a new menace to cotton agroecosystem of Punjab, Pakistan. International Journal of Agriculture and Biology, 11(2):163-167. http://www.fspublishers.org/

Bhosle BB, Sharma OP, More DG, 2009. Management of mealybugs (*Phenacoccus solenopsis*) in rainfed cotton (*Gossypium hirsutum*). Indian Journal of Agricultural Sciences, 79(3):199-202.

CABI/EPPO, 2012. Phenacoccus solenopsis. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 761.

CABI/EPPO, 2012. *Phenacoccus solenopsis*. [Distribution map]. Distribution Maps of Plant Pests, No.June. Wallingford, UK: CABI, Map 761.

Dhawan AK, Kamaldeep Singh, Ravinder Singh, 2009a. Evaluation of different chemicals for the management of mealy bug, *Phenacoccus solenopsis* Tinsley on Bt cotton. Journal of Cotton Research and Development, 23(2):289-294.

Dhawan AK, Sarika Saini, Kamaldeep Singh, 2008. Evaluation of novel and conventional insecticides for management of mealy bug, Phenacoccus solenopsis Tinsley in Punjab. Pesticide Research Journal, 20(2):214-216. http://www.spsindia.co.in

Dhawan AK, Singh K, Anand A, Sarika S, 2009b. Distribution of mealybug, *Phenacoccus solenopsis* Tinsley in cotton with relation to weather factors in South-Western districts of Punjab. Journal of Entomological Research, 33(1):59-63.

Dutt U, 2007. Mealy Bug Infestation in Punjab: Bt. Cotton Falls Flat. Countercurrents.org. Kerala, India: Countercurrents.org. http://www.countercurrents.org/dutt210807.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Ghulam Abbas, Arif MJ, Shafqat Saeed, Haider Karar, 2009. A new invasive species of genus Phenacoccus cockerell attacking cotton in Pakistan. International Journal of Agriculture and Biology, 11(1):54-58. http://www.fspublishers.org/

Goeden RD, 1971. Insect ecology of silverleaf nightshade. Weed Science, 19:45-51.

Hodgson CJ, Abbas G, Arif MJ, Saeed S, Karar H, 2008. Phenacoccus solenopsis Tinsley (Sternorrhyncha: Coccoidea: Pseudococcidae), an invasive mealybug damaging cotton in Pakistan and India, with a discussion on seasonal morphological variation. Zootaxa, 1913:1-35.

Hodgson CJ, Abbas G, Arif MJ, Saeed S, Karar H, 2008. *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Coccoidea: Pseudococcidae), an invasive mealybug damaging cotton in Pakistan and India, with a discussion on seasonal morphological variation. Zootaxa, 1913:1-35.

Jagadish KS, Shankaramurthy M, Kalleshwaraswamy CM, Viraktamath CA, Shadakshari YG, 2009. Ecology of the mealy bug, *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae) infesting sunflower and its parasitization by *Aenasius* sp. (Hymenoptera: Encyrtidae). Insect Environment, 15(1):27-28.

Jagadish KS, Shankaramurthy Y, Jagannatha D, Karuna K, Geetha K, Puttarangaswamy K, 2008. Role of ant (Hymenoptera: Formicidae) fauna in sunflower (Helianthus annuus L.). In: Memorial National Symposium on Plant Protection, UAS, Bangalore, December 4-6 [ed. by Coleman, L.]. unpaginated.

Jhala RC, Bharpoda TM, Patel MG, 2008. *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), the mealy bug species recorded first time on cotton and its alternate host plants in Gujarat, India. Uttar Pradesh Journal of Zoology, 28(3):403-406.

Lu Y, Zeng L, Wang L, Xu Y, Chen K, 2008. Guard against a dangerous invasion of China Phenacoccus. Precaution of solenopsis mealybug Phenacoccus solenopsis Tinsley. Journal of Environmental Insects, 4:1.

Muniappan R, 2009. A parasitoid to tackle the menace of the mealybug pest of cotton in India. IAPPS Newsletter, December(XII). http://www.plantprotection.org/news/NewsDec09.htm

Nagrare VS, Kranthi S, Biradar VK, Zade NN, Sangode V, Kakde G, Shukla RM, Shivare D, Khadi BM, Kranthi KR, 2009. Widespread infestation of the exotic mealybug species, Phenacoccus solenopsis (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. Bulletin of Entomological Research, 99(5):537-541. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=6191524&fulltextType=RA&fileId=S0007485308006573

Nalwar YS, Sayyed MA, Mokle SS, Zanwar PR, Vibhute YB, 2009. Synthesis and insect antifeedant activity of some new chalcones against *Phenacoccus solenopsis*. World Journal of Chemistry, 4(2):123-126.

Pinto JD, Frommer SI, 1980. A survey of the arthropods on jojoba (Simmondsia chinensis). Environmental Entomology, 9(1):137-143.

Prishanthini M, Vinobaba ML, 2009. Phenacoccus solenopsis. Daily News, Sri Lanka's National Newspaper, July., Sri Lanka: The Associated Newspapers of Ceylon Ltd. http://www.dailynews.lk/2009/07/01/fea30.asp

Saeed S, Ahmad M, Ahmad M, Kwon YJ, 2007. Insecticidal control of the mealy bug, *Phenacoccus gossypiphilous* (Hemiptera: Pseudococcidae), a new pest of cotton in Pakistan. Entomological Research, 37:76-80.

Sharma SS, 2007. Aenasius sp. nov. effective parasitoid of mealy bug (Phenacoccus solenopsis) on okra. Haryana Journal of Horticultural Sciences, 36(3/4):412.

Suresh S, Kavitha P, 2008. Seasonal incidence of economically important coccid pests in Tamil Nadu. In: Proceedings of the XI International Symposium on Scale Insect Studies, Oeiras, Portugal, 24-27 September 2007 [ed. by Branco, M. \Franco, J. C. \Hodgson, C. J.]. Lisbon, Portugal: ISA Press, 285-291.

Tanwar RK, Jeyakumar P, Monga D, 2007. Mealybugs and their management. National Centre for Integrated Pest Management, New Delhi, Technical Bulletin, 19:1-16.

Wang YP, Wu SA, Zhang RZ, 2009. Pest risk analysis of a new invasive pest, *Phenacoccus solenopsis*, to China. Chinese Bulletin of Entomology, 46(1):101-106.

Williams DJ, Granara de Willink MC, 1992. Mealybugs of Central and South America. Wallingford, UK: CAB International.

Pest-3:	**Alfalfa thrips, *Frankliniella occidentalis* (Pergande)**

5.3.3.1. Hazard Identification

Scientific name: *Frankliniella occidentalis* (Pergande)

Synonyms: *Frankliniella californica* (Moulton)
Frankliniella helianthi (Moulton)
Frankliniella moultoni Hood
Frankliniella trehernei Morgan

Common names: Western flower thrips,
Alfalfa thrips (English)

Taxonomic tree

- Phylum: Arthropoda
  - Subphylum: Mandibulata
    - Class: Insecta
      - Order: Thysanoptera
        - Family: Thripidae
          - Genus: *Frankliniella*
            - Species: *Frankliniella occidentalis*

EPPO Code: FRANOC. This pest has been included in EPPO A2 list: No. 177

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI/EPPO, 1999]

5.3.3.2. Biology

F. occidentalis reproduces throughout the year producing as many as 12-15 generations per year. The total life-cycle from egg to egg at 15, 20, 25 and 30°C is 44.1, 22.4, 18.2 and 15 days, respectively. Each female lays between 20 and 40 eggs. Pre-oviposition time is 10.4 days at 15°C and 2-4 days at both 20 and 30°C; highest reproductive rate (95.5 hatched eggs/female) is at 20°C. The eggs are inserted in the parenchyma cells of leaves, flower parts and fruits, and hatch in about 4 days at 27°C. This period is lengthened to 13 days at 15°C. The eggs are susceptible to desiccation, and high mortality at this stage is not uncommon. Adult thrips have been observed entering closed chrysanthemum buds, presumably to lay eggs, a behavior pattern which makes control very difficult (Bryan & Smith, 1956; Lublinkhof & Foster, 1977).

5.3.3.3. Hosts

a. Major hosts: The main host of *F. occidentalis includes orchid, safflower, Chrysanthemum morifolium, roses, Gerbera, gypsophila, Zinnia, Begunia, Poinsettia, balsam. amaranth, carrot, lettuce, cabbage, wild radish, wild mustard, sugarbeet,* ***melon, cucumber,*** *pea, peach, apple, apricot, tomato, aubergine, potato, grapevine etc.*

b. Minor hosts: The minor or other hosts of this pest include pumpkin, *Chrysanthemum indicum,* pistachio etc.

5.3.3.4. Distribution

F. occidentalis is distributed in many Asian countries including **India** (CABI/EPPO, 1999; EPPO, 2014; Kaomud & Tyagi Vikas Kumar, 2015), **Thailand**, Sri Lanka (CABI/EPPO, 1999; EPPO, 2014), **Japan** (Nakahara, 1997; CABI/EPPO, 1999; EPPO, 2014), **China** (EPPO, 2014; Reitz et al., 2011; Zhang et al., 2003), Iran (EPPO, 2014).

F. occidentalis is naturally abundant in many wild flowers throughout western North America from southern California (and presumably Mexico) into Canada. In the late 1970s and 1980s, it spread across the **USA** and Canada. It reached the Netherlands in 1983 and then spread outwards across Europe (Kirk and Terry, 2003). This sudden explosion remains unexplained but is possibly the result of some undetected genetic change in a population on a crop under intensive cultivation and insecticide treatment (Immaraju et al., 1992). Having become well established in Europe and Israel, it spread to the highlands of eastern Africa and subsequently entered New Zealand in 1992 and Australia in 1993. In Australia it has spread around Sydney, Adelaide and Brisbane, but in Western Australia summer temperatures that routinely exceed 40°C may be limiting its spread to the vicinity of Perth. It is present in southern Brazil (Monteiro et al., 1995), and also in the Cameron Highlands of Peninsular Malaysia (Fauziah and Saharan, 1991), and it is becoming more common in tropical lowland countries. In Costa Rica and Colombia, although abundant in screen houses where chrysanthemums are grown, it remains rare outside on native plants or crops, whereas in Guatemala it has been reported as a pest of field-grown crops. In Florida, USA, it can be abundant in crop fields but becomes progressively less abundant away from crop areas, presumably because of competition from native thrips and predation (Reitz et al., 2006; Paini et al., 2007, 2008; Northfield et al., 2008).

5.3.3.5. Hazard identification conclusion

Considering the facts that *Frankliniella occidentalis* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 1999];
- is potentially economic important to Bangladesh because it is an important pest of cucurbits in Asia including **China, India, Thailand**, **Japan** [EPPO, 2014; CABI/EPPO, 1999] from where cucurbits and flowers are imported to Bangladesh.
- can become established in Bangladesh through imports of the cucurbits. It has capability to cause direct economic and ecological damage to many valuable cultivated crops, because the eggs are laid in leaves, flower structures or fruit (Childers and Achor, 1995). The major method of long distance dispersal for this pest is via transportation of infested cucurbits and nursery stock [EPPO, 2016].

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

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

Table-3.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years?-Yes, • This pest has been established in many Asian countries. The introduction of this pest in India was first reported in 2015; Japan in 1990, the Republic of Korea in 1993; Sri Lanka in 1996, Israel in 2003). • *Frankliniella occidentalis* is highly polyphagous, breeding on many horticultural crops that are transported around the world. The international movement of plant material has fostered the rapid spread of the species throughout the world and many populations are now highly resistant to various insecticides. It is considered likely that the development of resistance in the late 1970s is the factor that triggered the worldwide spread and establishment of this species (Kirk and Terry, 2003). **b. Posibility of survival during transport, storage and transfer of this pest? - Yes** • The total life-cycle of Alfalfa thrips, *F. occidentalis* from egg to adult at 15, 20, 25 and 30°C is 44.1, 22.4, 18.2 and 15 days, respectively. The eggs are inserted in the parenchyma cells of leaves, flower parts and fruits, and hatch in about 4 days at 27°C. This period is lengthened to 13 days at 15°C (Bryan & Smith, 1956; Lublinkhof & Foster, 1977). Therefore, the period of time taken for shipment through transportation pathways from the exporting countries to Bangladesh is sufficient enough for survival. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with high risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Internationally, *F. occidentalis* is liable to be carried on any plants for planting or on cucurbits, and nursery stocks, which are the main means of dispersal of this pest [EPPO, 2016]. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *F. occidentalis* is a remarkably polyphagous species with 244 plant species from 62 families being recorded as hosts. The host range of *F. occidentalis* is flowers of roses, carnations, *Gladiolus*, chrysanthemums, *Gerbera*, sweet peas, plums, peas, tomatoes, *Capsicum*, Cucurbitaceae and strawberries, *Beta*, carrots, cotton, grapefruits, grapes, onions, *Phaseolus*, safflower (EPPO, 2016), which are mostly common in Bangladesh.	**YES and HIGH**

• As long as environmental conditions are favourable, *F. occidentalis* reproduce continuously, with up to 15 generations in a year being recorded under glass (Bryan and Smith, 1956; Lublinkhof and Foster, 1977). Development and reproductive rates are temperature dependent. The total life cycle from egg to egg has been recorded as 44.1, 22.4, 18.2 and 15 days at 15, 20, 25 and 30°C. Each female lays typically between 20 and 40 eggs during its life. At 15°C, pre-oviposition time is longer (10.4 days) than at higher temperatures of 20 or 30°C (2-4 days). However, because of faster development times, greater population growth rates are seen at temperatures of 30^{o}C (Gaum et al., 1994).	
• 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

5.3.3.7. Determine the <u>Consequence</u> establishment of this pest in Bangladesh

Table-3. 2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. **Is this a serious pest of Bangladesh? - Yes.** • *F. occidentalis* is a remarkably polyphagous species with 244 plant species from 62 families being recorded as hosts. In the USA, the host range of *F. occidentalis* is flowers of roses, carnations, *Gladiolus*, sweet peas, apricots, peaches and nectarines, plums, peas, tomatoes, *Capsicum*, **Cucurbitaceae** and strawberries. *Beta*, carrots, cotton, grapefruits, grapes, onions, *Phaseolus*, *Purshia tridentata*, safflower. In Europe, this pest is most commonly on chrysanthemums, *Gerbera*, roses and *Saintpaulia* [EPPO, 2016]. • *F. occidentalis* is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in flowers and other crops, illustrate clearly the serious nature of this pest and the potential threat to the cucurbits as well as other crops in Bangladesh still free from the pest. • This is a fairly serious pest of several important cucurbits, flowers and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *F. occidentalis* attacks the flowers and foliage of a great number of crops. As well as feeding on plant fluids with their sucking mouthparts, *F. occidentalis* also eats the pollen and nectar of many plants, and the spreading of pollen during this feeding result in pollination and premature senescence - which can be a serious problem with certain ornamental crops such as *Saintpaulia*. • *F. occidentalis* is a very important pest of ornamental flower crops as it takes only a few individuals to scarthe marketable portion of the crop, the flower and reduces the aesthetic quality of the crop. • *F. occidentalis* also attacks vegetables under glass and the decline in	**Yes and High**

cucumber production in British Columbia (Canada) is attributed mainly to the spread of this pest. For example, in 1985, *F. occidentalis* was estimated to have caused a 20% yield loss in the glasshouse cucumber crop. • In California (USA), *F. occidentalis* also causes damage outdoors, on lucerne (by larval feeding on flowers and young pods) and on fruit trees (by scarring and silvering the surface of the fruit, especially in *Prunus*). Nursery stock of fruit trees and roses is also damaged, the terminal buds being killed or weakened. A range of other crops in North America is damaged by this pest to a greater or lesser extent. • *F. occidentalis* may affect most fruiting vegetables with the exception of tomatoes. Problems are most severe on cucumbers where the blossoms can be reduced or so extensively damaged that no fruit is produced. The cucumber fruits often show severe distortion. • *F. occidentalis* has been associated with outbreaks of tomato spotted wilt virus (TSWV) on tomatoes in Ontario (Canada). The symptoms of this disease include stunting, distortion and mosaic mottling of leaves, and clearing of leaf veins and fruit. TSWV causes severe loss (50-90%) of lettuces in Hawaii (USA), particularly in the major vegetable-growing area of Kula. Twenty-five weed species found in Kula serve as reservoirs for *F. occidentalis*, 17 of which may harbour TSWV. In lettuce fields there is a high correlation between thrips populations and TSWV incidence. In Louisiana (USA) the incidence of TSWV in tomato, pepper and tobacco crops has increased dramatically since about 1978. The infection can reach 60% in commercial fields and 100% in gardens. It is thought that the expanded geographical range of *F. occidentalis* into Louisiana is responsible for the increase of TSWV. However, it has also been suggested that the role of *F. occidentalis* as the vector of the virus in California has been over-emphasized, and that *Thrips tabaci* is probably more important. **c. Environmental Impact** • *F. occidentalis* represents a potential threat to many crops. The establishment of it could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment. • Chemical control is important and widely practised, but is often constrained by the secretive habits of *F. occidentalis*, and because populations have been found to develop resistance quickly. For example, MacDonald (1995) demonstrated 30-fold differences in susceptibility to Malathion among populations of *F. occidentalis* in the remarkably small area of the southern half of England. A disturbing practice is mixing insecticides into 'cocktails' to obtain short-term control enhancement when one insecticide loses efficacy, because of the added risk of longer term resistance that this brings. The nature of quick resistance development of this pest against insecticides also triggers further changing of new chemical insecticides that also enhance harmful impact on the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-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

5.3.3.9. Risk Management Measures

- Avoid importation of cucurbits from countries, where this pest is available.
- Treatments against *F. occidentalis* on plants in transit are unlikely to be entirely successful because of the ability of the pest to secrete itself in small crevices and tightly closed plant parts, because the eggs are protected by the epidermis of the host, and because of the subterranean habit of certain stages (Zhang *et al.,* 2004).
- In addition, resistance of this pest has developed to certain pesticides. Accordingly, the only safe measure is to ensure that the place of production is free from the pest by appropriate inspection (OEPP/EPPO, 1990).

5.3.3.10. References

Agrawal AA, Karban R, Colfer RG, 2000. How leaf domatia and induced plant resistance affect herbivores, natural enemies and plant performance. Oikos, 89(1):70-80.

Bryan DE, Smith RF, 1956. The *Frankliniella occidentalis* complex in California. University of California, Publications in Entomology, 10:359-410.

CABI/EPPO , 1999. *Frankliniella occidentalis*. [Distribution map]. Distribution Maps of Plant Pests, December (1st revision). Wallingford, UK: CAB International, Map 538.

CABI/EPPO, 1998. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

Childers CC, Achor DS, 1995. Thrips feeding and oviposition injuries to economic plants, subsequent damage and host responses to infestation. In: Thrips biology and management: proceedings of the 1993 International Conference on Thysanoptera [ed. by Parker, B. L.\Skinner, M.\Lewis, T.]. London, USA: Plenum Publishing Co. Ltd, 31-51.

EPPO, 2016. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Gaum WG, Giliomee JH, Pringle KL, 1994. Life history and life tables of western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), on English cucumbers. Bulletin of Entomological Research, 84(2):219-224.

Hansen EA, Funderburk JE, Reitz SR, Ramachandran S, Eger JE, McAuslane H, 2003. Within-plant distribution of Frankliniella species (Thysanoptera: Thripidae) and Orius insidiosus (Heteroptera: Anthocoridae) in field pepper. Environmental Entomology, 32(5):1035-1044.

Immaraju JA, Paine TD, Bethke JA, Robb KL, Newman JP, 1992. Western flower thrips (Thysanoptera: Thripidae) resistance to insecticides in coastal California greenhouses. Journal of Economic Entomology, 85(1):9-14.

Kaomud Tyagi , Vikas Kumar, 2015. First report of western flower thrips, *Frankliniella occidentalis* (Pergande)(Thripidae: Thysanoptera) from India - a potential havoc to Indian Agriculture. HALTERES, 6:1-3.

Kirk WDJ, Terry LI, 2003. The spread of the western flower thrips *Frankliniella occidentalis* (Pergande). Agricultural and Forest Entomology, 5:301-310.

Lewis T, 1997. Thrips as Crop Pests. Wallingford, UK: CAB International, 740 pp.

Lublinkhof J, Foster DE, 1977. Development and reproductive capacity of *Frankliniella occidentalis* (Thysanoptera: Thripidae) reared at three temperatures. Journal of the Kansas Entomological Society, 50(3):313-316

Monteiro RC, Zucchi RA, Mound LA, 1995. *Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera, Thripidae) em Chrysanthemum sp. In: Anais do 15 Congresso de Entomologia. Sociedade Entomologica do Brasil, Caxambuco, MG. Caxambuco, Brazil: Sociedade Entomologica do Brasil.

Nakahara S, 1997. Annotated list of the Frankliniella species of the world (Thysanoptera: Thripidae). Contributions on Entomology, International, 2:353-389.

Northfield TD, Paini DR, Funderburk JE, Reitz SR, 2008. Annual cycles of Frankliniella spp. (Thysanoptera: Thripidae) thrips abundance on North Florida uncultivated reproductive hosts: predicting possible sources of pest outbreaks. Annals of the Entomological Society of America, 101(4):769-778. http://esa.publisher.ingentaconnect.com/content/esa/aesa/2008/00000101/00000004/art00008

OEPP/EPPO, 1990. Specific quarantine requirements. EPPO Technical Documents, No. 1008. Paris, France: EPPO.

Paini DR, Funderburk JE, Jackson CT, Reitz SR, 2007. Reproduction of four thrips species (Thysanoptera: Thripidae) on uncultivated hosts. Journal of Entomological Science, 42(4):610-615.

Reitz SR, 2008. Comparative bionomics of *Frankliniella occidentalis* and *Frankliniella tritici*. Florida Entomologist, 91(3):474-476. http://www.fcla.edu/FlaEnt/

Reitz SR, 2009. Biology and ecology of the western flower thrips (Thysanoptera: Thripidae): the making of a pest. Florida Entomologist [Western Flower Thrips Symposium Papers, Florida, USA, 15 July 2008.], 92(1):7-13. http://www.fcla.edu/FlaEnt/

Reitz SR, Funderburk JE, Waring SM, 2006. Differential predation by the generalist predator Orius insidiosus on congeneric species of thrips that vary in size and behavior. Entomologia Experimentalis et Applicata, 119(3):179-188. http://www.blackwell-synergy.com/doi/full/10.1111/j.1570-7458.2006.00408.x

Reitz SR, Gao YL, Lei ZR, 2011. Thrips: Pests of concern to China and the United States. Agricultural Sciences in China, 10:867-892.

Zhang Rong, Ma JianHua, Yang Fang, Xian ChengZhong, Zhang SheHui, 2004. Field trials of some insecticides for controlling *Frankliniella occidentalis*. Pratacultural Science, 21(1):20-21.

Zhang YJ, Wu QJ, Xu BY, Zhu GR, 2003. The occurrence and damage of *Frankliniella occidentalis* (Thysanoptera: Thripidae): a dangerous alien invasive pest in Beijing. Plant Protection, 4:58-59.

Pest-4:	**Lesser pumpkin fruit fly: *Dacus ciliatus*** (Loew)

5.3.4.1. Hazard Identification

Scientific Name: *Dacus ciliatus (Loew)*

Synonyms: *Dacus appoxanthus* var. decolor Bezzi
Dacus brevistylus Bezzi
Dacus cocciniae Premlata & Singh
Dacus insistens Curran
Dacus sigmoides Coquillett
Didacus ciliatus (Loew)
Leptoxyda ciliata (Loew)
Tridacus mallyi Munro [nomen nudum]

Common names: Lesser fruit fly;
Cucurbit fly;
Ethiopian fruit fly;
Lesser melon fly

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Tephritidae
Genus: Dacus
Species: *Dacus ciliates*

EPPO Code: DACUCI. This pest has been included in EPPO A1 list: No. 238

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2002; EPPO, 2014].

5.3.4.2. Biology

Eggs are laid below the skin of the host fruit in groups of three to nine. These hatch within 1-2 days and during the summer the larvae feed for another 5-6 days. Pupariation is in the soil under the host plant and adults emerge after 2-4 weeks. Adults occur throughout the year but are most numerous in summer (Annecke & Moran, 1982; Hancock, 1989). *D. ciliatus* adults reach their sexual maturity at 14-15 days although there are data from Egypt stating that the adults reach their reproductive maturity after 5-6 days during the summer and after 20-30 days during the winter (El Nahal *et al.,* 1971). As in most of the fruit flies belonging to the Dacinae, mating in *D. ciliatus* occurs at dusk under low light intensities (Fletcher, 1987; Smith, 1989). At light intensities lower than 50 lux, mating pairs start to copulate (Dehecq, 1995). They usually stay coupled during the entire night and are separated by the morning light (Dehecq, 1995). Although not yet confirmed, it seems that females mate only once in their life span (El Nahal et al., 1971).

5.3.4.3. Hosts

D. ciliatus is an oliphagous fly found in a wide range of **Cucurbitaceae**. Concerning the host range, *D. ciliatus* seems to be less wiling to exploit new hosts in comparison with *Bactrocera cucurbitae* (Vayssières *et al.,* 2002). In South-East Asia, six plant species in five plant genera of the Cucurbitaceae are classified as hosts of *D. ciliatus* (Drew, 2004). For a list of Asian hosts see Tsuruta *et al.* (1997) and Drew *et al*. (1998). Studies in India indicate that *D. ciliatus* is a field pest of round gourds (tinda) and squash melons (*Citrullus lanatus* var. *fistulossus*) and that it may also compete with *B. cucurbitae* (Kapoor, 2002).

a. **Major hosts:** *D. ciliatus* is mainly cucurbitaceous insect. The main crop species attacked by *D. ciliatus* are ***Citrullus lanatus***, ***Cucumis aculeatus***, ***Cucumis melo***, ***Cucumis metuliferus***, ***Cucumis sativus***, ***Cucurbita maxima***, ***Lagenaria siceraria***, ***Momordica charantia***, ***Momordica rostrata*** etc.).

b. **Minor hosts:** The minor or other hosts include cucurbits such as *Cucurbita pepo*, *Momordica balsamina, Luffa acutangula, Luffa aegyptiaca, Solanum lycopersicum* etc.

5.3.4.4. Distribution

EPPO region: Egypt.
Asia: India (Delhi, Gujarat, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh), Iran, Sri Lanka, Thailand, Myanmar, Pakistan, Saudi Arabia, Yemen (CABI/EPPO, 2002; EPPO, 2014).

Africa: Angola, Benin, Botswana, Cameroon, Chad, Egypt, Eritrea, Ethiopia, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia,, Nigeria, Réunion, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, St. Helena (possibly interception only), Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe.

EU: Absent.

5.3.4.5. Hazard Identification Conclusion

Considering the facts that *D. ciliatus:* -

- is not known to be present in Bangladesh [CABI/EPPO, 2002; EPPO, 2014];
- is potentially economic important to Bangladesh because it is an important pest of cucurbits in Asia and other countries including **India, Thailand, Pakistan** from where cucurbits are imported to Bangladesh.
- can become established in Bangladesh through imports of the vegetables and planting materials like seeds, seedlings etc. It has capability to cause direct economic and ecological damage to many valuable cultivated crops, because this pest has high reproductive potential, high dispersal ability for long distance and high survivability at adverse environment, the risk rating for establishment potential is high**.**
- *D. ciliatus* poses a phytosanitary risk to other countries with a suitable tropical climate and suitable cucurbit crops.
- *D. ciliatus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.4.6. Determine <u>likelihood of pest establishing</u> in Bangladesh via this pathway.

Table-4.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years?-Yes**, • This pest has been established in many Asian countries including India (Delhi, Gujarat, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh), Iran, Sri Lanka, Thailand, Myanmar, Pakistan, Saudi Arabia, Yemen (CABI/EPPO, 2002; EPPO, 2014). • It is an EPPO A1 quarantine pest within the category 'non-European Trypetidae' and is also of quarantine significance to CPPC (Caribbean Plant Protection Commission). *D. ciliatus* is a serious pest of cucurbit crops (Hancock, 1989). It is reported to cause serious economic damage in Egypt (El Nahal *et al.,* 1971) and South Africa (Hancock, 1989). In the Reunion Island, D. ciliatus, together with Dacus cucurbitae (and out of nine species of Tephritidae), represents the primary pests of Cucurbitaceae, having been reported in nine genera of this plant family (Dehecq, 1995; Vayssières *et al.,* 2008). **b. Posibility of survival during transport, storage and transfer of this pest? - Yes** • The adult females of *D. ciliatus* lay eggs below the skin of the host fruit in groups of three to nine. These hatch within 1-2 days and during the summer the larvae feed for another 5-6 days (Annecke & Moran, 1982; Hancock, 1989). This period is lengthened to 10 days in winter (Fetoh, 2006). Therefore, the period of time taken for shipment through transportation pathways from the 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. Therefore, this pest is rated with **high** risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Adult flight and the transport of infected fruit are the major means of movement and dispersal to previously uninfected areas. The flight capability of *D. ciliatus* has not been measured, but it is probably similar to that of many Bactrocera spp. which 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** • *D. ciliatus* is an oliphagous fly found in a wide range of Cucurbitaceae. Concerning the host range, *D. ciliatus* seems to be less wiling to exploit new hosts in comparison with *Bactrocera cucurbitae* (Vayssières et al., 2002*). D. ciliatus* is mainly cucurbitaceous insect. The main crop species attacked by *D. ciliatus* are ***Citrullus lanatus, Cucumis aculeatus, Cucumis melo, Cucumis metuliferus, Cucumis sativus, Cucurbita maxima, Lagenaria siceraria, Momordica charantia, Momordica rostrata*** etc among these hosts many of them mostly common in **Bangladesh**.	**YES and HIGH**

Description	Establishment Potential
• Adult female oviposits on an average of 210 eggs (El Nahal *et al.*, 1971). Fetoh (2006) recorded a mean egg production of 322.6. The eggs are laid in groups of 5-15 (El Nahal *et al.,* 1971). After the eggs hatch, the young larvae start to feed in the host, causing damage to the fruit. The final instar larvae of Bactrocera drop to the ground, find a crack to drop into, and then form a puparium within which pupation takes place. • *D. ciliatus* adults reach their sexual maturity at 14-15 days although there are data from Egypt stating that the adults reach their reproductive maturity after 5-6 days during the summer and after 20-30 days during the winter (El Nahal *et al.,* 1971). As in most of the fruit flies belonging to the Dacinae, mating in D. ciliatus occurs at dusk under low light intensities (Fletcher, 1987; Smith, 1989). At light intensities lower than 50 lux, mating pairs start to copulate (Dehecq, 1995). They usually stay coupled during the entire night and are separated by the morning light (Dehecq, 1995). Although not yet confirmed, it seems that females mate only once in their life span (El Nahal *et al.,* 1971). • These climatic requirements for growth and development of *D. ciliatus* are more or less similar with the climatic condition of **Bangladesh**.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.3.4.7. Determine the <u>Consequence</u> establishment of this pest in Bangladesh.

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

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *D. ciliatus* is an extremely serious pest of cucurbit crops (Hancock, 1989). Attacked fruit usually shows signs of oviposition punctures around which necrosis may occur. In heavy infestations the fruit may collapse leaving just the skin (El Nahal *et al.,* 1971). Females oviposit an average of 210 eggs (El Nahal *et al.,* 1971). Fetoh (2006) recorded a mean egg production of 322.6. The eggs are laid in groups of 5-15 (El Nahal *et al.,* 1971). After the eggs hatch, the young larvae start to feed in the host, causing damage to the fruit. The final instar larvae of Bactrocera drop to the ground, find a crack to drop into, and then form a puparium within which pupation takes place. • *D. ciliatus* poses a phytosanitary risk to other countries with a suitable tropical climate and suitable cucurbit crops. • This is a fairly serious pest of several important vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *D. ciliatus* is one of several cucurbit fruit flies that, if uncontrolled, causes	**Yes and High**

Description	Consequence potential
considerable loss of yield, although its impact is not as serious as the melon fly, *Bactrocera curcurbitae*, in areas where both species occur. • *D. ciliatus* is a serious pest of cucurbit crops (Hancock, 1989). It is reported to cause serious economic damage in Egypt (El Nahal et al., 1971) and South Africa (Hancock, 1989). In the Reunion Island, *D. ciliatus,* together with *Dacus cucurbitae* (and out of nine species of Tephritidae), represents the primary pests of Cucurbitaceae, having been reported in nine genera of this plant family (Dehecq, 1995; Vayssières et al., 2008). • It is an EPPO A1 quarantine pest within the category 'non-European Trypetidae' and is also of quarantine significance to CPPC (Caribbean Plant Protection Commission). However, the risk of establishment in most of the EPPO area is minimal, although in some areas, populations might enter and multiply during the summer months and, in southern areas may survive several winters (EPPO, 2009). The direct losses from these introductions are not believed to be high. However, its presence may cause indirect economic impact by **restricting exports**. • The major risk for EPPO countries arises from the probable imposition of much stricter phytosanitary restrictions on exported fruits (particularly to America) if *Bactrocera* spp. or tropical *Dacus* spp., such as *D. ciliatus,* enter and multiply, even temporarily. **c. Environmental Impact and Health Hazards** • Maklakov et al. (2001) reported that organophosphates were proved to be ineffective for the control of *D. ciliatus*, but pyrethroids have high potential for controlling it, showing satisfactory killing ability, massive knockdown effect, and prevention of oviposition. For example, Nestel (2008) found that pesticides such as Telstar (pyrethroid), Mospilan (neonicotinoid) and Avisect were effective against *D. ciliatus*. Organic insecticides such as Karlic[@] and Hot-Pepper[@] did not show any effectiveness in killing or deterring the fly (D Nestel, Agriculture Research Center, Israel, personal communication, 2008). • On the other hand, 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

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

Establishment Potential X Consequence Potential = Risk

Table-4.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.4.9. Risk Management Measures

- Consignments of fruits from countries where these pests occur 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 such fruits should come from an area where D. ciliatus does not occur and where routine intensive control measures are applied.
- Fruits may also be treated in transit by cold treatment (e.g. 13 or 14 days at 0.0 or 0.6°C,, respectively) or, for certain types of fruits, by vapour heat (e.g. keeping at 43-44°C for 6-9 h, according to commodity) (FAO, 1983) or hot water treatment. 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 (FAO, 1983; Armstrong & Couey, 1989). Treatment methods against fruit flies are currently under review within EPPO and as part of a common programme of the regional plant protection organizations.
- Plants of host species transported with roots from countries where these pests occur should be free from soil, or the soil should be treated against puparia. The plants should not carry fruits. Importation of such plants may indeed be prohibited.

5.3.4.10. References

Abbas, S. R., Srivastava, A. S., Sharma, S., and Haseeb, M. 2000. Note on oriental fruitfly of mango, a problem for mature mangoes in India. Biological Memoirs 26: 74-78.

Annecke, D.P.; Moran, V.C. (1982). Insects and mites of cultivated plants in South Africa. Butterworths, Durban, South Africa.

Armstrong, J.W.; Couey, H.M. (1989). Fruit disinfestation: fumigation, heat and cold. In: World crop pests 3(B).Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 411-424. Elsevier, Amsterdam, Netherlands.

CABI/EPPO, 2002. *Dacus ciliatus*. Distribution Maps of Plant Pests, No. 323. Wallingford, UK: CAB International.

Dehecq JS, 1995. Etude de la comunication pheromonale chez trois thephritidae de la Reunion: Dacus ciliatus Loew, Dacus demmerezi (Bezzi) et Trirhithromya cyanescens (Bezzi). France: Ecole Nationale Superieure Agronomique de Montpellier.

Dehecq JS, 1995. Etude de la comunication pheromonale chez trois thephritidae de la Reunion: Dacus ciliatus Loew, Dacus demmerezi (Bezzi) et Trirhithromya cyanescens (Bezzi). France: Ecole Nationale Superieure Agronomique de Montpellier.

Drew RAI, 2004. Biogeography and Speciation in the Dacini (Diptera: Tephritidae: Dacinae). Bishop Museum Bulletin in Entomology, 12:165-178.

El Nahal AKM, Azab AK, Swailem SM, 1971. Studies on the biology of the melon fruit fly, Dacus ciliatus Loew (Diptera:Trypanaeidae). Bulletin de la Societe Entomologique d'Egypte, 54:231-241.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

FAO (1983) International plant quarantine treatment manual. FAO Plant Production and Protection Paper No. 50. FAO, Rome, Italy.

Fetoh BEA, 2006. Occurrence, distribution and biology of the pumpkin fruit fly, *Dacus ciliatus* Loew (Diptera: Tephritidae) as re-appearing pest in Egypt. Egyptian Journal of Agricultural Research, 84(1):11-16.

Fletcher BS, 1987. The biology of dacine fruit flies. Annual Review of Entomology, 32:115-144

Fletcher, B.S. (1989) Ecology; movements of tephritid fruit flies. In: World crop pests 3(B). Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 209-219. Elsevier, Amsterdam, Netherlands.

Hancock, D.L. (1989) Pest status; southern Africa. In: World crop pests 3(A). Fruit flies; their biology,, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 51-58. Elsevier, Amsterdam, Netherlands.

Hancock, D.L. (1989) Pest status; southern Africa. In: World crop pests 3(A). Fruit flies; their biology,, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 51-58. Elsevier, Amsterdam, Netherlands.

Maklakov A, Ishaaya I, Freidberg A, Yawetz A, Horowitz AR, Yarom I, 2001. Toxicological studies of organophosphate and pyrethroid insecticides for controlling the fruit fly *Dacus ciliatus* (Diptera: Tephritidae). Journal of Economic Entomology, 94(5):1059-1066.

OEPP/EPPO (1990) Specific quarantine requirements. EPPO Technical Documents No. 1008.

Smith PH, 1989. Behavioural partitioning of the day and circadian rhytmicity. In: Fruit Flies: Their biology, natural enemies and control, World Crop Pests, 3A [ed. by Robinson AS, Hooper G,] Amsterdam, The Netherlands: Elsevier Science Publishers B.V., 325-341.

Tsuruta K, White IM, Bandara HMJ, Rajapakse H, Sundaraperuma SAH, Kahawatta SBMUC, Rajapakse GBJP, 1997. A preliminary notes on the hosts of fruit flies of the tribe dacini (diptera, tephritidae) in Sri Lanka. Esakia, 37:149-160.

