Government of the People's Republic of Bangladesh
Office of the Project Director
Strengthening Phytosanitary Capacity in Bangladesh Project
Plant Quarantine Wing
Department of Agricultural Extension
Khamarbari, Farmgate, Dhaka-1205

Pest Risk Analysis (PRA) of Sesame in Bangladesh

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REPORT ON PEST RISK ANALYSIS (PRA) OF SESAME IN BANGLADESH

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Submitted to

Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project
Plant Quarantine Wing, Department of Agricultural Extension
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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 Sesame in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and Development Technical Consultants Pvt. Ltd. (DTCL) on December 2016. The PRA study is a five month assignment commencing from 1 January 2017 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 sesame 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 69 upazila under 30 major sesame growing districts of Bangladesh. The study covered the interview 6900 sesame farmers. The key informant interviews were conducted with the extension personnel at field and head quarter level of DAE, officials of Plant Quarantine Centers at Sea and Land ports; Entomologist and Plant Pathologist of BARI/BADC and Agricultural Universities. A total of 45 key personnel were interviewed using a semi-structured KII Checklist. The survey was also covered 30 FGDs each of which conducted in one district for qualitative data and visits of the Sesame fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of Sesame.

The study findings evidenced that a total of 46 pests of sesame were recorded in Bangladesh, of which 26 were arthropod pests, 10 species of pathogenic microorganisms and 10 weeds. The study also revealed that 15 pests of sesame were identified as quarantine importance for Bangladesh that included 10 insect pests, 4 disease causing pathogen including one fungus, one bacterium, one nematode, one virus and one weed that could be introduced into Bangladesh through importation of commercially produced sesame. 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, out of fifteen (15) potential hazard organisms, 7 hazard organisms were identified with high risk potential, 4 identified with moderate risk potential and 4 with low risk rating. These mean that these pests pose unacceptable phytosanitary risk to Bangladesh's agriculture.

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 Sesame 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 sesame.

sd/-

(Dr. Mohammad Ali)
Project Director
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PREFACE

This report intends to respond to the national requirement to make a comprehensive list of pests like insect and mite pests, diseases and weed pests of sesame in Bangladesh as well as to identify the quarantine pests of sesame for Bangladesh, their pathways to be imported from exporting countries sesame, to assess their risks and to identify their management options agreement signed between Project Director of Strengthening Phytosanitary Capacity in Bangladesh (SPCB) and the Development Technical Consultants Pvt. Ltd. (DTCL) for **"Pest Risk Analysis (PRA) of Sesame 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 five month assignment commencing from 1 January 2017 under the SPCB-DAE.

Consultancy services for "Conducting Pest Risk Analysis (PRA) of Sesame in Bangladesh" were 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 sesame, 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.

sd/-

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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 Consultants Pvt. Ltd. (DTCL) to carry out the "**Pest Risk Analysis (PRA) of Sesame in Bangladesh"**. The report has been prepared based on the past five months (January 2017 to May 2017) activities of the survey study in major 30 Sesame 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. Mahbuba Jahan (Entomologist), Dr. M. Salahuddin M. Chowdhury (Plant Pathologist), Md. Lutfor Rahman (Agronomist) and Dr. Bazlul Ameen Ahmad Mustafi (Economist) of the PRA study team.

The authors are grateful to all persons involved in the PRA study. Our special gratitude to Md. Golam Maruf, 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 Mohammad Mohsin, Director, PQW of DAE for his kind cooperation and suggestions during the study period. The active support and inspiration and cooperation of Dr. M. M. Amir Hossain, Managing Director, Development Technical Consultants Pvt. Ltd. (DTCL) are praise-worthy during the entire period of study.

sd/-

Prof. Dr. Md. Razzab Ali
Team Leader

ACRONYMS

AEO	: Agricultural Extension Officer
BADC	: Bangladesh Agricultural Development Corporation
BARI	: Bangladesh Agricultural Research Institute
BBS	: Bangladesh Bureau of Statistics
BRRI	: Bangladesh Rice Research Institute
CABI	: Centre for Agriculture Bio-resources International
DAE	: Department of Agricultural Extension
DD	: Deputy Director
DPP	: Development Project Proforma
DTCL	: Development Technical Consultants Ltd.
EPPO	: European and Mediterranean Plant Protection Organization
FAO	: Food and Agricultural Organization
FGD	: Focus Group Discussion
FPC	: Finite Population Correction
HQ	: Headquarter
IPM	: Integrated Pest Management
IPPC	: International Plant Protection Convention
ISPM	: International Standard for Phytosanitary Measures
KII	: Key Informant Interview
LMOs	: Living Modified Organisms
Ltd.	: Limited
OEPP	: Organization for European and Mediterranean Plant Protection
PFA	: Pest Free Area
PFPP	: Pest Free Place of Production
PPW	: Plant Protection Wing
PQ	: Plant Quarantine
PQW	: Plant Quarantine Wing
PRA	: Pest Risk Analysis
QC	: Quarantine Centers
RMG	: Readymade Garments
RNQPs	: Regulated Non-Quarantine Pests
SPCB	: Strengthening Phytosanitary Capacity in Bangladesh Project
ToR	: Terms of References
USD	: United States Dollar
WTO	: World Trade Organization

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EXECUTIVE SUMMARY

The study "Pest Risk Analysis (PRA) of Sesame in Bangladesh" documents the pests of sesame crops available in Bangladesh and the risks associated with the import pathway of sesame from the exporting countries namely India, Vietnam, China, Taiwan, Japan, Korea, Malaysia and Thailand into Bangladesh.

The findings evidenced that the 46 pests of sesame were recorded in Bangladesh, of which 26 arthropod pests that included 24 insect pests and 2 mite pests; 10 disease causing pathogens and 10 weeds. The insect pests of sesame reported were green sting bug (*Nezara viridula);* hawk moth (*Ambulyx substrigilis*); hairy caterpillar (*Spilarctia obliqua*); leaf and pod borer (*Antigastra catalaunalis*); mired bug (*Cyrtopeltis tenuis*); semilooper (*Plusia orchalcea*); green grasshopper (*Atractomorpha crenulata*); black weevil (*Cyrtozemia cognata*); leaf beetle (*Monolepta signata*); grey weevil (*Myllocerus maculosus*); jassid (*Empoasca terminalis*); sesame pod bug (*Eusarcocoris ventralis*); thrips (*Frankliniella schultzei*); white fly (*Bemisia tabaci*); gall fly (*Asphondylia sesami*); tomato bug (*Nesidiocoris tenuis);* green peach aphid (*Myzus persicae* Sulzer); melon thrips (*Thrips palmi* Karny); small death's head hawkmoth (*Acherontia styx* (Westwood, 1847)); black cutworm (*Agrotis ipsilon* (Hufnagel, 1766)); turnip moth (*Agrotis segetum* Denis & Schiffermüller); sesame webworm (*Antigastra catalaunalis* Duponchel); dried currant moth (*Cadra cautella* Walker) and khapra beetle (*Trogoderma granarium* Everts), whereas two mite pests of sesame were recorded in Bangladesh named two-spotted spider mite (*Tetranychus urticae*) and mite (*Brevipalpus phoenicis*). Among these insect and mite pests of sesame hawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm, sesame webworm and turnip moth were more damaging than other arthropod pests. The hawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm, sesame webworm and turnip moth were designated as major pest of sesame 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.

A total number of 10 species of disease causing pathogens of sesame were reported in Bangladesh, among which 8 diseases were caused by fungi, 1 caused by nematode and 1disease of sesame was caused by virus. The incidences of fungal diseases of sesame reported in Bangladesh were Choanephora fruit rot (*Choanephora sesamearum);* cottony soft rot (*Sclerotinia sclerotiorum);* sclerotium rot (*Athelia rolfsii);* Aspergillus ear rot (*Aspergillus flavus);* charcoal rot (*Macrophomina phaseolina*); Fusarium wilt (*Fusarium oxysporum f.sp. vasinfectum*); Alternaria leaf spot (*Alternaria alternate)* and powdery mildew (*Podosphaera xanthii).*

The nemic disease of sesame was caused by reniform nematode (*Totyenchus reniformis*). The viral disease of sesame reported in Bangladesh was *Cowpea aphid-borne mosaic virus*. Among these diseases, the cottony soft rot and charcoal rot were more damaging than others. But diseases were reported as minor diseases of sesame and caused damage with low infection intensity in Bangladesh.

A total number of 10 weeds were reported as the problem in the field of sesame in Bangladesh. The incidences of weeds in the field of sesame and foliages as reported by the farmers were bermuda grass (*Cynodon dactylon*), nutsedge (*Cyperus esculentus*), pigweed (*Amaranthus acanthochiton*), spiny pigweed (*Amaranthus spinosus*), goose grass (*Eleusine indica* (L.) Gaertner), crab grass (*Digitaria ciliaris* (Retz.) Koeler); black nightshade (*Solanum nigrum* L.), cock's comb (*Celosia argentea* L.);

scorpion weed (*Heliotropium indicum* L.) and 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 sesame fields.

Information on pests associated with sesame in the exporting countries such as India, Vietnam, China, Taiwan, Japan, Korea, Malaysia and Thailand —revealed that pests of quarantine importance exist. The study also revealed 15 pest species of quarantine importance that included 10 insect pests, 1 fungus, 1 bacterium, 1 nematode species, 1 viruses and 1 weed. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced sesame. Pests of quarantine importance included insect pests namely cottony mealybug (*Phenacoccus solenopsis* Tinsley), two spotted sesame bug (*Eysarcoris guttiger* (Thunberg)); sesame Jassid (*Orosius orientalis);* desert locust (*Schistocerca gregaria);* death's head hawkmoth (*Acherontia atropos* Linnaeus); beet Webworm (*Loxostege sticticalis* Linnaeus); tiger moth (*Amsacta moorei* Butler); cassava hornworm (*Erinnyis ello* (Linnaeus, 1758)); pulse beetle (*Callosobruchus analis* Fabricius) and simsim flea beetle (*Alocypha bimaculata* Jacoby) On the other hand, one quarantine mite pest for Bangladesh is red spider mite (*Tetranychus evansi*). Four (4) quarantine disease causing pathogens of sesame have been identified for Bangladesh. Among these, black root rot (*Chalara elegans*); one quarantine bacteria namely yellow disease phytoplasmas (*Candidatus Phytoplasma asteris)*; one species of nematode namely pigeon pea cyst nematode (*Heterodera cajani Koshy*); one viruses namely *cucumber Peanut mottle virus*. One species of quarantine weed has been identified for Bangladesh named parthenium weed (*Parthenium hysterophorus*).

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

Out of 15 quarantine pests associated with the pathway risk assessed. Out of 15 potential hazard organisms, 7 hazard organisms were identified with high risk potential, 4 were moderate and 4 were identified with low 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 sesame 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

SCOPE AND METHODOLOGY OF PEST RISK ANALYSIS

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 has been importing sesame from different exporting counties such as India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand, or other counties of the world. Due to imports of sesame 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. Moreover, Bangladesh is highly suitable for sesame production due to its favorable climatic, topography and other conditions like labour cost and relatively low capital investment in contrast with high value addition. Besides importing, Bangladesh also exports sesame seeds in different countries of the world. Importing countries of sesame from Bangladesh are also necessitated the pests list of sesame that occurred in Bangladesh. Therefore, the pathway risk analysis of sesame from exporting countries to Bangladesh is essential. In this context, the Pest Risk Analysis (PRA) of Sesame in Bangladesh is indispensable. Thus, the assignment on PRA of Sesame in Bangladesh was undertaken aiming to identify pests and/or pathways of quarantine concern for the sesame 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 find out the potential hazard organisms like insect and mite pests, diseases, weeds or other pests likely to be associated with sesame imported from different exporting countries such as India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand (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) of Bangladesh to identify insect and mite pests, diseases, weeds or othe pests likely to be associated with sesame and/or pathways of quarantine pests to be associated with the sesame which brings along with them a certain risk of the introduction of insect and mite pests, diseases, weeds and othe pests of sesame that are harmful to agriculture of Bangladesh.

According to the Terms and Reference (ToR) of the study, the consulting firm is required to listing of the major and minor insect and mite pests, diseases, weeds or other pests of sesame in Bangladesh and identify quarantine pests of sesame for Bangladesh that follow the pathway(s) during importation, as well as to evaluate their risk, and finally to formulate the risk management options etc.

1.4. PRA Areas

The entire Bangladesh is considered as the PRA areas in this risk analysis. But the sesame is not grown all over the country. Therefore, the major sesame growing districts of Bangladesh are considered as the PRA area in this Pest Risk Analysis Process. Moreover, sesame is imported through different Sea and Land ports which are located all regions of Bangladesh, which are also considered as PRA areas. However, survey on insect and mite pests, diseases, weeds and other hazard organisms was done in major sesame growing districts of Bangladesh as well as ports through which sesame are being imported into Bangladesh.

1.5. Methodology of Pest Risk Analysis

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

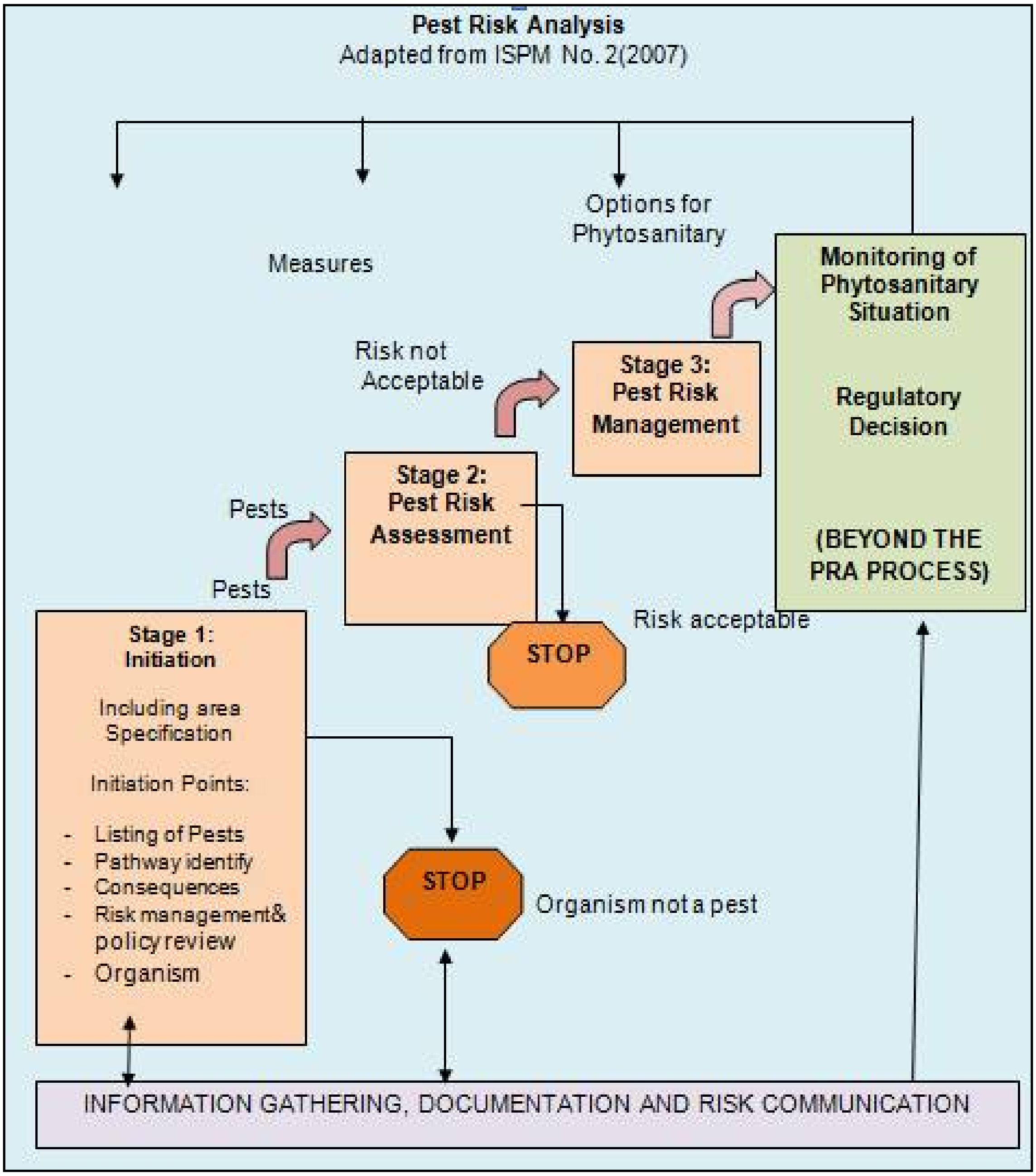


Figure 1: Schematic Diagram of Pest Risk Analysis

1.6. Methodology for data collection

1.6.1. Introduction

The methodology for the present PRA study used system-wide approach, which involved wide-ranging and sequenced discussion with relavent stakeholders aiming to identify the insect pests, diseases and other associated pests of sesame, 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.

1.6.2.Field survey

The study survey was conducted with the direct interview of sesame growers in 30 major sesamegrowing 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 sesame growers and through key informant interviews (KII) with extension personnel at field and headquarer level of DAE, Quarantine personnel of 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.

1.6.3. Secondary data collection and review

The current PRA related secondary data were collected and gathered from secondary sources such as journals, books, reports, proceedings, CD-ROM (CABI) searchand others. The documents were then critically reviewed, synthesized in relation to identify the quarantine pests of sesame available in the sesame exporting counties namelyIndia, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand etc as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

1.6.4. Internet browsing

The PRA related information on insect and mite pests, diseases, weeds and other pests likely to be associated with sesame were also collected and gathered through internet browsing especially through websites of CAB International, EPPO Bulletin and different LAN based e-Journals namely TEEAL, HINARI, AGORA, OARE etc. The documents were then critically reviewed, synthesized in relation to identify the quarantine pests of sesame available in the exporting counties of commodities as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

1.6.5. Listing of pests of sesame

There is no comprehensive list of sesame pests such as insect and mite pests, diseases, weeds and other pests likely to be associated with sesame in Bangladesh. Therefore, it is required to make a comprehensive list of sesame pests in Bangladesh through primary and secondary data collection for conducting the risk analysis of sesame pests.The insect and mite pests, diseases, weeds and other associated pests of sesame 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 sesame 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 sesame in Bangladesh were also listed.

1.6.6. PRA location and study sampling

The survey study sas conducted in the 30major sesame 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 69 upazilas were covered under the 30 sampled distrcts, where 10 agricultural blocks were covered under each upazilla and 10 sesamefarmers were interviewed in each block through pre-tested questionnaire. Thus, a total of 6900 sesame farmers were interviewed from all of 30 sampled districts. The focus group discussion (FGD) meeting was also conducted for each of 30 sampled districts with the participation of at least 10 sesame farmers for each FGD aiming to gather qualitative data related to the pests of sesame in Bangladesh. 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	Shariatpur	Sadar	10	100	1	1
		Gosairhat	10	100		
		Bedergonj	10	100		
2	Gopalgonj	Kashiani	10	100	1	1
		Tungipara	10	100		
		Sadar	10	100		
3	Madaripur	Shibchor	10	100	1	1
		Sadar	10	100		
4	Magura	Sadar	10	100	+1	1
		Shalikha	10	100		
5	Faridpur	Nagarkanda	10	100	1	1
		Bangha	10	100		
		Sadarpur	10	100		
		Sadar	10	100		
6	Pabna	Sadar	10	100	1	1
		Ishwardhi	10	100		
		Atgoria	10	100		
7	Noagaon	Sadar	10	100	1	1
		Manda	10	100		
8	Khulna	Dumuria	10	100	1	1
		Batiaghata	10	100		
9	Satkhira	Kolaroa	10	100	1	1
		Sadar	10	100		
10	Rajshahi	Charghat	10	100	1	1
		Puthia	10	100		
		Bagha	10	100		
11	Pirojpur	Bhandaria	10	100	1	1
		Mothbaria	10	100		
12	Norsingdhi	Sadar	10	100	1	1
		Raipura	10	100		
13	Sherpur	Nalitabari	10	100	1	1
		Nokhla	10	100		
14	Chuadanga	Damurhuda	10	100	1	1
		Sadar	10	100		
15	Kishoregonj	Sadar	10	100	1	1

SN	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII
		Pakundia	10	100		
16	Brammanbaria	Bancharampur	10	100	1	1
		Nabinagar	10	100		
17	Joipurhat	Sadar	10	100	1	1
		Akkelpur	10	100		
18	Panchagar	Sadar	10	100	1	1
		Tintulia	10	100		
19	Kurigram	Sadar	10	100	1	1
		Roumari	10	100		
20	Jenidah	Sadar	10	100	1	1
		Kaligonj	10	100		
21	Rajbari	Baliakandi	10	100	1	1
		Pansha	10	100		
22	Rangamati	Baghaichai	10	100	1	1
		Longadu	10	100		
23	Khagrachari	Sadar	10	100	1	1
		Dighinala	10	100		
24	Kushtia	Kumarkhali	10	100	1	1
		Sadar	10	100		
25	Bandarban	Sadar	10	100	1	1
		Thanchi	10	100		
26	Sirajgonj	Sadar	10	100	1	1
		Kazipur	10	100		
		Chouhali	10	100		
		Shajadpur	10	100		
27	Tangail	Sadar	10	100	1	1
		Mirzapur	10	100		
		Bhuapur	10	100		
28	Dhaka	Dhamrai	10	100	1	1
		Savar	10	100		
29	Satkhira	Sadar	10	100	1	1
		Kolaroa	10	100		
30	Rajbari	Baliakandi	10	100	1	1
		Pansha	10	100		
Total	**30**	**69**	**690**	**6900**	**30**	**30**

1.6.7. 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 30 major sesame growing districts of Bangladesh through face to face interview with 6900 sesame farmers using a set of pre-designed and pre-tested questionnaire (**Appendix-1)** encompassing the relevant study indicators.

Focus Group Discussion (FGD) guidelines: For qualitative analysis, 30 FGD meetings were organized considering one FGD for each sampled districts with the participantion of at least 10 sesame farmers for each. The FGD meetings were conducted using pre-designed FGD guidelines (**Appendix-2**).

Key Informant Interview (KII) checklist: 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; Entomologist and Plant Pathologist of BARI/BADC and Agricultural Universities. A total of 65 key personnel were interviewed using a semi-structured KII Checklist (**Appendix 3-5)** encompassing the qualitative issues of the study.

Field visit/physical observation checklist: 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**.**

CHAPTER 2

METHODOLOGY OF RISK ANALYSIS

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

2.1. Undertaking of Pest Risk Analysis (PRA)

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

PRA STAGE 1: INITIATION

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

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

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

PRA STAGE 2: PEST RISK ASSESSMENT

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

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

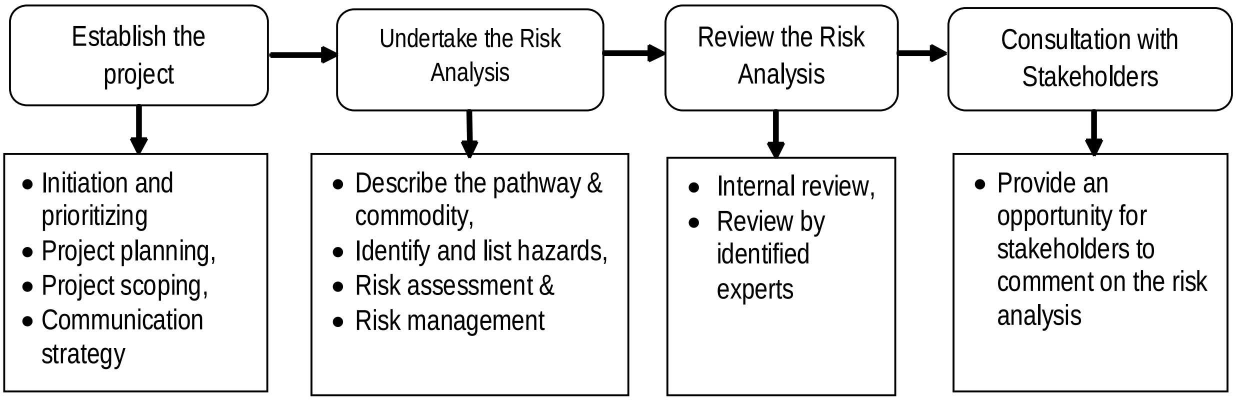
In most cases, these steps were applied sequentially in a PRA but it is not essential to follow a particular sequence. Pest risk assessment needs to be only as complex as is technically justified by the circumstances. This standard allows a specific PRA to be judged against the principles of necessity,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

PRA STAGE 3: PEST RISK MANAGEMENT

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

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

Figure 2: A summary of the risk analysis development process



2.2. Pathway Description

2.2.1. Import pathways of sesame

For the purpose of this risk analysis, sesame are presumed to be from anywhere in exporting countries such as India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand.

To comply with existing Bangladesh import requirements for sesame, 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 sesameand seeds.