Vayssières JF, Carel Y, Coubes M, 2002. Demographic parameters and biotic factors of two Dacini species, Bactrocera cucurbitae and Dacus ciliatus, on Réunion Island. In: Proceedings of the 6th International Symposium on fruit flies of economic importance, Stellenbosch, South Africa, 6-10 May 2002 [ed. by Barnes BN], 91-95.

Pest-5:	Malaysian fruit fly, *Bactrocera latifrons* (Hendel)

5.3.5.1. Hazard Identification

Scientific name: *Bactrocera latifrons* (Hendel)

Synonyms:

*Chaetodacus antennalis (*Shiraki, 1933)
*Chaetodacus latifrons (*Hendel)
Dacus latifrons (Hendel)
*Dacus parvulus (*Hendel, 1912)

Common names: Malaysian fruit fly

Taxonomic tree

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

EPPO Code: DACULA.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2015]

5.3.5.2. Biology

Eggs (9-587 eggs) are laid below the skin of the host fruit. These hatch within a few days (mean 2.3) and the larvae feed for about a week (mean 8.5 days). Pupariation is in the soil under the host plant for little over a week (mean 10.2 days). Adults occur throughout the year and females begin oviposition after 6-17 days, and continue laying eggs for 6-117 days (Vargas and Nishida, 1985). Adult flight and the transport of infected fruit are the major means of movement and dispersal of *Bactrocera spp*. to previously uninfected areas. Many *Bactrocera* spp. can fly 50-100 km (Fletcher, 1989).

5.3.5.3. Hosts

B. latifrons is a pest of fruit and vegetable species, mainly belonging to Solanaceae and to a lesser extent to Cucurbitaceae, such as: *Capsicum annuum, C. chinense, C. frutescens, Physalis peruviana, Solanum aethiopicum, S. lycopersicum, S. melongena, S. torvum - Cucumis sativus, C. melo, Cucurbita maxima, Citrullus lanatus, Lagenaria siceraria, Momordica charantia*. A recent review has also identified more than 50 plant species (in 14 plant families) on which field infestations by *B. latifrons* have been recorded (e.g. *Citrus aurantifolia* (Rutaceae), *Dimocarpus longan* (Sapindaceae), *Passiflora foetida* (Passifloraceae), *Psidium guajava* (Myrtaceae), *Punica granatum* (Lytraceae)).

5.3.5.4. Distribution

B. latifrons has a predominantly south and south-east Asian distribution. Waterhouse (1993) records this species from Indonesia, although no area is specified. Given that this species has been found in Sabah and **West Malaysia** it may at least be expected in Kalimantan and Sumatra. In Africa, B. latifrons has only been recorded from Tanzania and Kenya. Its occurance in other parts of Africa is currently unknown (Meyer et al., 2007). This species was recently introduced to Hawaii and was first discovered there in 1983 (Liquido et al., 1994). B. latifrons originates from Asia but its range has expanded through introductions into Africa (Kenya and Tanzania, first found in 2007 and 2006 respectively) and the islands of Hawaii (US, first found in Honolulu in 1983) and Yonaguni (Okinawa prefecture, Ryukyu Archipelago, **Japan,** first found in 1984).

EPPO region: Absent.

Africa: Kenya, Tanzania.

Asia: Brunei Darussalam, **China** (Fujian, Guangdong, Guangxi, Hainan, Xianggang (Hong Kong), Yunnan), **India** (Karnataka, Kerala, Himachal Pradesh, Tamil Nadu, West Bengal), Indonesia (Kalimantan, Sulawesi), **Japan** (Ryukyu), Laos, Malaysia (Sabah, West), Myanmar, **Pakistan**, Singapore, Sri Lanka, Taiwan, **Thailand**, Vietnam.

North America: USA (Hawaii only). Isolated outbreaks have been reported occasionally from California, but have been eradicated.

5.3.5.5. Hazard identification conclusion

Considering the facts that *B. latifrons* -

- is not known to be present in Bangladesh [CABI/EPPO, 2015];
- is potentially economic important to Bangladesh because it is an important pest of Solanaceae and Cucurbitaceae in Asia including China, India, Thailand, **Japan** [CABI/EPPO, 2015] from where brinjal seeds are imported to Bangladesh.
- can become established in Bangladesh through imports of the brinjal seeds. Some of the major host plants of B. latifrons, such as tomato, aubergine, sweet pepper, cucumber, melons and other cucurbits are widely grown in the Asia region, in both field and protected conditions. Economic damage has been reported from countries where *B. latifrons* occurs. According to the EPPO study on pest risks associated with the import of brinjal seeds, the climatic similarity between the area where *B. latifrons* occurs and Bangladesh region is same. As experience has shown that control and eradication of fruit flies is complex and costly, the introduction of *B. latifrons* in Bangladesh should be avoided.
- *B. latifrons* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years? -Yes, • This pest has been established in many Asian countries. The introduction of this pest in **India** was first reported in 2014; Japan in 2014, China in 2014; Thailand in 2014, Sri-lanka in 2014. **b. Posibility of survival during transport, storage and transfer of this pest? - Yes** • The adult females of *Bactrocera latifrons* lay 9-586 eggs below the skin of the host fruit. These hatch within a few days (mean 2.3) and the larvae feed for about a week (mean 8.5 days) (Vargas and Nishida, 1985). Therefore, the period of time taken for shipment	**YES and HIGH**

<table>
<tr><th>Description</th><th>Establishment Potential</th></tr>
<tr><td>through transportation pathways from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile to Bangladesh mainly by Airfreight, and or Landport (particularly from India) sufficient enough for survival of this pest. Over long distances, movement and trade of fruit and vegetables can transport this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. Therefore, this pest is rated with high risk potential.

c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,

• 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. Larvae have been found in peppers sent by mail from Hawaii to California (Foote et al., 1993).

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

• B. latifrons is a remarkably polyphagous species with 50 plant species from 14 families being recorded as hosts. The host range of B. latifrons is the fruits Capsicum annuum, C. chinense, C. frutescens, Physalis peruviana, Solanum aethiopicum, S. lycopersicum, S. melongena, S. torvum - Cucumis sativus, C. melo, Cucurbita maxima, Citrullus lanatus, Lagenaria siceraria, Momordica charantia (EPPO, 2016), which are mostly common in Bangladesh.

• Adult flight is the main means of natural spread. No data is specifically given for flying distances of B. latifrons, but several Bactrocera spp. have been reported to fly 50-100 km. Over long distances, movement and trade of fruit and vegetables can transport the pest. In the EPPO region, B. latifrons has been intercepted several times in imported fruits and vegetables from Asia, thus showing that the pest has pathways to enter the region.</td><td></td></tr>
<tr><td>• Not as above or below</td><td>Moderate</td></tr>
<tr><td>• This pest has not established in new countries in recent years, and
• The pathway does not appears good for this pest to enter Bangladesh and establish, and
• Its host(s) are not common in Bangladesh and climate is not similar to places it is established</td><td>Low</td></tr>
</table>

5.3.5.7. Determine the <u>Consequence</u> establishment of this pest in Bangladesh

Table-5.2: 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.

B. latifrons is a remarkably polyphagous species with 50 plant species from 14 families being recorded as hosts. The host range of *B. latifrons* is the fruits *Capsicum annuum, C. chinense, C. frutescens, Physalis peruviana, Solanum aethiopicum, S. lycopersicum, S. melongena, S. torvum - Cucumis sativus, C. melo, Cucurbita maxima, Citrullus lanatus, Lagenaria siceraria, Momordica charantia* (EPPO, 2016), which are mostly common in Bangladesh.

- *B. latifrons* is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in field crops, illustrate clearly the serious nature of this pest and the potential threat to the field crops as well as other horticultural crops in Bangladesh still free from the pest.
- This is a fairly serious pest of several important field crops for Bangladesh.

b. Economic Impact and Yield Loss

- *B. latifrons* is Asian in origin. It was only very recently detected in Africa. The first specimens were trapped early in 2006 in Morogoro, Tanzania (Mwatawala et al., 2010). Surveys have shown that this species is widely distributed in Tanzania although not present in large numbers because of its limited host range (Mwatawala *et al.,* 2010). In 2007, it was also found in Kenya near the border with Tanzania (Ekesi, unpublished records). So far, the species has not been reported from any other African countries. *B. latrifons* was found in the Hawaiian Islands around 1983 (Vargas and Nishida, 1985) and causes a great economic lost of fruits and planting materials.
- Adult fruit fly (*Bactrocera spp*.) 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 brinjal can be killed by hot water treatment of mature fruit (Wadhi and Sharma, 1972), cold treatments (Burikam et al. 1992), vapor heat treatment (Heard et al. 1992, Heather et al. 1992), and gamma irradiation (Heather et al. 1991). The expense required to control fruit flies and the loss of export potential due to the presence of fruit flies would have a High Economic Impact.

c. Environmental impact

•The appearance of the Malaysian fruitefly within new areas is in most cases, the result of movement of infested plant material. The movement and establishment of fruitefly populations through this route bring along the possibility of insecticide resistance genes. This invariably leads to an increase in the use of insecticides as fruitfly control becomes increasingly more difficult. This in turn can produce an ever increasing spiral in the levels of insecticide resistance and insecticide use, having a direct impact on the environment.

- Adult fruit fly (*Bactrocera spp*.) can be controlled with methyl eugenol

</td><td>

Yes
and
High

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

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 mango would have a High 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

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

Establishment Potential X Consequence Potential = Risk

Table-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

5.3.5.9. Risk Management Measures

- Avoid importation of fruits and vegetables from countries, where this pest is available.
- Many countries, such as the mainland USA, forbid the import of susceptible fruit without strict post-harvest treatment having been applied by the exporter. This may involve fumigation, heat treatment (hot vapour or hot water), cold treatments, insecticidal dipping, or irradiation (Armstrong and Couey, 1989). However, recent research has indicated that B. latifrons is more heat tolerant than other species (Jang *et al*., 1999). Irradiation is not accepted in most countries and many have now banned methyl bromide fumigation. Heat treatment tends to reduce the shelf life of most fruits and so the most effective method of regulatory control is to preferentially restrict imports of a given fruit to areas free of fruit fly attack.
- One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper, a paper bag, or in the case of long/thin fruits, a polythene sleeve. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked. Little information is available on the attack time for most fruits but few Bactrocera spp. attack prior to ripening.
- Although cover sprays of entire crops are sometimes used, the use of bait sprays is both more economical and more environmentally acceptable. A bait spray consists of a suitable insecticide (e.g. malathion) mixed with a 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. In Malaysia this has been developed into a very effective commercial product derived from brewery waste.

- This species is not attracted to either cue lure or methyl eugenol. Field monitoring is by sampling susceptible fruits for larvae. In Hawaii a new lure chemical is being developed (White and Liquido, 1995).

5.3.5.10. References

Armstrong J.W. and Couey H.M., 1989. Control; fruit disinfestation; fumigation, heat and cold. In: Robinson AS, Hooper G, eds. Fruit Flies; their Biology, Natural Enemies and Control. World Crop Pests. Amsterdam, Netherlands: Elsevier, 3(B):411-424.

Baker R.T. and Cowley J.M., 1991. A New Zealand view of quarantine security with special reference to fruit flies, In: Vijaysegaran S, Ibrahim AG, eds. First International Symposium on Fruit Flies in the Tropics, Kuala Lumpur, 1988. Kuala Lumpur, Malaysia: Malaysian Agricultural Research and Development Institute, 396-408.

CABI Invasive Species Compendium. Bactrocera latifrons (Solanum fruit fly) http://www.cabi.org/isc/datasheet/8719

EPPO (2015). EPPO Study on Pest Risks Associated with the Import of Tomato Fruit. EPPO Technical Document No. 1068. Available at http://www.eppo.int

Fletcher B.S., 1989. Ecology; life history strategies of tephritid fruit flies, In: Robinson AS, Hooper G, eds. Fruit Flies; their Biology, Natural Enemies and Control. World Crop Pests. Amsterdam, Holland: Elsevier, 3(B):195-208.

Foote R.H., Blanc F.L. and Norrbom A.L., 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Ithaca, USA: Comstock.

Jang E.B., Nagata J.T., Chan H.T.Jr. and Laidlaw W.G., 1999. Thermal death kinetics in eggs and larvae of Bactrocera latifrons (Diptera: Tephritidae) and comparative thermotolerance to three other tephritid fruit fly species in Hawaii. Journal of Economic Entomology, 92(3):684-690; 37 ref.

Liquido N.J., Harris E.J. and Dekker L.A., 1994. Ecology of Bactrocera latifrons (Diptera: Tephritidae) populations: host plants, natural enemies, distribution, and abundance. Annals of the Entomological Society of America, 87(1):71-84.

Meyer M. De., Mohamed S. and White I.M., 2007. Invasive fruit fly pests in Africa. Tervuren, Belgium: Royal Museum for Central Africa. http://www.africamuseum.be/fruitfly/AfroAsia.htm

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.

Vargas R.I. and Nishida T., 1985. Life history and demographic parameters of Dacus latifrons (Diptera: Tephritidae). *Journal of Economic Entomology*, 78(6):1242-1244.

Waterhouse D.F., 1993. The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia. ACIAR Monograph No. 21. Canberra, Australia: Australian Centre for International Agricultural Research, 141 pp.

White I.M. and Liquido N.J.,1995. Case 2967; Chaetodacus latifrons Hendel, 1915 (currently Bactrocera latifrons; Insecta, Diptera): proposed precedence of the specific name over that of Dacus parvulus Hendel, 1912. Bulletin of Zoological Nomenclature, 52:250-252.

Pest- 6:	Mediterranean fruit fly, *Ceratitis capitata (Wiedemann)*

5.3.6.1. Hazard Identification

Scientific name: *Ceratitis capitata (Wiedemann)*

Synonyms: *Ceratitis citriperda* MacLeay
Ceratitis hispanica De Brême
Pardalaspis asparagi Bezzi
Tephritis capitata Wiedemann

Common names: Mediterranean fruit fly,
Medfly (English)

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Tephritidae
Genus: Ceratitis
Species: *Ceratitis capitata*

EPPO Code: CERTCA. This pest has been included in EPPO A2 list: No. 105

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI/EPPO, 2015]

5.3.6.2. Biology

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 and adults emerge after 6-11 days (24-26°C; longer in cool conditions) and adults live for up to 2 months (field-caged) (Christenson & Foote, 1960). *C. capitata* will not in practice survive sub-zero winter temperatures; it is well named Mediterranean, for the area in which it survives in the EPPO region is precisely that (virtually coinciding with where Citrus is grown). Worner (1988) uses the climate-matching system to evaluate the areas of potential establishment of *C. capitata* in New Zealand.

5.3.6.3. Hosts

C. capitata is a highly polyphagous species whose larvae develop in a very wide range of unrelated fruits. On Hawaii (USA), 60 out of 196 fruit species examined over the years 1949-85 were at least once found as hosts of *C. capitata*; the two most important hosts were coffee (*Coffea arabica*) and *Solanum pseudocapsicum* (Liquido et al., 1989). In the EPPO region, important hosts include **Cucumis (melons, cucuimbers, gerkins),** apples (*Malus pumila*), avocados (*Persea americana*), Citrus, figs (*Ficus carica*), kiwifruits (*Actinidia deliciosa*), mangoes (*Mangifera indica*), medlars (*Mespilus germanica*), pears (*Pyrus communis*), *Prunus* spp. (especially peaches, *P. persica*), in fact practically all the tree fruit crops. It has also been recorded from wild hosts belonging to a large number of families.

5.3.6.**4. Distribution**

C. capitata originates in tropical Africa, from where it has spread to the Mediterranean area and to parts of Central and South America.

EPPO region: Southern part of the EPPO region, i.e. Albania, Algeria, Croatia (Kovacevic, 1965), Cyprus, Egypt, **France** (very limited distribution in south only; Cayol & Causse, 1993), Greece (including Crete), Hungary (found but not established), Israel, Italy, Lebanon, Libya, Malta, Morocco, Portugal (including Azores and Madeira), Russia (southern, found but not established), Slovenia, Spain (including Balearic and Canary Islands), Switzerland (limited distribution), Syria, Tunisia, Turkey, Ukraine (outbreaks in the south eradicated). Records in northern or central Europe (Austria, Belgium, Bulgaria, Czech Republic, **Germany**, Hungary, Luxemburg, **Netherland**, Sweden, UK) refer to interceptions or short-lived adventive populations only (Karpati, 1983; Fischer-Colbrie & Busch-Petersen, 1989).

Asia: Afghanistan (unconfirmed), Cyprus, **India** (single interception, Kapoor, 1989), Israel, Jordan, Lebanon, Saudi Arabia, Syria, Turkey, Yemen.

Africa: Algeria, Angola, Benin, Burkina Faso, Burundi, Botswana, Cameroon, Cape Verde Islands, Congo, Côte d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Libya, Madagascar (also the related species C. malgassa), Malawi, Mali, Mauritius, Morocco, Mozambique, Niger, Nigeria, Réunion, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, St. Helena, Sudan, Tanzania, Togo, Tunisia, Uganda, Zaire, Zimbabwe. Karpati (1983) lists some other African countries but does not give the source of his data.

North America: Bermuda (eradicated). **USA** (only Hawaii); introduced and eradicated several times in California during 1980s and 1990s; introduced, eradicated and still absent in Florida and Texas (Cunningham, 1989b; Lorraine & Chambers, 1989). Eradicated from Mexico.

Central America and Caribbean: Belize (eradicated), Costa Rica, El Salvador, Guatemala, Honduras, Jamaica, Netherlands Antilles, Nicaragua, Panama. The related species C. malgassa, from Madagascar, was at one time established in Puerto Rico (Steyskal, 1982).

South America: Argentina (locally), Bolivia, **Brazil** (Espirito Santo, Goias, Minas Gerais, Paraná, Rio Grande do Sul, São Paulo), **Chile** (extreme north only, declared eradicated in 1996), Colombia, Ecuador, Paraguay, Peru, Suriname, Uruguay, Venezuela.

Oceania: Australia (found but not established in New South Wales, limited distribution in Western Australia), Northern Mariana Islands.

EU: Present.

5.3.6.5. Hazard identification conclusion

Considering the facts that *B. cabitata* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 2015]
- *C. capitata* is a highly polyphagous species whose larvae develop in a very wide range of unrelated fruits. On Hawaii (USA), 60 out of 196 fruit species examined over the years 1949-85 were at least once found as hosts of *C. capitata*; the two most important hosts were coffee (*Coffea arabica*) and *Solanum pseudocapsicum* (Liquido *et al*., 1989). In the EPPO region, important hosts include Cucumis (melons, cucuimbers, gerkins), apples (*Malus pumila*), avocados (*Persea americana*), Citrus, figs (*Ficus carica*), kiwifruits (*Actinidia deliciosa*), mangoes (*Mangifera indica*),

medlars (*Mespilus germanica*), pears (*Pyrus communis*), *Prunus* spp. (especially peaches, *P. persica*), in fact practically all the tree fruit crops.

- *C. capitata* is an EPPO A2 quarantine pest (OEPP/EPPO, 1981), and is also of quarantine significance throughout the world (CPPC, NAPPO, APPPC) and especially for Japan and the USA. In the EPPO region, *C. capitata* has reached the limits of its natural distribution and does not appear likely to establish in any major new areas (but possibly around the Black Sea). However, its presence even as temporary adventives populations could lead to severe additional constraints for export of fruits to uninfested areas in other continents.
- *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). Frequent incursions into North America require expensive eradication treatments and many countries maintain extensive monitoring networks.
- *C. capitata* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-6.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years?-yes, • This pest has been established in many Asain, American, Oceania and Europian countries including **India** (single interception), USA, **Australia**, Russia, Saudi Arabia, Turkey, Canada, Italy, Germany, Brazil, Chile [CABI/EPPO, 1999; EPPO, 2014]. **b. Posibility of survival during transport, storage and transfer?-Yes** • 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). Therefore, this pest can survive during transport, storage and transfer of infested fruits from exporting countries into Bangladesh. **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 major means of movement and dispersal to previously uninfested areas. There is evidence that *C. capitata* can fly at least 20 km (Fletcher, 1989). 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, which was recently called into question when fruits still on the tree were found to be infested (Liquido *et al.,* 1995). But this insect is not present in South Asian countries.	**Yes and High**

c. **Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?- Yes** • *C. capitata* is a highly polyphagous species whose larvae develop in a very wide range of unrelated fruits. In the EPPO region, important hosts include Cucumis (melons, cucumbers, gerkins), apples (*Malus pumila*), avocados (*Persea americana*), Citrus, figs (*Ficus carica*), kiwifruits (*Actinidia deliciosa*), mangoes (*Mangifera indica*), medlars (*Mespilus germanica*), pears (*Pyrus communis*), *Prunus* spp. (especially peaches, *P. persica*), in fact practically all the tree fruit crops. Among these host plants, the cucumbers, citrus, mangoes are common in Bangladesh. • Eggs of *C. capitata* 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 and adults emerge after 6-11 days (24-26°C; longer in cool conditions) and adults live for up to 2 months (field-caged) (Christenson & Foote, 1960). • Therefore, the climatic requirements of this insect pest are more or less similar to Bangladesh to establish it.	
• 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 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

5.3.6.7. Determine the <u>Consequence establishment</u> of this pest in Bangladesh-

Table-6. 2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • *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). Frequent incursions into North America require expensive eradication treatments and many countries maintain extensive monitoring networks. • This is a fairly serious pest of several important fruits, vegetables and other crops 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 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). • It has a high economic impact, affecting production, control costs and	**Yes and High**

market access. • The quarantine importance of this pest restricts the international trades of the cucurbit fruits. **c. Environmental Impact and Health Hazards** • 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 your country.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-6.3: Calculating risk

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

5.3.6.9. Risk Management Measures

- 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/m3 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).

5.3.6.10. 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. Journal of Economic Entomology 88, 678-682.

CABI/EPPO, 2015. *Ceratitis capitata*. [Distribution map]. Distribution Maps of Plant Pests, No.December. Wallingford, UK: CABI, Map 1 (5th revision).

Cayol, J.P.; Causse, R. (1993) Mediterranean fruit fly Ceratitis capitata back in Southern France. Journal of Applied Entomology 116, 94-100.

Cayol, J.P.; Causse, R.; Louis, C.; Barthes, J. (1994) Medfly Ceratitis capitata as a rot vector in laboratory conditions. Journal of Applied Entomology 117, 338-343.

Christenson, L.D.; Foote, R.H. (1960) Biology of fruit flies. Annual Review of Entomology 5, 171-192.

Cunningham, R.T. (1989b) Population detection and assessment; population detection. In: World crop pests 3(B). Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 169-173. Elsevier, Amsterdam, Netherlands.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Fischer-Colbrie, P.; Busch-Petersen, E. (1989) Pest status; temperate Europe and west Asia. In: World crop pests 3(A). Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 91-99. Elsevier, Amsterdam, Netherlands.

Jang, E.B. (1990) Fruit fly disinfestation of tropical fruits using semipermeable shrinkwrap film. Acta Horticulturae No. 269, 453-458.

Kapoor, V.C. (1989) Pest status; Indian sub-continent. In: World crop pests 3(A). Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 59-62. Elsevier, Amsterdam, Netherlands.

Karpati, J.F. (1983) The Mediterranean fruit fly (its importance, detection and control). FAO, Rome, Italy.

Kovacevic, Z. (1965) [Remarks on the population movements of the Mediterranean fruit fly on the Yugoslavian Adriatic coast]. Anzeiger für Schädlingskunde 38, 151-153.

Liquido, N.J.; Cunningham, R.T.; Nakagawa, S. (1989) Host plants of Mediterranean fruit fly on the island of Hawaii (1949-1985 survey). Journal of Economic Entomology 83, 1863-1878.

Lorraine, H.; Chambers, D.L. (1989) Control; eradication of exotic species: recent experiences in California. In: World crop pests 3(B). Fruit flies; their biology, natural enemies and control (Ed. by Robinson, A.S.; Hooper, G.), pp. 399-410. Elsevier, Amsterdam, Netherlands.

Malacrida AR, Gomulski LM, Bonizzoni M, Bertin S, Gasperi G, Guglielmino CR, 2007. Globalization and fruitfly invasion and expansion: the medfly paradigm. Genetica, 131(1):1-9. http://springerlink.metapress.com/link.asp?id=100267

OEPP/EPPO (1990) Specific quarantine requirements. EPPO Technical Documents No. 1008.

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

Sharp, J.L.; Picho-Martinez, H. (1989) Hot-water quarantine treatment to control fruit flies in mangoes imported into the United States from Peru. Journal of Economic Entomology 83, 1940-1943.

Steyskal, G.C. (1982) A second species of Ceratitis (Diptera: Tephritidae) adventive in the New World. Proceedings of the Entomological Society of Washington 84, 165-166.

USDA (1994) Treatment manual. USDA/APHIS, Frederick, USA

Worner, S.P. (1988) Ecoclimatic assessment of potential establishment of exotic pests. Journal of Economic Entomology 81, 973-983.

Pest-7:	**Queensland fruit fly, *Bactrocera tryoni***

5.3.7.1. Hazard Identification

Scientific name: *Bactrocera tryoni* (Froggatt)

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

Common names: Fruchtfliege,
Queensland

Taxonomic tree

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

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

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 1999; EPPO, 2014]

5.3.7.2. Biology

Eggs are laid below the skin of the host fruit. These hatch within 1-3 days and the larvae feed for 10-31 days. Pupariation is in the soil under the host plant and adults emerge after 1-2 weeks (longer in cool conditions) and adults occur throughout the year (Christenson & Foote, 1960). *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. A projection was also made of the behaviour of *B. tryoni* in North America following hypothetical introduction into Los Angeles county, California (USA).

5.3.7.3. Hosts

B. tryoni has a very wide host range on both cultivated and wild species (in 25 families). As shown by Fitt (1986), adults of *B. tryoni* exhibit no particular preference in the species of fruits on which they will lay. The main hosts are in practice mostly tree 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. Many tree fruit crops of the EPPO region are potential hosts.

5.3.7.**4. Distribution**

EPPO region: Absent.

North America: USA (found but not established in California).

South America: Chile (twice adventive in Easter Island, but eradicated; Bateman, 1982). **Oceania:** Australia (throughout eastern half of Queensland, eastern New South Wales, and extreme east of Victoria; recently found in Tasmania, where it is now under eradication; outbreaks repeatedly occur in South Australia, but are regularly eradicated (Maelzer, 1990); established in the Perth area of Western Australia in 1989 but now believed eradicated). A few males have been trapped in Papua New Guinea but *B. tryoni* is unlikely to be established there (Drew, 1989). Adventive in New Caledonia and French Polynesia (Austral Islands and many of the Society Islands). New Zealand (intercepted only). Doubtful records in Northern Mariana Islands, Vanuatu.

EU: Absent.

5.3.7.5. Hazard identification conclusion

Considering the facts that *B. tryoni* -

- is not known to be present in Bangladesh [CABI/EPPO, 1999; EPPO, 2014]
- potentially economic important to Bangladesh because 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. Many tree fruit crops of the EPPO region are potential hosts.
- It is a serious pest of Australia from where a large amount of fruits are imported to Bangladesh.
- *B. tryoni,* the Queensland fruit fly, is the most costly horticultural pest in Australia and has invaded several countries in the surrounding region (White and Elson-Harris, 1994). It has the potential to spread to many places around the world because of its wide climatic and host range (Meats 1989b; Sutherst *et al*., 2000) and a tendency to be carried by human travellers at the larval stage inside infested fruit. *B. tryoni* is a very serious pest of a wide variety of fruits throughout its range. Damage levels can be anything up to 100% of unprotected fruit.
- The major risk is from the importation of fruit containing larvae, either as part of cargo, or through the smuggling of fruit in airline passenger baggage or mail. 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. An isolated catch of B. tryoni in a cue lure baited trap in California (Foote *et al.,* 1993) probably had an origin of this sort.

- 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.

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

Table-7.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years? - Yes, • This pest has been established in many Oceania and Europian countries including USA, Australia, New Zealand, Canada, Italy, Germany [CABI/EPPO, 1999; EPPO, 2014]. But it is not present in Asain countries. **b. Posibility of survival of this pest during transport, storage and transfer? – Yes** • The adult females of *B. tryoni* lay eggs below the skin of the host fruit. These hatch within 1-3 days and the larvae feed for 10-31 days (Christenson & Foote, 1960). This period of time taken for shipment through transportation pathways from the above mentioned exporting countries to Bangladesh is sufficient enough for survival of this pest. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. • On the other hand, the adults are best able to survive low temperatures. *Bactrocera* spp. generally having a normal torpor threshold of 7°C, dropping as low as 2°C in winter. The ability of *B. tryoni* to survive repeated frosts has been studied by Meats & Fitt (1987). Sutherst & Maywald (1991) have used the CLIMEX model to describe the potential for population growth of *B. tryoni* in Australia, together with the climatic factors which limit its geographical distribution and abundance. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • 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	**Yes and High**

Description	Establishment Potential
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: **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; 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 not 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

5.3.7.7. Determine the <u>Consequence</u> establishment of this pest in Bangladesh

Table-7. 2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • It is an important pest of many cultivated plants including most characteristically fruits: Annona, Averrhoa carambola, avocados (*Persea americana*), **Citrus**, Fortunella, **guavas** (*Psidium guajava*), Malus, **mangoes** (*Mangifera indica*), passion fruits (*Passiflora edulis*), **pawpaws** (*Carica papaya*), peaches (*Prunus persica*), plums (*Prunus domestica*) and Pyrus. However, vegetables such as **tomatoes** (*Lycopersicon esculentum*) are also infested. Therefore, it is a high risk, if fruits and plant material are imported from Australia there is possibility to established the pest in Bangladesh. • This is a fairly serious pest of several important fruits, vegetables and other crops for Bangladesh.	**Yes and High**

b. Economic Impact and Yield Loss • There are about 4,500 species of tephritid flies (Diptera: Tephritidae). Approximately one third are frugivorous and around 250 are considered economic pests, with 23 of these known to be serious pests in Australia, Oceania and tropical Asia (White and Elson-Harris, 1994; Vijaysegaran, 1997). Adults of frugivorous Tephritidae lay their eggs beneath the skin of sound ripening fruit; the larvae feed within the fruit and cause direct damage and induce decay and premature fruit drop (Allwood and Leblanc, 1997). • The percentage of produce lost has been estimated to be 10-50% in tropical Asia and Oceania and higher levels can occur in other parts of the world if control measures are not in place (Allwood and Leblanc, 1997). • *B. tryoni* has a permanent presence in the eastern Australian states as well as the Northern Territory and the north of Western Australia (Meats et al., 2008; Cameron et al., 2010). Various statutory authorities have estimated economic losses in Australia due to *B. tryoni* to be between $28.5 million and $100 million per annum (Sutherst et al., 2000). **c. Environmental Impact** • **Impact on Natural Habitats:** Impacts on natural habitats are unlikely because *B. tryoni* is a generalist and is mainly abundant in crops, villages and towns, and in natural habitats it would be only one of several fruit fly species present (Drew et al., 1984; Raghu et al., 2000). • **Impact on Biodiversity:** Impacts on biodiversity are also unlikely for the same reasons as for impacts on natural habitats. However, as far as fruit flies are concerned an unequivocal answer to the question - whether there is an impact of a pest species on other species in a district - should be assessed only by experiment or by incubating field-sampled fruit individually in order to rear out and identify surviving adult insects (Gibbs, 1967; Fitt, 1986). Conversely, frugivorous birds and rodents can destroy a large percentage of wild fruit in some places that would be otherwise available to fruit flies or have fruit fly larvae already in them (Drew, 1987). • **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

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

Establishment Potential X Consequence Potential = Risk

Table-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

5.3.7.9. Risk Management Measures

Consignments of fruits of *Annona, Averrhoa carambola, Carica papaya, Citrus, Fortunella, Malus, Mangifera indica, Passiflora edulis, Persea americana, Prunus domestica, Prunus persica, Psidium guajava and Pyrus* from countries where *B. tryoni* occurs should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. EPPO recommends 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. Fruits may also be treated in transit by cold treatment (e.g. 14, 18 or 20 days at 0.5, 1 or 1.5°C, respectively; USDA, 1994), by hot-water dip (Heard *et al.,* 1991; Jessup, 1991) or, for certain types of fruits, by vapour heat (e.g. keeping at 43°C for 4-6 h) (Heard *et al.,* 1992; USDA, 1994). 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, but treatment schedules are available (e.g. 32 g/m3 for 2 h at 21-26°C; USDA, 1994). Insecticides such as fenthion, dimethoate and omethoate can be applied as sprays during grading and packing of tomatoes and mangoes (Heather *et al.,* 1987). Irradiation is now being investigated as a treatment against B. tryoni (Jessup, 1990; Heather *et al*., 1991; Lescano *et al.,* 1994). 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. Such plants may indeed be prohibited importation.

5.3.7.10. 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.

Bateman, M.A. (1982) Chemical methods for suppression or eradication of fruit fly populations. In: Economic fruit flies of the South Pacific Region (Ed. by Drew, R.A.I.; Hooper, G.H.S.; Bateman, M.A.) (2nd edition), pp. 115-128. Queensland Department of Primary Industries, Brisbane, Australia.

CABI/EPPO, 1998. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

Cameron EC, Sved JA, Gilchrist AS, 2010. Pest fruit fly (Diptera: Tephritidae) in northwestern Australia: one species or two? Bulletin of Entomological Research, 100(2):197-206. http://journals.cambridge.org/action/displayJournal?jid=ber

Christenson, L.D.; Foote, R.H. (1960) Biology of fruit flies. Annual Review of Entomology 5, 171-

Drew RAI, 1987. Reduction in fruit fly (Tephritidae: Dacinae) populations in their endemic rainforest habitat by frugivorous vertebrates. Australian Journal of Zoology, 35(3):283-288.

Drew RAI, Zalucki MP, Hooper GHS, 1984. Ecological studies of eastern Australian fruit flies (Diptera: Tephritidae) in their endemic habitat. I. Temporal variation in abundance. Oecologia, 64(2):267-272.

Drew, R.A.I. (1989) The tropical fruit flies (Diptera: Tephritidae: Dacinae) of the Australasian and Oceanian regions. Memoirs of the Queensland Museum 26, 1-521.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Fitt GP, 1986. The influence of a shortage of hosts on the specificity of oviposition behaviour in species of Dacus (Diptera, Tephritidae). Physiological Entomology, 11(2):133-143

Fitt GP, 1986. The roles of adult and larval specialisations in limiting the occurrence of five species of Dacus (Diptera: Tephritidae) in cultivated fruits. Oecologia, 69:101-109.

Fitt, G.P. (1986) The roles of adult and larval specialisations in limiting the occurrence of five species of Dacus in cultivated fruits. Oecologia 69, 101-109.

Foote RH, Blanc FL, Norrbom AL, 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Ithaca, USA: Comstock.

Heard, T.A.; Heather, N.W.; Corcoran, R.J. (1991) Dose-mortality relationships for eggs and larvae of Bactrocera tryoni immersed in hot water. Journal of Economic Entomology 84, 1768-1770.

Heard, T.A.; Heather, N.W.; Peterson, P.M. (1992) Relative tolerance to vapor heat treatment of eggs and larvae of Bactrocera tryoni in mangoes. Journal of Economic Entomology 85, 461-463.

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.

Heather, N.W.; Hargreaves, P.A.; Corcoran, R.J.; Melksham, K.J. (1987) Dimethoate and fenthion as packing line treatments for tomatoes against Dacus tryoni. Australian Journal of Experimental Agriculture 27, 465-469.

Jessup, A.J. (1990) Gamma irradiation as a quarantine treatment for sweet cherries against Queensland fruit fly. HortScience 25, 456-458.

Jessup, A.J. (1991) High-temperature dip and low temperatures for storage and disinfestation of avocados. HortScience 26, 1420.

Lescano, H.G.; Congdon, B.C.; Heather, N.W. (1994) Comparison of two potential methods to detect Bactrocera tryoni gamma-irradiated for quarantine purposes. Journal of Economic Entomology 87, 1256-1261.

Maelzer, D.A. (1990) Fruit fly outbreaks in Adelaide, S.A., from 1948-49 to 1986-87. I. Demarcation, frequency and temporal patterns of outbreaks. Australian Journal of Zoology 38, 439-452.

Meats A, 1989. Water relations of Tephritidae. Biology, natural enemies and control, 3A. Rotterdam, Netherlands: Elsevier World Crop Pest Series, 241-246.

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.

Raghu S, Clarke AR, Drew RAI, Hulsman K, 2000. Impact of habitat modification on the distribution and abundance of fruit flies (Diptera: Tephritidae) in Southeast Queensland. Population Ecology, 42:153-160.

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.

Sutherst, R.W.; Maywald, G.F. (1991) Climate modelling and pest establishment. Climate-matching for quarantine, using CLIMEX. Plant Protection Quarterly 6, 3-7.

USDA (1994) Treatment manual. USDA/APHIS, Frederick, USA.

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.

Pest: 8	**Tomato leaf miner, *Liriomyza bryoniae* (Kaltenbach)**

5.3.8.1. Hazard identification

Scientific Name: *Liriomyza bryoniae* (Kaltenbach)

Synonyms: *Agromyza bryoniae* Kaltenbach

Liriomyza solani, Hering
Liriomyza citrulla Rohdendorf

Common names: Tomato leaf miner (English)
Tomatenminierfliege (German)

Taxonomic tree

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Insecta
Order: Diptera
Family: Agromyzidae
Genus: *Liriomyza*
Species: *Liriomyza bryoniae*

EPPO Code: LIRIBO.

Bangladesh status: Not present in Bangladesh [EPPO, 2016; CABI/EPPO, 1997]

5.3.8.2. Biology

Details about the life history of this leafminer are summarized from Spencer (1973), Nedstam (1985), Minkenberg & Lenteren (1986) and Lee et al. (1990a).