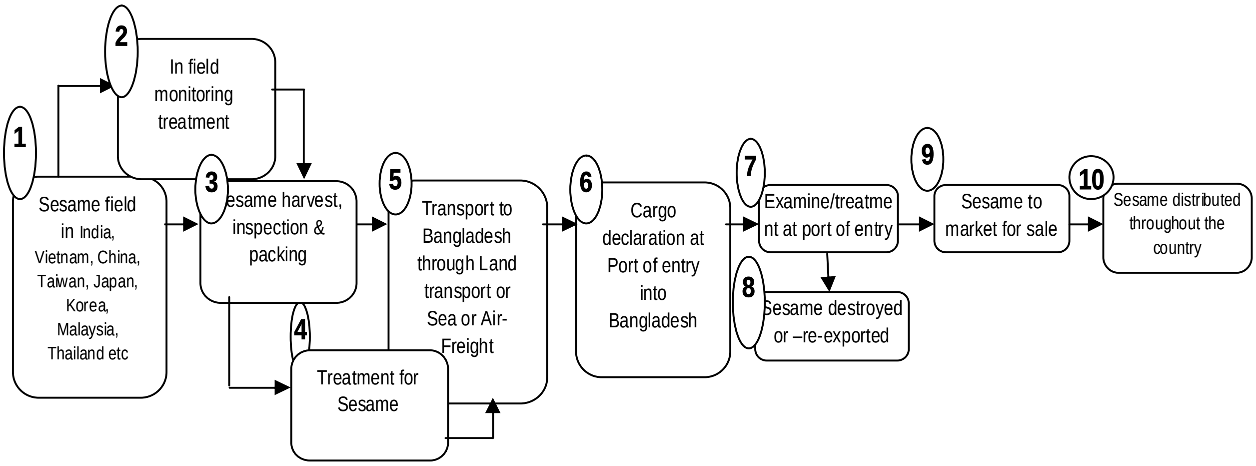
2.2.2. Pathway Description

- Sesamein India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand are being grown in thefield, 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 sesame is undertaken, with appropriate controls applied.
- Sesame isbeing harvested, inspected and the best quality sesamewashed, pre-treated and packed in boxes.
- Post harvest disinfestations including fumigation or cold disinfestations are being undertaken either before or during transport of the sesame 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 sesame, any treatments completed, or other information required to help for mitigating the risks.
- Sesameare examined at the border to ensure compliance.
- Any sesame not complying with Bangladesh biosecurity requirements (e.g. found harboring pest organisms) are either treated or re-shipped or destroyed.
- Beside these, natural entry of some pests of sesame may occure from other neighbouring country(ies) into Bangladesh. For example, beet wabworm adult can fly continuously for 24 hours and have flown a maximum distance more than 100 Km. (Luo and Li, 1992). Moth can migrate 300-500 Km. (Sun and Chen, 1995).
- Possibility of entry of pests of onion and garlic from exporting country(ies) into Bangladesh through transportation of commodities by escaping the phytosanitary

inspection in the port of entry. For example, the spores of black root rot are soilborne, airborne within the nursery and its immediate surrounds and waterborne in drainage water. It can easily enter into Bangladesh via ornamental plants.

- Sesame are stored before being distributed to market for sale.
- Dealers and sellers of sesame 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 sesame is furnished in the following figure:

Figure 3: Linear Pathway Diagram of Import Risk of Sesame



2.3. Hazard Identificationy

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 sesamewhich could be introduced into Bangladesh by risk goods, and are potentially capable of causing harm to sesame production, must be identified. This process begins with the collection of information on insect pests, diseases (pathogen) or weed or any other pests of sesamepresent 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.

2.4. Risk Assessment of Potential Hazards

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

2.5. Assessment of Uncertainties

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

2.6. Risk Management

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:

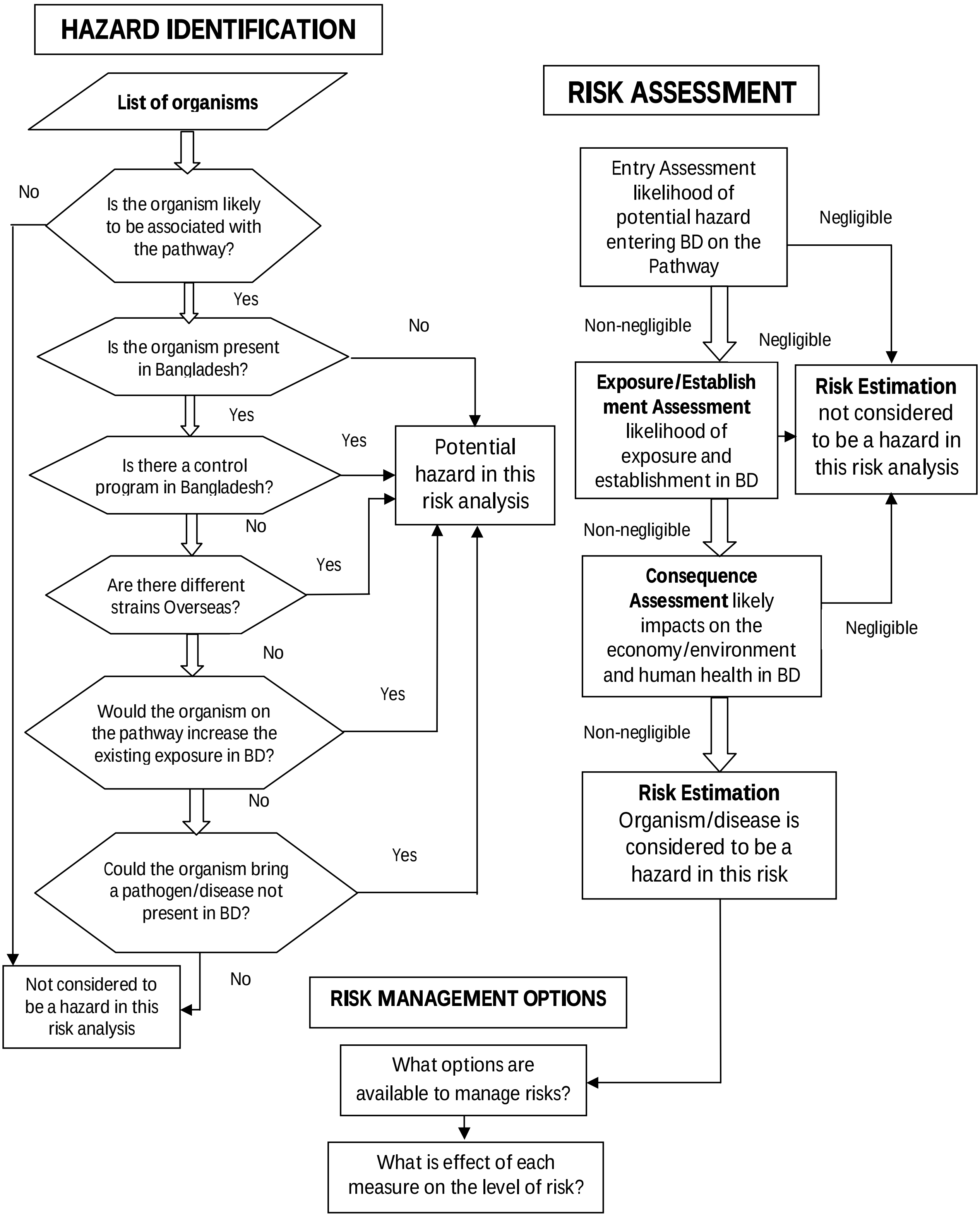
2.7. Risk Evaluation

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

2.8. Option Evaluation

Measures that are expected to be effective against the hazard species are considered. A package of risk management measures is likely to be required to address the risk from all identified hazards. While there are currently six established pathways India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand for sesameseeds 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.

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



2.9. Review and Consultation

Peer review is a fundamental component of a risk analysis to ensure it is based on the most up-to-date and credible information available. Each analysis must be submitted to a peer review process involving appropriate staff within those government departments with applicable 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.

REFERENCES

Akbar, M. A. 2011. Adoption of modern rapeseed mustard and sesame varieties with production technology for yield gap reduction. Project No. 16. Agrarian Research Foundation (ARF), Dhaka.

Akter, M., Miah, M. A. M., Rahman, M. S. and Khurram, M. M. H. 2010. Adoption and relative profitability of groundnut (Arachis hypogaea L.) cultivation in char areas of Bangladesh. Bangladesh J. of Agri., 35 (1): 85-95.

BBS, 2012. Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh.

BBS, 2013. Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh.

CBD (2000). Cartagena Protocol on Biosafety to the Convention on Biological Diversity, 2000. CBD, Montreal.

FAO (1990). FAO Glossary of phytosanitary terms, FAO Plant Protection Bulletin, 38(1) 1990: 5-23.

FAO (1996). Report of the 3rd meeting of the FAO Committee of Experts on Phytosanitary Measures, 1996. FAO, Rome.

FAO (1998). Report of the 1st meeting of the Interim Commissionon Phytosanitary Measures, 1998. FAO, Rome.

FAO (1999). Report of the 6th meeting of the FAO Committee of Experts on Phytosanitary Measures, 1999. FAO, Rome.

FAO (2001).Report of the 3rd meeting of the Interim Commission on Phytosanitary Measures, 2001. FAO, Rome.

FAO (2002).Report of the 4th meeting of the Interim Commission on Phytosanitary Measures, 2002. FAO, Rome.

FAO (2003).Report of the 5th meeting of the Interim Commission on Phytosanitary Measures, 2003. FAO, Rome.

FAO (2004). Report of the 6th meeting of the Interim Commission on Phytosanitary Measures, 2004. FAO, Rome

FAO (2005). Report of the 7th meeting of the Interim Commission on Phytosanitary Measures, 2005. FAO, Rome

FAO (2007). Report of the 2nd session of the Commission on Phytosanitary Measures, 2007. FAO, Rome.

IPPC (1997). International Plant Protection Convention, 1997. FAO, Rome.

ISPM No. 10 (1999). Requirements for the establishment of pest free places of production and pest free production sites, 1999. ISPM No. 10, FAO, Rome.

ISPM No. 11 (2004). Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms, 2004. ISPM No. 11, FAO, Rome.

ISPM No. 12 (2001). Guidelines for phytosanitary certificates, 2001. ISPM No. 12, FAO, Rome.

ISPM No. 13 (2001). Guidelines for the notification of non-compliance and emergency action, 2001. ISPM No. 13, FAO, Rome.

ISPM No. 14 (2002). The use of integrated measures in a systems approach for pest risk management, 2002. ISPM No. 14, FAO, Rome

ISPM No. 15 (2002). Guidelines for regulating wood packaging material in international trade, 2002. ISPM No. 15, FAO, Rome.

ISPM No. 16 (2002). Regulated non-quarantine pests: concept and application, 2002. ISPM No. 16. FAO, Rome.

ISPM No. 18 (2003). Guidelines on the use of irradiation as a phytosanitary measure, 2003. ISPM No. 18, FAO, Rome.

ISPM No. 2 (1996). Guidelines for pest risk analysis, 1996. ISPM No. 2, FAO, Rome.

ISPM No. 2 (2007). Framework for pest risk analysis, 2007. ISPM No. 2, FAO Rome.

ISPM No. 20 (2004). Guidelines for a phytosanitary import regulatory system, 2004. ISPM No. 20, FAO, Rome.

ISPM No. 22 (2005). Requirements for the establishment of areas of low pest prevalence, 2005. ISPM No. 22, FAO, Rome.

ISPM No. 23 (2005). Guidelines for inspection, 2005. ISPM No. 23, FAO, Rome.

ISPM No. 24 (2005). Guidelines for the determination and recognition of equivalence of phytosanitary measures, 2005. ISPM No. 24, FAO, Rome.

ISPM No. 25 (2006). Consignments in transit, 2006. ISPM No. 25, FAO, Rome.

ISPM No. 27 (2006). Diagnostic protocols for regulated pests, 2006. ISPM No. 27, FAO, Rome.

ISPM No. 28 (2007). Phytosanitary treatments for regulated pests, 2007. ISPM No. 28, FAO, Rome.

ISPM No. 3 (1996). Code of conduct for the import and release of exotic biological control agents, 1996. ISPM No. 3, FAO, Rome

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

ISPM No. 4 (1996). Requirements for the establishment of pest free areas, 1996. ISPM No. 4, FAO, Rome.

ISPM No. 5 (1995). Glossary of phytosanitary terms, 1995. ISPM No. 5, FAO Rome. [published 1996]

ISPM No. 6 (1997). Guidelines for surveillance, 1997. ISPM No. 6, FAO, Rome.

ISPM No. 7 (1997). Export certification system, 1997.ISPM No. 7, FAO, Rome

ISPM No. 8 (1998). Determination of pest status in an area, 1998. ISPM No. 8, FAO, Rome.

ISPM No. 9 (1998). Guidelines for pest eradication programmes, 1998. ISPM No. 9, FAO, Rome.

Khan, M. A. H., Sultan, N. A., Islam, M. N. and Hasanuzzaman, M. 2009. Yield and yield contributing characters of sesame as affected by different management practices. American-Eurasian Journal of Scientific Research, 4(3): 195-197.

Luo, L. Z., and G. B. Li. 1992. Variation of the flight ability and behavior of adult meadow moth, *Loxostege sticticalis* at different ages. Transactions of the Ecological Society of Chinese Youths. pp. 303Ð308. In Ecology Research Society of China and IPM Institute of Chinese Agricultural University (eds). Chinese Science and Technology Press, Beijing, China.

Malik, S. J., Mushtaq M. and Gill, M. A. 1991. The role of institutional credit in the agricultural development of Pakistan. The Pakistan Development Review, 30(4): 1039-1048.

Sun, Y. J., and R. L. Chen. 1995. Studies on migration, oc-currence by region and life history of meadow moth (*Loxostege sticticali* L.) in China. Acta Agric. Boreali-Sin.10: 86-91.

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

CHAPTER 3

INITIATION

3.1. 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 sesame. 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.

3.2. Commodity Description

3.2.1. Introduction

Common Names: Beni; benne; beniseed

Scientific Names: *Sesamum indicum*

General Description: Sesame (*Sesamum orientale*) is an introduced annual broadleaf plant that grows 5–6 ft (155-185 cm) tall. It produces a 1–2 in (2.5–5cm) long white, bellshaped inflorescence growing from the leaf axils (where the leaf stalk joins the stem). The blooms do not open all at once, but gradually, from the base of the stem upwards to the top of the plant. The flowers are both male and female and will self-pollinate. The seed is produced in a 1–1.5 in (2.5–3.8 cm) long, divided seed capsule that opens when the seeds are mature. There are 8 rows of seed within each seed capsule, and seed may be yellow, white, brown, or black (Morris, 2002). Due to the nonuniform, indeterminate nature of the bloom period, the reproductive, ripening, and drying phases of the seed tend to overlap. Seed lowest on the plant will mature first, even as the upper part of the plant is still flowering or has just formed seed capsules. Sesame varieties have single or multiple stems. The stem is covered with short, soft hairs. Sesame is very leafy; with 3–5 in (7.5–12.7 cm) long, somewhat rough, lanceshaped, entire upper leaves, and tri-lobed lower leaves. Sesame has been grown in many parts of the world for over 4000 years. First introduced in the southern United States by slaves, the plant's potential as an oil seed was quickly recognized and enthusiastically promoted by Thomas Jefferson. Currently, the United States imports more sesame than it grows, so there is potential for increasing production acres in the US, especially as more shatter-resistant varieties are developed.

Distribution: Sesame is most commonly planted in the south and southwestern United States, but is also being promoted in the southeast because it grows well in hot weather and sandy soils.

Habitat: Sesame grows best in well-drained, sandy loam soils, with a pH from 5–8. Sesame cannot survive standing water or high salinity environments.

Adaptation: Sesame is notable for its ability to grow under droughty conditions and in extreme heat. It is often grown where cotton can grow, under conditions few other crops can survive, requiring very few inputs. These attributes make sesame an excellent candidate for low-input sustainable food systems. Sesame is deep-rooted and will scavenge nutrients from below most crop root zones (Langham *et al.,* 2008). When grown from East Texas to the Atlantic coast sesame becomes more susceptible to leaf diseases (Langham *et al.,* 2008). Sesame has moderate salt tolerance (Bahrami and Razmjoo, 2012), but will not grow under flooded conditions. Generally, the plant will have a better chance of survival when it is grown in hotter than optimal temperatures rather than lower than optimal temperatures (Langham *et al.,* 2008).

3.2.2. History

Sesame seed is considered to be the oldest oilseed crop known to humanity. The genus has many species, and most are wild. Most wild species of the genus Sesamum are native to sub-Saharan Africa. *Sesame indicum*, the cultivated type of sesame was originated in India.

Charred remains of sesame recovered from archeological excavations have been dated to 3500-3050 BC. Fuller claims trading of sesame between Mesopotamia and the Indian sub-continent occurred by 2000 BC. Some reports claim sesame was cultivated in Egypt during the Ptolemiac period, while others suggest the New Kingdom.

Records from Babylon and Assyria, dating about 4000 years ago, mention sesame. Egyptians called it sesemt, and it is included in the list of medicinal drugs in the scrolls of the Ebers Papyrus dated to be over 3600 years old. Archeological reports from Turkey indicate that sesame was grown and pressed to extract oil at least 2750 years ago in the empire of Urartu.

The historic origin of sesame was favored by its ability to grow in areas that do not support the growth of other crops. It is also a robust crop that needs little farming support—it grows in drought conditions, in high heat, with residual moisture in soil after monsoons are gone or even when rains fail or when rains are excessive. It was a crop that could be grown by subsistence farmers at the edge of deserts, where no other crops grow. Sesame has been called a survivor crop.

3.2.3. Sesame in Bangladesh

Sesame (*Sesamum indicum* Linn.), an oil seed crop belongs to the family Pedaliaceae. It is cultivated widely in China, India, Mexico, Burma, Sudan, and Turkey. Bangladesh and in many other countries of the world sesame is cultivated as an oil seed crop. Sesame prefers to grow on light well drained soil with adequate moisture. In Bangladesh, the soil texture and climatic condition are quite suitable for the cultivation of sesame.

In Bangladesh, sesame is an important summer oilseed crop occupying 9.4% of the total oilseed area (BBS, 2012). Sesame is highly beneficial as it contains 42-50% oil and the oil contains 42% essential linoleic acid, 25% protein and 16-18% carbohydrate. Moreover, premium quality edible and medicinal oil can be extracted from sesame, which can be conserved for a long time. Sesame oilcake is good feed for poultry, fish, cattle, goat and sheep (Khan *et al.,* 2009).As an annual crop, sesame is considered as the second major oil seed crop in Bangladesh both in respect of acreage and production (Annon, 1991). Most of the sesame seeds are used for oil extraction and the rest are used for planting and edible purposes (Rahman *et al.* 2007). On account of its good agreeable flavour, sesame seeds are also used as nourishing and flavouring agent (Annon, 1988).

3.2.4. Morphological characteristics

Sesame is an annual plant growing 50 to 100 cm (1.6 to 3.3 ft) tall, with opposite leaves 4 to 14 cm (1.6 to 5.5 in) long with an entire margin; they are broad lanceolate, to 5 cm (2 in) broad, at the base of the plant, narrowing to just 1 cm (0.4 in) broad on the flowering stem. The flowers are yellow, tubular, 3 to 5 cm (1.2 to 2.0 in) long, with a four-lobed mouth. The flowers may vary in colour, with some being white, blue, or purple.

Sesame seeds occur in many colours depending on the cultivar. The most traded variety of sesame is off-white coloured. Other common colors are buff, tan, gold, brown, reddish, gray, and black. The colour is the same for the hull and the fruit.

Sesame fruit is a capsule, normally pubescent, rectangular in section, and typically grooved with a short, triangular beak. The length of the fruit capsule varies from 2 to 8 cm, its width varies between 0.5 and 2 cm, and the number of loculi varies from four to 12. The fruit naturally splits open (dehisces) to release the seeds by splitting along the septa from top to bottom or by means of two apical pores, depending on the varietal cultivar. The degree of dehiscence is of importance in breeding for mechanised harvesting, as is the insertion height of the first capsule.

Sesame seeds are small. Their size, form, and colours vary with the thousands of varieties now known. Typically, the seeds are about 3 to 4 mm long by 2 mm wide and 1 mm thick. The seeds are ovate, slightly flattened, and somewhat thinner at the eye of the seed (hilum) than at the opposite end. The weight of the seeds is between 20 and 40 mg. The seed coat (testa) may be smooth or ribbed.

3.2.5. Classification of sesame

The genus Sesamum consists of 35 recognized species (Total is over 60). Out of these, *S. indicum* L. is cultivated extensively. The other 6 partially cultivated species include *S. radiatum* (India, Africa, Sri Lanka), *S. angustifolium* (Congo, Mozambique, Uganda), *S. occidentale* (Africa, Sri Lanka, India), *S. calycinum* (Angola, Mozambique), *S. bauymii* (Angola). All other species are wild and found in tropical African countries. Nine wildspecies have been found in peninsular India.

Based on maturity period, sesame cultivars are classified as: *Early* (possess less number of flowers and branches) and *Late* (possess more number of flowers and branches) types. Based on seed coat colour, they are grouped into *white* and *black* seeded cultivars. Using the number of carpels in the capsules, sesame cultivars are classified as *Bicarpellatum* (two carpels) and *Quadricarpellatum* (four capels in the capsule). On the basis of chromosome number, sesame species are classified into the following three groups.

Group	Chromosome number	Species
I	2n=26	*Sesamum indicum*, *S. alatum*, *S. malabaricum, S. mulayanum, S.schenckii*
II	2n=32	*S. prostratum, S. laciniatum, S. angolense, S. angustifolium*
III	2n=64	*S. radiatum, S. occidentale*

(a) *Sesamum indicum:*Sesamum indicum is an ANNUAL growing to 1 m (3ft 3in) by 0.5 m (1ft 8in). It is hardy to zone (UK) 10 and is frost tender. It is in flower in July. The flowers are hermaphrodite (have both male and female organs). Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It cannot grow in the shade. It prefers moist soil.

(b) *S. prostratum:*Strong smelling, abundantly branched, prostrate herbs; stems and branches obtusely quadrangular in upper part, furrowed, villous-tomentose. Leaves small, broadly ovate to obovate, rarely shallowly 3-lobed, 6-17 mm long, 6-16 mm broad; base rounded, margin crenate-dentate, apex rounded, sparsely pubescent on upper surface, densely covered with villous hairs on veins below, numerous white mucilagenous hairs between veins below; petioles 1-2 mm long. Pedicels 1-2 mm long. Calyx lobes nearly free to base, lanceolate, c. 5 mm long,

c. 1 mm broad. Corolla reddish to pinkish-violet without, similar with purple flecks and spots within, densely pubescent without, 20-30 mm long. Capsule is ovate-oblong, 6-12 mm long, 4-9 mm broad, densely villous and with white mucilagenous hairs, apex rounded and truncated, beaked. Seeds c. 2 mm long, black, reticulate-pitted.

(c) *S. radiatum:* Erect annual herb up to 120(-150) cm tall; stem simple or branched, glandular pubescent. Leaves opposite or alternate in upper part of plant, simple; stipules absent; petiole up to 2.5 cm long in lower leaves, short in upper leaves; blade lanceolate to ovate or elliptical, 3-10(-12) cm × 1.5-5(-7) cm, cuneate to obtuse at base, acute at apex, coarsely serrate in lower leaves, usually entire in upper leaves, pubescent and densely mealy glandular below. Flowers solitary in leaf axils, bisexual, zygomorphic, 5-merous, with 2 bracts at base, each bract with an auxiliary, sessile gland; pedicel (2-)3-4(-5) mm long; calyx with narrowly triangular lobes up to 7 mm long, connate at base; corolla obliquely campanulate, 2.5-5 cm long, pubescent, pink to purplish, sometimes white, lower lobe slightly longer than other lobes; stamens 4, inserted near base of corolla tube and included; ovary superior, 2-celled but each cell divided by a false septum almost to apex, style long and slender, with 2-lobed stigma. Fruit an oblong-quadrangular capsule 2–3.5 cm long, slightly compressed laterally, pubescent, with a very short beak at apex, often with 2 lateral short protuberances, loculicidally dehiscent, many-seeded. Seeds obovate in outline, compressed laterally, 2.5-3.5 mm×1.5-2 mm, testa with radial sculptures, black or brown. Seedling follows epigeal germination; hypocotyl 1-2 cm long; cotyledons broadly elliptical, up to 1 cm long, entire, leafy.

3.2.6. Cultivation

Sesame can be planted as a primary crop or a secondary crop after wheat (Langham *et al.,* 2008). Generally, sesame is a low-input crop, requiring no herbicide use, so production costs tend to be less than soybean or sorghum (Myers, 2002). Weed control is typically achieved through inter-row cultivation and irrigation requirements are minimal. Sesame is a drought-tolerant crop that only requires one heavy irrigation prior to establishment, with fast and light irrigation after establishment when needed (Langham *et al.,* 2008). Approximately 120–150 days after planting (DAP) (Langham *et al.,* 2008) or by October, sesame will have dropped its leaves and dried for seed harvesting. If part of the sesame stem remains green, the plant can be further dried by cutting and raking into windrows before combining. Seed should be below 6% moisture at harvesting (Langham *et al.,* 2008). Harvesting should be done before frost to avoid seed damage (Myers, 2002). A row crop header like the one used for soybean may be used with a reduced air and cylinder speed.

3.2.7. Climatic requirements

Sesame varieties have adapted to many soil types. The high-yielding crops thrive best on well-drained, fertile soils of medium texture and neutral pH. However, these have low tolerance for soils with high salt and water-logged conditions. Commercial sesame crops require 90 to 120 frost free days. Warm conditions above 23 °C (73 °F) favor growth and yields. While sesame crops can grow in poor soils, the best yields come from properly fertilized farms.Initiation of flowering is sensitive to photoperiod and to sesame variety. The photoperiod also impacts the oil content in sesame seed; increased photoperiod increases oil content. The oil content of the seed is inversely proportional to its protein content.Sesame is drought-tolerant, in part due to its extensive root system. However, it requires adequate moisture for germination and early growth. While the crop survives drought, as well as presence of excess water, the yields are significantly lower in either conditions. Moisture levels before planting and flowering impact yield most.Most commercial cultivars of sesame are intolerant of water-logging. Rainfall late in the season prolongs growth and increases loss to dehiscence, when the seedpod shatters, scattering the seed. Wind can also cause shattering at harvest.