App7oximately 30% of males emerge 1 day before females and copulation takes place immediately females have emerged; non-fertilized females are not able to oviposit. Female flies puncture the cotyledons or the young leaves of the host plants with their ovipositor causing wounds which serve as sites for feeding or oviposition. Females can live for a week or more but males only up to 3 days. Eggs are mostly inserted in the upper surface of leaves but also occasionally in the lower surfaces. Each egg puncture contains a single egg and the duration of this stage varies from 4 to 8 days at a mean temperature of 20.6°C.

Females lay an average of seven eggs per day but totals of 104 eggs per female have been observed. Under glass in Europe, the leafminer breeds continuously throughout the spring, summer and autumn months.

There are three larval instars which, in total, last 7-13 days, depending on the temperature. The larva feeds rapidly and forms an irregular linear mine. If a leaf is not sufficient for full development, then the larva can move up in the stem into a second leaf; larvae are unable to penetrate leaves from the outside. Just before pupation, the mature larvae cut semi-circular exit slits in the upper surface of the leaves. After a short period the larvae drop to the ground and then burrow just below the surface of the soil before pupating. Very occasionally, larvae pupate on the upper or lower surfaces of the leaves.

The duration of the pupal stages depends on the temperature but under glass in the spring and summer months in England, it averages 3 weeks. During winter, the pupae go into diapause or retarded development until the following spring.

5.3.8.3. Hosts

L. bryoniae is a highly polyphagous species and important primary hosts of economic importance include: cabbages (*Brassica oleracea* var. *capitata*), cucumbers (*Cucumis sativus*), lettuces (*Lactuca sativa*), **courgettes (*Cucurbita pepo*), melons (*Cucumis melo*)**, tomatoes (*Lycopersicon esculentum*) and **watermelons (*Citrullus lanatus*)** (Abul-Nasr & Assem, 1961; Spencer, 1973; Lee *et al*., 1990b). In the pan-temperate region, *L. bryoniae* has been reported to complete its life cycle on plants from 16 families (Spencer, 1990).

In the EPPO region, *L. bryoniae* is common in the wild in southern Europe, although the insect is now common under glass in many other parts of the region. This pest has the potential to spread to any areas where Asteraceae, Brassicaceae, **Cucurbitaceae** or Solanaceae are grown under glass.

5.4.7.4. Distribution

L. bryoniae probably originates from southern Europe but has now spread to many parts of the EPPO region where crops are grown under glass. The insect is also present in the Far East and the USA.

EPPO region: Albania, Belgium, Bulgaria, Czech Republic, Denmark, Egypt, France, Germany, Greece (Crete), Hungary, Israel, Italy (Sicily), Moldova, Morocco, Netherlands, Romania, Russia, Spain (including Canary Islands), Sweden, UK (England, Guernsey), Ukraine.

Asia: Israel, **Japan, Taiwan**.
Africa: Egypt, Morocco.
North America: USA (Massachusetts).
EU: Present.

5.3.8.5. Hazard Identification Conclusion

Considering the facts that *Liriomyza bryoneae:*

- is not known to be present in Bangladesh [EPPO, 2016; CABI/EPPO, 1997];
- is potentially economic important to Bangladesh because it is an important pest of cucurbits in Asia including **Japan** and Taiwan as well as in many Eropean counties

including France, Germany, Italy, Netherlands [EPPO, 2016; CABI/EPPO, 1997] from where cucurbits are imported to Bangladesh.

- can become established in Bangladesh through imports of the cucurbits. It has capability to cause direct economic and ecological damage to many valuable cultivated crops.
- Adults are capable of limited flight, but, within the EPPO region, the most probable means of movement is on plants or cuttings intended for propagation [EPPO, 2016].
- *L. bryoniae* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-8.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. Has this pest been established in several new countries in recent years?-Yes, • *L. bryoniae* probably originates from southern Europe but has now spread to many parts of the EPPO region where crops are grown under glass. The insect is also present in the Far East and the USA. **b. Posibility of survival of this pest during transport, storage & transfer?-Yes** • Female flies puncture the cotyledons or the young leaves of the host plants with their ovipositor causing wounds which serve as sites for feeding or oviposition. Eggs are mostly inserted in the upper surface of leaves but also occasionally in the lower surfaces. Each egg puncture contains a single egg and the duration of this stage varies from 4 to 8 days at a mean temperature of 20.6°C. There are three larval instars which, in total, last 7-13 days, depending on the temperature. • In case of cucurbits, either seeds or fruits of cucurbits are imported from the exporting countries into Banagladesh. Therefore, the possibility of survival of this pest is less during transport of the cucurbits. But high possibility for transportation of plant stocks particularly leaves of any plants such as flowers and foliages. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,** • Adults are capable of limited flight, but, within the EPPO region, the most probable means of movement is on plants or cuttings intended for propagation. • Internationally, *L. bryoniae* is liable to be carried on any plants for planting or on cucurbits, nursery stocks and ornamental flowers, which are the main means of dispersal of this pest [EPPO, 2016]. But there is less possibility to appear on the seeds of cucurbits. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *L. bryoniae* is a highly polyphagous species and important primary hosts of economic importance include: cabbages (*Brassica oleracea* var. *capitata*), cucumbers (*Cucumis sativus*), lettuces (*Lactuca sativa*), courgettes (*Cucurbita pepo*), melons (*Cucumis melo*), tomatoes (*Lycopersicon esculentum*) and watermelons (*Citrullus lanatus*) (Abul-	HIGH

Description	Establishment Potential
Nasr & Assem, 1961; Spencer, 1973; Lee *et al.*, 1990b). In the pan-temperate region, *L. bryoniae* has been reported to complete its life cycle on plants from 16 families (Spencer, 1990). Many of these **hosts are mostly common** in Bangladesh. • The duration of larval development also varies with temperature and host plant but is generally 4-7 days at mean temperatures above 24°C (Harris & Tate, 1933). Adult emergence of *Liriomyza* species occurs 7-14 days after pupariation, at temperatures between 20 and 30°C (Leibee, 1982). At low temperatures emergence is delayed. • These climatic requirements for growth and development of *L. bryoniae* are more or less similar with the climatic condition of **Bangladesh**.	
• Not as above or below	**Yes & 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

5.3.8.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	Consequence potential
a. **Is this a serious pest of Bangladesh? - Yes.** • The principal impact of the fly is through the larvae mining into leaves and petioles; the photosynthetic ability of the plant is reduced and growth is retarded. Young host plants are particularly susceptible to attack and frequently die (Spencer, 1973). • Larvae feeding on tomato cotyledons prevent normal development of the plants and can cause them to collapse (Speyer & Parr, 1940 in Spencer, 1973). • In Egypt cucurbit plants were frequently attacked in the seedling stage; during heavy attacks, leaves appeared dwarfed and droopy and fruit production was reduced (Abul-Nasr & Assem, 1961). • *L. bryoniae* is a major problem on crucifers, cucurbits, lettuces and tomatoes grown under glass in all areas where the pest is present or in the open field in southern Europe and in Taiwan. • *L. bryoniae* has not been listed as a quarantine pest by EPPO or any other regional plant protection organization. In the western part of the EPPO region, *L. bryoniae* is a major pest of crops within the Asteraceae, Brassicaceae, Cucurbitaceae and Solanaceae grown under glass or in the warmer parts of the region in the field. • Until the introduction of *L. trifolii* and L. *huidobrensis* from North America, it was never considered a quarantine pest and no regulatory measures were taken to control it. In view of its great similarity to *L. huidobrensis*, *L. bryoniae* has been conveniently included in the regulatory package which includes the recently introduced alien species (EPPO/CABI, 1996).	**Yes and High**

Description	Consequence potential
However, this is not a good reason for EPPO to consider it as an A2 quarantine pest. • This is a fairly serious pest of several important cucurbits, flower and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • The principal impact of the fly is through the larvae mining into leaves and petioles; the photosynthetic ability of the plant is reduced and growth is retarded. Young host plants are particularly susceptible to attack and frequently die (Spencer, 1973). Larvae feeding on tomato cotyledons prevent normal development of the plants and can cause them to collapse (Speyer & Parr, 1940 in Spencer, 1973). • In Egypt cucurbit plants were frequently attacked in the seedling stage; during heavy attacks, leaves appeared dwarfed and droopy and fruit production was reduced (Abul-Nasr & Assem, 1961). *L. bryoniae* is a major problem on crucifers, cucurbits, lettuces and tomatoes grown under glass in all areas where the pest is present or in the open field in southern Europe and in Taiwan. • *L. bryoniae* is able to transmit tobacco mosaic tobamovirus (Kalutskii, 1992). **c. Environmental Impact** • Some insecticides, particularly abamectin (Weintraub and Horowitz, 1998; Weintraub 2001; Hidrayani et al, 2005), the growth regulator cyromazine (Veire, 1991; Staay, 1992; Leuprecht, 1993; Weintraub and Horowitz, 1998; Weintraub 2001) and spinosad (Weintraub and Mujica, 2006) provide effective control against larvae because these insecticides are translaminar, but leaf miner resistance can sometimes make control of adults difficult (Parrella et al., 1984; Macdonald, 1991). • The establishment of it could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 8.3 – Calculation of risk rating

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

Calculated Risk Rating - High

5.3.8.9. Risk Management Measures

- Avoid importation of cucurbits, flowers and other susceptible crops from countries, where this pest is available.
- To avoid the introduction and spread of other *Liriomyza* spp., EPPO (OEPP/EPPO, 1990) recommends that propagating material (except seeds) of host plants from countries where the pests occur must have been inspected at least every month during the previous 3 months and found free from the pests.
- A phytosanitary certificate should be required for vegetables with leaves. In practice, these measures will also control the spread of *L. bryoniae*.
- Studies on a similar agromyzid, *L. trifolii*, have shown that newly laid eggs in chryanthemums can survive cold storage at 0°C for up to 3 weeks but larvae were killed in 1-2 weeks under the same conditions (Webb & Smith, 1970). Thus plant material infested with *L. trifolii* could be maintained under normal glasshouse conditions for at least 4 days and then stored at 0°C for a minimum of 2 weeks. Specific studies have not been conducted to confirm whether this procedure is also effective against *L. bryoniae*.

5.3.8.10. References

CABI/EPPO .1997. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI 2007. Crop Protection Compendium, Edition 2006. Center for Agricuture Biosciences International, Wallingford, UK: CAB International, xviii + 768 pp.

EPPO (2016). Data Sheets on Quarantine Pests: *Liriomyza bryoniae,* In: *Quarantine pests for Europe*. 2nd edition (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB INTERNATIONAL, Wallingford, UK.

Abul-Nasr, S.; Assem, A.H. (1961) A leaf miner, *Liriomyza bryoniae* (Kalt), attacking cucurbitaceous plants in Egypt. *Bulletin of the Entomological Society of Egypt* **45**, 401-403.

EPPO/CABI (1996) *Liriomyza huidobrensis*. *Liriomyza trifolii*. In: *Quarantine pests for Europe*. 2nd edition (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB INTERNATIONAL, Wallingford, UK.

Hendrikse, A.; Zucchi, R.; Lenteren, J.C. van; Woets, J. (1980) *Dacnusa sibirica* Telenga and *Opius pallipes* Wesmael (Hym., Braconidae) in the control of the tomato leafminer *Liriomyza bryoniae* Kalt. *Bulletin SROP* **3**, 83-98.

Hussey, N.W.; Stacey, D.L.I.; Parr, W.J. (1976) Control of the leaf-miner *Liriomyza bryoniae* within an integrated programme for the pests and diseases of tomato. In: *Proceedings of the eighth British insecticide and fungicide conference*, pp. 109-116. British Crop Protection Council, Croydon, UK.

Lee, H.S.; Lu, F.M.; Wen, H.C. (1990a) Effects of temperature on the development of leafminer *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae) on head mustard. *Chinese Journal of Entomology* **10**, 143-150.

Lee, H.S.; Wen, H.C.; Lu, F.M. (1990b) The occurrence of *Liriomyza bryoniae* (Kaltenbach) (Diptera: Agromyzidae) in Taiwan. *Chinese Journal of Entomology* **10**, 133-142.

Linden, A. van der (1986) Addition of the exotic leaf miner parasites *Chrysocharis parksi* and *Opius dimidiatus* to the native Dutch parasite complex on tomato. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **51**, 1009-1016.

Menken, S.B.J.; Ulenberg, S.A. (1986) Allozymatic diagnosis of four economically important *Liriomyza* species (Diptera, Agromyzidae). *Annals of Applied Biology* **109**, 41-47.

Minkenberg, O.P.J.M.; Lenteren, J.C. van (1986) The leafminers *Liriomyza bryoniae* and *L. trifolii* (Diptera: Agromyzidae), their parasites and host plants: a review. *Agricultural University Wageningen Papers* No. 86-2, 50 pp.

Nedstam, B. (1985) Development time of *Liriomyza bryoniae* Kalt. (Diptera: Agromyzidae) and two of its natural enemies, *Dacnusa sibirica* Telenga (Hymenoptera: Braconidae) and *Cyrtogaster vulgaris* Walker (Hymenoptera: Pteromalidae) at different constant temperatures. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **50**, 422-417.

Nedstam, B. (1987) Biological control of *Liriomyza bryoniae* on tomato by *Cyrtogaster vulgaris* and *Diglyphus iseae*. *Bulletin SROP* **10**, 129-133.

OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents* No. 1008.

OEPP/EPPO (1992) Quarantine procedures No. 42. Identification of *Liriomyza* spp. *Bulletin OEPP/EPPO Bulletin* **22**, 235-238.

Spencer, K.A. (1973) *Agromyzidae (Diptera) of economic importance (Series Entomologica* No. 9), 418 pp. Junk, The Hague, Netherlands.

Spencer, K.A. (1990) *Host specialization in the world Agromyzidae (Diptera)*. Kluwer Academic Publishers, London, UK.

Veire, M. van de (1991a) Progress in IPM in glasshouse vegetables in Belgium. *Bulletin SROP* **14**, 22-32.

Veire, M. van de (1991b) Control of leafminer flies in glasshouse tomatoes and lettuce with the selective insecticide cyromazine. *Revue de l'Agriculture* **44**, 923-927.

Wardlow, L.R. (1984) Monitoring the activity of tomato leaf miner (*Liriomyza bryoniae*, Kalt.) and its parasites in commercial glasshouses in Southern England. *Mededelingen van de Faculteit Landbouwwetenschappen, Rijksuniversiteit Gent* **49**, 781-791.

Webb, R.E.; Smith, F.F. (1970) Survival of eggs of *Liriomyza munda* in chrysanthemums during cold storage. *Journal of Economic Entomology* **63**, 1359-1361.

Pest-9:	**Serpentine leaf miner, *Liriomyza trifolii* (Burgess)**

5.3.9.1. Hazard identification

Scientific Name: *Liriomyza trifolii* Burgess in Comstock, 1880

Synonyms: *Agromyza phaseolunata* Frost, 1943
Liriomyza alliivora Frick, 1955
Liriomyza alliovora Frick, 1955
Liriomyza phaseolunata (Frost, 1943)
Oscinis trifolii Burgess in Comstock, 1880

Common names: Chrysanthemum leaf miner
Serpentine leaf miner

Taxonomic tree

- Phylum: Arthropoda
  - Subphylum: Mandibulata
    - Class: Insecta
      - Order: Diptera
        - Family: Agromyzidae
          - Genus: *Liriomyza*
            - Species: *Liriomyza trifolii*

EPPO Code: LIRITR. This pest has been included in EPPO A2 list: No. 131

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI/EPPO, 1997]

5.3.9.2. Biology

Peak emergence of adults occurs before midday (McGregor, 1914). Males usually emerge before females. Mating takes place from 24 h after emergence and a single mating is sufficient to fertilize all eggs laid. Female flies puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition. Feeding punctures cause the destruction of a larger number of cells and are more clearly visible to the naked eye. About 15% of punctures made by *L. trifolii* contain viable eggs (Parrella et *al*., 1981). Eggs are inserted just below the leaf surface. The number of eggs laid varies according to temperature and host plant. *L. trifolii* females each laid 25 eggs in celery at 15°C and 400 eggs at temperatures around 30°C. One female of *L. trifolii* laid 493 eggs in peas (Poe, 1981) and another laid 639 eggs in chrysanthemums (cv. Fandango).

The life-cycle is probably continuous throughout the year. There is a noticeable first generation which reaches a peak in April (Spencer, 1973). On celery *L. trifolii* completes its life-cycle (oviposition to adult emergence) in 12 days at 35°C, 26 days at 20°C, and 54 days at 15°C (Leibee, 1982). On chrysanthemums the life-cycle is completed in 24 days at 20°C but on *Vigna sinensis* and *Phaseolus lunatus* it takes only 20 days at this temperature (Poe, 1981). Adults of *L. trifolii* live between 15 and 30 days. On average, females live longer than males.

5.3.9.3. Hosts

a. **Major hosts:** The main host of *L. trifolii* includes **cucurbits such cucumbers, melons, watermelons** (Stegmaier (1968)*,* Ageratum*,* Aster, marigold*, Callistephus,* safflower, *Chrysanthemum morifolium,* Dahlia, Gerbera (barbeton daisy), sunflower, carnation, gypsophila (baby's breath), Zinnia, salvia (sage), garlic, Begunia, groundnut, lettuce, Chinese cabbage, spinach, ornamental gourd, beans, soyabean, common bean, cow pea, okra, cotton, tomato, aubergine *etc.*

b. **Minor hosts:** The minor or other hosts of this pest include Goosefoot, ***citrullus, pumpkin,*** **bottle gourd, loofah,** *castor bean, Chrysanthemum indicum,* faba bean, onion etc.

5.3.9.4. Distribution

L. trifolii has not yet been reported from many countries where it is actually present. It is generally recognized that all the countries bordering the Mediterranean have *L. trifolii* in varying degrees and that it occurs in all mainland states of the USA. *L. trifolii* has been recorded from the Juan Fernandez Islands (an offshore territory of Chile; Martinez and Etienne, 2002; EPPO, 2009). The record for Argentina has been changed to 'Absent, unreliable record' as Martinez and Etienne (2002) and EPPO (2006) are based on Burgess (in Comstock, 1880 (1879)) and there have been no other reports of the pest in Argentina. *L. trifolii* is a quarantine pest for Argentina (SENASA, personal communication, 2008).

L. trifolii originates in North America and spread to other parts of the world in the 1960-1980s and in India, it was first reported in 1991 (EPPO, 2014). A detailed review of its spread is given in Minkenberg (1988).

- **EPPO region**: First detected in 1976. Now present in Austria, Belgium, Bulgaria, Cyprus, Egypt, France, Greece, Ireland, Israel, Italy, Lebanon, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain (including Canary Islands), Switzerland, Turkey, Yugoslavia. Eradicated in the Czech Republic, Denmark, Finland, Germany, Hungary, Norway, Sweden, UK.
- **Asia**: Cyprus, ***India*** (Andhra Pradesh), Israel, ***Japan*** (Honshu), Korea Republic, Lebanon, Philippines, ***Taiwan***, Turkey (EPPO, 2014), ***China*** (CABI, 1997).

- **Africa**: Egypt, Ethiopia, Kenya, Mauritius, Nigeria, Réunion, Senegal, South Africa, Tanzania, Tunisia.
- **North America**: Canada (Alberta, Nova Scotia, Ontario, Quebec), Mexico (unconfirmed), USA (outside in New Mexico, California, most eastern states from Florida northward to New Jersey, Wisconsin and Iowa; under glass in other southern states).
- **Central America and Caribbean**: Bahamas, Barbados, Costa Rica, Cuba, Dominican Republic, Guadeloupe, Guatemala, Martinique, Trinidad and Tobago.
- **South America**: Brazil, Colombia, French Guiana, Guyana, Peru, Venezuela.
- **Oceania**: American Samoa, Guam, Micronesia, Northern Mariana Islands, Samoa, Tonga.

5.3.9.5. Hazard Identification Conclusion

Considering the facts that *Liriomyza trifolii* (Burgess) -

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 1997];
- is potentially economic important to Bangladesh because it is an important pest of cucurbits in Asia including China, India, Thailand (absent, unreliable record), **Japan**, Sri Lanka, Cyprus, Israel, Turkey, Lebanon, Philippines, Taiwan, [EPPO, 2014; CABI/EPPO, 1997] from where flowers are imported to Bangladesh.
- can become established in Bangladesh through imports of the cucurbits. It has capability to cause direct economic and ecological damage to many valuable cultivated crops, because one female of *L. trifolii* can lay 493 eggs in peas (Poe, 1981) and another laid 639 eggs in chrysanthemums and larvae develop within the leaf surface. Dispersal over long distances is on planting material of host species. Cucurbits can also present a danger as a means of dispersal; it should be noted, for example, that the vase life of chrysanthemums is sufficient to allow completion of the life-cycle of the pest. [EPPO, 2016].
- *L. trifolii* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.9.6. Determine <u>likelihood of pest establishing</u> in Bangladesh via this pathway

Table-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?—Yes. • This pest has been established in many Asian countries. The introduction of this pest in India was first reported in 1991; Turkey in 1985, Tunisia in 1992, introduced in Kenya in 1976, now present in many Asian countries including Japan, Korea, the Republic, Thailand (absent, unreliable record) and China. • *L. trifolii* originates in North America and spread to other parts of the world in the 1960-1980s. • In EPPO region, this pest has been first detected in 1976. Now present in Austria, Belgium, Bulgaria, Cyprus, Egypt, France, Greece, Ireland, Israel, Italy, Lebanon, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain (including Canary Islands), Switzerland, Turkey, Yugoslavia. Eradicated in the Czech Republic, Denmark, Finland, Germany, Hungary, Norway, Sweden, UK.	HIGH

Description	Establishment Potential
b. Posibility of survival of this pest during transport, storage & transfer?-Yes • Female flies puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition (Parrella et *al*., 1981). Eggs are inserted just below the leaf surface. *L. trifolii* females each laid 25 eggs in celery at 15°C and 400 eggs at temperatures around 30°C. One female of *L. trifolii* laid 493 eggs in peas (Poe, 1981). Eggs hatch in 2-5 days according to temperature. Harris and Tate (1933) give 4-7 days at 24°C. Many eggs may be laid on a single leaf. The duration of larval development also depends on temperature and probably host plant. • In case of cucurbits, either seeds or fruits of cucurbits are imported from the exporting countries into Banagladesh. Therefore, the possibility of survival of this pest is less during transport of the cucurbits. But high possibility for transportation of plant stocks particularly leaves of any plants such as flowers and foliages. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,** • Internationally, *L. trifolii* is liable to be carried on any plants for planting or on cucurbits, nursery stocks and ornamental flowers, which are the main means of dispersal of this pest [EPPO, 2016]. But there is no possibility of this pest to appear on the seeds and less possibility on the fruits of cucurbits. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *L. trifolii* has been recorded from 25 families with preference shown for the Asteraceae, including the following important crops: *Aster* spp., chrysanthemums, *Dahlia* spp., *Dianthus* spp., *Gerbera* spp., *Gypsophila* spp., *Lathyrus* spp., *Zinnia* spp., beetroots, *Bidens* spp., *Brassica chinensis*, *Capsicum annuum*, celery, Chinese cabbages, cotton, **cucumbers,** garlic, leeks, lettuces, lucerne, marrows, **melons,** onions, peas, *Phaseolus coccineus*, *P. lunatus*, *P. vulgaris*, potatoes, spinach, tomatoes, *Tropaeolum* spp., *Vigna* spp., **watermelons** (Stegmaier (1968). which are mostly common in Bangladesh. • On celery *L. trifolii* completes its life-cycle (oviposition to adult emergence) in 12 days at 35°C, 26 days at 20°C, and 54 days at 15°C (Leibee, 1982). On chrysanthemums the life-cycle is completed in 24 days at 20°C but on *Vigna sinensis* and *Phaseolus lunatus* it takes only 20 days at this temperature (Poe, 1981). *L. trifolii* females each laid 25 eggs in celery at 15°C and 400 eggs at temperatures around 30°C. One female of *L. trifolii* laid 493 eggs in peas (Poe, 1981) and another laid 639 eggs in chrysanthemums (cv. Fandango). • The duration of larval development also varies with temperature and host plant but is generally 4-7 days at mean temperatures above 24°C (Harris & Tate, 1933). Adult emergence of *Liriomyza* species occurs 7-14 days after pupariation, at temperatures between 20 and 30°C (Leibee, 1982). At low temperatures emergence is delayed. In the laboratory *L. trifolii* survived cold storage at 4.5°C for 8 weeks (Miller, 1978). • In the southern USA, the life-cycle is probably continuous throughout the	

Description	Establishment Potential
year. There is a noticeable first generation which reaches a peak in April (Spencer, 1973). In southern Florida, *L. trifolii* has two or three complete generations followed by a number of incomplete, overlapping generations (Spencer, 1973). • These climatic requirements for growth and development of *L. trifolii* are more or less similar with the climatic condition of **Bangladesh**.	
• Not as above or below	**Yes & 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

5.3.9.7. Determine the <u>Consequence establishment</u> of this pest in Bangladesh

Table 9.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *L. trifolii* is a remarkably polyphagous species and has been recorded from 25 families with preference shown for the Asteraceae, including the following important crops: *Aster* spp., chrysanthemums, *Dahlia* spp., *Dianthus* spp., *Gerbera* spp., *Gypsophila* spp., *Lathyrus* spp., *Zinnia* spp., beetroots, *Bidens* spp., *Brassica chinensis*, *Capsicum annuum*, celery, Chinese cabbages, cotton, **cucumbers,** garlic, leeks, lettuces, lucerne, marrows, **melons,** onions, peas, *Phaseolus coccineus*, *P. lunatus*, *P. vulgaris*, potatoes, spinach, tomatoes, *Tropaeolum* spp., *Vigna* spp., **watermelons** (Stegmaier, 1968). • Damage is caused by larvae mining into leaves and petioles. The photosynthetic ability of the plants is often greatly reduced as the chlorophyll-containing cells are destroyed. Severely infested leaves may fall, exposing plant stems to wind action, and flower buds and developing fruit to scald (Musgrave *et al*., 1975). The presence of unsightly larval mines and adult punctures in the leaf palisade of ornamental plants can further reduce crop value (Smith *et al*., 1962; Musgrave *et al*., 1975). • *L. trifolii* is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in flowers and other crops, illustrate clearly the serious nature of this pest and the potential threat to the cucurbits as well as other crops in Bangladesh still free from the pest. • This is a **fairly serious pest** of several important cucurbit, flower and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *L. trifolii* is an economically important key pest of both ornamental crops (Bogran, 2006) and vegetables (Cheri, 2012). • Vegetable losses in the USA are also considerable. For example, losses	**Yes and High**

Description	Consequence potential
for celery were estimated at US$ 9 million in 1980 (Spencer, 1982). It was noted, however, that damage to celery during the first 2 months of the 3-month growing season was insignificant and largely cosmetic, whereas considerable yield loss resulted from pest presence during the final month (Foster et al., 1988). 1.5 million larval mines per hectare were recorded from onions in Iowa (Harris et al., 1933). • Damage is caused by *L. trifolii* larvae mining into leaves and petiole. The photosynthetic ability of the plants is often greatly reduced as the chlorophyll-containing cells are destroyed. Severely infested leaves may fall, exposing plant stems to wind action, and flower buds and developing fruit to scald (Musgrave et al., 1975). The presence of unsightly larval mines and adult punctures caused by L. trifolii in the leaf palisade of ornamental plants, such as chrysanthemums, can further reduce plant value (Smith et al., 1962; Musgrave et al., 1975). In young plants and seedlings, *L. trifolii* mining may cause considerable delay in plant development, even leading to plant loss. The level of damage depends on many factors, including climate suitability, host resistance, crop distribution, growing conditions, control methods in place and the degree of infestation (EFSA, 2012). • *L. trifolii* is also known to be a vector of plant viruses (Zitter et al., 1980). **c. Environmental Impact** • *L. trifolii* has developed resistance to most commonly used insecticides that were recommended for its control before 1990 (Parella et al., 1984; Nuessly and Webb, 2013), including carbamates, organophosphates, pyrethroids, avermectins, spinosyns and moulting disruptors, such as cyromazina (Hernandez, 2009). • The development of resistance to insecticides could trigger repeated changing of different insecticides that creates toxic and harmful impact to the 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

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

Establishment Potential X Consequence Potential = Risk

Table-9.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.9.9. Risk Management Measures

- Avoid importation of cucurbits, flowers and other susceptible crops from countries, where this pest is available.
- In chrysanthemum cuttings, *L. trifolii* survives cold storage at 1.7°C for at least 10 days. Newly laid eggs of *L. trifolii* in chrysanthemums survived for up to 3 weeks in cold storage at 0°C (Webb & Smith, 1970). Eggs incubated for 36-48 h were killed after 1 week under the same conditions (Webb & Smith, 1970). All stages of larvae were killed after 1-2 weeks at 0°C (Webb & Smith, 1970). These authors, therefore, proposed that chrysanthemum cuttings should be maintained under normal glasshouse conditions for 3-4 days after lifting to allow eggs to hatch. Subsequent storage of the plants at 0°C for 1-2 weeks should then kill off the larvae.
- Gamma irradiation of eggs and first larval stages at doses of 40-50 Gy provided effective control (Yathom *et al*., 1991), but lower doses were ineffective.
- EPPO (OEPP/EPPO, 1990) recommends that planting material (except seeds) of celery, *Cucumis*, lettuces and tomatoes, and material (except seeds and pot plants) of *Capsicum*, carnations, chrysanthemums, *Gerbera*, *Gypsophila* and *Senecio hybridus* from countries where the pest occurs must either have been inspected at least every month during the previous 3 months and found free from the pests, or have been treated by a recommended method. It is left optional as to whether countries make the same requirements for pot plants of the second group of plants mentioned above.
- A phytosanitary certificate may be required for cucurbits and for vegetables with leaves.

5.3.9.10. References

Bogran CE, 2006. Biology and Management of Liriomyza Leafminers in Greenhouse Ornamental Crops. Agrilife Extension Texas A&M System. Texas, USA: Texas A&M University. World Wide Web Page: https://insects.tamu.edu/extension/publications/epubs/ eee_00030.cfm

CABI/EPPO, 1997. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 1998. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

Cheri MA, 2012. DPhil Thesis. Athens, Georgia, USA: University of Georgia.

D'Aguilar, J.; Martinez, M. (1979) Sur la présence en France de *Liriomyza trifolii* Burgess. *Bulletin de la Société Entomologique de France* **84**, 143-146.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2016. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Foster RE, Sanchez CA, 1988. Effect of Liriomyza trifolii (Diptera: Agromyzidae) larval damage on growth, yield, and cosmetic quality of celery in Florida. Journal of Economic Entomology, 81(6):1721-1725.

Harris HM, Tate HD, 1933. A leafminer attacking the cultivated onion. Journal of Economic Entomology, 26:515-516.

Leibee, G.L. (1982) Development of *Liriomyza trifolii* on celery. In: *Proceedings of IFAS-Industry Conference on Biology and Control of* Liriomyza *leafminers, Lake Buéna Vista, Florida* (Ed. by Schuster, D.J.), pp. 35-41.

Miller, G.W. (1978) *Liriomyza* spp. and other American leafminer pests associated with chrysanthemums. Diptera: Agromyzidae. *EPPO Publications, Series C* No. 57, pp. 28-33.

Minkenberg, O.P.J.M. (1988) Dispersal of *Liriomyza trifolii*. *Bulletin OEPP/EPPO Bulletin* **18**, 173-182.

Musgrave CA, Poe SL, Weems HV Jr, 1975. The vegetable leafminer, Liriomyza sativae Blanchard (Diptera: Agromyzidae), in Florida. Entomology Circular, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, No. 162:4 pp.

Musgrave, C.A.; Poe, S.L.; Weems, H.V. (1975) The vegetable leafminer *Liriomyza sativae* Blanchard. *Entomology Circular, Florida Department of Agriculture and Consumer Services, Division of Plant Industry* No. 162, pp. 1-4.

OEPP/EPPO (1984) Data sheets on quarantine organisms No. 131, *Liriomyza trifolii*. *Bulletin OEPP/EPPO Bulletin* **14**, 29-37.

OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents* No. 1008.

OEPP/EPPO (1992) Quarantine procedures No. 42. Identification of *Liriomyza* spp. *Bulletin OEPP/EPPO Bulletin* **22**, 235-238.

OEPP/EPPO, 1990. Specific quarantine requirements. EPPO Technical Documents, No. 1008. Paris, France: EPPO.

Poe, S.L. (1981) Miner notes. *Society of American Florists* **2**, 1-10.

Smith, F.F.; Boswell, A.L.; Wave, H.E. (1962) New chrysanthemum leaf miner species. *Florists' Review* **130**, 29-30.

Spencer KA, 1982. US celery under threat. Grower, 97:15-18.

Spencer KA, 1990. Host specialization in the world Agromyzidae (Diptera). Dordrecht, Netherlands: Kluwer Academic Publishers, 444 pp.

Spencer KA, Steyskal GC, 1986. Manual of the Agromyzidae (Diptera) of the United States. Agriculture Handbook, USDA, No. 638:vi + 478pp.

Spencer, K.A. (1973) *Agromyzidae (Diptera) of economic importance* (*Series Entomologica* No. 9), 418 pp. Junk, The Hague, Netherlands.

Spencer, K.A. (1982) US celery under threat. *Grower* **97**, 15-18.

Stegmaier, C.E. (1968) A review of recent literature of the host plant range of the genus *Liriomyza* (Diptera: Agromyzidae) in the continental United States and Hawaii, excluding Alaska. *Florida Entomologist* **51**, 167-182.

Webb, R.E.; S (1970) Survival of eggs of *Liriomyza munda* in chrysanthemums during cold storage. *Journal of Economic Entomology* **63**, 1359-1361.

Webster, F.M.; Parks, T.H. (1913) The serpentine leafminer. *Journal of Agricultural Research, Washington D.C.* **1**, 59-87.

Yathom, S.; Padova, R.; Chen, M.; Ross, I. (1991) Effect of gamma irradiation on sterility of *Liriomyza trifolii* flies. *Phytoparasitica* **19**, 149-152.

Zitter TA, Tsai JH, Harris KF, 1980. Flies. In: Harris KF, Maramorosch K. Vectors of Plant Pathogens. New York, USA: Academic Press, 165-176.Spencer KA, 1985. East

African Agromyzidae (Diptera): further descriptions, revisionary notes and new records. Journal of Natural History, 19(5):969-1027

Zitter, T.A.; Tsai, J.H.; Harris, K.F. (1980) Flies. In: *Vectors of plant pathogens* (Ed. by Harris, K.F.; Maramorosch, K.), pp. 165-176. Academic Press, New York, USA

Pest-10:	**Pea leaf miner, *Liriomyza huidobrensis* (Blanchard)**

5.3.10.1. Hazard Identification

Scientific Name: *Liriomyza huidobrensis* (Blanchard)

Synonyms: *Agromyza huidobrensis* Blanchard
Liriomyza cucumifoliae Blanchard
Liriomyza langei Frick
Liriomyza dianthi Frick

Common names: Pea leaf miner,
South American leaf miner

Taxonomic tree

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Insecta
Order: Diptera
Family: Agromyzidae
Genus: *Liriomyza*
Species: *Liriomyza huidobrensis*

EPPO Code: LIRIHU. This pest has been included in EPPO A2 list: No. 152

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2002; EPPO, 2014].

5.3.10.2. Biology

Males usually emerge before females. Mating takes place from 24 h after emergence and a single mating is sufficient to fertilize all eggs laid. Female flies puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition. Feeding punctures cause the destruction of a larger number of cells and are more clearly visible to the naked eye. About 15% of punctures made by *L. trifolii* and *L. sativae* contain viable eggs (Parrella *et al*., 1981). The life-cycle is probably continuous throughout the year. There is a noticeable first generation which reaches a peak in April (Spencer, 1973). In California, *L. huidobrensis* completes its life-cycle in 17-30 days during the summer and in 50-65 days during the winter (Lange et al., 1957). Adults of Liriomyza spp. live, on average, between 15 and 30 days, and females generally live longer than males.

5.3.10.3. Hosts

a. Major hosts: The main host of *L. huidobrensis includes* Celery, lettuce, marigold, gypsophila (baby's breath), ornamental gourd, common bean, pea, onion, garlic *etc.*

b. Minor hosts: The minor or other hosts of this pest include *Amaranthus*, Aster, gerbera, marigold, zinnia, spinach, **melon, cucumber**, faba bean, bell pepper, *petunia, tomato, aubergine, potato,* etc.

5.3.10.4. Distribution

c. *L. huidobrensis* originates in Central and South America and was absent from other continents until the 1980s. It was first detected in the EPPO region in 1987 in the Netherlands where it was found on glasshouse lettuces; it is presumed to have been imported directly from South America. It has since spread considerably in the EPPO region, but remains absent from a significant number of countries, in particular in central and Eastern Europe.

- **EPPO region**: Austria, Belgium, Cyprus, Czech Republic, France (Trouvé *et al.*, 1991), Israel, Italy (Suss, 1991; including Sicily), Malta, Netherlands, Portugal, Spain (including Canary Islands), UK (England, Northern Ireland, Scotland). *L. huidobrensis* has been intercepted, or has occurred and been eradicated, in Denmark, Finland, Germany (Leuprecht, 1991), Ireland and Sweden.
- **Asia**: **India** (Uttar Pradesh), **Thailand, Japan (**restricted distribution), Sri Lanka, Cyprus, Israel, Lebanon, **Philippines, Taiwan,** [CABI/EPPO, 2002; EPPO, 2014]
- **Africa**: Mauritius, Réunion.
- **North America**: Mexico (unconfirmed), USA (California, Hawaii and in glasshouses in Florida and Virginia).
- **Central America and Caribbean**: Belize, Costa Rica, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Honduras, Nicaragua, Panama.
- **South America**: Argentina, Brazil (Matto Grosso, São Paulo), Chile, Colombia, Peru, Venezuela.
- **Oceania**: Australia.