3.2.8. Uses of sesame

Asia is the largest consumer of sesame. In most of Asia the primary use of sesame is as a cooking oil. Most commercial sesame contains 48-52% oil. The oil is very stable oil is known as the King of the vegetables oils in the east and Queen of the vegetable oils in the west. Sesame contains natural oil-soluble and water-soluble antioxidants: sesamin, sesamolin, sesaminol, and sesaminol glucosides. In heating additional lignans are formed: sesamol. Foods fried in sesame oil have longer shelf-life. In Japan the seed is toasted prior to oil extraction resulting in a toasted oil that is extremely stable and provides flavor to the foods. In India the oil is a bit bitter for easy identification to avoid adulteration with cheaper oils. The stability of sesame is further illustrated by the fact that researchers trying to induce mutations have had to use much higher levels of mutagens than most crops.

As with other vegetable oils, sesame oil has been used to make soap and margarine, but the high cost of the sesame oil precludes these uses presently. In the past sesame oil was used in lanterns. The oil is used in many intra-muscular injections as a carrier to spread the medicine faster. Many insecticides use sesame oil as a synergist for the active agent. In Asia the seed is also used as whole seed. The Japanese eat with their eyes before they taste the food. Sesame is used as a garnish with black sesame decorating light foods such as fish and light sesame decorating dark foods. In Japan sesame sits on most tables and is used as a flavoring much as salt and pepper are used in the West. The sesame is ground on to the food right at the table. In Japan sesame is also fried until it pops giving a unique flavor. In Korea, whole seed is added to many sauces used in daily meals. In the Middle East the sesame is ground into a paste known as tahini. In Saudi Arabia in the desert the tahini is very stable and is a staple in the diet of the Bedouins. They mix the tahini with ground chick pea kernels making hummus. The tahini is also eaten by itself as an energy food. In places the sesame paste is mixed with peanut butter to enhance the flavor and the extend the shelf-life. In the Middle East sesame is made into a sweet known as halva, which is considered as a high energy food. Similarly, sesame is used in many sweets throughout Asia. The use of sesame bars with sesame and honey is spreading in the West where a bar in British Columbia was made in Poland from sesame seed imported from India.

In the western world sesame is primarily used as a confectionary. The seed is dehulled and placed on top of buns and breads. Increasingly, the seeds are incorporated into crackers, food products and items such as sesame sticks. The use of hummus is spreading into most deli counters in grocery stores. Health food stores sell sesame in bulk. Even though the price of oil is 3 times higher than most oils, there is an increasing amount of oil consumed: there is some crushing in the US. Some of the oil is used in cooking and is commonly used in Chinese and Japanese restaurants in the US. Sesame oil is further refined and used extensively in cosmetics. In looking at labels, particularly on facial crèmes, sesame oil is one of the ingredients. In India the effects on the human skin have been long known and many bathe with sesame oil regularly. Increasingly processors are extracting minor components from sesame oil.

Sesamin can be bought from commercial sources. One Japanese company puts the sesamin in pills and markets them for reducing hangovers after drinking alcohol. The potential use of the sesame plant as a source of protein was studied by Yermanos. There is potential to do one cutting for plant protein and then harvest the crop for seed. However, work still needs to be done on the palatability of the fresh material. In Venezuela, sugar had to be added to dry sesame stalks for cattle to feed on it. In Venezuela, horses have been turned into sesame fields to eat the weeds and leave the sesame plants; similar results in the US have occurred with cattle and sheep. Goats will eat the plants. In India sesame is used in religious ceremonies and is used in festivals. In the Sandarn Koil Tapasu Festival, sesame seeds are cooked very slowly in sugar creating a sugar coating around the individual seed. The treat is then given to friends and relatives to bring luck in the next year. The original wedding cakes used in the West come from sesame cakes served at weddings in ancient Greece. In China sesame is sprinkled over rice and red beans and served at the exchange of wedding presents. The slaves in the US brought sesame from Africa and planted it at their doors to bring luck and ward off evil spirits. Sesame is used in flower gardens because they provide flowers over a 30-40 day period. Gardeners use sesame as a companionate plant because they inhibit root knot nematodes. Decorators use sesame stems in dry arrangements.

3.2.9. Pests of sesame

Insect pests: The incidences of insect pests of sesame recorded in Bangladesh were green sting bug (*Nezara viridula);* hawk moth (*Ambulyx substrigilis*); hairy caterpillar (*Spilarctia obliqua*); leaf and pod borer (*Antigastra catalaunalis*); mired bug (*Cyrtopeltis tenuis*); semilooper (*Plusia orchalcea*); green grasshopper (*Atractomorpha crenulata*); black weevil (*Cyrtozemia cognata*); leaf beetle (*Monolepta signata*); grey weevil (*Myllocerus maculosus*); jassid (*Empoasca terminalis*); sesame pod bug (*Eusarcocoris ventralis*); thrips (*Frankliniella schultzei*); white fly (*Bemisia tabaci*); gall fly (*Asphondylia sesami*);tomato bug (*Nesidiocoris tenuis);* green peach aphid (*Myzus persicae* Sulzer); melon thrips (*Thrips palmi* Karny); small death's head hawkmoth (*Acherontia styx* (Westwood, 1847)); black cutworm (*Agrotis ipsilon* (Hufnagel, 1766)); turnip moth (*Agrotis segetum* Denis & Schiffermüller); sesame webworm (*Antigastra catalaunalis* Duponchel); dried currant moth (*Cadra cautella* Walker) and khapra beetle (*Trogoderma granarium* Everts), whereastwo mite pests of sesame were recorded in Bangladesh named two-spotted spider mite (*Tetranychus urticae*) and mite (*Brevipalpus phoenicis*).

Among these insect and mite pests of sesamehawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm, sesame webworm and turnip moth were more damaging than other arthropod pests. The hawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm,sesame webworm and turnip moth were designated as major pest of sesame 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.

Diseases: The incidences of fungal diseases of sesame reported in Bangladesh were Choanephora fruit rot (*Choanephora sesamearum);* cottony soft rot (*Sclerotinia sclerotiorum);* sclerotium rot (*Athelia rolfsii);* Aspergillus ear rot (*Aspergillus flavus);* charcoal rot

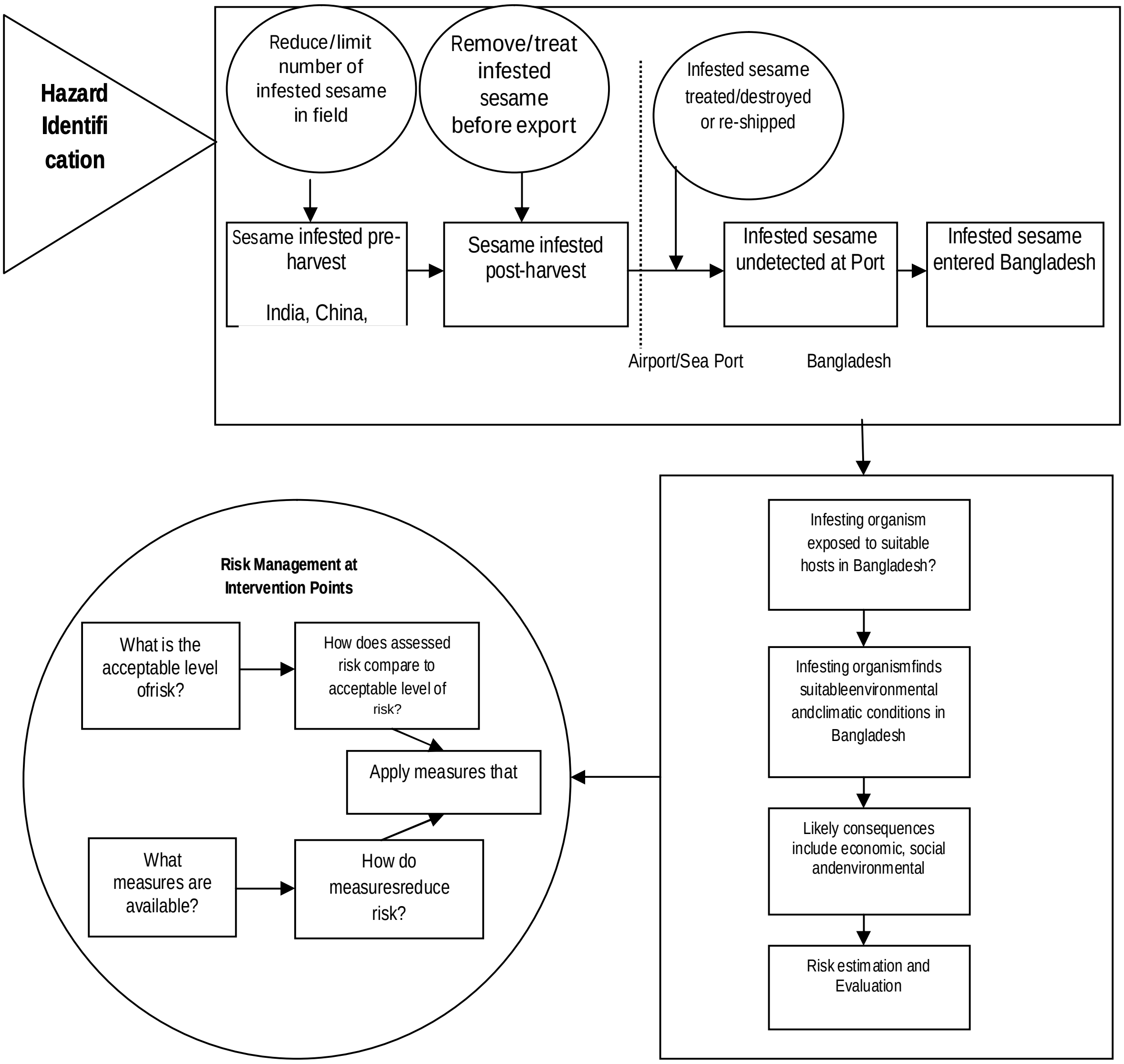
(*Macrophomina phaseolina*); Fusarium wilt (*Fusarium oxysporum f.sp. vasinfectum*); Alternaria leaf spot (*Alternaria alternate)* andpowdery mildew (*Podosphaera xanthii).*

The nemic disease of sesame was reniform nematode (*Totyenchus* reniformis). The viral disease of sesame reported in Bangladesh was *Cowpea aphid-borne mosaic virus*.

3.3. Description of the Proposed Import Pathway

For the purpose of this risk analysis, sesame are presumed to be from anywhere in India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand (DAE, 2016). To comply with existing Bangladesh import requirements for sesame, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests are not associated with the product. Sesame 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 sesame. The proposed import pathway of sesameindicating how the risk analysis process applied at the pathway level is given in the following figure:

Figure 5.Import pathway of sesame



3.4.General Climate of Exporting Countries

3.4.1. India

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 a 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 climate, a hot tropical Rainforest climate with monsoon rains and all months above 18°C. Central and Northwest India have a BSh climate, a dry Steppe climate with an annual average Temperature above 18°C. Finally, the northern mountainous areas can be classified as Cfa climate; a Temperated, humid climate with tha warmest month above 22°C (WeatherOnline, 2015a)

3.4.2. Thailand

Thailand's Climate can be described as tropical monsoonclimate. 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 a climate, a hot, humid climate with all months above 18°C (WeatherOnline, 2015c).

3.4.3. China

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

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

3.4.4. Japan

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

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

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

3.4.5. Pakistan

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

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

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

3.4.6. Taiwan

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

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

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

3.4.7. Vietnam

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

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

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

3.4.8. Malaysia

The main variable of Malaysia’s climate is not temperature or air pressure, but rainfall. In general, the climate of Malaysia can be described as typical 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 between 70 and 90 percent.

Malaysia has extreme variations in rainfall that 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 Malaysia experiences the most precipitation, since the north- and westward-moving monsoon clouds are heavy with moisture by the time they reach these more distant regions.

Typhoons can sometimes hit Malaysia from July to mid November, and can cause heavy damage, flooding and erosion.

3.5. General Climate of Bangladesh

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

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

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

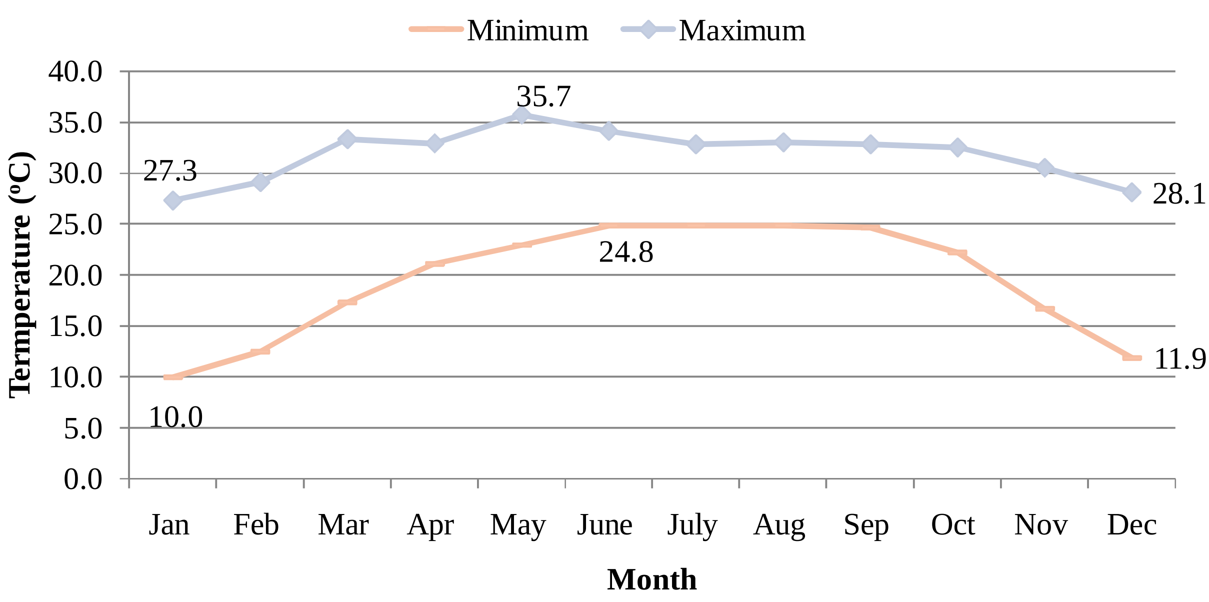


Figure 6. Monthly distribution pattern of standard normal temperature in Bangladesh, 1981-2012

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

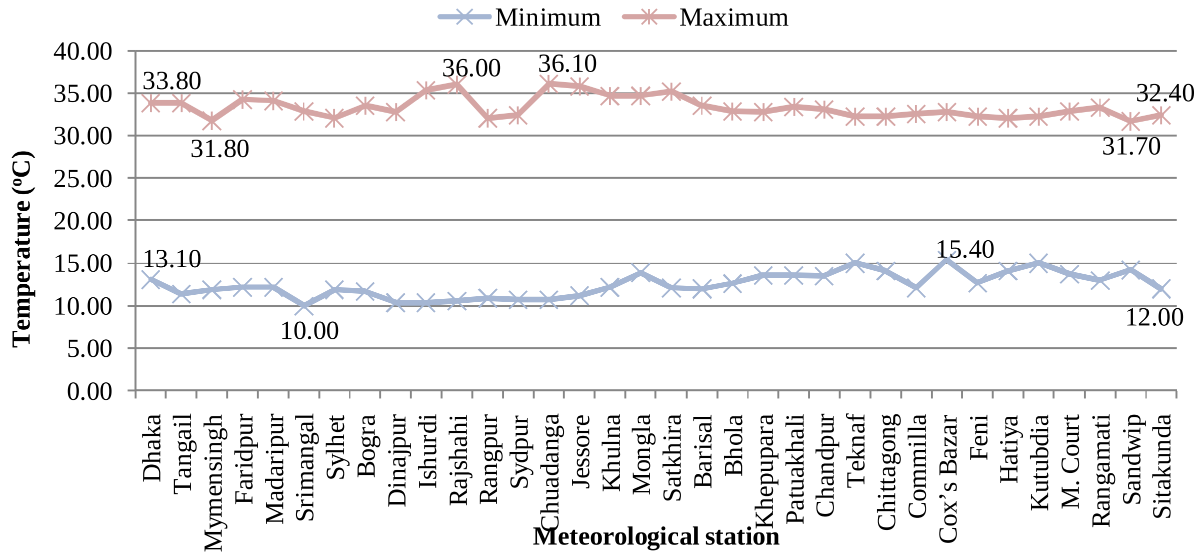


Figure 7. Location-wise distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

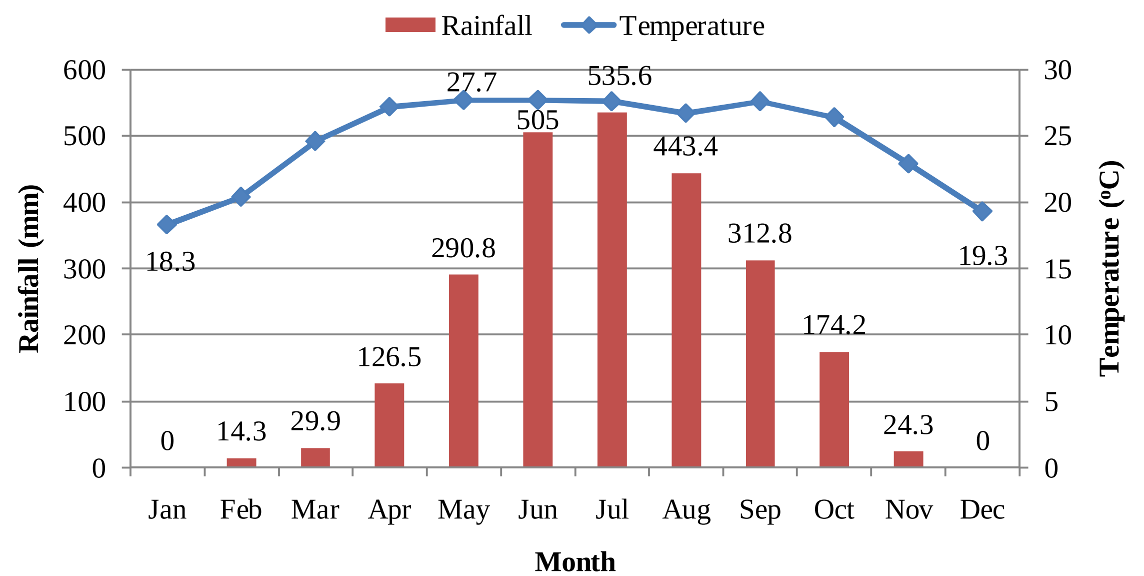


Figure 8. Average monthly Temperature and Rainfall for Bangladesh from 1960-1990

Source: World Bank Group (2015)

References

Abhilash, P.C. and N. Singh. 2010. Effect of growing Sesamum indicum L. on enhanced dissipation of lindane (1,2,3,4,5, 6-hexachlorocyclohexane) from soil. Int. J. of Phyt. 12 (5): 440–453. doi: 10.1080/15226510903213944

Akbar, M. A. 2011. Adoption of modern rapeseed mustard and sesame varieties with production technology for yield gap reduction. Project No. 16. Agrarian Research Foundation (ARF), Dhaka.

Akter, M., Miah, M. A. M., Rahman, M. S. and Khurram, M. M. H. 2010. Adoption and relative profitability of groundnut (Arachis hypogaea L.) cultivation in char areas of Bangladesh. Bangladesh J. of Agri., 35 (1): 85-95.

Bahrami, H. and J. Razmjoo. 2012. Effect of salinity stress (NaCl) on germination and early seedling growth of ten sesame cultivars (Sesamum indicum L.). Int. J. Agric. Sci. 2(6): 529–537.

Creamer, N.G., and K.R. Baldwin. 2000. An evaluation of summer cover crops for use in vegetable production systems in North Carolina. HortScience 35(4): 600– 603.

Gold, M.A., and J.W. Hanover. 1987. Agroforestry systems for the temperate zone. Agrofor. Syst. 5(2): 109–121.

Jahanbakhshi, A., M.R. Imanpoor, V. Taghizadeh, and A. Shabani. 2013. Hematological and serum biochemical indices changes induced by replacing fish meal with plant protein (sesame oil cake and corn gluten) in the Great sturgeon (Huso huso). Comp Clin Pathol 22: 1087–1092. doi: 10.1007/s00580-012-1532-4.

Khan, M. A. H., Sultan, N. A., Islam, M. N. and Hasanuzzaman, M. 2009. Yield and yield contributing characters of sesame as affected by different management practices. American-Eurasian Journal of Scientific Research, 4(3): 195-197.

Langham, D. R., J. Riney, G. Smith, and T. Wiemers. 2008. Sesame grower guide. Sesaco Sesame Coordinators, Lubbock, TX. www.sesaco.net (accessed 18 Jul. 2014).

Malik, S. J., Mushtaq M. and Gill, M. A. 1991. The role of institutional credit in the agricultural development of Pakistan. The Pakistan Development Review, 30(4): 1039-1048.

McSorley, R. 1999. Host suitability of potential cover crops for root-knot nematodes. J. Nematol. 31 (4S): 619–623.

Morris, J.B. 2002. Food, industrial, nutraceutical, and pharmaceutical uses of sesame genetic resources. In: J. Janick and A. Whipkey, eds., Trends in new crops and new uses. ASHS Press, Arlington, VA. p. 153– 156. http://www.hort.purdue.edu/newcrop/ncnu02/v5-153.html (accessed 22 July 2014).

Myers, R. 2002. Alternative crop guide: Sesame. Jefferson Institute, Columbia, MO. www.jeffersoninstitute.org (accessed 15 Jul. 2014).

Nang Thu, T.T., N. Bodin, S. de Saeger, Y. Larondelle, and X. Rollin. 2011. Substitution of fish meal by sesame oil cake (Sesamum indicum L.) in the diet of rainbow trout (Oncorhynchus mykiss W.). Aquaculture Nutrition 17: 80–89. doi: 10.1111/j.1365-2095.2009.00732.x

Pimbert, M. 2003. Designing integrated pest management for sustainable and productive futures. International Institute for Environment and Development, Sustainable Agriculture Programme, Gatekeeper Series No. SA29.

Rodriguez-Kabana, R., P.S. King, D.G. Robertson, and C.F. Weaver. 1988. Potential of crops uncommon to Alabama for management of root-knot and soybean cyst nematodes. Ann. Appl. Nem. 2:116–120

Sipes, B.S., and A.S. Arakaki. 1997. Root-knot nematode management in dryland taro with tropical cover crops. J. Nematol. 29 (4S): 721–724.

CHAPTER 4

HAZARD IDENTIFICATION

4.1. Introduction

This chapter outlines the potential hazards associated with sesame inIndia, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailandand considerssome of the major risk characteristics of the commodity and its hazards.

An initial hazard list was made of all pests and pathogens associated with sesame found India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand. The Plant Quarantine Wing of theDepartment of Agricultural Extension (DAE) in Bangladesh list for pests of sesame from these exporting countries was used as its basis, withvarious species added or excluded after considerations of association. This original list waslater refined to include only those organisms directly associated with sesame and found tobe present in these exporting countries. Some hitch-hiker pests are included in the pest analyses where entryand establishment of a species into the country would cause potential economic,environmental or health consequences. The following a list of those organisms assessed anddiscarded as likely hazards based on biology, and lack of association with the commodity. Then all potential hazards and individual pest riskassessments and recommend measures where required.

4.2. Potential Hazard Groups

Pests and pathogens can be grouped in two main ways regarding their association with thecommodity. Under their taxonomic category, i.e. Lepidoptera, Coleoptera, Acari, Fungi etc, orwithin 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 organismsare grouped according to their general taxonomic category. Where a genus contains more thanone species, information on all species is contained within one pest risk assessment. Iforganisms 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

4. 3. Interception of Pests of Sesame from Existing Pathways

In the past, there was no previous pest risk assessment on sesame from any of the exporting countries including the India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand. As reported by the Plant Quarantine Wing (PQW) under Department of Agricultural Extension (DAE), Bangladesh, during inspection in port of entry of sesame from these exporting counties, not a pest had been intercepted yet today on the commodity imported into Bangladesh.

4.4. Review of earlier PRA

No PRA on Sesame had been done in Bangladesh earlier. However, damage assessment and other studies on insect pests, diseases or other pests associated with sesame in Bangladesh and abroad helped to prepare this PRA report.

4.5. Other Risk Characteristics of the Commodity

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

4.5.1 Unlisted Pests

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

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

4.5.2 Symptomless Micro-organisms

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

Many fungi can infect sesameafter arrival making it difficult to distinguish the origin ofsaprobes and pathogens without adequate identification. Consumers tend to throw awaymoulded sesame rather than take it to a diagnostic laboratory so there is little data on post entryappearance of “invisible organisms”.

4.6 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 ofsesamein India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailandand other countries of sesameexport.

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

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

4.7. Assumptions and Uncertainties around hazard biology

- The species of mealybug (*Pseudococcus* spp.)and two spotted sesame bug are the well known hitch-hiker species, and has been associated withsesamein India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand. 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.

4.8.Assumption and Uncertaintiesaround the Inspection Procedure

- There are distinct temperature requirements for optimum development and reproduction for the different pests like *Eysarcoris guttiger. Therefore, the molecular data* on race detection of the insect pests rather than occurrence of biological information would be required to clarify this issue.

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

- An assumption is made around the time thesesameseeds take to get from the field in India, Vietnam, China, Taiwan, Japan, Korea, Malaysia and Thailand to Bangladesh ready for wholesale if it is transported by Landport or Sea shipment.