5.3.10.5. Hazard Identification Conclusion

Considering the facts that *Liriomyza huidobrensis* -

- is not known to be present in Bangladesh [CABI/EPPO, 2002; EPPO, 2014];
- is potentially economic important to Bangladesh because it is an important pest of cucurbits Asia including China (restricted distribution), India (restricted distribution), Thailand, **Japan (**restricted distribution), Sri Lanka, Cyprus, Israel, Lebanon, Philippines, Taiwan, [CABI/EPPO, 2002; EPPO, 2014] from where cucurbits and susceptible crops such as flowers are imported to Bangladesh.
- can become established in Bangladesh through imports of the cucurbits. It has capability to cause direct economic and ecological damage to many valuable cultivated crops, Female flies of *L. huidobrensis* puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition and eggs are inserted into the epidermis and mesophyll layer of the leaf (Poe, 1981). Adult flies are capable of limited flight. Dispersal over long distances is on planting material of host species. Cucurbits can also present a danger as a means of dispersal; it should be noted, for example, that the vase life of chrysanthemums is sufficient to allow completion of the life-cycle of the pest [EPPO, 2016].
- *L. huidobrensis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-10.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years?-Yes • This pest has been established in many Asian countries. The introduction of this pest in India was first reported in 1994; Indonesia in 1994 (Mujica & Cisneros, 1997), Thailand in 1994; Taiwan in 1991; Cyprus in 1994; Finland in 1997; Ireland in 1997; Italy in 1991; Turkey in 1985, Netherlands in 1989; Slovenia in 1999 (CABI/EPPO, 2002; EPPO, 2014). Now present in many Asian countries including Japan, China etc.	HIGH

Description	Establishment Potential
b. Possibility of survival of this pest during transport, storage and transfer of commodity?-Yes • Female flies puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition (Parrella *et al*., 1981). In California, *L. huidobrensis* completes its life-cycle in 17-30 days during the summer and in 50-65 days during the winter (Lange et al., 1957). Adults of *Liriomyza* spp. live, on average, between 15 and 30 days, and females generally live longer than males. • In case of cucurbits, either seeds or fruits of cucurbits are imported from the exporting countries into Banagladesh. Therefore, the possibility of survival of this pest is less during transport of the cucurbits. But high possibility for transportation of plant stocks particularly leaves of any plants such as flowers and foliages. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,** • Internationally, *L. huidobrensis* is liable to be carried on any plants for planting or on cucurbits, and nursery stocks, which are the main means of dispersal of this pest [EPPO, 2016]. But there is no possibility of this pest to appear on the seeds and less possibility on the fruits of cucurbits. **c. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • Fourteen families of plants have been recorded as hosts of *L. huidobrensis*, without a clear preference for any particular family. *L. huidobrensis* has been reported from *Amaranthus* spp., *Aster* spp., chrysanthemums (*Dendranthema morifolium*), *Dahlia* spp., *Dianthus* spp., *Gypsophila* spp., *Zinnia* spp., hemp (*Cannabis sativa*), aubergines (*Solanum melongena*), beets (*Beta vulgaris*), *Capsicum annuum*, celery (*Apium graveolens*), **cucumbers (*Cucumis sativus*)**, faba beans (*Vicia faba*), garlic (*Allium sativum*), *Lathyrus* spp., lettuces (*Lactuca sativa*), lucerne (*Medicago sativa*), **melons (*Cucumis melo*)**, onions (*Allium cepa*), peas (*Pisum sativum*), *Phaseolus vulgaris*, potatoes (*Solanum tuberosum*), *Primula* spp., radishes (*Raphanus sativus*), spinach (*Spinacia oleracea*), tomatoes (*Lycopersicon esculentum*), *Tropaeolum* spp., and *Verbena* spp., which are mostly common in **Bangladesh**. • In the southern USA, the life-cycle is probably continuous throughout the year. There is a noticeable first generation which reaches a peak in April (Spencer, 1973). In California, *L. huidobrensis* completes its life-cycle in 17-30 days during the summer and in 50-65 days during the winter (Lange *et al*., 1957). The duration of larval development also varies with temperature and host plant but is generally 4-7 days at mean temperatures above 24°C (Harris & Tate, 1933). Reductions in population levels of *L. huidobrensis* occurred in California (USA) when the daily maximum temperature rose to 40°C (Lange *et al*., 1957). • These climatic requirements for growth and development of *L. huidobrensis* are more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	**Yes &**

Description	Establishment Potential
	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

5.3.10.7. Determine the Consequence establishment of this pest in Bangladesh

Table-10. 2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *L. huidobrensis* is a remarkably polyphagous species and has been recorded from 14 families without a clear preference for any particular family including the following important crops: Fourteen families of plants have been recorded as hosts of *L. huidobrensis*, without a clear preference for any particular family. *L. huidobrensis* has been reported from *Amaranthus* spp., *Aster* spp., chrysanthemums (*Dendranthema morifolium*), *Dahlia* spp., *Dianthus* spp., *Gypsophila* spp., *Zinnia* spp., hemp (*Cannabis sativa*), aubergines (*Solanum melongena*), beets (*Beta vulgaris*), *Capsicum annuum*, celery (*Apium graveolens*), **cucumbers (*Cucumis sativus*)**, faba beans (*Vicia faba*), garlic (*Allium sativum*), *Lathyrus* spp., lettuces (*Lactuca sativa*), lucerne (*Medicago sativa*), **melons (*Cucumis melo*)**, onions (*Allium cepa*), peas (*Pisum sativum*), *Phaseolus vulgaris*, potatoes (*Solanum tuberosum*), *Primula* spp., radishes (*Raphanus sativus*), spinach (*Spinacia oleracea*), tomatoes (*Lycopersicon esculentum*), *Tropaeolum* spp., and *Verbena* spp. (Spencer, 1990). • *L. huidobrensis* is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in flowers and other crops including cucumbers and melons, illustrate clearly the serious nature of this pest and the potential threat to the cucurbits as well as other crops in Bangladesh still free from the pest. • This is a **fairly serious pest** of several important cucurbits, flowers and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • *L. huidobrensis* is a serious pest of potato, vegetables and ornamental plants in the field and glasshouses in many parts of the world (Lange et al., 1957). In South America, it is a key pest of potato. In Europe and Mediterranean regions, *L. huidobrensis* is already a major pest of chrysanthemums, Primula spp., Verbena, lettuces (OEPP/EPPO, 1994), Phaseolus vulgaris, cucumbers, celery and Cucurbita pepo (ADAS, 1991). • Although it initially proved to be a much more serious pest than *L. trifolii* in Israel (Weintraub and Horowitz, 1995), it has since come under natural biological control and is only occasionally a pest (Weintraub, 2001b).	**Yes and High**

• Damage is caused by larvae mining into leaves and petioles. The photosynthetic ability of the plants is often greatly reduced as the chlorophyll-containing cells are destroyed (Parrella and Bethke, 1984). Severely infested leaves may fall, exposing plant stems to wind action, and flower buds and developing fruit to scald (Musgrave et al., 1975). • The presence of unsightly larval mines and adult punctures in the leaf palisade of ornamental plants can further reduce crop value (Smith et al., 1962; Musgrave et al., 1975). In young plants and seedlings, mining may cause considerable delay in plant development, leading to plant loss. **c. Environmental Impact** • Some insecticides, particularly abamectin (Weintraub and Horowitz, 1998; Weintraub 2001; Hidrayani et al, 2005), the growth regulator cyromazine (Veire, 1991; Staay, 1992; Leuprecht, 1993; Weintraub and Horowitz, 1998; Weintraub 2001) and spinosad (Weintraub and Mujica, 2006) provide effective control against larvae because these insecticides are translaminar, but leaf miner resistance can sometimes make control of adults difficult (Parrella et al., 1984; Macdonald, 1991). • The development of resistance to insecticides could trigger repeated changing of different insecticides that creates toxic and harmful impact to the 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

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

Establishment Potential X Consequence Potential = Risk

Table-10.3: Calculation of risk rating

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

Calculated Risk Rating – High

5.3.10.9. Risk Management Measures

- Avoid importation of cucurbits from countries, where this pest is available.
- All stages are killed within a few weeks by cold storage at 0°C. Newly laid eggs are, however, the most resistant stage and it is recommended that cuttings of infested ornamental plants be maintained under normal glasshouse conditions for 3-4 days after lifting, to allow eggs to hatch. Subsequent storage of the plants at 0°C for 1-2 weeks should then kill off the larvae of leaf miner species (Webb & Smith, 1970).

- To avoid the introduction of *L. huidobrensis* (and the other leaf miner species, including *L. sativae* and *Amauromyza maculosa*; EPPO/CABI, 1996), EPPO (OEPP/EPPO, 1990) recommends that propagating material (except seeds) of *Capsicum*, carnations, celery, chrysanthemums, *Cucumis*, *Gerbera*, *Gypsophila*, lettuces, *Senecio hybridus* and tomatoes from countries where the pests occur must have been inspected at least every month during the previous 3 months and found free from the pests.
- A phytosanitary certificate may be required for cucurbits and for vegetables with leaves.

5.3.10.10 References

ADAS, 1991. Protected crops technical notes. Booklet, Agricultural Development and Advisory Service, Ministry of Agriculture, Fisheries and Food. UK: MAFF, No. 144.

CABI/EPPO, 1997. Distribution maps of quarantine pests for Europe (edited by Smith, I. M. and Charles, L. M. F.). Wallingford, UK: CAB International, xviii + 768 pp.

CABI/EPPO, 2002. *Liriomyza huidobrensis*. Distribution Maps of Plant Pests, No. 568. Wallingford, UK: CAB International.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO, 2016. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO/CABI (1996) *Amauromyza maculosa*, *Liriomyza sativae*, *Liriomyza trifolii*. In: *Quarantine pests for Europe*. 2nd edition (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB INTERNATIONAL, Wallingford, UK.

Harris, H.M.; Tate, H.D. (1933) A leafminer attacking the cultivated onion. *Journal of Economic Entomology* **26**, 515-516.

Hidrayani P, Rauf A, Ridland PM, Hoffmann AA, 2005. Pesticide applications on Java potato fields are ineffective in controlling leafminers, and have antagonistic effects on natural enemies of leafminers. International Journal of Pest Management, 51(3):181-187.

IIE, 1996. Distribution Maps of Plant Pests, No. 586. Wallingford, UK: CAB INTERNATIONAL.

Knodel-Montz, J.J.; Poe, S.L. (1982) Ovipositor morphology of three economically important *Liriomyza* species (Diptera: Agromyzidae). *Proceedings of the Third Annual Industry Conference on Leaf Miners, San Diego, USA*, pp. 186-195.

Lange, W.H.; Gricarick, A.A.; Carlson, E.C. (1957) Serpentine leafminer damage. *California Agriculture* **11**, 3-5.

Leuprecht, B. (1992) [*Liriomyza huidobrensis*, a new, dangerous leaf- miner]. *Gesunde Pflanzen* **44**, 51-58.

Leuprecht, B. (1993) [Studies on the chemical and biological control of a dangerous leafminer in greenhouse vegetables]. *Gesunde Pflanzen* **45**, 89-93.

Macdonald OC, 1991. Responses of the alien leaf miners *Liriomyza trifolii* and *Liriomyza huidobrensis* (Diptera: Agromyzidae) to some pesticides scheduled for their control in the UK. Crop Protection, 10(6):509-513.

Menken, S.B.J.; Ulenberg, S.A. (1986) Allozymatic diagnosis of four economically important *Liriomyza* species (Diptera, Agromyzidae). *Annals of Applied Biology* **109**, 41-47.

Mujica N, Cisneros F, 1997. Developing IPM components for leafminer fly in the Ca±ete Valley of Peru. Program Report 1995-96. Lima, Peru: International Potato Center (CIP), 177-184.

Musgrave CA, Poe SL, Weems HV Jr, 1975. The vegetable leafminer, Liriomyza sativae Blanchard (Diptera: Agromyzidae), in Florida. Entomology Circular, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, No. 162:4 pp.

Musgrave, C.A.; Poe, S.L.; Weems, H.V. (1975) The vegetable leafminer *Liriomyza sativae* Blanchard. *Entomology Circular, Florida Department of Agriculture and Consumer Services, Division of Plant Industry* No. 162, pp. 1-4.

OEPP/EPPO (1984) Data sheets on quarantine organisms No. 131, *Liriomyza trifolii*. *Bulletin OEPP/EPPO Bulletin* **14**, 29-37.

OEPP/EPPO (1990) Specific quarantine requirements. *EPPO Technical Documents* No. 1008.

OEPP/EPPO (1992) Quarantine procedures No. 42. Identification of *Liriomyza* spp. *Bulletin OEPP/EPPO Bulletin* **22**, 235-238.

OEPP/EPPO (1994) Guidelines on good plant protection practice. No. 3. Glasshouse lettuce. *Bulletin OEPP/EPPO Bulletin* **24**, 847-856.

OEPP/EPPO, 1990. Specific quarantine requirements. EPPO Technical Documents, No. 1008. Paris, France: EPPO.

OEPP/EPPO, 1990. Specific quarantine requirements. EPPO Technical Documents, No. 1008. Paris, France: EPPO.

Parrella MP, Allen WW, Morishita P, 1981. Leafminer species causes California mum growers new problems. California Agriculture, 35(9/10):28-30

Parrella MP, Bethke JA, 1984. Biological studies of Liriomyza huidobrensis (Diptera: Agromyzidae) on chrysanthemum, aster, and pea. Journal of Economic Entomology, 77(2):342-345

Parrella MP, Keil CB, Morse JG, 1984. Insecticide resistance in *Liriomyza trifolii*. California Agriculture, 38(1/2):22-23.

Poe SL, 1982. Implications of the USDA/APHIS-PPQ Decision on Flower Imports. Proceedings of the 3rd Annual Industry Conference on the Leafminer. San Diego, Califormia, USA, 117-121.

Poe, S.L. (1981) Miner notes. *Society of American Florists* **2**, 1-10.

Smith FF, Boswell AL, Wave HE, 1962. New chrysanthemum leaf miner species. Florists' Review, 130:29-30.

Smith, F.F.; Boswell, A.L.; Wave, H.E. (1962) New chrysanthemum leaf miner species. *Florists' Review* **130**, 29-30.

Spencer, K.A. (1973) *Agromyzidae (Diptera) of economic importance* (*Series Entomologica* No. 9), 418 pp. Junk, The Hague, Netherlands.

Spencer, K.A. (1982) US celery under threat. *Grower* **97**, 15-18.

Staay M van der, 1992. Chemical control of the larvae of the leafminer Liriomyza huidobrensis (Blanchard) in lettuce. Mededelingen van de Faculteit Landbouwwetenschappen, Universiteit Gent, 57(2b):473-478.

Suss, L. (1991) [First record in Italy of *Liriomyza huidobrensis*]. *Bollettino di Zoologia Agraria e di Bachicoltura* **23**, 197-202.

Trouvé, C.; Martinez, M.; Phalip, M.; Martin, C. (1991) [A new pest in Europe, the South American miner fly]. *Phytoma* No. 429, 42-46. 6 *Liriomyza huidobrensis*

Veire M van de, 1991. Control of leafminer flies in glasshouse tomatoes and lettuce with the selective insecticide cyromazine. Revue de l'Agriculture, 44(5):923-927.

Webb, R.E.; Smith, F.F. (1970) Survival of eggs of *Liriomyza munda* in chrysanthemums during cold storage. *Journal of Economic Entomology* **63**, 1359-1361.

Weintraub PG, 2001. Changes in the dynamics of the leafminer, *Liriomyza huidobrensis*, in Israeli potato fields. International Journal of Pest Management, 47(2):95-102; 17 ref.

Weintraub PG, 2001. Effects of cyromazine and abamectin on the pea leafminer *Liriomyza huidobrensis* (Diptera: Agromyzidae) and its parasitoid Diglyphus isaea (Hymenoptera: Eulophidae) in potatoes. Crop Protection, 20(3):207-213; 17 ref.

Weintraub PG, Horowitz AR, 1995. The newest leafminer pest in Israel, Liriomyza huidobrensis. Phytoparasitica, 23(2):177-184.

Weintraub PG, Horowitz AR, 1996. Spatial and diel activity of the pea leafminer (Diptera: Agromyzidae) in potatoes, Solanum tuberosum. Environmental Entomology, 25(4):722-726; 17 ref.

Weintraub PG, Horowitz AR, 1997. Systemic effects of a neem insecticide on Liriomyza huidobrensis larvae. Phytoparasitica, 26:231-240.

Weintraub PG, Horowitz AR, 1998. Effects of translaminar versus conventional insecticides on *Liriomyza huidobrensis* (Diptera: Agromyzidae) and Diglyphus isaea (Hymenoptera: Eulophidae) populations in celery. Journal of Economic Entomology, 91(5):1180-1185; 19 ref.

Weintraub PG, Mujica N, 2006. Systemic effects of a spinosad insecticide on Liriomyza huidobrensis larvae. Phytoparasitica, 34:21-24.

Pest-11:	**Green looper caterpillar: *Chrysodeixis eriosoma* Doubleday**

5.3.11.1 Hazard Identification

Preferred Scientific Name: *Chrysodeixis eriosoma* Doubleday

Synonym: *Phytometra eriosoma* (Doubleday)
Plusia eriosoma Doubleday

Common names: Green looper caterpillar, caterpillar, green looper; false looper; moth, Pacific silver Y; moth, silver Y; silver Y moth

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Noctuidae
Genus: Chrysodeixis
Species: *Chrysodeixis eriosoma*

EPPO Code: CHRXER.

Bangladesh status: Not present in Bangladesh [EPPO, 2014].

5.3.11.2. Biology

Eggs are laid on the underside of leaves and hatch in 7-10 days in New Zealand (Ferro, 1978) or 2-4 days in Malaysia. Females lay about 170 eggs each (Khoo et al., 1991). There are five larval instars. Larvae take 4-6 weeks to mature in New Zealand (2-3 weeks in Malaysia). Young larvae feed on the underside of leaves, leaving the upper leaf cuticle as a transparent membrane. Later instars feed on whole pieces of the leaf. Larvae favour mild, moist and shaded conditions. On legumes larvae may excavate maturing pods. When fully fed, larvae spin silken cocoons attached to the underside of leaves, and brown pupae form within. At 10-27^{0}C (45-85% RH), adults emerge from pupae within 13-16 days. Development varies according to the host food plant. Adult lifespan varies from 7-14 days (Tripathi & Tripathi, 1988). In Malaysia, it may take only 5-6 weeks to complete a generation (egg to adult to egg) at temperatures between 22^{0}C and 32^{0}C (Tripathi & Shari, 1992), while in New Zealand it takes 7-9 weeks. Temperatures of 18- 25^{0}C were optimum for the build up of *Chrysodeixis eriosoma* populations, relative humidities of >90% and rainfall were also important (Tripathi & Akhtar, 1988).

5.3.11.3. Hosts

Major hosts: The main host of *Chrysodeixis eriosoma* includes *Arachis hypogea* (peanut), *Brassica oleracea* (cabbage, cauliflower), *Cicer arietinum* (chick peas/ gram**), *Cucumis sativus* (cucumber), *Cucurbita pepo* (pumpkin)**, *Cyphomandra betacea* (tree tomato/ tamarillo), *Glycine max* (soya bean), *Helianthus annuus* (sunflower)*, Lens culinaris* (lentils)*, Lycopersicon esculentum* (tomato)*, Medicago sativa* (alfalfa / lucerne)*, Phaseolus vulgaris* (beans), *Pisum sativum* (peas), *Solanum tuberosum* (potato), *Trifolium alexandrinum* (berseem), *Solanum tuberosum* (potato), *Solanum melongena* (aubergine), *Solanum lycopersicum* (tomato) etc.

Minor hosts: The minor or other hosts of this pest include *Aesculus* (buckeyes), *Althaea* (hollyhocks), *Betula* (birches), *Castanea* (chestnuts), *Hibiscus* (rosemallows), *Juglans nigra* (American walnut), *Platanus* (planes), *Populus* (poplars), *Salix* (willow), *Sassafras albidum* (common sassafras), *Sorbus americana* (American mountain ash), turf grasses, *Capsicum annuum* (bell pepper). *Nicotiana tabacum* (tobacco) etc.

5.3.11.4. Distribution

- **EPPO region**: Absent, except for one island in the Azores (Portugal), where the pest has spread from a USA air base; Russia (Far East).
- **Asia**: China (Fujian; Guangdong)(EPPO, 2014), India (Asam, Delhi, Maharashtra, Tamil Nadu, Uttar Pradesh) (Saha & Saharia, 1983; EPPO, 2014), Japan, Korea Democratic People's Republic, Sri Lanka, Thailand, Vietnam (Waterhouse, 1993; EPPO, 2014).
- **North America**: USA (Hawaii) (Luther et al., 1996; EPPO, 2014).
- **EU**: Absent.
- **Oceania:** Australia, Fiji, New Zealand (Rogers et al., 1997; EPPO, 2014)

5.3.11.5. Hazard Identification Conclusion

Considering the facts that *C. eriosoma* -

- is not known to be present in Bangladesh [EPPO, 2014].
- is potentially economic important to Bangladesh because it is an important pest of various vegetables under the family of Amaranthaceae, Amaranthaceae, Brassicaceae, Convolvulaceae, **Cucurbitaceae**, Fabaceae, Liliaceae in Asia other countries including

China (Fujian; Guangdong)(EPPO, 2014), India (Asam, Delhi, Maharashtra, Tamil Nadu, Uttar Pradesh) (Saha & Saharia, 1983; EPPO, 2014), Japan, Korea Democratic People's Republic, Sri Lanka, Thailand, Vietnam (Waterhouse, 1993; EPPO, 2014), USA (Hawaii), Australia from where cucurbitaceous vegetables are imported to Bangladesh.

- In Australia *C. eriosoma* is a sporadic pest of limited importance although it can cause serious defoliation in large numbers. In India *C. eriosoma* is a major pest of peas and soyabean (Prasad *et al.,* 1983; Saha & Saharia, 1983). Larvae can cause up to 15% defoliation although this does not reduce seed yields significantly (Cameron et al., 1986).
- Eggs, larvae and pupae of this pest can all be carried on the leaves of host plants. If this pest continues to be carried via trade in ornamentals or vegetables from its existing locations, there is a good chance that it will eventually establish somewhere in the Bangladesh. It is highly fecund, mobile, polyphagous and in warm and humid conditions, has a short generation time. Areas at most risk in Bangladesh would be protected cultivation, growing vegetables or ornamentals.
- *C. eriosoma* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-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, • China (Fujian; Guangdong) (EPPO, 2014), India (Asam, Delhi, Maharashtra, Tamil Nadu, Uttar Pradesh) (Saha & Saharia, 1983; EPPO, 2014), Japan, Korea Democratic People's Republic, Sri Lanka, Thailand, Vietnam etc. • Widespread in the Indo-Australalasian region (Holloway *et al.,* 1987). Occurs in the temperate and subtropical regions of Australia (Jones & Elliot 1986) including Tasmania (Hardy *et al.,* 1982) **b. Posibiity of survival of this pest during transport, storage and transfer of commodity?-Yes** • The adult female lays about 170 eggs (Khoo et al., 1991) on the underside of leaves and hatch in 7-10 days in New Zealand (Ferro, 1978) or 2-4 days in Malaysia. Larvae take 4-6 weeks to mature in New Zealand (2-3 weeks in Malaysia) (Tripathi & Tripathi, 1988). This period of time for development of this pest is sufficient enough for survival during transport, storage and transfer of commodity. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Currently *C. eriosoma* is restricted to the Indo- Australasian region. Since adult females lay eggs on the underside of host leaves, it is possible that eggs, developing larvae and pupae, (which hang from leaves) can be carried and spread with international trade. • Therefore, the plants for planting, fruits and vegetables, cut flowers and branches of host plants from countries where *C. eriosoma* occurs are	**YES and HIGH**

Description	Establishment Potential
the good pathways for this pest to enter into Bangladesh and establish. **c. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • More than 170 species of plants in 29 plant families are known to be host to *C. eriosoma*. The beetles are particularly attracted to certain species of Amaranthaceae, Amaranthaceae, Brassicaceae, Convolvulaceae, **Cucurbitaceae**, Fabaceae, Liliaceae • Some of the better-known hosts (CABI 2004) of this pest include species of: *Arachis hypogea (peanut), Brassica oleracea (cabbage, cauliflower), Cicer arietinum (chick peas / gram),* ***Cucumis sativus (cucumber), Cucurbita pepo (pumpkin),*** *Cyphomandra betacea (tree tomato/ tamarillo), Glycine max (soya bean), Helianthus annuus (sunflower), Lens culinaris (lentils), Lycopersicon esculentum (tomato), Medicago sativa (alfalfa / lucerne), Phaseolus vulgaris (beans), Pisum sativum (peas), Solanum tuberosum (potato), Trifolium alexandrinum (berseem), Solanum tuberosum (potato), Solanum melongena (aubergine), Solanum lycopersicum (tomato),* among which many of these are available in Bangladesh. • At 10 – 270C (45-85% RH), adults emerge from pupae within 13 - 16 days. Development varies according to the host food plant. Adult lifespan varies from 7-14 days (Tripathi & Tripathi, 1988). In Malaysia, it may take only 5 - 6 weeks to complete a generation (egg to adult to egg) at temperatures between 22^0C and 32^0C (Tripathi & Shari, 1992), while in New Zealand it takes 7-9 weeks. Temperatures of 18- 25^0C were optimum for the build up of Chrysodeixis eriosoma populations, relative humidities of > 90% and rainfall were also important (Tripathi & Akhtar, 1988). • These climatic requirements for growth and development of *C. eriosoma* are more or less similar with the climatic condition of **Bangladesh**.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.3.11.7. Determine the <u>Consequence establishment</u> of this pest in Bangladesh

Table-11.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Larvae are highly polyphagous and feed on foliage and fruit of many field and vegetable crops, ornamentals and weeds. Its wide host range includes: chickpeas (*Cicer arietinum*), lucerne (*Medicago sativa*), maize (*Zea mays*), potato (*Solanum tuberosum*), sunflower (*Helianthus annuus*), soybean (*Glycine max*), tobacco (*Nicotiana tabacum*) - beans (*Phaseolus vulgaris*,) cabbages (*Brassica oleracea*), **cucurbits**	**Yes and High**

Description	Consequence potential
(***Curcurbita pepo*, *Cucumis sativus***), peas (*Pisum sativum*), tomato (*Lycopersicon esculentum*)-many ornamentals, e.g *Coleus*, chrysanthemums, dahlia, freesia, pelargonium, *Tibouchina*. • Eggs are laid on the underside of leaves. Damage is done by the larvae. They feed on the underside of the leaf, making windows between the veins (young larvae leave the upper leaf cuticle and later instars make ragged holes). On tomato, larvae can chew into green fruits and can excavate legume pods. In heavy infestations, plants can be completely defoliated. • This is a **fairly serious pest** of several important vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • Larvae of this pest can cause up to 15% defoliation although this does not reduce seed yields significantly (Cameron et al., 1986). In Australia C. eriosoma is a sporadic pest of limited importance although it can cause serious defoliation in large numbers. In New Zealand, its occurrence is sporadic in south of Christchurch, but is common from Blenheim (latitude 42°S) northwards in all horticultural areas. In India *C. eriosoma* is a major pest of peas and soyabean (Prasad et al., 1983; Saha & Saharia, 1983). **c. Environmental Impact** • The use of insecticides remains the most common means of controlling this pest (CABI/EPPO, 1992). Thus, the introduction of this insect pest would stimulate the use of insecticides in the field and the use of toxic and harmful chemical insecticides for controlling this pest is suspected to cause significant and direct ecological disruptions. • Therefore, the establishment of this pest could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-11.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.11.9. Risk Management Measures

- Avoid importation of vegetables from countries, where this pest is available.
- A phytosanitary certificate may be required for vegetables with leaves.
- Some chemical treatments are effective, e.g. a mixture of 50% pirimiphos-methyl with 50% permethrin gave excellent control of *C. eriosoma* larvae in tamarillo, (*Cyphomandra betacea*) (Holland *et al.,* 1982). Acephate also gave good control. Neem oil, chlorfluazuron and triflumuron have been used on cabbage in Sri Lanka (Bandara & Kudagamage,1991).
- Bactospeine, Dipel and Thuricide (*Bacillus thuringiensis* subsp. *kurstaki*) applied to greenhouse grown tomatoes in New Zealand prevented fruit damage by *C. eriosoma* larvae (Martin & Workman, 1986).
- In Hawaii, experiments with trap crops such as Indian mustard *Brassica juncea*, and 'Tastie' head cabbage, *Brassica oleracea* variety *capitata* showed potential for use as part of an integrated control program (Luther *et al*., 1996)
- A 10:1 ratio of the pheromones (Z)-7-dodecenyl acetate and (Z)-9-dodecenyl acetate attracted males of *C. eriosoma* in Japan (Sugie *et al*., 1990).

5.3.11.10. References

Bandara, K. & Kudagamage, C. (1991). Potential of chitin inhibitors and botanical insecticides for the control of cabbage caterpillars. *Tropical Agriculturist*, **145**, 125-127.

Cameron, P.J.,Allan, D.J. & Walker, G.P. (1986) Insect pests and crop damage in soybeans. New Zealand Journal of Agricultural Research, 29, (1), 93-100.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Ferro, D. (Ed.) (1978) *New Zealand Insect Pests*, Lincoln University, 312pp

Holland, P.T., McFarlane, D.W., McGhie, T.K. & Hartley, M.J. (1982). Spray programmes for pest and disease control in tamarillos. *Proceedings of the Thirty-Fifth New Zealand Weed and Pest Control Conference.* Waikato Motor Hotel, August 9th to 12th, 1982. Edited by M.J. Hartley, p 32-35.

Luther, G.C., Valenzuela, H.R. & Defrank, J. (1996) Impact of cruciferous trap crops on lepidopteran pests of cabbage in Hawaii. *Environmental Entomology*, **25** (1), 39-47.

Martin, N.A. & Workman, P. (1986) Greenlooper caterpillar control on greenhouse tomatoes with *Bacillus thuringiensis. Proceedings of the Thirty-Ninth New Zealand Weed and Pest Control Conference*. New Zealand Weed and Pest Control Society, Quality Inn, Palmerston North, August 12th to 14th, 1986. 130-132.

Prasad, D., Singh, K.M. & Katiyar, R.N. (1983) Succession of insect pests in early maturing high yielding variety of pea, Pisum sativum Linn. Indian Journal of Entomology, 45, (4), 451-455.

Rogers CE, Marti OGJr, Clayton JA, 1997. Report of the ectoparasitic nematode Noctuidonema (Acugutturidae) infesting Lepidoptera in the Fiji Islands. Nematologica, 43(6):505-506; 6 ref.

Saha, N.N. & Saharia, D. (1983) Insects injurious to soybean in Assam*. Journal of Research, Assam Agricultural University*, **4**, (2), 167-169.

Sugie, H., Kawasaki,K., Higuchi, H., Kitamura, C. & Tamaki, Y. (1990) Identification of the sex pheromone of the three-spotted plusia, *Acanthoplusia agnata* Staudinger (Lepidoptera: Noctuidae). *Applied Entomology and Zoology* **25**, (4), 467-473.

Tripathi, S.R. & Akhtar, S. (1988) Population dynamics of a cabbage noctuid *Plusia eriosoma* (Doubleday) (Lepidoptera) in response to certain ecological parameters. *Annals of Entomology*, **6,** (1), 41-45.

Tripathi, S.R. & Shari, A.K. (1992) Fecundity table and intrinsic rate of natural increase in Plusia eriosoma (Doubleday) (Lepidoptera: Noctuidae). Indian J. of Ecology. 19, (1), 65-68.

Tripathi, S.R. & Tripathi, A.K. (1988) Development and growth of larva and pupa of Plusia eriosoma (Doubleday) (Lepidoptera: Noctuidae) in relation to larval diets. Journal of Advanced Zoology, 9, (1), 11-14.

Tripathi, S.R.& Akhtar, S. (1986) Nutritive suitability of different food plants in Plusia eriosoma (Doubleday) (Noctuidae: Lepidoptera), Journal of Advanced Zoology, 7, (2), 115-117.

Waterhouse DF, 1993. The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia. ACIAR Monograph No. 21. Canberra, Australia: Australian Centre for International Agricultural Research, 141 pp.

Pest-12:	**Cucumber moth, *Diaphania indica* (Saunders, 1851) and Cucumber worm, *Diaphania nitidalis* (Stoll)**

5.3.12.1. Hazard identification

Scientific Name: *Diaphania indica* (Saunders, 1851)

Synonyms: *Botys hyalinalis* Boisduval, 1833
Eudioptis capensis Zeller, 1852
Eudioptis indica
Glyphodes indica Saunders
Hedylepta indica Saunders
Margaronia indica Saunders
Palpita indica Saunders
Phacellura indica Saunders
Phakellura curcubitalis Guenée, 1862
Phakellura gazorialis Guenée, 1854
Phakellura indica
Phakellura zygaenalis Guenée, 1854

Common names: Cucumber moth
Cotton caterpillar (Japan);
Cucurbit caterpillar;
Melon moth;
Pumpkin caterpillar

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa

Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Crambidae
Genus: Diaphania
Species: *Diaphania indica*

EPPO Code: DPHNIN.

Bangladesh status: Not present in Bangladesh [EPPO, 2014; CABI, 2015]

5.3.12.2. Hazard identification

Scientific Name: *Diaphania nitidalis (Stoll)*

Synonyms: *Eudioptis nitidalis*
Glyphodes nitidalis Stoll
Margaronia nitidalis Cramer
Palpita nitidalis Stoll
Phacellura nitidalis Cramer, 1781
Phakellura nitidalis
Phalaena nitidalis Stoll
Zinckenia nitidalis Stoll

Common names: Cucumber worm
Pickle worm;
Pickleworm

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Crambidae
Genus: Diaphania
Species: *Diaphania nitidalis*

EPPO Code: DPHNNI.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2000; EPPO, 2014]

5.3.12.2. Biology

Diaphania indica, D. hyalinata and *D. nitidalis undergo* multiple generations per year, possibly over 10 in some regions, as for *D. indica* populations in Hainan Province, China. Active populations of the moths can occur throughout the year, but tend to peak between April and September. Adults of *D. nitidalis* are nocturnal, with most individuals actively flying around midnight. Mating occurs three days after emergence and is induced by a female produced sex pheromone. This behaviour is likely to be similar in both *D. indica* and *D. hyalinata*. Females of *D. indica* and *D. nitidalis* have been recorded laying hundreds of eggs, with as many as 1053 eggs reported for the former. In both species, there is a preference for egg laying on leaves (hairy leaves in *D. nitidalis*), though eggs of *D. nitidalis* are also deposited on stems, buds and flowers. *Diaphania hyalinata* has similarly been observed laying its eggs on leaves, stems and buds. Eggs of all three species are laid in clusters, as well as singly in *D. indica*, and hatch within around 2-5 days. All three species feed on leaves, flowers, fruit, and stems. *Diaphania indica* larvae have been observed binding leaves together with silk and feeding from within. The larval period lasts roughly 8-10 days in *D. indica* and 14 days in *D. hyalinata* and *D. nitidalis*. Towards the end of this period, mature larvae spin a silky cocoon either on the leaves or among leaf debris on the ground. In South Korea, *D. indica* also overwinters as pupae 5-10 cm below the soil surface. The pupal period generally lasts 7-12 days if the pupa is not overwintering.

5.3.12.3. Hosts

Diaphania indica, D. hyalinata and *D. nitidalis* primarily feed on plants within the Cucurbitaceae family, including economically important crops such as **cucumber (*Cucumis sativus*), melon (*Cucumis melo*), pumpkin (*Cucurbita moschata*) and watermelon (*Citrullus lanatus*)**. *Diaphania nitidalis* also feeds on the cucurbit weeds, such as wild balsam apple (*Momordica charantia*), which may act as reservoirs for the pest during times when cultivated crops are unavailable. While *D. hyalinata* and *D. nitidalis* are confined to the Cucurbitacaeae family, *D. indica* has also been recorded on plants within the Leguminosae, Brassicaceae, Fabaceae and Malvaceae.

5.3.12.4. Distribution

This is primarily a tropical and sub-tropical species from Africa, Asia and the Pacific.

North America: USA (Florida) (Zhang, 1994; EPPO, 2014).
Central America: Cuba, Jamaica (EPPO, 2014).
South America: Paraguay, Venezuela (EPPO, 2014)
Caribbean: Cuba, French Guiana, Jamaica, Puerto Rico, Dominican Republic
Europe: UK, Portugal (EPPO, 2014)
Africa: Widespread in sub-Saharan Africa (Clarke, 1986; Zhang, 1994; EPPO, 2014)
Middle East: Saudi Arabia, Yemen
Asia: India (Vamsree *et al*., 2005; EPPO, 2014), China (Clarke, 1986; Ke *et al.*, 1986; Ke *et al.*, 1988; EPPO, 2014), Japan, South Korea, Malaysia, Myanmar, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (Waterhouse, 1993; EPPO, 2014).
Oceania: Australia (common in Northern Territory), wide spread through Pacific Islands (Schreiner, 1991; EPPO, 2014)

5.3.12.5. Hazard Identification Conclusion

Considering the facts that *Diaphania indica* and *D. nitidalis*-

- are not known to be present in Bangladesh [EPPO, 2014; CABI, 2015];
- are potentially economic important to Bangladesh because these are important pests of vegetables especially cucurbitaceous vegetables in Asia including China, India, Thailand ,**Japan**, Sri Lanka, Malaysia, Myanmar, Philippines, Taiwan, [EPPO, 2014] from where most of the Cucurbitaceous vegetables are imported to Bangladesh.
- can become established in Bangladesh through imports of the cucurbitaceous vegetables. It has capability to cause direct economic and ecological damage to many valuable cultivated crops (Patel & Kulkarny, 1956).
- *D. indica* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.12.6. Determine likelihood of pest establishing in our country via this pathway

Table-12.1: 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 Asian countries. *Diaphania indica* was first observed in Yemen in 1977 in fields of cucurbits (Ba-Angood, 1979). This pest is already introduced in most of the Asain countries from where most of the cucurbitaceous vegetables are imported in Bangladesh. The Asian countries are China, India, Thailand, Japan, Sri Lanka, Malaysia, Myanmar, Philippines, Taiwan, [EPPO, 2014]. • *Diaphania indica* was first observed in Yemen in 1977 in fields of cucurbits (Ba-Angood, 1979). There have been no reports of further spread within the region. *D.indica* is present in Florida (USA) but there are no reports of it spreading from there to other US states. Note however that the USA recognises *D. indica* as a quarantine pest (EPPO, 2005), so phytosanitary measures may be preventing spread that would otherwise occur in the USA. **b. Posibiity of survival of this pest during transport, storage and transfer of commodity?-Yes** • The adult female lays about 170 eggs (Khoo et al., 1991) on the underside of leaves and hatch in 7-10 days in New Zealand (Ferro, 1978) or 2-4 days in Malaysia. Larvae take 4-6 weeks to mature in New Zealand (2-3 weeks in Malaysia) (Tripathi & Tripathi, 1988). • Females of *D. indica* and *D. nitidalis* have been recorded laying hundreds of eggs, with as many as 1053 eggs reported for the former. In both species, there is a preference for egg laying on leaves, though eggs of *D. nitidalis* are also deposited on stems, buds and flowers. Eggs hatch within around 2-5 days. Larvae feed on leaves, flowers, fruit, and stems. The larval period lasts roughly 8-10 days in *D. indica* and 14 days in *D. hyalinata* and *D. nitidalis*. Towards the end of this period, mature larvae spin a silky cocoon either on the leaves or among leaf debris on the ground. This period of time for development of this pest is sufficient enough for survival during transport, storage and transfer of commodity. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** Internationally, *Diaphania indica* is liable to be carried on any vegetables, especially cucurbitaceous vegetables and planting materials like seeds, seedlings, fruits etc, which are the main means of dispersal of this pest [EPPO, 2014]. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?- Yes** • *Diaphania indica, D. hyalinata* and *D. nitidalis* primarily feed on plants within the **Cucurbitaceae** family, including economically important crops such as **cucumber (*Cucumis sativus*), melon (*Cucumis melo*), pumpkin (*Cucurbita moschata*) and watermelon (*Citrullus lanatus*).**	**YES and HIGH**

Diaphania nitidalis also feeds on the cucurbit weeds, such as wild balsam apple (*Momordica charantia*), which may act as reservoirs for the pest during times when cultivated crops are unavailable. *D. indica* has also been recorded on plants within the Leguminosae, Brassicaceae, Fabaceae and Malvaceae. • The cucumber moth, *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae), is a tropical and sub-tropical cucurbits pest and a key greenhouse pest in the Jiroft region of Iran. In this study, the effect of different temperatures on the development of this pest was investigated on cucumber, Cucumis sativus L. (Cucurbitales: Cucurbitaceae), leaves in a growth chamber at various constant temperatures (20, 25, 30, and 35°C). The results indicated that the development period from egg to adult death at the decreased with increasing temperature. Mortality was greatest at 35°C. Based on a linear model, the highest and lowest temperature thresholds were recorded for male insects and pupal stage as 16°C and 9.04°C with thermal constants of 100 and 144.92 degree days, respectively (S. Hosseinzade,2014). • *Diaphania indica* is considered a serious pest in Africa and Asia, and greatly reduces fruit yield on some hosts in some years. *Diaphania hyalinata* and *D. nitidalis* are also considered serious pests in South and North America, and although these two moths are only able to successfully overwinter in the extreme southern parts of USA, considerable damage is still seen further north later in the summer (Reid and Cuthbert, 1956). • These climatic requirements for growth and development of *D. indica* are more or less similar with the climatic condition of **Bangladesh**.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.3.12.7. Determine the <u>Consequence establishment</u> of this pest in Bangladesh

Table-12.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *Diaphania indica, D. hyalinata* and *D. nitidalis* primarily feed on plants within the Cucurbitaceae family, including economically important crops such as cucumber (*Cucumis sativus*), melon (*Cucumis melo*), pumpkin (*Cucurbita moschata*) and watermelon (*Citrullus lanatus*). *Diaphania nitidalis* also feeds on the cucurbit weeds, such as wild balsam apple (*Momordica charantia*), which may act as reservoirs for the pest during times when cultivated crops are unavailable. *D. indica* has also been recorded on plants within the Leguminosae, Brassicaceae, Fabaceae and Malvaceae. • Leaf feeding by *D. hyalinata* and *D. indica* often results in skeletonization	**Yes and High**

Description	Consequence potential
(or lace like patches of intact small leaf veins), and in serious outbreaks, leads to much of the foliage on plants being destroyed. *Diaphania nitidalis* also tunnels into stems, resulting in impeded plant growth. However, more serious damage tends to occur on flowers and in fruit in all three species. Damage to the inner portions of flowers can prevent fruit developing. While entry of larvae into soft fruit and feeding on the rind of hard fruit often leaves the fruit unmarketable, particularly after suffering from secondary infection by pathogens. Characteristic signs of fruit feeding in *D. nitidalis* include entry holes, greenish/brown/white frass, and silk webs, which are formed over entry holes to block the path of natural enemies. *Diaphania hyalinata* has also been observed producing frass on leaves and fruit. • *Diaphania hyalinata* is of quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in cucurbitaceous vegetables and other crops, illustrate clearly the serious nature of this pest and the potential threat to the cucurbitaceous vegetables as well as other crops in Bangladesh still free from the pest. • This is a **fairly serious pest** of several important cucurbitaceous vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • No quantitative data are available, but *D. indica* is a serious pest of Cucurbitaceae in Asia and Africa. On hatching, the young larvae cluster around the main veins, folding or binding leaves together. Early symptoms of infestation are the development of lace-like patches of networks of intact small leaf veins. • Damage is most serious in the early stages of fruit formation, when the pests feed on and puncture the skin of young fruit, particularly where they touch leaves or the soil, but well developed fruits with hard rinds may escape attack (Patel & Kulkarny, 1956). Morgan & Midmore (2002) reported *D. indica* being a common problem in the Northern Territory of Australia. **c. Environmental Impact** • The use of insecticides remains the most common means of controlling this pest. Thus, the introduction of this insect pest would stimulate the use of insecticides in the field. Therefore, the establishment of this pest could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-12.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.12.9. Risk Management Measures

- Avoid importation of cucurbitaceous vegetables and planting materials from countries, where this pest is available.
- The Panel concluded that *D. indica* should not be recommended for regulation as no pathway currently existed and the potential for establishment was very limited. In the case interceptions on consignments from Far East are noted in the future, this PRA should be revisited. D. indica will be added to the Alert List to raise awareness.

A phytosanitary certificate may be required for importation of cucurbitaceous vegetables and planting materials including seeds, seedling and other propagating materials.

5.3.12.10. References

Ba-Angood SAS. 1979. Bionomics of the melon worm *Palpita* (*Diaphania*) *indica* (Saund) (Pyralidae: Lepidoptera) in PDR of Yemen. *Zeitschrift fur Angewandte Entomologie*. **88** (3), 332-336.

Clarke JFG, 1986. Pyralidae and Microlepidoptera of the Marquesas Archipelago. Smithsonian Contributions to Zoology, No. 416:iii + 485pp.

CABI/EPPO, 2000. Diaphania nitidalis. Distribution Maps of Plant Pests, Map No. 611. Wallingford, UK: CAB International.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Ke LD, Li ZQ, Xu LX, Zheng QF, 1986. A brief report of a study on Diaphania indica. Zhejiang Agricultural Science, 3:139-142

Ke LD, Li ZQ, Xu LX, Zheng QF, 1988. Host plant preference and seasonal fluctuation of *Diaphania indica* Saunders. Acta Entomologica Sinica, 31(4):379-386.

Morgan, W, Midmore D. 2002. Bitter melon in Australia: A report for the Rural Industries Research and Development Corporation, RIRDC Publication No. 02/134.

Patel RC, Kulkarny HL, 1956. Bionomics of the pumpkin caterpillar –*Margaronia indica* Saund. (Pyralidae: Lepidoptera). *Journal of the Bombay Natural History Society*, **54**:118-127.

S. Hosseinzade, H. Izadi, P. Namvar, and M. A. Samih, 2014. Biology, Temperature Thresholds, and Degree-Day Requirements for Development of the Cucumber Moth, *Diaphania indica*, under Laboratory Conditions. *J. Insect Sci.*; **14**: 61.

Schreiner IH, 1991. Damage threshold for Diaphania indica Saunders (Lepidoptera: Pyralidae) on cucumbers in Guam. Tropical Pest Management, 37(1):17-20; 7 ref.

Vamsree K, Rajasekhar P, Rao VRS, Rao VS, 2005. Seasonal incidence of pumpkin caterpillar Diaphania indica (Saunders) on cucumber in Krishna-Godavari zone. Journal of Plant Protection and Environment, 2(1):127-129.

Waterhouse DF, 1993. The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia. ACIAR Monograph No. 21. Canberra, Australia: Australian Centre for International Agricultural Research, 141 pp.

Zhang BC(Compiler), 1994. Index of economically important Lepidoptera. Wallingford, UK: CAB International, 599 pp.

Pest-13:	**Cucumber beetle, *Diabrotica undecimpunctata***

5.3.13.1. Hazard Identification

Scientific name: *Diabrotica undecimpunctata* Mannerheim

Synonyms: *Diabrotica soror Le Conte*
Common names: Spotted cucumber beetle (English)

Taxonomic tree

Phylum: Arthropoda
Subphylum: Mandibulata
Class: Insecta
Order: Coleoptera
Family: Chrysomelidae
Genus: *Diabrotica*
Species: *Diabrotica undecimpunctata*

EPPO Code: DIABUN. This pest has been included in EPPO A1 list: No. 299

Bangladesh status: Not present in Bangladesh [OEPP/EPPO, 1999; EPPO, 2014]

5.3.13.2. Biology

After overwintering under leaves and trash in woodland, the adults become active in the spring and feed on the flowers and foliage of many different host plants, moving to cucurbits as soon as they become available. They can fly when temperatures reach 21°C (Metcalf & Metcalf, 1993). Females lay 200 to 1,200 eggs singly in the soil, close to the bases of larval host plants. Newly laid eggs are dependent on sufficient soil moisture for survival within the first 24 to 72 h (Krysan, 1976); thus females prefer to oviposit in moist or wet, organic or clay soils (Brust & House, 1990). The larvae hatch after 7-10 days and bore into the roots of their usually poaceous hosts where they feed for 2-4 weeks, passing through three instars. During the latter part of the third instar, the larvae leave the host plants, burrow into the soil and enter the inactive or prepupal stage of the larval period which usually lasts 6-8 days. Pupation takes place in an earthen shell and lasts 6-12 days (Arant, 1929).

It should be noted that *D. undecimpunctata* overwinters as adults, in contrast to *D. virgifera*, which overwinters as eggs. Populations of the latter species are accordingly concentrated in fields of the larval host (maize), whereas *D. undecimpunctata* tends to be associated with the host plants of the adults (cucurbits).

5.3.13.3. Hosts

D. undecimpunctata howardi is polyphagous. Adults attack many cultivated plants including most characteristically ***Cucurbitaceae* (e.g. *Cucumis sativus, Cucumis melo, Cucurbita pepo*, *Citrullus vulgaris*)** but also groundnut (*Arachis hypogea*), soybean (*Glycine max*), *Phaseolus vulgaris* and other legumes, maize (*Zea mays*), sweet potato (*Ipomoea batatas*). If flowers are available, adults will feed on them rather than leaves causing reductions in fruit yield. If flowers are not available, adults prefer the foliage of cucurbits to other crops. The larvae feed mainly on the roots of maize, but can also feed on various other plants (cucurbits, legumes, sweet potato, weeds). They differ in this from the larvae of the closely associated striped cucumber beetle *Acalymma vittata*, which feed exclusively on the same cucurbit hosts as the adults. *D. undecimpunctata undecimpunctata* has a more restricted host range, the adults feeding mainly on cucurbits and the larvae on maize (like *D. virgifera*).

5.3.13.4. Distribution

The older literature did not distinguish the two subspecies and CABI/EPPO (1998a) does not attempt to present their distribution separately. In the distribution given below, the records of subsp. *undecimpunctata* are believed to be reliable, and show its presence essentially in the southwest; it is possible that some of the records in western North America given for subsp. *howardi* in fact refer to subsp. *undecimpunctata* (or both).

- ***Diabrotica undecimpunctata undecimpunctata***

EPPO region: Absent.
North America: USA (Arizona, California, Colorado, Oregon)
EU: Absent.

- ***Diabrotica undecimpunctata howardi***

EPPO region: Absent.
North America: Canada (Alberta, British Columbia, New Brunswick, Nova Scotia, Ontario, Québec, Saskatchewan), Mexico (Central highlands: Guanajuato, Morelos, Michoácan and Querétaro states), USA (Alabama, Arizona, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Maine, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, West Virginia, Wyoming)

EU: Absent.

5.3.13.5. Hazard identification conclusion

Considering the facts that *Diabrotica undecimpunctata* -

- is not known to be present in Bangladesh [OEPP/EPPO, 1999; EPPO, 2014];
- is potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically **Cucurbitaceae (e.g. *Cucumis sativus, Cucumis melo, Cucurbita pepo, Citrullus vulgaris*)** in USA [EPPO/CABI, 1997a] from where a large amount of planting materials especially cucurbitaceous seeds are imported to Bangladesh.
- can become established in Bangladesh through imports of the vegetable seeds. It has capability to cause direct and indirect economic and ecological damage to many

valuable cultivated crops, because In Canada, Beirne (1971) reported a 100% loss of watermelon seedlings as a result of attack by *D. u. howardi*. Attacks on older plants result in a general leaf parching. Attacked fruits of cucumber and pumpkin have a characteristic pinhole appearance that can reduce their market value (Beirne, 1971). The adults are strong fliers and can disperse rapidly, travelling readily from field to field during the summer. As in *D. virgifera* (western corn rootworm) which has already been introduced into the EPPO region (EPPO/CABI, 1997a), adults can be carried long distances by high-altitude air currents, e.g. up to 800 km in 3-4 days (Shands & Landis, 1964).

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

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

Table-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 • This pest has been established in many American and Europian countries from including USA, Canada, Italy, Germany [OEPP/EPPO, 1999; EPPO, 2014]. But not in Asian countries from the most of the seeds and some fruits are being imported into Bangladesh. **b. Possibility of survival of this pest during transport, storage and transfer of commodity?-Yes** • The adults feed on the flowers and foliage of many different host plants, moving to cucurbits as soon as they become available (Metcalf & Metcalf, 1993). Females lay 200 to 1,200 eggs singly in the soil, close to the bases of larval host plants (Krysan, 1976; Brust & House, 1990). The larvae hatch after 7-10 days and bore into the roots of their usually poaceous hosts where they feed for 2-4 weeks. Pupation takes place in an earthen shell and lasts 6-12 days (Arant, 1929). Therefore, the possibility of survival of this pest less during transport, storage and transfer of the commodity. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes** • *D. undecimpunctata* is highly polyphagous, breeding on many agricultural crops that are transported around the world. The international movement of plant material has fostered the rapid spread of the species throughout the world and many populations are now highly resistant to various insecticides. The adults are strong fliers and can disperse rapidly, travelling readily from field to field during the summer. As in *D. virgifera* (western corn rootworm) which has already been introduced into the EPPO region (EPPO/CABI, 1997a), adults can be carried long distances by high-altitude air currents, e.g. up to 800 km in 3-4 days (Shands & Landis, 1964). **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *D. undecimpunctata howardi* is polyphagous. Adults attack many cultivated plants including most characteristically **Cucurbitaceae**	**Low**

Description	Establishment Potential
(e.g. *Cucumis sativus, Cucumis melo, Cucurbita pepo, Citrullus vulgaris*) but also groundnut *(Arachis hypogea),* soybean *(Glycine max), Phaseolus vulgaris* and other legumes, maize *(Zea mays),* sweet potato *(Ipomoea batatas).* (OEPP/EPPO, 1999; EPPO, 2014), which are mostly common in Bangladesh. • The climate of Bangladesh is not 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

5.3.13.7. Determine the Consequence establishment of this pest in Bangladesh

Table-12. 2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *D. undecimpunctata* Howardi is polyphagous. Adults attack many cultivated plants including most characteristically Cucurbitaceae (e.g. *Cucumis sativus, Cucumis melo, Cucurbita pepo, Citrullus vulgaris*) but also groundnut (*Arachis hypogea*), soybean (*Glycine max*), *Phaseolus vulgaris* and other legumes, maize (*Zea mays*), sweet potato (*Ipomoea batatas*). (OEPP/EPPO, 1999; EPPO, 2014), which are mostly common in Bangladesh. • *F. occidentalis* has a little quarantine significance for Bangladesh. Its introduction and rapid spread to many countries, and the problems presented by its presence in flowers, fruits and plant parts of vegetable crops. But there is high risk if vegetables and plant material are imported from USA there is possibility to established the pest in Bangladesh. • This is a fairly serious pest of several important vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • **Impact on crop loss:** Adults of *D. undecimpunctata* damage various vegetable and flower crops, especially cucurbits. In this respect, they are more significant pests than the adults of *D. virgifera* and *D. barberi*. • In Canada, Beirne (1971) reported a 100% loss of watermelon seedlings as a result of attack by *D. u. howardi*. Attacks on older plants result in a general leaf parching. Attacked fruits of cucumber and pumpkin have a characteristic pinhole appearance that can reduce their market value (Beirne, 1971). *D. u. howardi* has been reported to attack glasshouse-grown cucumbers after moving from field-grown cucumber plantings (Beirne, 1971). • *D. undecimpunctata* is also cited as the most important soil-inhabiting pest which feeds on the foliage of groundnut in North Carolina and	**Moderate**

Virginia. *D. undecimpunctata* is also a root pest of maize, but is of lesser importance on this crop than the related *D. virgifera* and *D. barberi*. Subspecies *howardi* is mainly concerned in this respect. • **Impact on disease transmission:** *D. undecimpunctata* is also important as a vector, particularly of cucurbit diseases, such as bacterial wilt (*Erwinia tracheiphila*), *Pseudomonas syringae* pv. *lachrymans* and cucumber mosaic cucumovirus (Howard *et al.,* 1994). On maize, in addition to direct feeding damage, *D. undecimpunctata* can vector viruses such as maize chlorotic mottle machlovirus, which can cause lethal necrosis in conjunction with maize dwarf mosaic or wheat streak mosaic potyviruses (Nault *et al.*, 1978). *D. undecimpunctata* also vectors the pathogen of bacterial wilt of maize (*Pantoea stewartii*) (EPPO/CABI, 1997b), but to a lesser extent than *Chaetocnema pulicaria*. Legume viruses vectored by *D. undecimpunctata* include bean mild mosaic carmovirus, bean southern mosaic sobemovirus and cowpea mosaic comovirus. **c. Environmental Impact** • Soil application of insecticides to control corn rootworms (*D. undecimpunctata*) represents one of the largest uses of plant protection products in North America, mainly directed at *D. virgifera* and *D. barberi* (EPPO/CABI, 1997a). Control techniques used in North America include treating the soil with granular insecticides such as terbufos or isofenphos at the time of planting (Sutter *et al.*, 1990), late planting into land that has been ploughed earlier in the spring and applying granular baits containing cucurbitacin arrestants, which control adults when broadcast just before egg laying. • Thus, the introduction of this insect pest would stimulate the use of soil insecticides in the field. Therefore, the establishment of this pest could trigger chemical control programs by using different insecticides that are toxic and harmful to the soil and environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-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 - Low

5.3.13.9. Risk Management Measures

- No specific measures have yet been recommended at the European level. The risk of the presence of *D. undecimpunctata* in consignments of plants with soil arises particularly for fields of preferred hosts of the pest (such as cucurbits), rather than for fields on which maize was previously grown (as in the case of *D. virgifera*). These preferred hosts are relatively unlikely to enter transatlantic trade, while nurseries in which the more regularly traded plants are grown are relatively unlikely to harbour *D. undecimpunctata*.
- In most cases, the regular phytosanitary certificate requirement should be adequate, but for preferred hosts, such as cucurbits, place of production freedom might be required.

5.3.13.10. References

Anon, 1999. EPPO data sheets on quarantine pests: Diabrotica undecimpunctata. Bulletin OEPP, 29(4):477-482; 19 ref.

Arant FS (1929) Biology and control of the southern corn rootworm. Bulletin of the Alabama Agricultural Experiment Station, no. 230.

Beirne BP (1971) Pest insects of annual crop plants in Canada. I. Lepidoptera, II. Diptera, III. Coleoptera. Memoirs of the Entomological Society of Canada 78, 1-124.

Brust GE & House GJ (1990) Influence of soil texture, soil moisture, organic cover, and weeds on oviposition preference of southern corn rootworm. Environmental Entomology 19, 966-971.

CABI/EPPO (1998a) *Diabrotica undecimpunctata*. Distribution Maps of Plant Pests No. 580. CAB International, Wallingford (GB).

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO/CABI (1997a) Diabrotica barberi and Diabrotica virgifera. In Quarantine Pests for Europe (2nd ed), pp. 233-237. CAB International, Wallingford (GB).

Krysan JL (1976) Moisture relationships of the egg of the southern corn rootworm Diabrotica undecimpunctata howardi Entomologia Experimentalis et Applicata 20, 154-162.

Metcalf RL & Metcalf RA (1993) Destructive and Useful Insects: their Habits and Control (5th ed). McGraw-Hill, New York (US).

Shands WA & Landis BJ (1964) Potato Insects: their Biology and Biological and Cultural Control. USDA, Washington (US).

ARTHROPOD: MITE PESTS

Pest-14:	Red spider mite: *Tetranychus evansi*

5.3.14.1 Hazard Identification

Scientific name: *Tetranychus evansi* Baker & Pritchard, 1960

Synonyms: No synonyms recorded, but *Tetranychus takafujii* Ehara & Ohashi, 2002, is suspected to be the same species.

Common names: Red tomato spider-mite (English)
Cassava stem mussel scale;
White mussel scale

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Class: Arachnida
Order: Acarina
Family: Tetranychidae
Genus: *Tetranychus*
Species: *Tetranychus evansi*

EPPO Code: TETREV. This pest has been included in EPPO A2 list: No. 349

Bangladesh status: Not present in Bangladesh [EPPO, 2016].

5.3.14.2 Biology

Arrhenotokous parthenogenesis is the rule for Tetranychid mites. Unfertilised eggs develop into haploid males while diploid females are produced biparentally from fertilized eggs. The sex-ratio is about 70% females.

Tetranychus evansi reproduction is continuous throughout the year. No diapause has been observed even in the coldest parts of its distribution area or for *T. takafujii* in Tokyo Bay (Ohashi *et al.*, 2003). This could limit the distribution to areas with moderately cold winters.

Qureshi *et al.* (1969), Moraes & McMurtry (1987) and Bonato (1999) have studied the life-history of the mite. The theoretical minimal growing temperature varies from 10.3°C to 13.7°C depending on authors and stages. The optimal temperature is 34°C and the maximal 38°C. The duration of development from egg to adult ranges from 46 days at 15°C to 8-13 days at 25°C and 6 days at 35°C. The number of eggs laid by females varies from 80 with extreme low and high temperatures to a range of 120-250, depending on the authors, for optimal temperatures. This mite has one of the highest rates of population increase among *Tetranychus* species (~0.4) which leads to heavily infested plants at the end of a favourable growing season. This phenomenon causes spectacular outbreaks and high mite populations can kill host plants. Dispersal behaviour is associated with outbreaks, in which mites form large aggregates at the top of the infested plants and are blown with the wind.

5.3.14.3 Hosts

T. evansi is polyphagous. It has been reported on 31 plant families (Spider Mites Web Database, Migeon & Dorkeld, 2007). Major hosts are within the *Solanaceae.*

Cultivated hosts

The primary cultivated solanaceous hosts are tomato (*Lycopersicon esculentum*) (Silva, 1954; Migeon, 2007), aubergine (*Solanum melongena*) (Moraes *et al.*, 1987a; Leite *et al.*, 2003), potato (*S. tuberosum*) (Escudero & Ferragut, 2005), tobacco (*Nicotiana tabacum*) (Blair, 1989) and to a lesser degree peppers and chillies (*Capsicum annuum*) (Silva, 1954). Bean (*Phaseolus vulgaris*) is a cultivated non-solanaceous host (Gutierrez & Etienne, 1986).

The EWG regarded the following crops as secondary, or minor, hosts since there are very few records in the literature of *T. evansi* occurring on them, *Abelmoschus esculentus* (Tuttle *et al.* 1977), beetroot (*Beta vulgaris*) (Aucejo *et al.*, 2003), *Phacelia* sp. (Qureshi *et al.* 1969), cotton (*Gossypium hirsutum*) (Wene, 1956), castor bean (*Ricinus communis*) (Ho *et al.* 2004), peanuts (*Arachis hypogea* and *A. prostrata*) (Moutia 1958, Chiavegato & Reis 1969, Feres & Hirose 1986), sweet potato (*Ipomea batatas*) (Moutia, 1958), **watermelon (*Citrullus lanatus*)** (Ferragut, pers. comm. 2007), and *Rosa* spp. (Qureshi *et al.* 1969).

Weeds

The preferred host for *T. evansi* is the widespread weed *Solanum nigrum* (Migeon, 2007). Other weed hosts include *Amaranthus blitoides*, *Chenopodium* spp. (El Jaouani, 1988), *Convolvulus arvensis*, *Conyza* spp., *Diplotaxis erucoides*, *Hordeum murinum, Lavatera trimestris*, *Sonchus* spp. (Ferragut & Escudero, 1999; Aucejo, Foo, Gimeno, *et al.*, 2003). INRA Spider Mites Web database (Migeon & Dorkeld, 2007) provides a more extensive lists of hosts / plants on which *T. evansi* has been recorded.

5.3.14.4 Geographical distribution

T. evansi is suspected to originate from South America. It has been unintentionally introduced to other parts of the world.
Because the pest can easily be confused with other *Tetranychus* species, there is uncertainty on the pest distribution, e.g. it could be present on crops but considered to be another *Tetranychus* species, or present but disregarded on non-crop plants. The geographic distribution of *T. evansi* is given below:

EPPO region: **France** (Pyrénées-Orientales, Alpes Maritimes, Var), Greece (EPPO, 2007), Israel (EPPO, 2006a), **Italy** (Liguria, EPPO 2006b), Jordan (Palevsky, pers. comm. 2007), Portugal (from Algarve to Lisbon including Madeira), Spain (Canary Islands, Baleares Islands, along the Mediterranean coast, Atlantic coast of Andalusia).

Asia: Israel (EPPO, 2006), Jordan (Palevsky, pers. comm. 2007), **Taiwan** (including Kinmen and Lienchang Islands). If *T. takafujii* is shown to be a synonym of *T. evansi*, then the pest would also be known to occur in **Japan** (EPPO, 2006).

Africa: Democratic Republic of Congo, Congo, Gambia, Kenya, Malawi, Mauritius (including Rodrigues island), Morocco, Mozambique, Namibia, Niger (pers. comm. Migeon, 2007), Reunion Island, Senegal, Seychelles, Somalia, South Africa, Tunisia, Zambia, Zimbabwe. Detections of *T. evansi* on consignments of plant products from Gambia, suggest that *T. evansi* may also be present in Gambia (MacLeod, pers. comm. 2007).

North America: USA (Arizona, California, Florida, Texas, Hawaii).

Central America and Caribbean: Puerto Rico, Virgin Islands

South America: **Brazil**, Argentina

Oceania: Hawaii (USA).

5.3.14.5 Hazard Identification Conclusion

Considering the facts that *T. evansi*

- is not known to be present in Bangladesh [EPPO, 2006].
- is potentially economic important to Bangladesh because it is an important pest of cucurbits and ornamental flowers in Asia including Japan, Taiwan (EPPO, 2006) from where cucurbits and cut flowers are imported to Bangladesh.
- Local movement is mainly linked to wind currents. In international trade, *T. evansi* may be carried on Solanaceous plants for planting (except tubers and seeds) and this is the hypothesis used to explain the introduction of the pest e.g. in Africa. The mites are less likely to infest fruits, these only present a risk where peduncles are present (aubergines, vine tomatoes, fresh beans, and to a lesser degree, chillies and peppers).
- *T. evansi* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.14.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-14.1: 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?-Yes,

- *T. evansi* is suspected to originate from South America. It has been unintentionally introduced to other parts of the world. However, this pest is widely distributed in many Asian countries including Japan, Taiwan (CABI, 2015).
- *T. evansi* is a tropical species of New World origin. There is no mention in the literature of the history of its spread, but it has undoubtedly reached countries outside the New World as a result of human transport of infested planting materials.

b. Posibility of survival during transport, storage and transfer?-Yes

- The mites are less likely to infest fruits, these only present a risk where peduncles are present (cucurbits, aubergines, vine, tomatoes, fresh beans, and to a lesser degree, chillies and peppers).
- The duration of development from egg to adult ranges from 46 days at 15°C to 8-13 days at 25°C and 6 days at 35°C. Within this period the eggs and mites can easily survive on fruit surfaces of cucurbits. Secondly, fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with High risk potential.

c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No,

- Internationally, *T. evansi* is liable to be carried on any plants for planting or on roses, and nursery stocks, which are the main means of dispersal of this pest [EPPO, 2006]. There is no possibility of this pest to appear on seeds and less possibility to appear on the fruits of cucurbits.

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

- The preferred host (*S. nigrum*) and at least three major cultivated hosts (aubergines, tomatoes and potatoes) and rose are widely distributed in many Asian countries including Japan, China, Thailand, India (CABI, 2015), among of these are common in **Bangladesh**.
- *T. evansi* is a warmth-loving pest. A study by Bonato (1999) showed that the optimal temperature for population growth is 34°C. The shortest developmental time (6.3 days) occurs at 36°C. At 25°C, the life cycle is completed in 13.5 days.
- These climatic requirements for growth and development of *T. evansi* are more or less similar with the climatic condition during summer season of **Bangladesh**.

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

- NOT AS ABOVE OR BELOW

</td><td>Yes & Moderate</td></tr>
<tr><td>

- This pest has not established in new countries in recent years, and
- The pathway does not appears good for this pest to enter Bangladesh

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

Description	Establishment Potential
and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	

5.3.14.7 Determine the Consequence establishment of this pest in Bangladesh

Table-14.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • If infested plants for planting are introduced in protected cultivation where no plant protection products are used, *T. evansi* has the potential to cause economic damage although we do not know about the susceptibility of cultivars used. • In African countries where *T. evansi* is established, it has been reported as a serious pest in particular of tomato. Of the thirteen known spider mite species on Reunion, *T. evansi* is one of the most destructive pests on crops (Gutierrez & Etienne, 1986). In Southern Africa *T. evansi* is considered as the most important dry season acarine pest of tomatoes (Fiaboe, 2007). Severe damage is also recorded on aubergine (Migeon, pers. comm. 2007). Infested tomato plants turn yellow, green then brown. Plants generally show a bleached yellow-orange or russeted appearance. Infested plants may be killed very rapidly (Jeppson *et al.*, 1975). In Zimbabwe, up to 90% yield losses have been recorded from field trials. However, it should be noted that with improved use of plant protection products, the damage on crops could be significantly reduced (Knapp *et al* 2003). • This is a **fairly serious pest** of several important other crops rather than flowers for Bangladesh. **b. Economic Impact and Yield Loss** • *Tetranychus evansi* is regarded as an important pest of tomato and other solanaceous crops. In East and South Africa it has been considered the most important dry season pest of tomatoes (Knapp, 2002) since it was first recorded in 1979 and yield losses are noted. In Western Africa, it damages tomatoes and aubergines (Duverney & Ngueye-Ndiaye, 2005). • *Tetranychus evansi* is one of four species of red spider mites causing damage in vegetable crops in eastern Spain (Escudero and Ferragut, 2005), although there is no specific data on economic impact caused by *T. evansi* alone (Ferragut, pers. com. 2007). In Spain, damage has only been recorded in outdoor crops such as aubergine, potato and tomato (Ferragut, pers com. 2007) the same situation occurs in Israel on aubergine and potato. • The most severe damage in Israel occurs on aubergine (Palevsky pers. com. 2007). Few outbreaks are recorded under protected conditions, even in areas where the pest is present outdoors on weeds. • An outbreak in organic farming production unit was detected in southern France on tomato in protected cultivation in October 2007 (Migeon, pers. com. 2007). This illustrates the potential of the pest to	**Yes and High**

cause damage in protected organic farming cultivation. **c. Environmental Impact** • Acaricides are commonly used against *T. evansi* and other spider mites on Solanaceous crops. Mite populations have developed resistance, in particular in Zimbabwe during the 1980s but current use of non organo-phosphorous acaricides is effective at controlling populations although it does not allow integrated crop protection or organic production. • The pesticide resistance invariably leads to an increase in the use of insecticides as whitefly control becomes increasingly more difficult. This in turn can produce an ever increasing spiral in the levels of insecticide resistance and insecticide use, having a direct impact on the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-14.3: Calculation of risk rating

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

Calculated Risk Rating – High

5.3.14.9 Risk Management Measures

a. Measures related to consignments

- **Visual inspection:** Visual detection of mites is possible but confusion with other mites (such as *T. urticae (syn. cinnabarinus), T. turkestani, T. ludeni, T. neocaledonicus, T. lombardini)* is possible. Mites and eggs in low numbers would be difficult to detect.
- **Treatment of the consignment:** Chemical treatments (combining treatments targeting adults and eggs) may be recommended, but their efficacy has to be verified by inspection.

b. Measures related to the crop or to places of production

- Pest Free Area for *T. evansi*
- Pest Free Place of Production:
  (i) Mites are expected to spread more than five kilometres.
  (ii) Having a five km buffer zone free from host plants is not a realistic option but a place of production freedom should consist in:

- Isolation: no other host plants in the immediate vicinity of the place of production (minimum 5 m recommended by Clark, 2001)
- Hygienic measures to prevent the pest to enter the greenhouse.
- Treatment of the crop during the production (the active ingredients which have resulted in more than 90% of mortality in adult females are: hexythiazox, propargite, dicofol, acrinatrin, fenbutatin oxide, dicofol+hexythiazox, fenpyroximate and dicofol.)
- Two inspections of the consignment prior to export

c. Other possible measures

- Surveillance in the importing country was not considered as a possible measure.

5.3.14.10 References

Aucejo S, Foo M, Gimeno E, Gomez-Cadenas A, Monfort R, Obiol F, Prades E, Ramis M, Ripolles JL, Tirado V, Zaragoza L, Jacas J A & Martinez-Ferrer MT (2003). Management of Tetranychus urticae in citrus in Spain: acarofauna associated to weeds. *Bulletin OILB/SROP*, **26 (6)**: 213-220.

Blair B W (1989). Laboratory screening of acaricides against Tetranychus evansi Baker & Pritchard. *Crop Protection*, **8 (3):** 212-216.

Bonato O (1999). The effect of temperature on life history parameters of Tetranychus evansi (Acari: Tetranychidae). *Experimental & Applied Acarology*, **23 (1):** 11-19.

Bonato, O. (1999). The effect of temperature on life history parameters of *Tetranychus evansi* (Acari: Tetranychidae). *Experimental & Applied Acarology* **23**(1): 11-19.

Chiavegato LG & Reis PR (1969). Presence Tetranychus evansi Baker and Pritchard, 1960 (Acarina, Tetranychidae) in peanuts (Arachis hypogea L.) in Saõ Paulo state. *Ciencia e Cultura,* **21** (2): 372.

Clark J (2001). Illustrating the value of weed clearance around polyhouses. In, Medhurst, A. (ed.), Western Flower Thrips Newsletter No. 24, December 2001 (National Strategy [in Australia] for the management of Western Flower Thrips and Tomato Spotted Wilt Virus), pp. 20-21.

El-Jaouani N (1988). *Contribution à la connaissance des acariens phytophages au Maroc et étude bio-écologique de Tetranychus evansi Baker et Pritchard (Acarina: Tetranychidae)*. Rabat, Maroc, Institut Agronomique et Vétérinaire Hassan II: 60.

EPPO (2004). Introduction of *Tetranychus evansi* in some Mediterranean countries: Addition to the EPPO Alert List. *EPPO Reporting Service 2004* (5), 80.

EPPO (2006a). *Tetranychus evansi* is present in Israel. *EPPO Reporting Service 2006* (1), 005.

EPPO (2006b). First report of *T. evansi* in Italy. *EPPO Reporting Service 2006* (9), 185.

EPPO (2007). First report of *Tetranychus evansi* in Crete, Greece. *EPPO Reporting Service 2007* (3), 049.

EPPO (2016). Report of a Pest Risk Analysis for *Tetranychus evansi.* European and Mediterranean Plant Protection Organization. *https://www.eppo.int/QUARANTINE/Alert.../Tetranychus_evansi.doc*

Escudero LA & Ferragut F (2005). Life-history of predatory mites *Neoseiulus californicus* and *Phytoseiulus persimilis* (Acari: Phytoseiidae) on four spider mite species as prey, with special reference to *Tetranychus evansi* (Acari: Tetranychidae). *Biological Control*, **32 (3):** 378-384.

Feres RJF & Hirose M (1986). Presence of *Tetranychus evansi* Baker & Pritchard (Acari, Tetranychidae) sobre Arachis prostrata Benth (Fabaceae) no campus da UNESP de São José do Rio Preto, Estado de São Paulo. Resumos do 13° Coloquio de Incentivo à Pesquisa, IBILCE, UNESP, Pesquisa: 42.

Ferragut F & Escudero LA (1999). *Tetranychus* evansi Baker & Pritchard (Acari, Tetranychidae), a new red spider mite in Spanish horticultural production. *Boletin de Sanidad Vegetal, Plagas,* 25 (2): 157-164 (In Spanish).

Fiaboe KKM, Gondim MGC Jr., Moraes GJ, de Ogol CKPO & Knapp M (2007). Surveys for natural enemies of the tomato red spider mite *Tetranychus evansi* (Acari: Tetranychidae) in northeastern and southeastern Brazil. Zootaxa, **1395:** 33-58.

Gillet JL, HansPetersen HN, Leppla NC & Thomas DD (2006) Grower's IPM guide for Florida Tomato and Pepper Production http://ipm.ifas.ufl.edu/resources/success_stories/T&PGuide/index.shtml [last accessed 2008-01-28]

Gutierrez J & Etienne J (1986). Les Tetranychidae de l'île de la Réunion et quelques-uns de leurs prédateurs. *Agronomie Tropicale,* **41 (1)**: 84-91.

Ho CC, Wang SC & Chien YL (2004). *Field* observation on 2 newly recorded spider mites in Taiwan. *Plant Protection Bulletin*, **47:** 391-402.