4.10. Assumption around Commodity Growon in Bangladesh

Section of PRA	Uncertainties	Further work that would reduce uncertainties
Taxonomy	None	-
Pathway	Presence of a pathwayfrom 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 sesame exporting countries

Section of PRA	**Uncertainties**	**Further work that would reduce uncertainties**
Distribution	None	**-**
Hosts	None	**-**
Establishment	Establishment potential under glasshouse in the PRA area.	Continue to monitor the literature for reports of establishment in protected environments.
Spread	Rate of potential spread in areas at risk within the PRA area	Continue to monitor the literature for reports on ability to spread.
Impact	Potential to cause damage in protected environments	Continue to monitor the literature for reports on damage caused in protected environments
Management	None	-

CHAPTER 5

REVIEW OF MANAGEMENT OPTIONS

5.1. Introduction

The following assessment of pre- and post-harvest practices reflects the current systems approach for risk management employed for commercially produced sesame. 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 sesame from exporting countries. The management options for different insect and mite pests as well as diseases of sesame crops have been reviewed and presented below:

5.2. Insect and Mite Pest Management of Sesame

Sesameis the most common oil seed crop grown in Bangladesh. Although there are few very important pests attack in sesame such as Green stink bug, Tomato bug, Green peach bug, Melon thrips, Small death's head hawkmoth, black cutworm, turnip moth, webworm and khapra beetle 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 sesame 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.

5.2.1. Green sting bug

IPM Programmes

Participation in soyabean IPM programmes in Georgia, USA, have been low, probably because of the risk involved (Szmedra *et al.,* 1990). In contrast, a soyabean IPM programme developed in Brazil is seen as a 'spectacular success story of IPM implementation for a major crop over a wide area', and has returned substantial economic, ecological and social benefits (Moscardi, 1993). The *N. viridula* component involves release of Trissolcus basalis (at least in the state of Paraná), which are produced centrally. See section on Egg Parasitoids for more information on these releases. Insecticides are applied at half the recommended doses with 0.5% NaCl added to the spray tank (Corso, 1993).In the southern states of Brazil, early-maturing soyabean varieties are planted to escape *N. viridula* attack. Such varieties have also been used successfully as trap crops to concentrate bugs before the true crop matures, when they are treated chemically or with mass-released T. basalis. But this tactic is still at the experimental stage in relation to IPM in Brazil. Biological control efforts against *N. viridula* are likely to be enhanced if carried out in association with selective plantings of species that encourage both *N. viridula* and its parasitoids (Bennett, 1990). Different tillage treatments for soyabean plantings did not influence *N. viridula* population dynamics, so the tilling operations can be selected for predator conservation (Funderburk *et al.,* 1990). The possible use of neem seed extract (azadirachtin) in IPM programmes in pecans has been investigated by Seymour *et al.* (1995). This plant-derived compound seems to reduce feeding by the bugs even at low concentrations, so may well prove useful.

Chemical Control

Fourth- and fifth-stage *N. viridula* nymphs and adults bask outside the plant canopy until about mid-day, so application of insecticides is most effective at that time. Damage to nut crops may not be restricted to the time they are on the tree. For example, full-sized macadamia nuts may be damaged whilst on the tree, but even more so up to 1 week after they drop to the ground, and this needs to be taken into account when applying chemical treatment (Jones and Caprio, 1994).A range of carbamates and organophosphates may control N. viridula, but their persistence is too low to prevent subsequent outbreaks (Waterhouse and Norris, 1987; Martins *et al.,* 1990).

Alternative insecticides (tralomethrin, lambda-cyhalothrin and acephate) are less toxic and may reduce production costs, increase yield and improve soyabean quality (Chyen *et al.,* 1992; Le Page, 1996; McPherson, 1996). Some of the synthetic pyrethroids tested gave greater residual control than acephate; however, permethrin, did not control *N. viridula* in soyabean (McPherson *et al.,* 1995).Peaches have been protected effectively with chlorpyrifos (Johnson *et al.,* 1985).The permissible amount of stained rice grains (including pecky rice) is too low to establish reliable control thresholds, and prophylactic applications of insecticides tend to be made against hemipteran rice pests in Japan, with *N. viridula* being the principal species in southern Japan (Ito, 1986).

Trials on insecticidal plant extracts such as azidarachtin do not compare in efficiency with synthetic insecticides (Ivbijaro and Bolaji, 1990). Some research has been conducted on insect growth regulators but they do not appear to be effective (Canela *et al.,* 1995; McPherson and Gascho, 1999).Disease transmission by *N. viridula* to citrus fruits has resulted in the use of insecticidal control methods in Cuba (Grillo and Alvares, 1983).In South America, the addition of NaCl to insecticides is recommended because it lowers the required dosage (see IPM Programmes).

Resistance and chemical control in soyabean were evaluated by Gazzione (1995) and Rosso *et al.,* (1995).

5.2.2. Green peach aphid

IPMProgrammes

Insecticidal soaps have been found useful in greenhouses, where they have low toxicity to many beneficial organisms. The fungal pathogen*Lecanicillium lecanii* is compatible with insecticides and is effective against *M. persicae* in a wide range of greenhouse crops, but only where high humidities can be maintained. In field crops, however, the main form of IPM is the modification of choice of insecticide and time of application to minimise damage to indigenous natural enemies.

Chemical Control

As *M. persicae* is mainly important as a virus vector, a high level of control as provided by insecticides is often required. However, insecticides are relatively ineffective for non-persistent viruses, because transmission by the aphid occurs in just a few seconds. Moreover, there are varied restrictions on active ingredients in different parts of the world, and further restrictions on formulation, method of application, crop and time of year. Additionally, resistance to most groups of insecticides that defeats their use has appeared in many places (Foster *et al.,* 2007; Bass *et al.,* 2014). The aphid has several mechanisms conferring resistance primarily to different groups of insecticides; amplification of carboxylesterase for organophosphate insecticides, insensitive target site (MACE) against dimethyl carbamates, knock-down resistance (kdr and super-kdr) against pyrethroids and most recently a mechanism known as Nic-R++ against neonicotinoids (Bass *et al.,* 2011). Other insecticides such as pymetrozine and flonicamid may therefore be required to obtain adequate control of the aphid, and diamide insecticides should become available in the future.

5.2.3. Melon thrips

Chemical Control

Chemical control has given a measure of protection in many countries, for example, on cucurbits in New Caledonia (Guterierrez, 1981) and on watermelon in Hawaii (Johnson, 1986). Nine insecticides were tested against *T. palmi* on potato in Mauritius, but none gave satisfactory results (Anon, 1987b). Seal et al. (1994) tested the effectiveness of five insecticides for the control of *T. palmi* on *Phaseolus vulgaris, Cucurbita pepo* and aubergine in Florida during 1993. Some insecticide screening has also been recorded from South America. In Brazil, Cermeli et al. (1993) tested 11 insecticides and observed a high level of tolerance to chemical control. Flufenoxuron, imidacloprid and chlorfluazuron were the most effective insecticides; however, no insecticide was more than 81.5% effective.

Integrated Pest Management

Hirose (1991) stressed the importance of considering biological control for *T. palmi* and also suggested that the resurgence of this pest in South-East Asia during the last 10 years was due to the elimination of its natural enemies by repeated insecticide applications. The effect of insecticides on Orius sp. was investigated by Nagai (1990b) in Japan. Eggs were treated by dipping and results showed that chinomethionate, bromopropylate, pirimicarb and phosalone showed low toxicity. However, carbaryl, a mixture of malathion and fenobucarb, phenthoate and fenthion showed high toxicity to the eggs. Orius apparently showed no susceptibility to buprofezin or bromopropylate when aubergines were sprayed in the field for control of *T. palmi,* but phosalone, chlorfluazuron and flufenoxuron were highly toxic to Orius species. Nagai (1990a) used fenthion as a control measure when evaluating the effects of predation by Orius. Further evaluation was presented by Nagai (1991a, 1992).

5.2.4. Black cutworm

General Management Tactics

- If possible, avoid planting crops in fields with a known history of cutworm problems.
- Avoid planting crops (especially maize) following longstanding pastures, meadows, lucerne or red clover.
- Plough in the autumn and use shallow tillage to keep down late autumn and early spring vegetation (where conservation practices allow).
- Monitor larvae with larval cutworm bait traps (Story and Keaster, 1982, 1983; Munson et al., 1986).

- Monitor adults to predict attacks (Hachler and Brunetti, 2002).
- Monitor weather to predict attacks (Bhagat and Praveen Sharma, 2000; Zhou and Chen, 2004).
- Low mow grass to remove eggs, disposing of cuttings at a distance (Williamson and Potter, 1997).
- Topdressing with sand does not kill larvae but deters them from travelling (Williamson and Potter, 1997).
- Encourage predators by encouraging their other prey species nearby, e.g. by having conservation strips between fields or golf fairways (Frank and Shrewsbury, 2004).

Chemical Control

Clothianidin, a new synthetic chloronicotinyl insecticide, has been found to be effective as a seed treatment against A. ipsilon (Andersch and Schwarz, 2003).

The effectiveness of diazinon 20 EC, quinalphos 25 EC, chlorpyrifos 20 EC, fenitrothion 50 EC, deltamethrin 2.8 EC and malathion 5% dust against A. ipsilon on potatoes was tested in India (Tripathi et al., 2003). Chlorpyriphos 20 EC was the most effective. Chlorpyriphos, quinalphos, cypermethrin, phosalone and carbaryl have also been tested in similar conditions (Mishra, 2002).

Common alum, aluminium potassium sulfate (solid) and aluminium oxide (liquid) were found to be toxic to A. ipsilon larvae, and synergised the effectiveness of other insecticides (Youssef, 1997).

5.2.5. Two-spotted 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 sesame: 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).

5.3. Disease Management of Sesame

5.3.1. 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 sesame 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.

5.4. Phytosanitary measures

5.4.1. Post-Harvest Procedures

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

5.4.2.Visual Inspection

Visual inspection of pods/seeds occurs at several points during the routine production and post-harvest pathway for seeds. 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 thrips insects as they are easily detected on the surface ofsesame.

5.4.3. 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.

5.4.4.. General conditions for sesame

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

5.4.5. Pre-shipment requirements

Inspection of the consignment: Bangladesh requires that the NPPO of the country of origin sample and inspect theconsignment according to official procedures for all the visually detectable regulated pestsspecified 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 sesame from which the sesame were collected, have beentreated as specified by PQW of Bangladesh.

Documentation

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

5.4.6. Phytosanitary certification

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

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

The sesamehave:

i) been inspected in accordance with appropriate official procedures and found to be freeof 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 (inaccordance with the International Standards for Phytosanitary Measures; Requirementsfor the Establishment of Pest Free Areas, IPPC, FAO, Publication 4, 1996), free from aregulated pest(s).
iii) been sourced from a pest free place of production that is, as verified by pest surveillancemethods (in accordance with the International Standards for Phytosanitary

Measures;Requirements for the Establishment of Pest Free Places of Production and Pest FreeProduction Sites, IPPC, FAO, Publication 10, 1996), free from a regulated pest(s).

AND;

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

5.4.7. 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 sesame 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."

5.4.8. Transit requirements

The sesame 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.

5.4.9. 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.

5.4.10. Testing for regulated pests

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

5.4.11. 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.

5.4.12. 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 clearancegiven.

5.4.13. 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 otherphytosanitary requirements.

References

Andersch W, Schwarz M, 2003. Clothianidin seed treatment (PonchoReg.) - the new technology for control of corn rootworms and secondary pests in US-corn production. (Pflanzenschutz Nachrichten Bayer) 56(1):147-172.

Anon., 1987. Beans. Pests. Annual Report 1986. Reduit, Mauritius: Mauritius Sugar Industry Research.

Bass C, Puinean AM, Andrews M, Culter P, Daniels M, Elias J, Paul VL, Crossthwaite AJ, Denholm I, Field LM, Foster SP, Lind R, Williamson MS, Slater R, 2011. Mutation of a nicotinic acetylcholine receptor beta subunit is associated with resistance to neonicotinoid insecticides in the aphid Myzus persicae. BMC Neuroscience, 12(51):(31 May 2011). http://www.biomedcentral.com/content/pdf/1471-2202-12-51.pdf

Bass C, Puinean AM, Zimmer CT, Denholm I, Field LM, Foster SP, Gutbrod O, Nauen R, Slater R, Williamson MS, 2014. The evolution of insecticide resistance in the peach potato aphid, Myzus persicae. Insect Biochemistry and Molecular Biology, 51:41-51. http://www.sciencedirect.com/science/journal/09651748

Bennett FD, 1990. Potential for biological control of the stink bug Nezara viridula, a pest of macadamias. Acta Horticulturae, 275:679-684.

Bhagat RM, Praveen Sharma, 2000. Status of Agrotis ipsilon Hufn. in Kangra Valley of Himachal Pradesh. Insect Environment, 5(4):166-167.

Cermeli M, Montagne A, 1993. Present situation of Thrips palmi Karny (Thysanoptera: Thripidae) in Venezuela. Manejo Integrado de Plagas, No. 29:22-23

Corso IC, 1993. Use of cooking salt for reducing insecticide dosage in the control of soyabean pests. Comunicado Tecnico - Centro Nacional de Pesquisa de Soja Londrina, Brazil: Centro Nacional de Pesquisa de Soja, No. 45:7 pp.