Jeppson LR, Keifer HH, Baker EW (1975) In: Mites injurious to economic plants, pp. 223-224. Bishen Singh Mahendra Pal Singh India (in arrangement with University of California Press, Berkeley, Etats-Unis).

Knapp M, Wagener B & Navajas M (2003). Molecular discrimination between the spider mite Tetranychus evansi Baker & Pritchard, an important pest of tomatoes in southern Africa, and the closely related species T. urticae Koch (Acarina: Tetranychidae). *African Entomology*, **11 (2):** 300-304.

Krainacker DA & Carey JR (1990). Ambulatory dispersal and life history response to food deprivation in twospotted spider mites. *Entomologia Experimentalis et Applicata* **56(2):** 139-144.

Leite GLD, Picanco M, Zanuncio J C & Marquini F (2003). Factors affecting mite herbivory on eggplants in Brazil. *Experimental and Applied Acarology*, **31 (3/4)**: 243-252.

Migeon A (2005). Un nouvel acarien ravageur en France: *Tetranychus evansi* Baker et Pritchard. *Phytoma - La Défense des Végétaux*, **579**: 38-43

Migeon A (2007). Acarien rouge de la tomate: nouvelles observations et perspectives. *PHM Revue Horticole*, **488**: 20-24.

Migeon, A. & F. Dorkeld (2007) Spider mites web. *http://www.montpellier.inra.fr/CBGP/spmweb*.

Moraes GJ de, McMurtry JA 1987a. Effect of temperature and sperm supply on the reproductive potential of *Tetranychus evansi* Acari Tetranychidae. *Experimental and Applied Acarology* **3** (2), 95-108.

Moraes, G J de & Lima HC (1983) Biology of *Euseius concordis* (Chant) (Acarina: Phytoseiidae) a predator of the tomato russet mite. *Acarologia*, 24 (3): 251-255

Moraes, G. J. d. and J. A. McMurtry (1987). Effect of temperature and sperm supply on the reproductive potential of *Tetranychus evansi* (Acari: Tetranychidae). *Experimental & Applied Acarology* **3**(2): 95-107.

Moutia LA (1958). *Contribution to* the study of some phytophagous Acarina and their predators in Mauritius. *Bulletin of Entomological Research,* **49**: 59-75.

Oatman, E. R., C. A. Fleschner and J. A. McMurtry (1967). New, highly destructive spider mite present in Southern California. *Journal of Economic Entomology* **60**(2): 477-480.

Ohashi, K, Y. Kotsubo and A. Takafuji (2003). Distribution and overwintering ecology of *Tetranychus takafujii* (Acari: Tetranychidae), a species found from Kinki district, Japan. *Journal of the Acarological Society of Japan* **12**(2): 107-113.

Qureshi SA, Oatman ER & Fleschner CA (1969). Biology of the spider mite, *Tetranychus evansi*. Annals *of the Entomological Society of America*, **62 (4):** 898-903.

Qureshi, S. A., E. R. Oatman and C. A. Fleschner (1969). Biology of the spider mite, *Tetranychus evansi*. *Annals of the Entomological Society of America* **62**(4): 898-903.

Silva P (1954). A new acari harmful to tomato in Bahia. *Boletim do Instituto Biologica da Bahia*, **1 (1):** 1-20.

Tuttle D M, Baker EW & Sales F M (1977) Spider mites (Tetranychidae: Acarina) of the state of Ceara, Brazil*. International Journal of Acarology*, **3 (1):** 1-8.

Wene GP (1956). *Tetranychus marianae* McG., a new pest of tomatoes. *Journal of Economic Entomology*, **49 (5):** 712.\

Yaninek JS (1988) Continental dispersal of the cassava green mite, an exotic pest in Africa, and implications for biological control. *Experimental and Applied Acarology* **4:** 211-224

DISEASE CAUSING PATHOGEN: FUNGI

Pest-15:	Phytophthora root rot: *Phytophthora megasperma*

5.3.15.1 Hazard Identification

Scientific Name: *Phytophthora megasperma* Drechsler

Synonyms: *Phytophthora fragariae* var. *fragariae*
Phytophthora fragariae var. *rubi*

Common names: Phytophthora root rot
Red core disease
Red stele disease

Taxonomic tree

Domain: Eukaryota
Phylum: Heterokontophyta
Class: Oomycetes
Order: Pythiales
Family: Pythiaceae
Genus: *Phytophthora*
Species: *Phytophthora megasperma*

EPPO Code: PHYTDR

Bangladesh status: Not present in Bangladesh [CABI, 2006]

5.3.15.2 Biology

The fungus survives in crop debris in the soil, principally as oospores. Oospores germinate and form sporangia especially in spring. The temperature optima for oospore germination and production, determined in laboratory experiments, are 27°C and 18-23°C, respectively (Schechter & Gray, 1987). After flooding or heavy rainfall, sporangia release zoospores.

Zoospores, moving in soil water on crop residues, are attracted by host roots, encyst, germinate and penetrate the roots without forming an appressorium (Odermatt et al., 1988).

Lateral roots are destroyed and the whole plant may be killed at the seedling stage. Older plants are attacked more slowly, the fungus spreading gradually from the taproot up the stem to the lower branches. Leaves may be infected directly from soil splashed onto their surface. Pods and seeds are not normally infected, although the fungus has been reported from seeds.

The disease is favoured by high soil moisture and rainfall, and is most severe on heavy soils. Tightly compacted soil also increases the incidence of P. megasperma f.sp. glycines (Moots et al., 1988). Most root damage occurs under cool conditions (15°C). Under warm, dry conditions, plants recover by replacing the lateral roots destroyed by the fungus.

5.3.15.3 Hosts

Phytophthora megasperma has been recorded to attack multiple species in multiple families including: Liliaceae (asparagus), Brassicaceae (cabbage, cauliflower), Apiaceae (carrot), Solanaceae (tomato, potato, eggplant), Rosaceae (apple, apricot, cherry, plum, peach, strawberry and rose), Rutaceae (lemon, grape fruit), Asteraceae (sunflower), Poaceae (rice, sugar cane), Sterculiaceae (cacao), **Cucurbitaceae (cucumber)**, Caryophyllaceae (carnation, *Dianthus caryophyllus*), Lauraceae (avocado) Malvaceae (hollyhock, *Alcea rosea*) (CABI, 2006).

5.3.15.4 Distribution

Phytophthora megasperma is found in Australia, New Zealand, United States, France, Greece, Ireland, Italy, Spain, United Kingdom, Scotland. **Asia:** *P. megasperma* widespread in Japan, Philippines. (http://zipcodezoo.com/Chromista/ P/Phytophthora_medicaginis.asp, (CABI, 2006).

5.3.15.5 Hazard Identification Conclusion

Considering the facts that *Phytophthora megasperma* -

- is not known to be present in Bangladesh.
- is potentially economic important to Bangladesh because it is an important pest of cucurbits in Asia including Japan from where flowers are imported to Bangladesh.
- There is no evidence that *Phytophthora megasperma* is seed borne (Richardson, 1979). It can be introduced in diseased nursery stock, so nursery hygiene is essential. Zoospores can be passively spread long distances in irrigation water, or in drainage ditches (Ribeiro and Linderman, 1991).
- *Phytophthora megasperma* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.15.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-15.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. This pest has established in several new countries in recent years?-Yes • This disease is widely established in Japan and Philippines. P. megasperma f.sp. glycines was formerly considered to be an A1	**YES and High**

Description	Establishment Potential
quarantine pest for EPPO (OEPP/EPPO, 1989), but was transferred to the EPPO A2 list in 1992 due to its recent appearance within the EPPO region. There is every reason to suppose that it could establish itself widely and cause losses in the Euro-Mediterranean region. **b. Posibility of survival during transport, storage and transfer of this pest? Yes** • The fungus survives in crop debris in the soil, principally as oospores (Schechter & Gray, 1987). After flooding or heavy rainfall, sporangia release zoospores. Zoospores, moving in soil water on crop residues, are attracted by host roots, encyst, germinate and penetrate the roots without forming an appressorium (Odermatt et al., 1988). • Lateral roots are destroyed and the whole plant may be killed at the seedling stage. Older plants are attacked more slowly, the fungus spreading gradually from the taproot up the stem to the lower branches. Leaves may be infected directly from soil splashed onto their surface. Fruits and seeds are not normally infected, although the fungus has been reported from seeds (Moots et al., 1988). Most root damage occurs under cool conditions (15°C). Therefore, the oospores can also survive during transportation of plants or seeds. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? Yes** • The natural spread of the pathogen is very slow and over extremely short distances. The main path of distribution is by means of infected cuttings which may be obtained from infected but symptomless mother plants. • By itself, the fungus has low dispersal potential. It is liable to be moved as oospores in debris accompanying seeds, or possibly in seeds. Bangladesh imports flower seeds from many flower exporting countries including Japan. Therefore, seed transmission appears to be of high significance in Bangladesh; it may be supposed that the risk is virtually high with low-quality seed. Theoretically, the fungus might be introduced with soil from infested fields. **d. Are the host(s) of this pest fairly common in Bangladesh and the climate is similar to places it established? - Yes** • *Phytophthora megasperma* has been recorded to attack multiple species in multiple families including: Solanaceae (tomato, potato, eggplant), Brassicaceae (cabbage, cauliflower), Liliaceae (asparagus), Apiaceae (carrot), Rutaceae (lemon, grape fruit), Asteraceae (sunflower), Poaceae (rice, sugar cane), Sterculiaceae (cacao), Cucurbitaceae (cucumber), Caryophyllaceae (carnation, *Dianthus caryophyllus*), Lauraceae (avocado) Malvaceae (hollyhock, *Alcea rosea*), Rosaceae (apple, apricot, cherry, plum, peach, strawberry and rose) (CABI, 2006). Many of these hosts are fairly common in Bangladesh. • The fungus survives in crop debris in the soil, principally as oospores. Oospores germinate and form sporangia especially in spring. The temperature optima for oospore germination and production, determined in laboratory experiments, are 27°C and 18-23°C,	

Description	Establishment Potential
respectively (Schechter & Gray, 1987). After flooding or heavy rainfall, sporangia release zoospores. Zoospores, moving in soil water on crop residues, are attracted by host roots, encyst, germinate and penetrate the roots without forming an appressorium (Odermatt et al., 1988). • These climatic requirements for proper growth and development of this fungus also more or less similar with the climatic conditions 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

5.3.15.7 Determine the Consequence establishment of this pest in Bangladesh

Table 15.2 – Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? Yes • In the USA, *P. megasperma* f.sp. *glycines* causes severe losses of soyabean plants (Schmitthenner, 1989). Yield losses may reach 50% in susceptible cultivars. The disease can be avoided by planting in well drained fertile soils under warm conditions. Oospores survive for long periods in the soil, so sites where the disease has occurred should preferably be avoided. • This is a fairly serious pest of several important cucurbits and cut flowers and other crops for Bangladesh. **b. Economic impact and yield loss** • Generally, *Phytophthora megasperma* is one of the less aggressive species of Phytophthora, and causes debilitation rather than substantial plant death (CABI, 2006). **c. Environment Impact** • Soil water management techniques, particularly those that minimize prolonged periods of flooding (Wilcox and Mircetich, 1985b), are regarded as one of the most effective ways of managing all diseases caused by *P. megasperma*. • The Oomycete-active fungicides have the capacity to slow disease development, but they will not eradicate *P. megasperma* from the soil.	**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

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

Establishment Potential X Consequence Potential = Risk

Table-15.3: Calculation of risk rating

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

Calculated Risk Rating **- High**

5.3.15.9 Phytosanitary Measures

- Only good-quality clean seed should be imported (OEPP/EPPO, 1990).
- Normal precautions taken against truly seed borne pathogens of soyabeans should be more than adequate to protect against the low risk of introduction with soil.

5.3.15.10 References

CABI (2006). Crop Protection Compendium, 2006 Edition. CAB International, Wallingford, UK.

EPPO/CABI (1992) *Phytophthora megasperma* f.sp. *glycinea*. In: Quarantine pests for Europe (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Harris, K.M.). CAB International, Wallingford, UK.

EPPO/CABI (1992) *Phytophthora megasperma* f.sp. *glycinea*. In: Quarantine pests for Europe (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Harris, K.M.). CAB International, Wallingford, UK.

Moots, C.K.; Nickell, C.D.; Gray, L.E. (1988) Effects of soil compaction on the incidence of *Phytophthora megasperma* f.sp. *glycinea* in soybean. Plant Disease 72, 896-900.

Odermatt, M.; Rothlisberger, A.; Werner, C.; Hohl, H.R. (1988) Interactions between agarose-embedded plant protoplasts and germ tubes of Phytophthora. Physiological and Molecular Plant Pathology 33, 209-220.

OEPP/EPPO (1989) Data sheets on quarantine organisms No. 169, *Phialophora gregata*. Bulletin OEPP/EPPO Bulletin 19, 699-702.

OEPP/EPPO (1990) Specific quarantine requirements. EPPO Technical Document No. 1008.

Schechter, S.E.; Gray, L.E. (1987) Oospore germination in *Phytophthora megasperma* f.sp. *glycinea*. Canadian Journal of Botany 65, 1465-1467.

DISEASE CAUSING PATHOGEN: BACTERIA

Pest-16:	Cucurbit bacterial wilt*: Erwinia tracheiphila* (Smith 1895)

5.3.16.1 Hazard Identification

Scientific Name: *Erwinia tracheiphila* (Smith 1895)

Synonyms: *Bacillus tracheiphilus* Smith 1895
Bacillus tracheiphilus f.sp. *cucumis*

Bacterium tracheiphilum (Smith) Chester 1897
Erwinia amylovora var. *tracheiphila* (Smith) Dye 1968

Common names: Cucurbit bacterial wilt
bacterial wilt of cucurbits;
bacterial: cucurbits wilt;
cucurbit vascular wilt

Taxonomic tree

Domain: Bacteria
Phylum: Proteobacteria
Class: Gammaproteobacteria
Order: Enterobacteriales
Family: Enterobacteriaceae
Genus: *Erwinia*
Species: *Erwinia tracheiphila*

EPPO Code: ERWITR (*Erwinia tracheiphila*)

Bangladesh status: Not present in Bangladesh [CABI, 2016; CABI, 2007]

5.3.16.2 Biology

In early spring, cucumber beetles feed on plants that store *E. tracheiphila* over winter, acquire the pathogen, and then are able to contaminate cucurbit plants. The cucumber beetles feed on cucurbit leaves, injuring them in the process, and deposit contaminated feces on the wounds left behind. The bacteria enter the plant's xylem vessels by swimming through the sap at the wounds, multiply, and spread to all parts of the plant. As the bacteria multiply in the xylem, the efficiency of the water conducting system of the plant is reduced. Infected stems provide less than one-fifth the normal water flow, indicating that extensive plugging of the vessels may be the primary cause of wilting (Agrios, 1978).

Infections take place only when a film of water is present which provides the pathogen the means to reach a wound and move into the xylem vessels. Wilt symptoms appear 6 to 7 days after infection and the plant is usually completely wilted by the fifteenth day. The bacteria in infected plants die within one or two months after the plant dries up (Agrios, 1978).

Some cucurbit and non-cucurbit plants may be infected by *E. tracheiphila* but do not become diseased. Watterson et al. (1971) inoculated watermelon plants with *E. tracheiphila* when they were at the 10-leaf stage. Inoculated leaves wilted then dried up, as did the petioles, but no other symptoms were seen. "One to two weeks later, a vascular browning and longitudinal stem cracks appeared in the first or second internodes above the inoculated leaf. Cankers oozing slime occurred at the internode below the inoculated leaf. Isolations made from this region indicated that there were approximately 106 bacteria/cm stem sections. Normally, these infected plants produced numerous symptomless runners below the point of inoculation, thus allowing the plant to outgrow the disease. A few plants which failed to produce vigorous runners below the cankers died." *E. tracheiphila* has not been reported to infect watermelon naturally (Rand and Enlows, 1920; Watterson et. al., 1971).

5.3.16.3 Hosts

The preferred hosts of *E. tracheiphila* are in the cucurbit family (wild and cultivated species), of which cucumbers are "the most susceptible host, followed by **muskmelon, squash, and pumpkin**" (Agrios, 1978). Watermelon, however, is extremely resistant to bacterial wilt. Watterson et al. (1971) tested 14 watermelon cultivars and found that each was susceptible to the pathogen when the plants were at the 1-leaf stage, but plants inoculated at the 10-leaf stage exhibited no bacterial wilt symptoms, although isolations of these plants indicated that the bacteria were still present.

E. tracheiphila is reported to attack non-cucurbit hosts, i.e., corn (Bach, 1980), but apparently with no significant losses. Golden rod (*Solidago nemoralis* Ait. and *A. altissima* L.) and johnson grass (*Sorghum halepense* L.) are believed to host *E. tracheiphila* over winter, though these hosts do not show symptoms of bacterial wilt (Bassi, 1982; Staub and Peterson, 1986).

5.3.16.4 Distribution

E. tracheiphila is found throughout the United States, although it is most severe in the East. It also occurs in USA, central and northern Europe, South Africa, and Asia includes China, Japan, Thailand, Taiwan, Korea, Iran, Iraq (CABI, 2007).

5.3.16.5 Hazard Identification Conclusion

Considering the facts that *Erwinia tracheiphila* -

- is not known to be present in Bangladesh.
- is potentially economic important to Bangladesh because it is an important bacterial disease of cucurbits in Asia including Japan, Thailand, China, Taiwan from where the cucurbits are imported to Bangladesh.

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

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

Table-16.1: Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. This pest has established in several new countries in recent years?-Yes • This disease is widely established in China, Japan, Thailand, Taiwan etc. **b. Posibility of survival during transport, storage and transfer?-Yes** • The cucumber beetles feed on cucurbit leaves, injuring them in the process, and deposit bacterium (*E. tracheiphila*) contaminated feces on the wounds left behind. The bacteria enter the plant's xylem vessels by swimming through the sap at the wounds, multiply, and spread to all parts of the plant (Agrios, 1978). • *E. tracheiphila* is known to invade squash and cause internal spoilage (slime) during storage. The fruit rots internally with little or no outside appearance. After several months in storage the exterior surface may show dark spots or blotches which coalesce and enlarge. In addition, infected squash become prime targets for invasion by soft-rot microorganisms (Agrios, 1978). • Bacterial wilt is spread by striped cucumber beetles (*Acalymma vittata*) and spotted cucumber beetles (*Diabrotica undecimpunctata*). The bacterium survives in their intestines. The beetles are responsible for the dissemination and inoculation of the pathogen. • Therefore, it evidenced that the bacteria can survive during transport,	**YES and HIGH**

storage and transfer of cucurbits from exporting countries to Bangladesh **c. Does the pathway appear good for this pest to enter Bangladesh and establish? Yes** • The plants and parts of plants including fruits infected with *E. tracheiphila* is known to good pathways for this pest to enter into Banlgadesh and establish it. • On the other hand, the striped cucumber beetles (*Acalymma vittata*) and spotted cucumber beetles (*Diabrotica undecimpunctata*) contaminated with *E. tracheiphila* bacterium also good pathways. Because, the bacterium survives in their intestines. The beetles are responsible for the dissemination and inoculation of the pathogen. • Each contaminated beetle can infect at least three or four healthy plants after one feeding on a wilted plant, although some beetles are capable of spreading infection for more than three weeks after one wilt feeding (Agrios, 1978). Bacterial wilt has long been thought to overwinter in adult beetles, though it is now believed to overwinter in symptomless plants of golden rod (*Solidago nemoralis* Ait. and *S. altissima* L.) and Johnson grass (*Sorghum halepense* L.). It is possible that other perennials are sources of primary inoculum also. (Bassi, 1982; Staub and Peterson, 1986). **c. Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established - Yes** • The preferred hosts of *E. tracheiphila* are in the cucurbit family, of which cucumbers are "the most susceptible host, followed by muskmelon, squash, and pumpkin" (Agrios, 1978). These hosts are fairly common in Bangladesh. • Weather conditions have an indirect effect on the disease. Environmental conditions which favor the over-wintering, feeding, and reproduction of the cucumber beetles will affect the prevalence of bacterial wilt. A year with a good winter snow cover followed by a warm March and April could be expected to increase the number of beetles and therefore increase the incidence of bacterial wilt. • The hosts of *E. tracheiphila* are common in Bangladesh and climatic condition of Bangladesh also favorable for this disease as well.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway 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

5.3.16.7 Determine the Consequence establishment of this pest in Bangladesh

Table-15.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? Yes • In the USA, *P. megasperma* f.sp. *glycines* causes severe losses of	

Description	Consequence potential
soyabean plants (Schmitthenner, 1989). Yield losses may reach 50% in susceptible cultivars. The disease can be avoided by planting in well drained fertile soils under warm conditions. Oospores survive for long periods in the soil, so sites where the disease has occurred should preferably be avoided. • This is a fairly serious pest of several important cucurbits and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • In early spring, cucumber beetles feed on plants that store *E. tracheiphila* over winter, acquire the pathogen, and then are able to contaminate cucurbit plants. The cucumber beetles feed on cucurbit leaves, injuring them in the process, and deposit contaminated feces on the wounds left behind. The bacteria enter the plant's xylem vessels by swimming through the sap at the wounds, multiply, and spread to all parts of the plant. • As the bacteria multiply in the xylem, the efficiency of the water conducting system of the plant is reduced. Infected stems provide less than one-fifth the normal water flow, indicating that extensive plugging of the vessels may be the primary cause of wilting (Agrios, 1978). Wilt symptoms appear 6 to 7 days after infection and the plant is usually completely wilted by the fifteenth day (Agrios, 1978). *E. tracheiphila* is reported to attack non-cucurbit hosts, i.e., corn (Bach, 1980), but apparently with no significant losses. **c. Environmental Impact** • As the bacteria is difficult to control using chemical pesticides, but its vector cucumber beetles can be controlled using insecticides. Thus, the introduction of this bacteria and its vector insect pest would stimulate the use of insecticides in the field. Therefore, the establishment of this pest could trigger chemical control programs by using different chemical pescticides that are toxic and harmful to the soil and environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-16.3: Calculation of risk rating

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

Calculated Risk Rating **- High**

5.3.16.9. Possibble Management Options

- Only good-quality clean seed should be imported (OEPP/EPPO, 1990).
- Cucumber and muskmelon are two cucurbit species that often fall to bacterial wilt. While there are some "less susceptible" varieties available, efforts to develop resistant varieties that provide adequate fruit are continuous.
- Squash rot can be avoided only in fruit from healthy plants by storing it in a clean, fumigated warehouse (Agrios, 1978).
- Bacterial wilt of cucurbits is controlled mostly by controlling the cucumber beetles with insecticides. However, recommended insecticides are often toxic to pollinators and should not be applied during pollination. In addition, beetles should be controlled early in order to limit multiplication and spread of the pathogen (Agrios, 1978; Staub and Peterson, 1986). Agrios (1978) lists carbaryl (Sevin), methoxychlor, and rotenone as likely insecticides.

5.3.16.10 References

CABI (2016). Dhata sheet on *Erwinia tracheiphila* (cucurbit bacterial wilt), CAB International, Wallingford, UK.

CABI (2007). Crop Protection Compendium, 2006 Edition. CAB International, Wallingford, UK.

Agrios, G.N. 1978. Plant Pathology, 2nd ed. pp.466-470.

Bach, C.E. 1980. Effects of plant diversity and time of colonization on an herbivore-plant interaction. Oecologia 44:319-326.

Bassi, A. 1982. The overwintering nature of *Erwinia tracheiphila* (Smith) and resistance to bacterial wilt in cucumber. PhD Diss. Univ. of Arkansas, Fayetteville.

MacNab, A.A., A.F. Sherf, and J.K. Springer. 1983. Identifying Diseases of Vegetables. The Pennsylvania State University.

Rand, F.V., and E.M.A. Enlows. 1920. Bacterial wilt of cucurbits. U.S. Dept. of Agr. Bull. 828. 43 pp.

Reed, G.L., and W.R. Stevenson. 1985. Bacterial wilt resistance in commercial muskmelon cultivars. Indiana Academy of Science 94:131-140.

Staub, J.E., and C.E. Peterson. 1986. Comparisons between bacterial wilt resistant and susceptible gynoecious cucumber lines and F1 progeny. HortScience 21:1428-1430.

Watterson, J.C., P.H. Williams, and R.D. Durbin. 1971. Response of cucurbits to *Erwinia tracheiphila.* Plant Disease Reporter 55:816-819.

Bassi A, 1982. The overwintering nature of Erwinia tracheiphila (Smith) and resistance to bacterial wilt in cucumber. PhD thesis. Fayetteville, USA: University of Arkansas.

Blancard D, Lecoq H, Pitrat M, 1994. A Colour Atlas of Cucurbit Diseases: observation, identification and control. London, UK: Manson Publishing Ltd.

Bradbury JF, 1970. Erwinia tracheiphila. CMI descriptions of Plant Pathogenic Fungi and Bacteria, No. 233. Wallingford, UK: CAB International.

Bradbury JF, 1986. Guide to Plant Pathogenic Bacteria. Wallingford, UK: CAB International.

Brust GE, 1997. Differential susceptibility of pumpkins to bacterial wilt related to plant growth stage and cultivar. Crop Protection, 16(5):411-414; 10 ref.

Brust GE, 1997. Seasonal variation in percentage of striped cucumber beetles (Coleoptera: Chrysomelidae) that vector Erwinia tracheiphila. Environmental Entomology, 26(3):580-584; 12 ref.

Brust GE, Foster RE, 1995. Semiochemical-based toxic baits for control of striped cucumber beetle (Coleoptera: Chrysomelidae) in cantaloupe. Journal of Economic Entomology, 88(1):112-116

Brust GE, Foster RE, 1999. New economic threshold for striped cucumber beetle (Coleoptera: Chrysomelidae) in cantaloupe in the midwest. Journal of Economic Entomology, 92(4):936-940; 16 ref.

Brust GE, Foster RE, Buhler WG, 1996. Comparison of insecticide use programs for managing the striped cucumber beetle (Coleoptera: Chrysomelidae) in muskmelon. Journal of Economic Entomology, 89(4):981-986; 14 ref.

Brust GE, Rane KK, 1995. Differential occurrence of bacterial wilt in muskmelon due to preferential striped cucumber beetle feeding. HortScience, 30(5):1043-1045

Burkholder WH, 1960. Some observations on Erwinia tracheiphila, the causal agent of the cucurbit wilt. Phytopathology, 50:179-180.

Dehghani M, Nasseri S, Amin S, Naddafee K, Taghavi M, Yunesian M, Maleky N, 2007. Isolation and identification of atrazine-degrading bacteria from corn field soil in Fars province of Iran. Pakistan Journal of Biological Sciences, 10(1):84-89. http://www.ansinet.org/pjbs

Dickey RS, Lelliott RA, 1984. Genus VII Erwinia. In: Krieg NR, Hold JG, eds. Bergey's Manual of Systematic Bacteriology, Volume 1. Baltimore, USA: Williams and Wilkins.

Fleischer SJ, Kirk D, 1994. Kairomonal baits: effect on acquisition of a feeding indicator by Diabroticite vectors in cucurbits. Environmental Entomology, 23(5):1138-1149

Fleischer SJ, Orzolek MD, Mackiewicz Dde, Otjen L, 1998. Imidacloprid effects on Acalymma vittata (Coleoptera: Chrysomelidae) and bacterial wilt in cantaloupe. Journal of Economic Entomology, 91(4):940-949; 23 ref.

Foster RE, 1994. Insect management strategies. In: Foster RE, ed. Midwest vegetable production guide for commercial growers. Purdue University Cooperative Extension Service Publication ID-45. Lafayett, USA: Purdue University, 13-15.

Harrison MD, Brewer JW, Merril LD, 1980. Insect involvement in the transmission of bacterial pathogens. In: Harris KF, Maramorosch K, eds. Vectors of plant pathogens. New York, USA: Academic Press, 201-292.

Hauben L, Moore ERB, Vauterin L, Steenakers M, Mergaert J, Verdonck L, Swings J, 1998. Phylogenetic position of phytopathogens within the Enterobacteriaceae. Systematic and Applied Microbiology 21:384-397.

Latin R, 1993. Diseases and Pests of Muskmelons and Watermelons. W. Lafayette, USA: Purdue University Cooperative Extension Service.

Leach JG, 1964. Observations on cucumber beetles as vectors of cucurbit wilt. Phytopathology, 54:606-607.

Mackiewicz Dde, Gildow FE, Blua M, Fleischer SJ, Lukezic FL, 1998. Herbaceous weeds are not ecologically important reservoirs of Erwinia tracheiphila. Plant Disease, 82(5):521-529; 36 ref.

Necibi S, Barrett BA, Johnson JW, 1992. Effects of a black plastic mulch on the soil and plant dispersal of cucumber beetles, Acalymma vittatum (F.) and Diabrotica undecimpunctata howardi Barber (Coleoptera: Chrysomelidae) on melons. Journal of Agricultural Entomology, 9(2):129-135

Pair SD, 1997. Evaluation of systemically treated squash trap plants and attracticidal baits for early-season control of striped and spotted cucumber beetles (Coleoptera: Chrysomelidae) and squash bug (Hemiptera: Coreidae) in cucurbit crops. Journal of Economic Entomology, 90(5):1307-1314; 21 ref.

Rand FV, 1915. Dissemination of bacterial wilt of cucurbits. Journal of Agronomic Research, 5:257-260.

Rand FV, Cash CC, 1920. Some insect relations of Bacillus tracheiphilus, Erw. Sm. Phytopathology, 10:133-140.

Rand FV, Enlows EMA, 1920. Bacterial wilt of cucurbits. USDA Bull. No. 828.

Raupach GS, Kloepper JW, 1998. Mixtures of plant growth-promoting rhizobacteria enhance biological control of multiple cucumber pathogens. Phytopathology, 88(11):1158-1164; 47 ref.

Reed DK, Reed GL, Creighton CS, 1986. Introduction of entomogenous nematodes into trickle irrigation systems to control striped cucumber beetle (Coleoptera: Chrysomelidae). Journal of Economic Entomology, 79(5):1330-1333

Sanogo S, Etarock BF, Clary M, 2011. First report of bacterial wilt caused by Erwinia tracheiphila on pumpkin and watermelon in New Mexico. Plant Disease, 95(12):1583. http://apsjournals.apsnet.org/loi/pdis

Sherf AF, MacNab AA, 1986. Cucurbits. In: Sherf AF, MacNab AA, eds. Vegetable diseases and their control. New York, USA: Wiley, 307-311.

Walker JC, 1952. Diseases of Vegetable Crops. New York, USA: McGraw-Hill Book Company, Inc.

Watterson JC, Williams PH, Durbin RD, 1971. Response of cucurbits to Erwinia tracheiphila. Plant Disease Reporter, 55:816-819.

Yardim EN, Arancon NQ, Edwards CA, Oliver TJ, Byrne RJ, 2006. Suppression of tomato hornworm (Manduca quinquemaculata) and cucumber beetles (Acalymma vittatum and Diabotrica undecimpunctata) populations and damage by vermicomposts. Pedobiologia, 50(1):23-29.

Zehnder G, Kloepper J, Tuzun S, Yao C, Wei G, Chambliss O, Shelby R, 1997. Insect feeding on cucumber mediatd by rhizobacteria-inducd plant resistance. Entomologia Experimentalis et Applicata, 83:81-85.

Zehnder G, Kloepper J, Yao C, Wei G, 1997. Induction of systemic resistance in cucumber against cucumber beetles (Coleoptera: Chrysomelidae) by plant growth-promoting rhizobacteria. Journal of Economic Entomology, 90:391-396.

Zehnder GW, Yao ChangBin, Wei Gang, Kloepper JW, 2000. Influence of methyl bromide fumigation on microbe-induced resistance in cucumber. Biocontrol Science and Technology, 10(5):687-693.

Pest-17:	**Bacterial fruit blotch: *Acidovorax citrulli (*Schaad *et al.)* Schaad *et al.***

5.3.17.1 Hazard Identification

Scientific Name: *Acidovorax citrulli (*Schaad *et al.)* Schaad *et al.*

Synonyms: *Acidovorax avenae* subsp. citrulli *(*Schaad *et al., 1978)* Willems *et al., 1992*

Pseudomonas avenae subsp. citrulli *(*Schaad *et al., 1978)* Hu *et al., 1991*

Pseudomonas pseudoalcaligenes subsp. citrulli Schaad *et al., 1978*

Common names: Fruit blotch;

Bacterial fruit blotch;
Seedling blight

Taxonomic tree

Domain: Bacteria
Phylum: Proteobacteria
Class: Betaproteobacteria
Order: Burkholderiales
Family: Comamonadaceae
Genus: *Acidovorax*
Species: *Acidovorax citrulli*

EPPO Code: PSDMAC.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2011; EPPO, 2014].

5.3.17.2. Biology

The fruit blotch bacterium may be introduced into a field from infested seed, infected transplants, contaminated volunteer crop cucurbits, or infected wild cucurbits. In the field, symptom development and spread of *A. avenae* subsp. *citrulli* on foliage and fruit is most rapid during periods when the weather is hot and humid, with thundershowers (Hopkins, 1993). These conditions are common during the summer. In addition to wind-driven rain, the bacterium can be spread by contact with farm workers, irrigation, and other cultivation equipment (D. Hopkins, University of Florida, USA, personal communication, 1997). The bacterium does not appear to spread as rapidly during cool, rainy weather. With favourable weather, a few primary infection sites in a field can result in infection of all plants by the time of harvest. Leaf lesions in the field do not result in defoliation, but are important reservoirs of bacteria for fruit infection. Under some environmental conditions, foliar symptoms may not be very conspicuous and the watermelon grower may not realize that there is a problem until fruit symptoms render the crop unmarketable.

A. citrulli is spread from leaf lesions to developing fruit by splash dispersal during rain or irrigation. Watermelon fruits are most vulnerable to bacterial infection 2 to 3 weeks after anthesis (Frankle *et al*., 1993). The bacterium invades the fruit through stomata on the fruit surface. Small, water-soaked lesions develop 3-7 days later. Mature watermelon fruit are covered with a wax layer that plugs stomata and prevents the entry of bacteria into the fruit. Once the wax layer forms, mature watermelons can be invaded by the bacterium only after wounding. Thus, the bacterium must invade the fruit seven days, or more, before maturity, but the symptoms continue to develop as long as the fruit is attached to the plant. Surface lesions cease to enlarge after harvest.

5.3.18.3. Hosts

- The most susceptible hosts are **watermelons (*Citrullus lanatus*)** and **melons (*Cucumis melo*)** which develop symptoms on fruit and leaves. Other cucurbits such as ***Cucumis sativus* (cucumber), *Cucurbita pepo* (squash),** and ***C. moschata*** only develop foliar symptoms. Wild cucurbits such as *Citrullus lanatus* var. *citroides*) can host *A. citrulli* and probably act as reservoirs for the bacterium. In artificial inoculation studies, solanaceous plant species (i.e. *Capsicum* spp., *Lycopersicon esculentum, Solanum melongena*) could develop foliar symptoms. There is also one record of the bacterium causing leaf blight on *Piper betle* (Piperaceae) in Taiwan.

- Citron (*Citrullus lanatus* var. citroides), a common weed in parts of the southern USA, is also a host for *A. citrulli*. Symptoms are produced on the foliage and fruit, and seed transmission occurs in this cucurbit weed, giving it the potential to serve as an alternate host to perpetuate the bacterium. A. citrulli has been distributed throughout the watermelon growing areas of the USA on contaminated seed, and probably in many other watermelon producing areas of the world (Latin and Hopkins, 1995). The bacterium was detected in the USA plant introduction collection several years before it appeared in commercial watermelon (Webb and Goth, 1965).

5.3.17.4. Distribution

EPPO region: Greece (first outbreaks in 2005), Hungary (first found in 2007 on watermelon crops in Southern Hungary), Israel (first outbreaks observed in 2000/2003 on melon and watermelon crops), Italy (1 outbreak was found in Emilia-Romagna in 2009 but eradicated in 2012 - another was found in Sardegna in 2010, still under eradication), Turkey (first found in 1995 in Edirne province (Marmara region) on watermelon crops, reported in 2005 in Adana Province (Mediterranean region)). In Israel, *A. citrulli* is a quarantine pest and in 2006, the NPPO declared that the disease was present only in a limited number of production sites and was under eradication (EPPO RS 2006/012). In Hungary, the disease was observed on 20-30 ha of watermelons in July 2007 during a hot summer period (mean maximum daytime temperature > 32°C). The source of infection could not be determined, but it was noted that grafted watermelon transplants had been imported from Turkey.

Asia: China (Anhui, Fujian, Gansu, Guangdong, Hainan, Hebei, Jilin, Neimenggu, Shandong, Xinjiang, Yunnan, Zhejiang), Japan (Honshu), Korea (Republic of), Taiwan, Thailand. There is an isolated record of *A. avenae* subsp. *citrulli* on *Paliurus spina-christi* (Rhamnaceae) from Iran.

North America: USA (Alabama, Arkansas, California, Delaware, Florida, Georgia, Iowa, Illinois, Indiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, Oregon, South Carolina, Texas). In a paper from Latin and Hopkins (1995), it is stated that that in some US states (Delaware, Iowa and Maryland) the disease was seen in 1989 but has not been found later on (at least until 1995, no more recent data could be found).

South America: Brazil (Ceará, Pernambuco, Minais Gerais, Rio Grande do Norte, Rio Grande doSul, Roraima).

Central America: Costa Rica. In Nicaragua, *A. citrulli* was reported on crops which had been grown from seeds imported from Costa Rica in 1997, but it was subsequently declared eradicated.

Oceania: Australia (Queensland), Guam, Northern Mariana Islands.

5.3.17.5. Hazard Identification Conclusion

Considering the facts that *Acidovorax citrulli* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 2014].
- is potentially economic important to Bangladesh because it is an important pest of cucurbits and other crops in Asia and other countries like China (Anhui, Fujian, Gansu, Guangdong, Hainan, Hebei, Jilin, Neimenggu, Shandong, Xinjiang, Yunnan, Zhejiang), Japan (Honshu), Korea (Republic of), Taiwan, Thailand, USA, Brazil, Australia (EPPO,

2014; CABI/EPPO, 2014) from where cucurbits vegetables and seeds are imported to Bangladesh.

- can become established in Bangladesh through imports of cucurbits vegetables and seed. It has capability to cause direct economic and ecological damage to many valuable cultivated crops, because Symptoms on fruits appear as dark olive green stain (or blotch) on the upper side of the fruit. Lesions usually become apparent shortly before fruit ripening. The epidermis of the rind can then rupture and frequently bacterial ooze is produced. On leaves, small dark brown, somewhat angular and water-soaked lesions can appear, but they are generally inconspicuous. On seedlings, water-soaked areas on the underside of cotyledons can be seen and lesions on the hypocotyl cause collapse of the emerging plants. Some seedlings may remain symptomless until fruit set. Over long distances, trade of infected seed lots or transplants of *Citrullus lanatus* and *Cucumis melo* is probably the most important pathway for spreading the disease.

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

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

Table-17.1: 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 Asian countries including China (Anhui, Fujian, Gansu, Guangdong, Hainan, Hebei, Jilin, Neimenggu, Shandong, Xinjiang, Yunnan and Zhejiang), Japan (Honshu), Korea (Republic of), Taiwan, Thailand. • Greece (first outbreaks in 2005), Hungary (first found in 2007 on watermelon crops in Southern Hungary), Israel (first outbreaks observed in 2000/2003 on melon and watermelon crops), Italy (1 outbreak was found in Emilia-Romagna in 2009 but eradicated in 2012 - another was found in Sardegna in 2010, still under eradication), Turkey (first found in 1995 in Edirne province (Marmara region) on watermelon crops, reported in 2005 in Adana Province (Mediterranean region)). In Israel, *A. citrulli* is a quarantine pest and in 2006, the NPPO declared that the disease was present only in a limited number of production sites and was under eradication (EPPO RS 2006/012). In Hungary, the disease was observed on 20-30 ha of watermelons in July 2007 during a hot summer period (mean maximum daytime temperature > 32°C). The source of infection could not be determined, but it was noted that grafted watermelon transplants had been imported from Turkey. **b. Posibility of survival during transport, storage and transfer?-Yes** • *A. citrulli* is spread from leaf lesions to developing fruit by splash dispersal during rain or irrigation. Watermelon fruits are most vulnerable to bacterial infection 2 to 3 weeks after anthesis (Frankle *et al*., 1993). The bacterium invades the fruit through stomata on the fruit surface. Mature watermelons can be invaded by the bacterium only after wounding.	**YES and HIGH**

b. **Does the pathway appear good for this pest to enter into Bangladesh and establish? - Yes,** • The fruit blotch bacterium may be introduced into a field from infested seed, infected transplants, contaminated volunteer crop cucurbits, or infected wild cucurbits. Therefore, the seeds, plants and fruits are the good pathways for this bacterium to enter into Bangladesh and establish. • *A. citrulli* was detected in watermelons grown in Tipitapa in Nicaragua in 1997 from contaminated seed (Munoz and Monterroso, 2002). In 2004 CABI was informed by the Ministerio Agropecuario y Forestal, Nicaragua, that the disease was eradicated and the pathogen had not been detected in subsequent plant and soil tests of the area. **c. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?- Yes** • The most susceptible hosts are watermelons (*Citrullus lanatus*) and melons (*Cucumis melo*) which develop symptoms on fruit and leaves. Other cucurbits such as *Cucumis sativus* (cucumber), *Cucurbita pepo* (squash), and *C. moschata* only develop foliar symptoms. Wild cucurbits such as *Citrullus lanatus* var. *citroides*) can host *A. citrulli* and probably act as reservoirs for the bacterium. In artificial inoculation studies, solanaceous plant species (i.e. *Capsicum* spp., *Lycopersicon esculentum*, *Solanum melongena*) could develop foliar symptoms. There is also one record of the bacterium causing leaf blight on Piper betle (Piperaceae) in Taiwan, among which mostly common in **Bangladesh**. • In the field, symptom development and spread of *A. avenae* subsp. *citrulli* on foliage and fruit is most rapid during periods when the weather is hot and humid, with thunder showers (Hopkins, 1993). These conditions are common during the summer. In addition to wind-driven rain, the bacterium can be spread by contact with farm workers, irrigation, and other cultivation equipment (D. Hopkins, University of Florida, USA, personal communication, 1997). The bacterium does not appear to spread as rapidly during cool, rainy weather. With favourable weather, a few primary infection sites in a field can result in infection of all plants by the time of harvest. Leaf lesions in the field do not result in defoliation, but are important reservoirs of bacteria for fruit infection. Under some environmental conditions, foliar symptoms may not be very conspicuous and the watermelon grower may not realize that there is a problem until fruit symptoms render the crop unmarketable. • These climatic requirements for growth and development of *Acidovorax citrulli* are more or less similar with the climatic condition of **Bangladesh**.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.3.17.7. Determine the Consequence establishment of this pest in Bangladesh

Table-17.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Symptoms on fruits appear as dark olive green stain (or blotch) on the upper side of the fruit. Lesions usually become apparent shortly before fruit ripening. The epidermis of the rind can then rupture and frequently bacterial ooze is produced. On leaves, small dark brown, somewhat angular and water-soaked lesions can appear, but they are generally inconspicuous. On seedlings, water-soaked areas on the underside of cotyledons can be seen and lesions on the hypocotyl cause collapse of the emerging plants. Some seedlings may remain symptomless until fruit set. Watermelon, cantaloupe and honeydew melons appear the most susceptible, with both foliar symptoms and blotch symptoms on the fruit (Isakeit et al., 1997). • In the spring of 1989 in the USA, bacterial fruit blotch of watermelon first occurred in commercial watermelon fields in Florida and, as the season progressed, the disease was observed in South Carolina, North Carolina, Maryland, Delaware, and Indiana (Somodi et al., 1991; Latin and Rane, 1990). In some fields, losses were more than 90% of the total marketable fruit. Since then, the disease also has been found in Alabama, Arkansas, California, Georgia, Iowa, Mississippi, Missouri, Oklahoma, Oregon and Texas. Bacterial fruit blotch of watermelon has continued to be a threat to the watermelon industry in the USA. In most years, the disease has occurred in relatively few fields but has been devastating in many of these, sometimes resulting in the loss of all marketable fruit. Losses to individual growers have been over $100,000 in many of these cases (D. Hopkins, University of Florida, USA, personal communication, 1997). Fruit blotch was prevalent in Georgia in 1992 and was especially widespread in 1994, causing losses in thousands of hectares distributed over at least 10 states. • This is a fairly serious pest of several important cucurbitaceous vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • In the USA, the disease usually occurs in relatively few fields but under favourable conditions (warm and wet weather) fruit losses of up to 90-100% have been observed in some commercial fields of watermelons. In Brazil, the disease is causing severe losses in the Nordeste (mainly Rio Grande do Norte and Ceará) on melon crops. In 2000, crop losses in Rio Grande do Norte were estimated at 40-50%, reaching 100% in some melon crops. In a survey carried out in 2001 in 18 melon fields, the disease was present in all fields with an incidence varying from 4% to 47%. **c. Environmental Impact** • Applications of copper-containing fungicides at the full recommended rates have reduced the incidence of fruit blotch symptoms when applications were initiated prior to fruit set (Hopkins, 1991; Hopkins, 1995). Thus, the introduction and establishment of this bacterium would stimulate the use of chemical pesticides in the field that are toxic and harmful to the soil and environment.	**Yes and High**

Description	Consequence potential
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-17.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.17.9. Risk Management Measures

- Applications of copper-containing fungicides at the full recommended rates have reduced the incidence of fruit blotch symptoms when applications were initiated prior to fruit set (Hopkins, 1991; Hopkins, 1995). If fruit blotch symptoms are observed, applications of copper-containing fungicides should begin at first flower, or earlier, and continue weekly until all fruit are mature. As a preventive treatment, biweekly applications of the full rate of copper or weekly applications at half the recommended rate of copper-containing fungicides may be used.
- Sticktly avoid importation of cucurbitaceous vegetables, seeds and planting material from those countries, where this pest is available.
- A phytosanitary certificate may be required for cucurbitaceous vegetables, seeds and planting material.

5.3.17.10. References

CABI/EPPO, 2011. *Acidovorax citrulli*. [Distribution map]. Distribution Maps of Plant Diseases, No.October. Wallingford, UK: CABI, Map 787 (Edition 2).

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Frankle WG, Hopkins DL, Stall RE, 1993. Ingress of the watermelon fruit blotch bacterium into fruit. Plant Disease, 77(11):1090-1092

Hopkins DL, 1993. Field spread of bacterial fruit blotch of watermelon. Phytopathology, 83:466.

Hu FP, Young JM, Triggs CM, 1991. Numerical analysis and determinative tests for nonfluorescent plant-pathogenic Pseudomonas spp. and genomic analysis and reclassification of species related to Pseudomonas avenae Manns 1909. International Journal of Systematic Bacteriology, 41(4):516-525

Latin RX, Hopkins D Isakeit T, Black MC, Barnes LW, Jones JB, 1997. First report of infection of honeydew with Acidovorax avenae subsp. citrulli. Plant Disease, 81(6):694; 1 ref. L, 1995. Bacterial fruit blotch of watermelon. The hypothetical exam question becomes reality. Plant Disease, 79(8):761-765

Munoz M, Monterroso D, 2002. Identification of Acidovorax avenae citrulli in watermelon seeds in Nicaragua. Manejo Integrado de Plagas y Agroecologi^acute~a, No.66:101-104; 1 ref.

Schaad NW, Sowell G Jr, Goth RW, Colwell RR, Webb RE, 1978. Pseudomonas pseudoalcaligenes subsp. citrulli subsp. nov. International Journal of Systematic Bacteriology, 28(1):117-125

Webb RE, Goth RW, 1965. A seedborne bacterium isolated from watermelon. Plant Disease Reporter, 49:818-821.

Willems A, Goor M, Thielemans S, Gillis M, Kersters K, Ley Jde, 1992. Transfer of several phytopathogenic Pseudomonas species to Acidovorax as Acidovorax avenae subsp. avenae subsp. nov., comb. nov., Acidovorax avenae subsp. citrulli, Acidovorax avenae subsp. cattleyae, and Acidovorax konjaci. International Journal of Systematic Bacteriology, 42(1):107-119.

DISEASE CAUSING PATHOGEN: NEMATODE

Pest-18:	**Sting nematode: *Belonolaimus longicaudatus* Rau, 1958**

5.3.18.1 Hazard Identification

Scientific Name: *Belonolaimus longicaudatus* Rau, 1958

Common name: Sting nematode

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Nematoda
Family: Belonolaimidae
Genus: *Belonolaimus*
Species: *Belonolaimus longicaudatus*

EPPO code: BELOLO

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2003].

5.3.18.2. Biology

B. longicaudatus is a migratory ectoparasite of plant roots. There are three juvenile stages in the soil; the first moult occurs within the egg. The life cycle takes about 28 days and the species is amphimictic. Although an ectoparasite, the exceptionally long spear allows the nematode to feed deep within the root tissue, causing severe damage to the host. The optimum temperature for reproduction is around 30ºC, but the nematode remains active and feeds at up to 39ºC. Light sandy soils are favoured and the nematode is absent in muck or marl soils.

The existence of physiological races has been demonstrated and these have differing host ranges (Smart and Nguyen, 1991). The presence of the nematode may overcome resistance to Fusarium wilt [*Fusarium oxysporum* f.sp. *vasinfectum*] in cotton leading to high crop losses in the field.

5.3.18.3. Hosts

B. longicaudatus has a wide host range including many grasses, crops and woody hosts. Differences in host range are reported between populations from various states in the USA (Smart and Nguyen, 1991).

a. Major hosts: The main host of *B. longicaudatus are Daucus carota (*carrot*), Helianthus annuus* (sunflower)*, Lactuca sativa* (lettuce)*, Brassica oleracea* (cabbages, cauliflowers)*, Ipomoea batatas* (sweet potato)*,* ***Citrullus lanatus* (watermelon)*, Cucumis melo* (melon)*, Cucumis sativus* (cucumber)***, Arachis hypogaea* (groundnut)*, Glycine max* (soyabean)*, Pisum sativum* (pea)*, Allium cepa* (onion)*, Abelmoschus esculentus* (okra)*, Triticum aestivum* (wheat)*, Zea mays* (maize)*, Solanum lycopersicum* (tomato)*, Solanum melongena* (aubergine)*, Solanum tuberosum* (potato) etc.

b. Minor hosts: The minor or other hosts of this pest include *Ligustrum sinennsis*, *Oriza* sp., *Phragmites australis*, *Ocimun basilicum*, and *Sapium sebiferum, Fragaria* (strawberry), *Citrus sinensis* (navel orange), *Capsicum annuum* (bell pepper) etc.

5.3.18.4. Distribution

B. longicaudatus is a major pest in southeastern USA and is widespread throughout the Atlantic coastal plain from Virginia to Florida. Outlier populations have been reported from Mexico and Central America. Reports from Bermuda, the Bahamas and Puerto Rico apparently refer to golf courses where infected turf was imported from the USA (Perry and Rhoades, 1982). Early reports of *B. gracilis* from southern USA almost certainly refer to *B. longicaudatus.*

Asia: Pakistan (Pathan *et al.*, 2004), Saudi Arabia (Abu-Gharbieh & Al-Azzeh, 2004), Turkey (Kepenekci, 2001).
North America: USA (Alabama, Arkansas, California, Delaware, Florida, Georgia, Illinois, Indiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas)(Mundo-Ocampo et al., 1994; Cherry et al., 1997; CABI/EPPO, 2003).
South and Central America: Bahamas, Costa Rica, Puerto Rico (Perry & Rhoades, 1982; CABI/EPPO, 2003).
Oceania: Absent.

EPPO: Absent.

5.3.18.5. Hazard Identification Conclusion

Considering the facts that *B. longicaudatus* -

- is not known to be present in Bangladesh [CABI/EPPO, 2003].
- is potentially economic important to Bangladesh because it is an important pest of various vegetables like Apiaceae, Asteraceae, Brassicaceae, **Cucurbitaceae**, Convolvulaceae, Fabaceae, Malvaceae, Poaceae, Solanaceaeous family in Worldwide including Pakistan, Saudi Arabia, Turkey, USA (CABI/EPPO, 2003) from where vegetables and planting matreials are imported to Bangladesh.
- *B. longicaudatus* feeds ectoparasitically near the root tip and along the root resulting in a reduced root system with stubby side branches and terminal galling. Dark lesions may appear on the outer root surface at the point of penetration. Above-ground symptoms include severe stunting, wilting in dry conditions, leaf chlorosis and, in severe cases, death of the plant. The main phytosanitary risk is probably via infected sods of turf exported for golf course establishment. *B. longicaudatus* may be extracted from soil and

turf using standard techniques. Because it is a relatively long nematode, centrifugation or immersion sieving methods should enhance recovery rates. The vegetables are imported from other countries through airfreight. Therefore, *B. longicaudatus* can easily enter in Bangladesh and establish.

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

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

Table-18.1: 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 has been established in many countries including Pakistan, Saudi Arabia, Turkey, USA (CABI/EPPO, 2003). But not established in many countries in recent years. **b. Posibility of survival during transport, storage and transfer?-Yes** • *B. longicaudatus* is a migratory ectoparasite of plant roots. The life cycle takes about 28 days and the species is amphimictic. Although an ectoparasite, the exceptionally long spear allows the nematode to feed deep within the root tissue, causing severe damage to the host. Therefore, this pest can survive during transport, storage and transfer of planting materials with roots and soils. **c. Does the pathway appear good for this pest to enter into Bangladesh and establish? - No** • *B. longicaudatus* is found in deep sandy soils where it is an ectoparasite of plant roots. In Virginia, USA, the sand content of infested soils ranged from 84 to 94% (Miller, 1972). The nematode is mainly confined to the top 30 cm of soil but may migrate vertically in response to temperature. • The main phytosanitary risk is probably via infected sods of turf exported for golf course establishment. Therefore, the less probability to enter this pest through seeds or fruits of the cucurbits into Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The host range of *B. longicaudatus* is very wide The main host of B. longicaudatus are *Daucus carota* (carrot), *Helianthus annuus* (sunflower), *Lactuca sativa* (lettuce), *Brassica oleracea* (cabbages, cauliflowers), *Ipomoea batatas* (sweet potato), ***Citrullus lanatus*** (watermelon), ***Cucumis melo*** (melon), ***Cucumis sativus*** (cucumber), *Arachis hypogaea* (groundnut), *Glycine max* (soyabean), *Pisum sativum* (pea), *Allium cepa* (onion), *Abelmoschus esculentus* (okra), *Triticum aestivum* (wheat), *Zea mays* (maize), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato). The numbers of plants attacked belong to the families are Apiaceae, Asteraceae, Brassicaceae, **Cucurbitaceae**, Convolvulaceae, Fabaceae, Malvaceae, Poaceae, Solanaceaeous. • The optimum temperature for reproduction is around 30ºC, but the nematode remains active and feeds at up to 39ºC. Light sandy soils are	HIGH

favoured and the nematode is absent in muck or marl soils. • The climatic requirements and hosts of *B. longicaudatus* are common in 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	**Yes and Low**

5.3.18.7. Determine the Consequence establishment of this pest in Bangladesh

Table-18.2: Which of these descriptions best fit of this pest?

Description	**Consequence potential**
a. Is this a serious pest of **Bangladesh? - Yes**. • *B. longicaudatus i*s a major pest in southeastern USA and is widespread throughout the Atlantic coastal plain from Virginia to Florida. • *B. longicaudatus* feeds ectoparasitically near the root tip and along the root resulting in a reduced root system with stubby side branches and terminal galling. Dark lesions may appear on the outer root surface at the point of penetration. Above-ground symptoms include severe stunting, wilting in dry conditions, leaf chlorosis and, in severe cases, death of the plant. • This is a fairly serious pest of several important vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • If introduced, this pest could lower the yield of several crops of economic importance and may cause plant mortality, but damages depend upon the type of crop and the growth stage affected. • *B. longicaudatus* can cause devastating losses to cotton, particularly when it occurs in association with Fusarium wilt [*Fusarium oxysporum* f.sp. *vasinfectum*]. It also causes severe losses to other crops including groundnut, soyabean, *Phaseolus vulgaris*, beet, crucifers, celery, okra, onion, pea, pepper, potato and maize and to forage and turf grasses, the latter being economically important in amenity grassland such as golf courses. **c. Environmental Impact** • Chemical treatment of soil using liquid or granular nematicides is usually highly effective due to the porous nature of the sandy soils that the nematode favours. But the application of chemical pesticides in the soils leads to soil and water pollutions. Thus, the introduction and establishment of this pest would stimulate the use of chemical pesticides in the field that are toxic and harmful to the soil and environment.	**Yes and High**
• Not as above or below	Moderate

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

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

Establishment Potential X Consequence Potential = Risk

Table-18.3: 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

5.3.18.9. Phytosanitary Measures

- Avoid importation of vegetables (Roots, Seedings, Micropropagated plants) from countries, where this pest is available.
- B. longicaudatus may be extracted from soil and turf using standard techniques. Because it is a relatively long nematode, centrifugation or immersion sieving methods should enhance recovery rates.
- A phytosanitary certificate may be required for vegetables with roots, seedlings and micropropagated plants

5.3.18.10. References

Abu-Gharbieh W, Al-Azzeh T, 2004. A checklist on nematode-plant associations in the Arab countries. Arab Journal of Plant Protection, 22(1):1-22.

CABI/EPPO, 2003. Belonolaimus longicaudatus. Distribution Maps of Plant Diseases, No. 879. Wallingford, UK: CAB International.

Cherry T, Szalanski AL, Todd TC, Powers TO, 1997. The internal transcribed spacer region of Belonolaimus (Nemata: Belonolaimidae). Journal of Nematology, 29(1):23-29; 27 ref.

Kepenekci I, 2001. Taxonomic investigations on the species of Tylenchida (Nematoda) in sunflower (Helianthus annuus L.) fields in Marmara Region. (Marmara Bölgesi'nde ayçiçegi (Helianthus annuus L.) ekilis alanlarInda saptanan Tylenchida (Nematoda) türleri üzerinde taksonomik arastIrmalar.) Bitki Koruma Bülteni, 41(3/4):101-134.

Miller LI, 1972. The influence of soil texture on the survival of Belonolaimus longicaudatus. Phytopathology, 62:670-671

Mundo-Ocampo M, Becker JO, Baldwin JG, 1994. Occurrence of Belonolaimus longicaudatus on Bermudagrass in the Coachella Valley. Plant Disease, 78(5):529.

Pathan MA, Talpur MA, Jiskani MM, Wagan KH, 2004. Studies on plant parasitic nematodes associated with banana in Sindh, Pakistan. Journal of Asia-Pacific Entomology, 7(2):249-252.

Perry VG, Rhoades HL, 1982. The genus Belonolaimus. In: Riggs RD, ed. Nematology in the Southern Region of the United States. Southern Cooperative Series Bulletin 276. Fayetville, USA: Arkansas Agricultural Experiment Station, University of Arkansas, 144-149.

Perry VG, Rhoades HL, 1982. The genus Belonolaimus. In: Riggs RD, ed. Nematology in the Southern Region of the United States. Southern Cooperative Series Bulletin 276. Fayetville, USA: Arkansas Agricultural Experiment Station, University of Arkansas, 144-149.

Smart GC, Nguyen KB, 1991. Sting and awl nematodes: Belonolaimus spp. and Dolichodorus spp. Manual of Agricultural Nematology., 627-667; 6 pp. of ref.

DISEASE CAUSING PATHOGEN: VIRUS

Pest-19:	***Cucumber yellow stunting disorder virus***

5.3.19.1 Hazard Identification

Scientific Name: *Cucumber yellow stunting disorder virus*

Synonyms: *Cucurbit yellow stunting disorder closterovirus*

Common names: CYSDV (acronym)

Taxonomic tree

- Domain: Virus
  - Group: "Positive sense ssRNA viruses"
    - Group: "RNA viruses"
      - Family: Closteroviridae
        - Genus: *Crinivirus*
          - Species: *Cucumber yellow stunting disorder virus*

EPPO Code: CYSDV0. This pest has been included in EPPO A2 list: No. 324

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2004; EPPO, 2014].

5.3.19.2. Biology

The life cycle of CYSDV is strongly dependent on its vector, the whitefly *Bemisia tabaci*, also a regulated pest (EPPO/CABI, 1997). In Portugal, the first symptoms of CYSDV in a field plot of cucumber were associated with heavy infestations of *B. tabaci* (Louro *et al.,* 2000). High populations were also associated with symptoms on melon in the USA (Kao et al., 2000). The spread of the virus may be related to the increase in distribution of the polyphagous B biotype of *B. tabaci* (also known as *B. argentifolii*; Bellows *et al*., 1994). This moves readily from one host species to the next and is estimated to have a host range of around 600 species. Transmission of CYSDV by biotype B is greater than by biotype A (Wisler *et al.,* 1998). However, biotype Q transmits as efficiently as biotype B (Berdiales *et al.,* 1999). The international trade in poinsettia is thought to have been a major means of dissemination of the B biotype within the EPPO region (EPPO/ CABI, 1997). Acquisition periods of 18 h or more and inoculation periods of 24 h or more are necessary for transmission rates of CYSDV of over 80% in tests using melon. However transmission was noted after an acquisition and transmission periods of 2 h (Célix et al., 1996). Research has also shown that CYSDV persists for at least 9 days in the vector with a 72.2-h half-life. This is the longest retention time of all whitefly-transmitted Closteroviridae (Wisler et al., 1998). CYSDV is not known to be seed-borne.

5.3.19.3. Hosts

The natural hosts of CYSDV are restricted to **Cucurbitaceae: watermelon, melon, cucumber**, courgette. In addition, the following experimental host plants have been identified: Cucurbita maxima and Lactuca sativa.

5.3.19.4. Geographical distribution

EPPO region: Israel (Wisler *et al.,* 1998), Jordan (Wisler *et al.,* 1998; Rubio *et al.,* 1999), Morocco (Desbiez *et al.,* 2000), Portugal (Louro *et al.,* 2000), Spain (Célix *et al.,* 1996; including Canary Islands), Turkey (Wisler *et al.,* 1998; Rubio *et al*., 1999). In the south of France, two isolated outbreaks were found in winter 2001/2002 but were successfully eradicated (Decoin, 2003)

Asia: Lebanon (Abou-Jawdah *et al*., 2000), Saudi Arabia (Wisler *et al.,* 1998; Rubio et al., 1999), Syria (Hourani & Abou-Jawdah, 2003), United Arab Emirates (Hassan & Duffus, 1991)

Africa: Egypt (Wisler *et al.,* 1998), Morocco

North America: Mexico, USA (Texas – Kao *et al.,* 2000)

EU: present

5.3.19.5. Hazard Identification Conclusion

Considering the facts that *CYSDV*

- is not known to be present in Bangladesh [CABI/EPPO, 2004; EPPO, 2014].
- is potentially economic important to Bangladesh because it is an important pest of **Cucurbites** and other vegetables in Asia and other countries including Lebanon, Saudi Arabia, Syria, United Arab Emirates, USA from where vegetables are imported to Bangladesh.
- In Lebanon, the incidence of CYSDV has been high in summer and early autumn cucurbit crops grown in polyethylene tunnels along the coast. Yield reductions of 40–60% have been reported by farmers. Incidence was much higher in unscreened tunnels than in screened tunnels (Abou-Jawdah et al., 2000). Within cucurbit crops, natural spread of CYSDV is ensured by its vector, B. tabaci. Adults of B. tabaci do not fly very efficiently but, once airborne, can be transported long distances in air currents. Internationally, infected young plants of cucurbits intended for planting are a likely pathway to introduce or spread the disease. Also, all stages of the whitefly vector can be carried on plants for planting. There is not, however, known to be a significant movement of cucurbit plants for planting from areas where the disease occurs.
- *CYSDV* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-19.1: 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 Asian and other countries including Lebanon, Saudi Arabia, Syria, United Arab Emirates, USA (CABI/EPPO, 2004; EPPO, 2014). • Since the late 1970s, cucumbers and melons grown in 16 000 ha of polyethylene-covered glasshouses in south-east Spain have been seriously affected by yellowing diseases transmitted by whiteflies. The first epidemics were caused by BPYV transmitted by T. vaporariorum. Since the early 1990s, in addition to BPYV, CYSDV has been associated with these diseases. In Lebanon, the incidence of CYSDV has been high in summer and early autumn cucurbit crops grown in polyethylene tunnels along the coast. Yield reductions of 40–60% have been reported by farmers. **b. Posibility of survival during transport, storage and transfer?-Yes** • The spread of the virus may be related to the increase in distribution of the polyphagous B biotype of *B. tabaci* (also known as *B. argentifolii*; Bellows *et al*., 1994). The international trade in poinsettia is thought to have been a major means of dissemination of the B biotype within the EPPO region (EPPO/ CABI, 1997). The virus can be retained at least for 7 days by the vector. • During the period of transportation of cucurbits, the eggs and crawlers of whitefly can easily survive on fruit surfaces of cucurbits. Secondly, cucurbit fruit is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with high risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Within cucurbit crops, natural spread of CYSDV is ensured by its vector, *B. tabaci.* Internationally, infected young plants of cucurbits intended for planting are a likely pathway to introduce or spread the disease. Also, all stages of the whitefly vector can be carried on plants for planting. There is not, however, known to be a significant movement of cucurbit plants for planting from areas where the disease occurs. There is good possibility of this virus appear in the seeds of cucurbits. d. **Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The natural hosts of CYSDV are restricted to **Cucurbitaceae: watermelon, melon, cucumber**, courgette. In addition, the following experimental host plants have been identified: *Cucurbita maxima* and *Lactuca sativa* among which mostly common in **Bangladesh**. • These climatic requirements for growth and development of *CYSDV* are more or less similar with the climatic condition of **Bangladesh**.	**YES and HIGH**

Description	Establishment Potential
• 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

5.3.19.7. Determine the <u>Consequence</u> establishment of this pest in Bangladesh

Table-19.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - no. • CYSDV is not present those countries from where we import vegetables. On the other hand it is only restricted under cucurbitaceous family. • Within cucurbit crops, natural spread of CYSDV is ensured by its vector, *B. tabaci.* Adults of *B. tabaci* do not fly very efficiently but, once airborne, can be transported long distances in air currents. Internationally, infected young plants of cucurbits intended for planting are a likely pathway to introduce or spread the disease. • So, if we stricktly prohibited the importation from those countries where not only the virus but also the vectors are present. **b. Economic Impact and Yield Loss** • Since the late 1970s, cucumbers and melons grown in 16000 ha of polyethylene-covered glasshouses in south-east Spain have been seriously affected by yellowing diseases transmitted by whiteflies. Epidemic levels are mentioned in the Middle East since 1985. The first epidemics were caused by BPYV transmitted by *T.vaporariorum.* Since the early 1990s, in addition to BPYV, CYSDV has been associated with these diseases. Surveys undertaken in 1994/1997 have shown that CYSDV has displaced BPYV as the major virus pathogen. No figures are available on losses caused by CYSDV. In Lebanon, the incidence of CYSDV has been high in summer and early autumn cucurbit crops grown in polyethylene tunnels along the coast. Yield reductions of 40 - 60% have been reported by farmers. Incidence was much higher in unscreened tunnels than in screened tunnels (Abou-Jawdah et al., 2000). **c. Environmental Impact** • CYSDV represents a potential threat to many crops. The establishment of it could trigger chemical control programs by using different insecticides for controlling vector of this virus that are toxic and harmful to the environment.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-19.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.19.9. Risk Management Measures

- Avoid importation of vegetables, where this pest and it's vector is available.
- A phytosanitary certificate may be required for vegetables with leaves.

5.3.19.10. References

CABI/EPPO, 2004. Cucurbit yellow stunting disorder virus. Distribution Maps of Plant Diseases, No. 910. Wallingford, UK: CAB International.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm.

Wisler GC, Duffus JE, Liu HY & Li RH (1998) Ecology and epidemiology of whitefly-transmitted closteroviruses. Plant Disease 82, 270–280

Rubio L, Soong J, Kao J & Falk BW (1999) Geographic distribution and molecular variation of isolates of three whitefly-borne closteroviruses of cucurbits: lettuce infectious yellows virus, cucurbit yellow stunting disorder virus, and beet pseudo-yellows virus. Phytopathology 89, 707–711.

Desbiez C, Lecoq H, Aboulama S & Peterschmitt M (2000) First report of Cucurbit yellow stunting disorder virus in Morocco. Plant Disease 84, 596.

Louro D, Vicente M, Vaira AM, Accotto GP & Nolasco G (2000) Cucurbit yellow stunting disorder virus (Genus Crinivirus) associated with the yellowing disease of cucurbit crops in Portugal. Plant Disease 84, 1156.

Célix A, López-Sesé A, Almarza N, Gómez-Guillamón ML & RodríguezCerezo E (1996) Characterization of cucurbit yellow stunting disorder virus, a Bemisia tabaci-transmitted closterovirus. Phytopathology 86, 1370–1376

Decoin M (2003) Tomates et concombres, gare aux nouveaux virus. Phytoma - la Défense des Végétaux n° 558, 27-29.

Abou-Jawdah Y, Sobh H, Fayad A, Lecoq H, Delécolle B & Trad-Ferré J (2000) Cucurbit yellow stunting disorder virus - a new threat to cucurbits in Lebanon. Journal of Plant Pathology 82, 55-60.

Hourani H & Abou-Jawdah Y (2003) Immunodiagnosis of Cucurbit yellow stunting disorder virus using polyclonal antibodies developed against recombinant coat protein. Journal of Plant Pathology 85, 197-204.

Hassan AA & Duffus JE (1991) A review of a yellowing stunting disorder of cucurbits in the United Arab Emirates. Emirates Journal of Agricultural Science 2, 1-16

Kao J, Jia L, Tian T, Rubio L & Falk BW (2000) First report of Cucurbit yellow stunting disorder virus (genus Crinivirus) in North America. Plant Disease 84, 101

Pest-19:	***Zucchini yellow mosaic virus***

5.3.20.1. Hazard identification

Scientific Name: *Zucchini yellow mosaic virus*

Synonyms:

Muskmelon yellow stunt virus
Zucchini mosaic potyvirus
Zucchini yellow mosaic potyvirus

Common names: ZYMV
Zucchini yellow mosaic

Taxonomic tree

Domain: Virus

Group: "Positive sense ssRNA viruses"

Group: "RNA viruses"

Family: Potyviridae

Genus: Potyvirus

Species: *Zucchini yellow mosaic virus*

EPPO Code: ZYMV00.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2003; EPPO, 2014]

5.3.20.2. Biology

- *Zucchini yellow mosaic virus* (ZYMV) has flexuous filamentous particles, 750nm long consisting of a singlestranded RNA of about 9600 nucleotides. It is transmitted non-persistently by a number of aphid species including the melon aphid (*Aphis gossypii*) and green peach aphid (*Myzus persicae*). ZYMV can also be spread by sap from infected plants contacting wounded healthy plants and is seed-borne at low levels. There are many strains of ZYMV and these vary in symptom severity and ability to overcome ZYMV resistance in commercial cucurbit cultivars.
- ZYMV can become establish in Bangladesh through imports of the vegetables, vegetable parts and flowers. *ZYMV* was mainly known as a pest of field crops in tropical and subtropical countries. ZYMV which are mostly common in Bangladesh. Is mostly **cucurbitaceous** pest which is transmitted by aphids
- Aphids transmit ZYMV in a non-persistent manner. This means only a few seconds of feeding are needed for an aphid to acquire the virus from an infected plant and transfer it to a healthy plant. Ten species of aphids are known vectors, but the cotton or melon aphid (*Aphis gossypii*) and the cowpea aphid (*A. craccivora*) are probably the most important vectors in Hawai'i.

5.3.20.3. Hosts

a. Major host: Cucurbitaceae is the host family for different varieties of squash, gourds, and melons particularly cucumbers (***Cucumis sativus***), zucchini, oriental squash (***C. maxima***, bittermelon (***Momordica charantia***), and pumpkin (***C. maxima***) (USDA 2010).

b. Alternate host: Weed species such as weedy bittermelon (***M. charantia***), wild cucumber (***Cucumis dipsaceus***), and bottle gourd or ipu (***Lagenaria siceraria***) are alternative hosts for ZYMV (Ullman et al. 1991). Most of these hosts are common in Bangladesh.

5.3.20.4. Distribution

- **EPPO region**: Present and widespread in the field in Austria, Belgium, Bulgaria, Cyprus, Finland, France, Germany, Algeria, Cyprus, France, Italy, Portugal, Spain, Turkey and Ukraine (CABI/EPPO, 2003; EPPO, 2014).
- **Asia**: China (Fujisawa *et al.,* 1990; Zheng & Dong, 1989; CABI/EPPO, 2003; EPPO, 2014), India (Sharma *et al.*, 2015; CABI/EPPO, 2003), Japan (Ohtsu *et al.*, 1985; Iwasaki et al., 1993; Maoka & Usugi, 1993; CABI/EPPO, 2003; EPPO, 2014), Iran, Iraq, Nepal, Pakistan, Saudi Arabia,Taiwan, Turkey (CABI/EPPO, 2003; EPPO, 2014)
- **Africa**: Algeria, Angola, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Morocco, Mozambique, Nigeria (Desbiez & Lecoq, 1997; De Bon et al., 1992; CABI/EPPO, 2003; EPPO, 2014).
- **North America**: Canada, Mexico, USA (CABI/EPPO, 2003; EPPO, 2014).
- **Central America and Caribbean:** Costa Rica, Dominica, Dominican Republic, Trinidad and Tobago
- **South America:** Argentina, Brazill.
- **Oceania:** Australia, New Zealand, Papua New Guinea, Samoa, Solomon Islands, Tuvalu. The B biotype is present in Australia.
- **EU**: Present.

5.3.20.5. Hazard Identification Conclusion

Considering the facts that *ZYMV*) -

- is not known to be present in Bangladesh [EPPO, 2014; CABI/EPPO, 1999];
- is potentially economic important to Bangladesh because it is an important pest of field crops and flowers in Asia including China (Fujisawa et al., 1990; Zheng & Dong, 1989; CABI/EPPO, 2003; EPPO, 2014), India (Sharma et al., 2015; CABI/EPPO, 2003), Japan (Ohtsu et al., 1985; Iwasaki et al., 1993; Maoka & Usugi, 1993; CABI/EPPO, 2003; EPPO, 2014), Iran, Iraq, Nepal, Pakistan, Saudi Arabia,Taiwan, Turkey from where many cucurbits are imported to Bangladesh.
- Infection by ZYMV during the early stages of plant development can cause significant losses in yield. Infected plants are undersized and their fruits are often distorted and unmarketable. ZYMV is transmitted by certain species of aphids, by plant sap containing the virus, and, for zucchini, through infected seeds. Aphids transmit ZYMV in a non-persistent manner. This means only a few seconds of feeding are needed for an aphid to acquire the virus from an infected plant and transfer it to a healthy plant. Ten species of aphids are known vectors, but the cotton or melon aphid (*Aphis gossypii*) and the cowpea aphid (*A. craccivora*) are probably the most important vectors in Hawai‘i.
- *ZYMV* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-20.1: 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, • ZYMV is an economically damaging disease of important cucurbit crops in Hawai‘i. ZYMV occurs globally on cucurbits and was first discovered in Hawai‘i on zucchini (*Cucurbita pepo*) in 1988 (*Ullman et al*. 1991). First reports of a newly evolved biotype of *B. tabaci*, the B biotype, appeared in the mid-1980s (Brown et al., 1995b). It is already estabilished in China, India, Japan, Thailand, Nepal, Malaysia, USA, from where most of our vegetables are imported. **b. Posibility of survival during transport, storage and transfer?-Yes** • *Zucchini yellow mosaic virus* (ZYMV) is transmitted non-persistently by a number of aphid species including the melon aphid (*Aphis gossypii*) and green peach aphid (*Myzus persicae*). ZYMV can also be spread by sap from infected plants contacting wounded healthy plants and is seed-borne at low levels. • During the period of transportation of cucurbits, the eggs, nymphs and adults of aphids can easily survive on fruit surfaces and planting materials of cucurbits. • Secondly, cucurbit 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 into Bangladesh and establish? - Yes,** • This virus may be entered into Banlgadesh by the importation of seeds, flowers, inflorescences, cones, calyx, fruits, leaves, roots, seedlings, micropropagated plants. Most of the cucurbits are imported in Bangladesh from India, China, Thailand, Japan, Taiwan, Pakistan, Australia, USA and other countries where this pathogen is common problem. So, the pathway appear good for this pest to entire in Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?- Yes** • **Cucurbitaceae** is the host family for different varieties of squash, gourds, and melons particularly cucumbers (***Cucumis sativus***), zucchini, oriental squash (***C. maxima***, bittermelon (***Momordica charantia***), and pumpkin (***C. maxima***) (USDA 2010). • Weed species such as weedy bittermelon (***M. charantia***), wild cucumber (***Cucumis dipsaceus***), and bottle gourd or ipu (***Lagenaria siceraria***) are alternative hosts for ZYMV (Ullman et al. 1991). Most of these hosts are common in Bangladesh. • These climatic requirements for growth and development of *ZYMV* are more or less similar with the climatic condition of **Bangladesh**.	**YES and HIGH**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and	Low

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

5.3.20.7. Determine the Consequence establishment of this pest in Bangladesh

Table 20.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • A variety of symptoms are produced in cucurbits, including stunting, yellowing, mosaics (light and dark green patterns), and deformed leaves and fruits. For instance, zucchini typically show severe mosaics, usually with distortions and blisters, on the leaves and fruits. Often the plants fail to set fruits and those that develop are smaller than normal. On watermelon, mosaics on the leaves are common. • **Vector:** ZYMV is spread by aphids; there are many species that do it naturally, although some species are more efficient than others. In the Pacific islands, the aphid, *Aphis gossypii*, is common and transmits the virus in a non-persistent way; this means that it acquires the virus on its mouth parts after a short feed on an infected plant (less than a minute), infects a healthy plant after another short feed, and then loses the ability to infect. It is known that even aphids that do not colonise cucurbits easily transmit ZYMS; in some cases they are more efficient in spreading the virus than *Aphis gossypii*, that does colonise cucurbits. The vector aphids for ZYMV are also common in Bangladesh. • This is a **fairly serious pest** of several important cucurbits for Bangladesh. **b. Economic Impact and Yield Loss** • *Zucchini yellow mosaic virus* causes one of the most important virus diseases in many sub-tropical and tropical countries. It is probably the most common virus infecting cucurbits. In general, the affect on yield depends on the time of infection; with early infection, of cucumber, melon or zucchini, complete loss is possible. • ZYMV causes various damages in cucurbits, including stunting, yellowing, mosaics, and deformed leaves and fruits that reduce the production and yield of cucurbits. Often the plants fail to set fruits and those that develop are smaller than normal. On watermelon, mosaics on the leaves are common. **c. Environmental Impact** • Chemical control is not effective against this disease because aphids are able to transmit the virus so quickly. Even though insecticides may kill the aphids, usually it is too late: by the time the insecticide has killed the aphid, the aphid has fed and the virus has been transmitted. • Thus, the introduction and establishment of this virus could trigger chemical control programs by using different insecticides against aphid vector of this virus that are toxic and harmful to the environment.	**Yes and High**
• Not as above or below	Moderate

Description	Consequence potential
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-20.3: Calculation of risk rating

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

Calculated Risk Rating - High

5.3.20.9. Risk Management Measures

- Avoid importation of vegetables, flowers and foliages from countries, where this pest is available.

5.3.20.10. References

CABI/EPPO, 2003. Zucchini yellow mosaic virus. Distribution Maps of Plant Diseases, No. 893. Wallingford, UK: CAB International.

De Bon H, Boissot N, Girard JC, Michellon R, Reynaud B, Vercambre B, 1992. A note on research on vegetable crops in Reunion. In: Ninth STASM (Societe de Technologie Agricole et Sucriere de Maurice) Conference. Reduit, Mauritius: Revue Agricole et Sucriere de l'Ile Maurice, 71:148-152.

Desbiez C, Lecoq H, 1997. Zucchini yellow mosaic virus. Plant Pathology, 46(6):809-829; 176 ref.

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Fujisawa I, Anang SJ, Shen YS, Zhou AJ, 1990. Identification of virus diseases affecting some vegetable crops in west Malaysia and the southern part of China. Tropical Agriculture Research Series, No. 23:218-228

Iwasaki M, Sasaya T, Yamamoto T, 1993. Seasonal prevalence of viral wilt in cucumber plants grafted on squash rootstocks. Annals of the Phytopathological Society of Japan, 59(4):481-484

Maoka T, Usugi T, 1993. Epidemiology of zucchini yellow mosaic virus infecting cucumber in Ishigaki Island. Proceedings of the Association for Plant Protection of Kyushu, 39:36-39; 10 ref.

Ohtsu Y, Sako N, Somowiyarjo S, 1985. Zucchini yellow mosaic virus isolated from pumpkin in Miyako and Ypyama Islands, Okinawa, Japan. Annals of the Phytopathological Society of Japan, 51(2):234-237

Sharma S, Kang SS, Sharma A, 2015. First report of mixed infection of Zucchini yellow mosaic virus and Tomato leaf curl New Delhi virus in bittergourd in India. Journal of Plan Pathology, 97(2):397.
http://sipav.org/main/jpp/index.php/jpp/article/view/3362/2032
Zheng D, Dong T, 1989. Occurrence of zucchini yellow mosaic virus in Xinjiang. Acta Phytopathologica Sinica, 21:72.

WEED

Pest-20:	Parthenium weed: *Parthenium hysterophorus*

5.3.20.1 Hazard Identification

Scientific name: *Parthenium hysterophorus* L.

Synonyms: *Parthenium hysterophorus* var. *lyratum* A.Gray
Argyrochaeta bipinnatifida Cav.
Argyrochaeta parviflora Cav.
Echetrosis pentasperma Phil.
Parthenium glomeratum Rollins,
Parthenium lobatum Buckley,
Parthenium pinnatifidum Stokes,
Villanova bipinnatifida Ortega

Common names: Parthenium weed, bitter weed, bitter-broom, bitterweed, carrot grass, congress grass, false camomile, false ragweed, feverfew, parthenium, parthenium weed, ragweed, ragweed parthenium, Santa Maria, Santa Maria feverfew, white top, whitehead, whitetop

Taxonomic tree

Kingdom: Plantae
Family: Asteraceae
Genus: *Parthnium*
Species: *Parthenium hysterophorus*

EPPO Code: PTNHY. This pest has been included in EPPO A2 list: No. 383

Bangladesh status: Present in restricted areas of Bangladesh possibly introduced from India.

5.3.21.2 Biology

P. hysterophorus reproduces only by seeds and is known to be highly prolific, as a single plant produces 15 000 seeds on average and up to 100 000 seeds (GISD Database, Global Invasive Species Database, 2010). Seed viability is high, 85% or higher (Navie et al., 1998). Buried seeds have been found to last longer than seeds on the soil surface, and a significant proportion can still germinate after 8–10 years. Freshly produced seeds demonstrate a degree of dormancy (up to several months) (Navie et al., 1998). In addition, the species is an opportunistic germinator. Seeds can germinate at any time of the year provided moisture is available but they require bare soil to do so (Parsons & Cuthbertson, 1992). The plant flowers 4-8 weeks after germination and flowering continue until drought or frost kills the plant. Under favourable conditions, 2 – 3 life cycles can be completed per year (Fatimah & Ahmad, 2009).

5.3.21.3 Hosts or habitats

- *P. hysterophorus* grows in a wide range of habitats, including degraded and disturbed lands and streams and rivers. It is a pioneer species that can invade grazing land and degraded pastures, crops, orchards, summer crops, disturbed and cultivated areas, forests, railway tracks and roadsides, recreation areas, as well as river banks and floodplains (Navie*et al*. 1996a).
- According to the Corine Land Cover nomenclature, the following habitats are invaded: arable land, permanent crops (e.g. vineyards, fruit tree and berry plantations, olive), pastures, riverbanks / canalsides (dry river beds), road and rail networks and associated land, other artificial surfaces (wastelands).
- In Australia, the main impact of *P. hysterophorus* has been in the pastoral region of Queensland, where it replaces forage plants, thereby reducing the carrying capacity for grazing animals (Haseler, 1976; Chippendale and Panetta, 1994). Serious encroachment and replacement of pasture grasses has also been reported in India (Jayachandra, 1971) and in Ethiopia (Tamado, 2001; Taye, 2002).
- *P. hysterophorus* is now being reported from India as a serious problem in cotton, groundnuts, potatoes and sorghum, as well as in more traditional crops such as okra (*Abelmoschus esculentus*), brinjal (*Solanum melongena*), chickpea and sesame (Kohli and Rani, 1994), and is also proving to be problematic in a range of orchard crops, including cashew, coconut, guava, mango and papaya (Tripathi et al., 1991; Mahadevappa, 1997).

- Similar infestations of sugarcane and sunflower plantations have recently been noted in Australia (Parsons and Cuthbertson, 1992; Navie et al., 1996). In Ethiopia, parthenium weed was observed to grow in maize, sorghum, cotton, finger millet (*Eleusine coracana*), haricot bean (*Phaseolus vulgaris*), tef (*Eragrostis tef*), vegetables (potato, tomato, onion, carrot) and fruit orchards (citrus, mango, papaya and banana) (Taye, 2002). In Pakistan, the weed has been reported from number of crops, including wheat, rice, sugarcane, sorghum, maize, squash, gourd and water melon (Shabbir 2006; Shabbir et al. 2011; Anwar et al. 2012).

5.3.21.4 Geographical distribution

Native distribution: *P. hysterophorus* is native to the area bordering the Gulf of Mexico, and has spread throughout southern USA, the Caribbean and Brazil.

- **North America**: Bermuda, Mexico, USA (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Hawaii, Illinois, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Missouri, Mississippi, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia).
- **Central America and Caribbean**: Belize, Costa Rica, Cuba, Dominican Republic, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Puerto Rico, Saint Barthelemy, Republic of Panama, Trinidad, Trinidad and Tobago.
- **South America**: Argentina, Bolivia, Brazil, Chile, Ecuador, French Guiana, Guyana, Peru, Paraguay, Suriname, Uruguay, Venezuela.

Exoticdistribution

- **EPPO region**: Israel.
- **Africa:** Comores, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Mauritius, Mayotte, Mozambique, Reunion, Seychelles, Somalia,South Africa, Swaziland, Tanzania, Uganda and Zimbabwe.
- **Asia:** Bangladesh,Bhutan, China (south of country), India, Oman and Yemen, Israel, Nepal, Pakistan, Sri Lanka, Japan, Republic of Korea, Taiwan and Vietnam.

- **Oceania:** Australia (Queensland, New South Wales, Northern Territory, Western Australia), French Polynesia, several Pacific islands including Bermuda, New Caledonia, Vanuatu and Christmas island.

5.3.21.5 Hazard identification conclusion

Considering the facts that *P. hysterophorus* :

- is not known to be present in all areas of Bangladesh;
- is potentially economic important to Bangladesh because it is an important pest of flowers and foliages in Asia including China, India, Nepal, Pakistan, **Japan** [EPPO, 2014; CABI/EPPO, 1999] from where agricultural crops and flowers are imported to Bangladesh.
- can become established in Bangladesh through the transportation of agricultural equipment and imports of the agricultural planting materials including flowers and foliages.
- *Parthenium hysterophorus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.3.21.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-21.1: 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 genus *Parthenium* contains 15 species, all native to North and South America. *P. hysterophorus* has a native range in the subtropical regions of North to South America. It is thought that the species originated in the region surrounding the Gulf of Mexico, including southern USA, or in central South America (Dale, 1981; Navie et al., 1996), but is now widespread in North and South America and the Caribbean, and Fournet and Hammerton (1991) indicate that it occurs in 'probably all islands' of the Lesser Antilles. • Since its accidental introduction into Australia and India in the 1950s, probably as a contaminant of grain or pasture seeds, it has achieved major weed status in those countries. It was first recorded in southern Africa in 1880 but was not reported as a common weed in parts of that region until the mid-1980s following extensive flooding on the east coast (McConnachie et al., 2011). Recent reports of the weed from other countries indicate that its geographic range continues to increase. • Because *P. hysterophorus* has shown invasive behaviour where it has been introduced elsewhere in the world and has a highly restricted distribution in the EPPO region, it can be considered an emerging invader in the EPPO region (EPPO, 2012). **b. Posibility of survival during transport, storage and transfer? Yes** • *P. hysterophorus* reproduces only by seeds and is known to be highly prolific, as a single plant produces 15000 seeds on average and up to 100000 seeds (GISD Database, Global Invasive Species Database, 2010). Seed viability is high, 85% or higher (Navie et al., 1998). Buried seeds have been found to last longer than seeds on the soil surface, and a significant proportion can still germinate after 8–10	**YES and HIGH**

Description	Establishment Potential
years. Freshly produced seeds demonstrate a degree of dormancy (up to several months) (Navie et al., 1998). In addition, the species is an opportunistic germinator. Seeds can germinate at any time of the year provided moisture is available but they require bare soil to do so (Parsons & Cuthbertson, 1992). Therefore, the seeds of this weed can survive during transport, storage and transfer of the commodity. c. **Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Entries as a contaminant of agricultural produce and machinery have historically been important pathways for the introduction of *P. hysterophorus* in new regions. • **Contaminant of used machinery:** *P. hysterophorus* can enter new territories as a contaminant of used machinery, either as seeds, e.g. lodged on the radiators and grills of automobiles, or as seeds in soil attached to machinery, such as harvesters, road construction and maintenance machinery, military equipment and other vehicles. Vehicles and harvesters may circulate quite frequently across EPPO countries. The release of seeds of *P. hysterophorus* from the vehicles on the roads networks may facilitate its transfer to other unintended habitats connected by roads. • **Contaminant of grain:** *P. hysterophorus* was accidentally introduced into Israel in 1980 most likely through import of contaminated grains from the USA for fishponds (Dafni& Heller 1982). Wheat and other cereals were reported for the introduction of *P. hysterophorus* in India (Sushilkumar&Varshney, 2010), and sorghum is also reported to be infested in Ethiopia (Tamado*et al*., 2002). • **Contaminant of seed:** - Pasture seeds (grass) from Texas into central Queensland (Everist, 1976), as well as in Egypt from Texas in the 1960s (Boulos& El-Hadidi, 1984); - Cereal seed from the United States in Africa, Asia and Oceania (Bhomik&Sarkar, 2005); - Soybean seed from the USA in the Shandong Province in China in 2004 (Li & Gao, 2012). **d.Are the host(s) and habitats of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • *P. hysterophorus* grows in a wide range of habitats, including degraded and disturbed lands and streams and rivers. It is a pioneer species that can invade grazing land and degraded pastures, crops, orchards, summer crops, disturbed and cultivated areas, forests, railway tracks and roadsides, recreation areas, as well as river banks and floodplains (Navie*et al*. 1996a). • *P. hysterophorus* is now being reported from India as a serious problem in cotton, groundnuts, potatoes and sorghum, as well as in more traditional crops such as okra (*Abelmoschus esculentus*), brinjal (*Solanum melongena*), chickpea and sesame (Kohli and Rani, 1994), and is also proving to be problematic in a range of orchard crops, including cashew, coconut, guava, mango and papaya (Tripathi et al.,	

Description	Establishment Potential
1991; Mahadevappa, 1997). • Where climatic conditions are appropriate (e.g. Mediterranean area, Black Sea, Eastern Asia, the warmest temperate area) there are numerous suitable habitats. Consequently, for these areas, the probability of establishment is high with low uncertainty. • Therefore, the hosts and habitats as well as climatic requirements for this weeds are mostly common in 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 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

5.3.21.7 Determine the Consequence establishment of this pest in Bangladesh

Table-21.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes • *P.hysterophorus*is a major pestinpastures and crops in its exotic range, and has major detrimental impact on human and animal health through allergies and dermatitis. • If introduced in the area of potential establishment, eradication or containment would be unlikely to be successful due to its high reproductive potential and high spread capacity through human activities. • • This is a **fairly serious pest** of several important crops and human health rather than flowers for Bangladesh. **b. Economic impact and yield loss** • The main impact of parthenium weed on crops relates to its allelopathic properties. The water soluble phenolics; caffeic acid, ferulic acid, vanicillic acid, anisic acid and fumaric acid; and sesquiterpene lactones, mainly parthenin and/or hymenin, occur in all parts of the plant and significantly inhibit the germination and subsequent growth of a wide variety of crops including pasture grasses, cereals, vegetables, other weeds and tree species (Navie *et al.,* 1996; Evans, 1997a). • Few critical assessments of yield losses have been made, although it has been determined that almost 30% grain loss can occur in irrigated sorghum in India (Channappagoudar *et al.,* 1990). As *Parthenium* pollen is also allelopathic (Kanchan and Jayachandra, 1980), heavy deposits on nearby crop plants may result in failure of seed set, and losses of up to 40% have been reported in maize yield in India (Towers *et al.,* 1977). In eastern Ethiopia, parthenium weed is the second most frequent weed after *Digitaria abyssinica* (Tamado and Milberg, 2000) and sorghum grain yield was reduced from 40 to 97% depending on the year and location (Tamado, 2001). • Although *P. hysterophorus* is not yet considered to be a major crop	**Yes and High**

Description	Consequence potential
weed in Australia (Navie *et al.,* 1996), it has started to spread into sorghum, sugarcane and sunflower growing areas and negatively affect yields (Parsons and Cuthbertson, 1992). Also, Chippendale and Panetta (1994) estimate that cultivation costs may be doubled since the prepared ground has to be re-worked to eliminate the emergent parthenium weed seedlings. **c. Environmental Impact** • Parthenium weed lacks predators, and cattle and livestock usually do not feed on it. As a result, the food chain is disturbed and the trophic structure changes, leading to an ecological imbalance in the invaded area. • It causes a prolonged toxic effect to the soil environment-for instance, Kanchan and Jayachandra (1981) reported that the leachates from parthenium weed have an inhibitory effect on nitrogen fixing and nitrifyingbacteria. • Parthenium weed is also an environmental weed that can cause irreversible habitat changes in native grasslands, woodlands, river banks and floodplains in both India and Australia (Jayachandra 1971; McFadyen, 1992; Evans, 1997a; Kumar and Rohatgi, 1999). • Parthenium weed, due to its allelopathic potential, replaces dominant flora and suppresses natural vegetation in a wide range of habitats and thus becomes a big threat to biodiversity. Batish et al. (2005) recorded 39 plant types in a *Parthenium*-free area, but only 14 were present in an infested area, and very little or sometimes no vegetation can be seen in some *Parthenium*-dominated areas (Kohli, 1992). Wherever it invades, it forms a territory of its own, replacing indigenous grasses and weeds which are supposedly useful for the grazing animals (De and Mukhopadhyay, 1983). Parthenium weed has an adverse effect on a variety of natural herbs which are the basis of traditional systems of medicines for the treatment of several diseases in various parts of the world (Mahadevappa *et al.,* 2001; Shabbir and Bajwa, 2006).	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in your country.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 21.3 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

5.3.21.9 Risk Management Measures

a. Contaminant of used machinery

- Cleaning or disinfection of machinery/ vehicles in combination with internal surveillance and/or eradication or containment campaign.

b. Contaminant of grain: Measures related to the crop or to places of production:

- Pest-free area
- Pest-free place of production/production site consist in the following combination of measures: visual inspection at the place of production, specified treatment of the crop, testing of the commodity, internal surveillance and/or eradication or containment campaign.
- Certification scheme
- Import under special licence/permit and specified restrictions (for grain which is aimed to be crushed or transformed).

c. Contaminant of seeds: Measures related to the crop or to places of production:

- Pest-free area
- Pest-free place of production/production site consist in the following combination of measures: visual inspection at the place of production, specified treatment of the crop, testing of the commodity, internal surveillance and/or eradication or containment campaign.
- Certification scheme for seeds.

d. Contaminant of growing media adherent to plants for planting: Measures related to the crop or to places of production:

- Pest-free area
- Pest-free place of production/production site consist in the following combination of measures: visual inspection at the place of production, specified treatment, growing in glasshouses and in sterilized soil, internal surveillance and/or eradication or containment campaign.
- Certification scheme for plants for planting
- Removal of the growing medium from plants for planting.

e. Contaminant of travelers (tourists, migrants, etc.) and their clothes, shoes and luggage

Systems approach:

- Publicity to enhance public awareness on pest risks
- Internal surveillance and/or eradication or containment campaign.

5.3.21.10 References

Ayele S (2007) Impact of Parthenium (*Partheniumhysterophorus* L.) on the range ecosystem dynamics of the Jijiga Rangeland, Ethiopia. M.Sc. Thesis, Haramaya University.134 pp.

Basappa H (2005) Parthenium an alternate host of sunflower necrosis disease and thrips, In *Second International Conference on Parthenium Management.*eds T. V. Ramachandra Prasad, H. V. Nanjappa, R. Devendra, A. Manjunath, Subramanya, S. C. Chandrashekar, V. K. KiranKuman, K. A. Jayaram, and T. K. PrabhakaraSetty, University of Agricultural Sciences, Bangalore, India, pp. 83-86.

Boulos L & El-Hadidi MN (1984). The Weed Flora of Egypt.American University of Cairo Press, Cairo, 178pp.

Bhomik PC &Sarkar D (2005) *Partheniumhysterophorus*: its world status and potential management. In *Proceedings of the Second International Conference on Parthenium*

Management, eds TV Ramachandra Prasad, HV Nanjappa, R Devendra, A Manjunath, Subramanya, SC Chandrashekar, VK Kiran Kumar, KA Jayaram& TK PrabhakaraSetty, University of Agricultural Sciences, Bangalore, India, pp. 1-5.

Chippendale JF & Panetta, FD (1994) The cost of parthenium weed to the Queensland cattle industry. *Plant Protection Quarterly***9**, 73–6.

DafniA& Heller D (1982) Adventive flora of Israel: phytogeographical, ecological and agricultural aspects. *Plant Systematics and Evolution***140**, 1-18.

Dale IJ (1981) Parthenium weed in the Americas: A report on the ecology of *Partheniumhysterophorus* in South, Central and North America.*Australian Weeds***1**, 8-14.

EPPO (2012) EPPO Prioritization process for invasive alien plants. PM5/6.*Bulletin OEPP/EPPO Bulletin***42**(3), 463-474.

Everist SL (1976) Parthenium weed. *Queensland Agricultural Journal***102**, 2.

Govindappa MR, Chowda Reddy RV, Devaraja, Colvin J, Rangaswamy KT &Muniyappa, V (2005) *Partheniumhysterophorus*: a natural reservoir of Tomato Leaf Curl Begomovirus, In *Second International Conference on Parthenium Management.* (eds), T.V. Ramachandra Prasad, H. V. Nanjappa, R. Devendra, A. Manjunath, Subramanya, S. C. Chandrashekar, V. K. KiranKuman, K. A. Jayaram and T. K. PrabhakaraSetty, (University of Agricultural Sciences, Bangalore, India, pp. 80-82.

Jayasuriya AHM (2005) Parthenium weed – status and management in Sri Lanka, In *Second International Conference on Parthenium Management.* eds. T. V. Ramachandra Prasad, H. V. Nanjappa, R. Devendra, A. Manjunath, Subramanya, S.C. Chandrashekar, V.K. KiranKuman, K.A. Jayaram and T.K. PrabhakaraSetty, University of Agricultural Sciences, Bangalore, India, pp. 36-43.

Kololgi PD, Kololgi SD &Kologi NP (1997) Dermatologic hazards of parthenium in human beings. In Mahadevappa M &Patil VC (Eds) First International Conference on Parthenium Management Vol 1.Pp 18-19.

Kriticos, D J, Webber, B L, Leriche, A, Ota, N, Bathols, J, Macadam, I & Scott, J K (2012) CliMond: global high resolution historical and future scenario climate surfaces for bioclimatic modelling. *Methods in Ecology and Evolution***3**, 53-64.

Lakshmi C &Srinivas CR (2007) Parthenium: a wide angle view. *Indian Journal of Dermatology, Venerology and Leprology***73**, 296-306

Li M &Gao X (2012) Occurrence and management of parthenium weed in Shandong Province, China. In Shabbir S & Adkins SW (Eds) (2012) International Parthenium news. Number 6, July 2012. 5-6.

McFayden RE (1992) Biological control against parthenium weed in Australia. *Crop Protection***11**, 400-407.

Mirek Z, Piękoś-Mirkowa H, Zając A &Zając M (2002) Flowering plants and pteridophytes of Poland. A Checklist.*Biodiversity Poland***1**, 9-442.

More PR, Vadlamudi VP &Qureshi MI (1982). Note on the toxicity of *Partheniumhysterophorus* in livestock. *Indian Journal of Animal Science***52**, 456-457.

Narasimhan TR, Ananth M, NaryanaSwamy M, RajendraBabu M, Mangala A &SubbaRao PV (1977a) Toxicity of *Partheniumhysterophorus* L. to cattle and buffaloes. *Experientia***33**, 1358-1359.

Narasimhan TR, Ananth M, NaryanaSwamy M, RajendraBabu M, Mangala A &SubbaRao PV (1977b) Toxicity of *Partheniumhysterophorus* L. *Current Science*, **46**, 15-16.

Navie SC, McFadyen RA, Panetta FD & Adkins SW (1996a) A comparison of the growth and phenology of two introduced biotypes of *Partheniumhysterophorus*. 11th Australian Weeds Conference Proceedings, pp 313-316

Navie SC, McFadyen RE, Panetta FD & Adkins SW (1996b) The Biology of Australian Weeds 27. *Partheniumhysterophorus* L. *Plant Protection Quarterly***11**, 76-88.

Ovies J &Larrinaga L (1988) Transmisson de *Xanthomonascampestris* PV *Phaseoli*mediante un hospedantesilvertre. *Ciencias Y Tecnica en la Agricultura***11**, 23-30.

PrasadaRao RD, Govindappa VJ, Devaraja MR &Muniyappa V (2005) Role of parthenium in perpetuation and spread of plant pathogens, In *Proceedings of the Second International Conference on Parthenium Management*, eds TV Ramachandra Prasad, HV Nanjappa, R Devendra, A Manjunath, Subramanya, SC Chandrashekar, VK Kiran Kumar, KA Jayaram& TK PrabhakaraSetty, University of Agricultural Sciences, Bangalore, India, pp. 65-72.

Ramachandra Prasad TV, Denesh GR, Kiran Kumar VK & Sanjay MT (2010) Impact of *Partheniumhysterophorus* L. on bio-diversity, ill effects and integrated approaches to manage in Southern Karanataka. International Conference on Biodiversity, 206-211.

Reddy KN & Bryson CY (2005) Why ragweed parthenium is not a pernicious weed in the continental USA? In *Proceedings of the Second International Conference on Parthenium Management*, eds TV Ramachandra Prasad, HV Nanjappa, R Devendra, A Manjunath, Subramanya, SC Chandrashekar, VK Kiran Kumar, KA Jayaram& TK PrabhakaraSetty, University of Agricultural Sciences, Bangalore, India, pp. 61-64.

Saxena U, Gupta T, Gautam S, Gautam CPN, Khan AM &Gautam RD (2010) Faunal diversity of Partheniumhysterophorus in Delhi. In. Scientific Presentations - Third International Conference on Parthenium, December 8-10, 2010, IARI, New Delhi, p.41-43.

Shabbir A (2012) Towards the improved management of parthenium weed: complementing biological control with plant suppression. PhD thesis, The University of Queensland, Australia.

Shabbir AK, Dhileepan K, O'Donnell C & Adkins SW (2013) Complementing biological control with plant suppression: implications for improved management of parthenium weed (*Parthenium hysterophorus* L.). *Biological* Control **64**(3), 270-275.

Sharma VK &Sethuraman G (2007) *Parthenium* dermatitis.*Dermatitis***18**, 183-190.

Siebert, S, Doll, P, Hoogeveen, J, Faures, J M, Frenken, K & Feick, S (2005) Development and validation of the global map of irrigation areas. *Hydrology and Earth System Sciences***9**, 535-547.

Sushilkumar&Varshney JG (2010) Parthenium infestation and its estimated cost management in India.*Indian Journal of Weed Science***42**, 73-77.

SwaminathanC, VinayaRai RS & Suresh, KK (1990) Allelopathic effects of *Partheniumhysterophorus* on germination and seedling growth of a few multi-purpose trees and arable crops.*The International Tree Crops Journal***6**, 143-150.

Tamado T, Ohlander L & Milberg P (2002) Interference by the weed *Partheniumhysterophorus* L. with grain sorghum: influence of weed density and duration of competition. *International Journal of Pest Management***48**(3), 183-188

Timsina, B, BabuShrestha B, BahadurRokaya M &Munzbergova, Z (2011) Impact of *Partheniumhysterophorus* L. invasion on plant species composition and soil properties of grassland communities in Nepal. *Flora***206**, 233-240.

Verloove F (2006) Catalogue of neophytes in Belgium (1800-2005).Meise, National Botanic Garden of Belgium.89 p.

Wise RM, van Wilgen BW, Hill MP, Schulthess F, Tweddle D, Chabi-Olay A& Zimmermann HG (2007) The Economic Impact and Appropriate Management of Selected Invasive Alien Species on the African Continent. Finale report.Global Invasive Species Programme.64 p.

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

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

From the quantitatively risk analysts of quarantine pests likely to be associated and follow the cucurbits pathway to Bangladesh from India, China, Pakistan, Japan, Thailand, Taiwan, UAE, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, and Brazil, Chille and other exporting countries, out 22 potential hazard organisms, 21 hazard organisms were identified with high risk potential, one namely *Belonolaimus longicaudatus* (sting nematode) was identified with moderate risk potential.

The overall pest risk potential ratings of 22 quarantine pests of cucurbits for Bangladesh have been included in the following Table 11:

Table 11: The Overall Pest Risk Potential Rating

Sl. No.	Potential Hazard Organism	Common Name	Family	Order	Pest Risk Potential
Insect pests					
1	*Bemisia tabaci B biotype*	Silver leaf whitefly	Aleurodidae	Homoptera	**High**
2	*Phenacoccus solenopsis*	Cotton mealy bug	Pseudococcidae	Homoptera	**High**
3	*Frankliniella occidentalis*	Alfalfa thrips	Thripidae	Thysanoptera	**High**
4	*Dacus ciliates*	Lesser fruit fly	Tephritidae	Diptera	**High**
5	*Bactrocera latifrons*	Malaysian fruit fly	Tephritidae	Diptera	**High**
6	*Ceratitis capitata*	Meditteranean fruit fly	Tephritidae	Diptera	**High**
7	*Bactrocera tryoni*	Quensland fruit fly	Tephritidae	Diptera	**High**
8	*Liriomyza bryoniae*	Tomato leaf miner	Agromyzidae	Diptera	**High**
9	*Liriomyza trifolii*	Serpentine leaf miner	Agromyzidae	Diptera	**High**
10	*Liriomyza huidobrensis*	Pea leaf miner	Agromyzidae	Diptera	**High**
11	*Chrysodeixis eriosoma*	Green looper caterpillar	Noctuidae	Lepidoptera	**High**
12	*Diaphania indica*	Cucumber moth	Crambidae	Lepidoptera	**High**
13	*Diaphania nitidalis*	Cucumber worm	Crambidae	Lepidoptera	**High**
14	*Diabrotica undecimpunctata*	Cucumber beetle	Chrysomeliae	Coleoptera	**High**
Mite					
15	*Tetranychus evansi*	Red spider mite	Tetranychidae	Acarina	**High**
Fungus					
16	*Phytophthora megasperma*	Phytopthora root rot	Peronosporaceae	Peronosporales	**High**
Bacteria					
17	Cucurbit bacterial wilt	*Erwinia tracheiphila*	Enterobacteriaceae	Enterobacteriales	**High**
18	Bacterial fruit blotch	*Acidovorax citrulli*	Comamonadaceae	Burkholderiales	**High**
Nematode					
19	Sting nematode	*Belonolaimus longicaudatus*	Belonolaimidae	Tylenchida	**Moderate**
Virus					
20	Cucumber yellow stunting disorder virus	*Cucumber yellow stunting disorder virus*	Closteroviridae	Group: RNA viruses	**High**
21	Zucchini yellow mosaic virus	*Zucchini yellow mosaic virus*	Potyviridae	Group: RNA viruses	**High**
Weed					
22	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	**High**

CHAPTER 6

RISK MANAGEMENT

6.1. Risk Management Options and Phytosanitary Procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests assessed to pose an unacceptable level of risk to Bangladesh via the importation of commercially produced cucurbits from India, China, Japan, Thailand, Taiwan, Vietnam, Philippines, Indonesia, U.S.A, Australia, France, Germany, Italy, Netherlands, Belgium, Brazil, and Chile or any other countries of cucurbit export (i.e. produced under standard cultivation, harvesting and packing activities). Plant Quarantine Wing of Bangladesh will consider the risk management measures proposed below is commensurate with the identified risks.

6.1.1. Pre-harvest Management Options

i. **Use of pest resistant varieties**: The use of resistant varieties is a common and effective component in reducing pest risk.

ii. **Chemical spray program**: Pre-harvest chemical sprays may be used to control pests within production fields, for example, the use of nematicides to control the root knot nematode.

iii. **Crop rotation**: Certain cucurbit diseases can survive from season to season in the field. Depending on the type of pathogen, it may survive in the resting form either in the soil or in cucurbit plant debris, or in a living form in surviving fallen fruit. On occasion, diseased fruits are the sources of contamination for the current season crops. Therefore, a crop rotation to minimize soil disease problems is recommended.

iv. **Control of Insects**: Sucking and chewing insects may transmit many diseases. For example the *Cucumber mosail virus*t disease was found to be transmitted by the aphids (EPPO, 1997). The control of these insects and the rouging of infected parts of plants as early as possible may prevent spread of diseases in the field.

v. **Irrigation practices and soil type**: A well drained soil is recommended for planting of cucurbits as this make conditions less favourable to disease infection (Johnson, 1969). Over irrigation and a poorly drained soil increases the susceptibility to diseases such as powdery mildew, scab etc. The type of irrigation system may also aid in the transmission of some diseases.

vi. **Pre-harvest Inspection**: The relevant officers and inspectors from the importing country should inspect and verify the cleaning and disinfecting of equipment and storage used in cucurbit production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of diseases detected.

6.1.2. Post-harvest Management Options

i. **Sanitization of equipment and material**: All machinery, transport and storage surfaces that the cucurbit seed will contact should be cleaned and disinfected prior to receiving new cucurbit seeds. Since most disinfectants are inactivated by soil and plant debris, it is essential that this material be removed by thoroughly cleaning the equipment and storage with a pressure washer or steam cleaner before the disinfectant is applied.

ii. **Disposal of infected fruits**: All infected fruits should be discarded away from production site (Rowe *et. al*).

iii. **Seed and fruit grading**: The class and variety of cucurbit fruits and seeds must be kept separate through harvesting, grading and storage. Grading must be done according to class, variety and disease tolerance. The class of cucurbits must clearly identifiable and labeled.

6.1.3. Phytosanitary Measures

i. **Pest free areas**: As a sole mitigation measure, the establishment of pest-free areas or pest-free places of production may be completely effective in satisfying an importing country's appropriate level of phytosanitary protection (IPPC, 1996b, 1999). Establishment and maintenance of pest-free areas or production sites should be in compliance with international standards (*e.g.*, IPPC, 1996b, 1999, 2006).

ii. **Stipulated commercial grade for cucubit fruits**: This ensures a certain level of quality and cleanliness which results from commercial handling. This is a significant measure for pests that affect quality or associated with contaminants (eg. soil). Bangladesh should therefore make request for a certain grade of potato that reflects the acceptable tolerance level of the country.

iii. **Accept only certified cucurbit seeds for crop production**: This measure is highly effective in mitigating pest risk, because it ensures the absence of specific pests, particularly pathogens, or a defined low prevalence of pests at planting. The main components of seed certification include: sampling and testing of production areas to ensure free from viruses; approval of land and seed to be multiplied; inspection of crops for variety purity and crop health; inspection of cucurbit fruit samples; and sealing and labeling of certified seed. Cucurbit seeds to be imported from the exporting countries should be sourced from an officially recognized seed certification system.

iv. **Shipments traceable to place of origin in exporting countries**: A requirement that cucurbit seeds and fruits be packed in containers with identification labels indicating the place of origin, variety and grade is necessary to ensure traceability to each production site.

v. **Pre export inspection and treatment:** The NPPOs of exporting countries will inspect all consignments in accordance with official procedures in order to confirm those consignments are satisfied with import requirements on phytosanitary of Bangladesh.If quarantine fruit flies with high risk potential are found during inspection, the phytosanitary procedures should maintained:

- Consignments of fruits from countries where these pests occur 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 such fruits should come from an area where fruit flies do not occur and where routine intensive control measures are applied.
- Fruits may also be treated in transit by cold treatment (e.g. 13 or 14 days at 0.0 or 0.6°C,, respectively) or, for certain types of fruits, by vapour heat (e.g. keeping at 43-44°C for 6-9 h, according to commodity) (FAO, 1983) or hot water treatment.
- 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 (FAO, 1983; Armstrong & Couey, 1989).

vi. **Requirement of phytosanitary certification from country of origin:** The phytopathological service of the country of origin should ensure the cucurbit seeds and fruits from which the consignment is derived was not grown in the vicinity of unhealthy cucurbit crops and was inspected by a duly authorized official/phytopathological service and the cucurbit seeds have been produced in areas within the country free from all pests and diseases.

vii. **Port-of-entry inspection and treatment**: Upon arrival in Bangladesh, each consignment of cucurbits should be inspected to detect pests, with export phytosanitary certificate and seed certificate. Sampling of cucurbit seeds and fruits consignments at port-of-entry in Bangladesh should combine visual inspection and laboratory testing. Visual inspection is useful to verify that certain phytosanitary certification requirements have been met and consignment is generally free of contaminants. The efficacy of this measure depends on the statistical level of sampling and the ability to detect the pests or article of concern (eg. soil). Laboratory testing requires that a portion of each sample taken for inspection be subjected to laboratory analysis for the detection of pathogens.

The consignment could re-export or destroy if quarantine pests or regulated articles with high risk potential are found during an inspection.

6.2 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.