Foster SP, Devine G, Devonshire AL, 2007. Insecticide resistance. In: Aphids as crop pests [ed. by Emden, H. F. van\Harrington, R.]. Wallingford, UK: CABI, 261-285. http://www.cabi.org/cabebooks/ebook/20073203993

Funderburk JE, Wright DL, Teare ID, 1990. Preplant tillage effects on population dynamics of soybean insect pests. Crop Science, 30(3):686-690

Hirose Y, 1991. Pest status and biological control of Thrips palmi in Southeast Asia. AVRDC Publication, No. 91-342:57-60

Moscardi F, 1993. Soybean integrated pest management in Brazil. FAO Plant Protection Bulletin, 41(2):91-100

Munson G, Keaster AJ, Grundler JA, 1986. Corn cutworm control. Agricultural Guide 4150, University of Missouri-Columbia Extension Division, Columbia, MO.

Nagai K, 1990. Suppressive effect of Orius sp. (Hemiptera: Anthocoridae) on the population density of Thrips palmi (Thysanoptera: Thripidae) in eggplant in an open field. Japanese Journal of Applied Entomology and Zoology, 34(2):109-114

Seal DR, Baranowski RM, Bishop JD, 1994. Effectiveness of insecticides in controlling Thrips palmi Karny (Thysanoptera: Thripidae) on different vegetable crops in south Florida. Proceedings of the Florida State Horticultural Society, 106:228-233

Seymour J, Bowman G, Crouch M, 1995. Effect of neem seed extract on feeding frequency of Nezara viridula L. (Hemiptera: Pentatomidae) on pecan nuts. Journal of the Australian Entomological Society, 34(3):221-223; 16 ref.

Story RN, Keaster AJ, 1982. Development and evaluation of a larval sampling technique for the black cutworm (Lepidoptera: Noctuidae). Journal of Economic Entomology, 75(4):604-610

Szmedra PI, Wetzstein ME, McClendon RW, 1990. Economic threshold under risk: A case study of soybean production. Journal of Economic Entomology, 83(3):641-646

Waterhouse DF, Norris KR, 1987. Biological control: Pacific prospects. viii + 454pp

Williamson RC, Potter DA, 1997. Nocturnal activity and movement of black cutworms (Lepidoptera: Noctuidae) and response to cultural manipulations on golf course putting greens. Journal of Economic Entomology, 90(5):1283-1289; 18 ref.

Zhou-ZhiCheng, Chen-YongNian, 2004. Forecasting tobacco loss damaged by Agrotis ipsilon with moth-rainfall coefficient. Chinese Tobacco Science, 25(2):13-16.

CHAPTER 6

IDENTIFICATION OF PESTS

6.1. Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding thesesameimported from anyexporting countries ofIndia, Vietnam, China, Taiwan, Japan, Korea, Malaysia and Thailandinto Bangladesh.

6.2. Pests of sesamerecorded in Bangladesh

The study for "Conducting Pest Risk Analysis (PRA) of Sesame in Bangladesh" was done in 30 major sesame 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:

6.2.1. Insect and mite pests of sesame in Bangladesh

A total number of 26 arthropod pests of sesame of which 24 insect pests and 2 mite pests were reported in Bangladesh.

The incidences of insect pests of sesame recorded in Bangladesh were green sting bug (*Nezara viridula);* hawk moth (*Ambulyx substrigilis*); hairy caterpillar (*Spilarctia obliqua*); leaf and pod borer (*Antigastra catalaunalis*); mired bug (*Cyrtopeltis tenuis*); semilooper (*Plusia orchalcea*); green grasshopper (*Atractomorpha crenulata*); black weevil (*Cyrtozemia cognata*); leaf beetle (*Monolepta signata*); grey weevil (*Myllocerus maculosus*); jassid (*Empoasca terminalis*); sesame pod bug (*Eusarcocoris ventralis*); thrips (*Frankliniella schultzei*); white fly (*Bemisia tabaci*); gall fly (*Asphondylia sesami*);tomato bug (*Nesidiocoris tenuis);* green peach aphid (*Myzus persicae* Sulzer); melon thrips (*Thrips palmi* Karny); small death's head hawkmoth (*Acherontia styx* (Westwood, 1847)); black cutworm (*Agrotis ipsilon* (Hufnagel, 1766)); turnip moth (*Agrotis segetum* Denis & Schiffermüller); sesame webworm (*Antigastra catalaunalis* Duponchel); dried currant moth (*Cadra cautella* Walker) and khapra beetle (*Trogoderma granarium* Everts), whereastwo mite pests of sesame were recorded in Bangladesh named two-spotted spider mite (*Tetranychus urticae*)and mite (*Brevipalpus phoenicis*).

Among these insect and mite pests of sesame hawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm, sesame webworm and turnip moth were more damaging than other arthropod pests. The hawk moth, hairy caterpillar, leaf and pod caterpillar, mirid bug, green peach aphid, small death's head hawkmoth, black cutworm,sesame webworm and turnip moth were designated as major pest of sesame 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 sesame in Bangladesh, their status, plant parts affected and infestation severity

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity
Insect pests							
1	Green sting bug	*Nezara viridula*	Pentatomidae	Hemiptera	Fruits, Seeds	Minor	Low
2	Hawk moth	*Ambulyx substrigilis* (Westwood)	Sphingidae	Lepidoptera	Leaves, Stem	Major	Low
3	Hairy caterpillar	*Spilarctia obliqua* (Walker)	Arctiidae	Lepidoptera	Leaves, Stem	Major	Medium
4	Leaf and pod caterpillar	*Antigastra catalaunalis* (Dup.)	Pyralidae	Lepidoptera	Leaves, Stem, Seeds	Major	Low
5	Mirid bug	*Cyrtopeltis tenuis* (Reuter)	Miridae	Hemiptera	Leaves, Stem	Major	Low
6	Semilooper	*Plusia orchalcea* (Fab.)	Noctuidae	Lepidoptera	Leaves, Stem	Minor	Low
7	Green grasshopper	*Atractomorpha crenulata* Fab.	Acrididae	Orthoptera	Leaves, Stem	Minor	Low
8	Black weevil	*Cyrtozemia cognata* Marshall	Curculionidae	Coleoptera	Leaves, Stem, Pod	Minor	Low
9	Leaf beetle	*Monolepta signata* Oliv.	Chrysomelidae	Coleoptera	Leaves, Stem, Pod, Seeds	Minor	Low
10	Grey weevil	*Myllocerus maculosus* Desb.	Curculionidae	Coleoptera	Leaves, Stem, Seeds	Minor	Low
11	Jassid	*Empoasca terminalis* Dist.	Jassidae	Homoptera	Leaves, Stem	Minor	Low
12	Sesame pod bug	*Eusarcocoris ventralis* Westwood	Pentatomidae	Hemiptera	Leaves, Stem, Pod	Minor	Low
13	Thrips	*Frankliniella schultzei* (Trybom)	Thripidae	Thysanoptera	Leaves, Stem	Minor	Low
14	White fly	*Bemisia tabaci* (Genn.)	Aleyrodidae	Diptera	Leaves, Stem	Minor	Low
15	Gall fly	*Asphondylia sesami* Felt	Cecidomyiidae	Diptera	Leaves, Stem	Minor	Low
16	Tomato bug	*Nesidiocoris tenuis*	Miridae	Hemiptera	Fruits, Seeds	Minor	Low
17	Green peach aphid	*Myzus persicae* Sulzer	Aphididae	Hemiptera	Fruits, Seeds	Major	Low
18	Melon thrips	*Thrips palmi* Karny	Thripidae	Thysanoptera	Leaves, Stem, Fruits	Minor	Low
19	Small death's head hawkmoth	*Acherontia styx* (Westwood, 1847)	Sphingidae	Lepidoptera	Leaves, Stem	Major	Low
20	Black cutworm	*Agrotis ipsilon* (Hufnagel, 1766)	Noctuidae	Lepidoptera	Seedlings	Major	High
21	Turnip moth	*Agrotis segetum* Denis & Schiffermüller	Noctuidae	Lepidoptera	Leaves, Stem	Major	Low
22	Sesame webworm	*Antigastra catalaunalis* Duponchel	Crambidae	Lepidoptera	Leaves,Fruits, Seeds	Major	Medium
23	Dried currant moth	*Cadra cautella* Walker	Pyralidae	Lepidoptera	Fruits, Seeds	Minor	Low
24	Khapra beetle	*Trogoderma granarium* Everts	Dermestidae	Coleoptera	Seeds	Minor	Low
Mites							
25	Two-spotted spider mite	*Tetranychus urticae* Koch	Tetranychidae	Acarina	Leaves, Fruits, Flowers	Minor	Low
26	Mite	*Brevipalpus phoenicis* (Geijsker)	Tenuipalpidae	Acarina	Leaves, Fruits, Flowers	Minor	Low

Some pictures of insect and mite pestssesame are presented below:

Plate-1: Green sting bug on sesame plant

Plate-2: Green peach aphid on sesame plant

Plate 3-Small death's head hawkmoth

Plate 4-Hawkmoth caterpillar

Plate-5: Turnip moth on sesame plant

Plate-6: Sesame webworm affected plant

6.2.2. Diseases of sesame recorded in Bangladesh

A total number of 10 species of disease causing pathogens of sesame were recorded in Bangladesh, among which 8diseases were caused by fungi, 1 caused by nematode and 1 disease was caused by virus.

The incidences of 8 fungal diseases of sesame as recorded in Bangladesh were choanephora fruit rot (*Choanephora sesamearum);* cottony soft rot (*Sclerotinia sclerotiorum);* Sclerotium rot (*Athelia rolfsii);* Aspergillus ear rot (*Aspergillus flavus);* charcoal rot (*Macrophomina phaseolina*); Fusarium wilt (*Fusarium oxysporum* f.sp. *vasinfectum*); Alternaria leaf spot (*Alternaria alternate)* andpowdery mildew (*Podosphaera xanthii).*

The nemic disease of sesame as recorded in Bangladesh was reniform nematode (*Totyenchus* reniformis). The viral disease of sesame recorded in Bangladesh was *Cowpea aphid-borne mosaic virus*.

Among these diseases, the cottony soft rot and charcoal rot were more damaging than others. But diseases were reported as minor diseases of sesame and caused damage with low infection intensity in Bangladesh. Most of the cases, the damage severity was controlled by the farmers through routine application of fungicides and other pesticides in the field of sesame.

6.2.3. Weeds of sesame recorded in Bangladesh

A total number of 10 weeds were recorded as the problem in the field of sesame in Bangladesh. The incidences of weeds in the field of sesame were bermuda grass (*Cynodon dactylon*), nutsedge (*Cyperus esculentus*), pigweed (*Amaranthus acanthochiton*), spiny pigweed (*Amaranthus spinosus*), goose grass (*Eleusine indica* (L.) Gaertner), crab grass (*Digitaria ciliaris* (Retz.) Koeler); black nightshade (*Solanum nigrum* L.), Cock's comb (*Celosia argentea* L.); scorpion weed (*Heliotropium indicum* L.) and parthenium weed (*Parthenium hysterophorus*). 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 ten 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 sesame. 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 sesame as recorded 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	Choanephora fruit rot	*Choanephora sesamearum*	Choanephoraceae	Mucorales	Fruits, Leaves, Seeds	Minor	Medium
2	Cottony soft rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales	Fruits, Leaves, Seeds, Stem	Major	High
3	Sclerotium rot	*Athelia rolfsii*	Atheliaceae	Polyporales	Fruits, Leaves, Stems, Seeds	Minor	Low
4	Aspergillus ear rot	*Aspergillus flavus*	Trichocomaceae	Eurotiales	Fruits, Leaves, Stems, Seeds	Minor	Low
5	Charcoal rot	*Macrophomina phaseolina*	Botryosphaeriaceae	Botryosphaeriales	Leaves, Roots and Seeds	Major	Medium
6	Fusarium wilt	*Fusarium oxysporum f.sp. vasinfectum*	Nectriaceae	Hypocreales	Whole plant	Minor	Low
7	Alternaria leaf spot	*Alternaria alternate*	Pleosporaceae	Pleosporales	Leaves, Pods	Minor	Low
8	Powdery mildew	*Podosphaera xanthii*	Erysiphaceae	Erysiphales	Leaves, Stems	Minor	Low
Causal organism: Nematode							
9	Reniform nematode	*Rotylenchulus reniformis*	Hoplolaimidae		Roots, seeds and pods	Minor	Low
Causal organism: Virus							
10	Cowpea aphid-borne mosaic	*Cowpea aphid-borne mosaic virus*	Potyviridae	RNA viruses	Leaves, Fruits, Seeds	Minor	Low

Table 4. Weeds of sesame as recorded 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	Goose grass	*Eleusine indica* (L.) Gaertner	Poaceae	Cyperales	Vegetative stage	Minor	Low
6	Crab grass	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	Cyperales	Vegetative stage	Minor	Low
7	Black nightshade	*Solanum nigrum* L.	Solanaceae	Solanales	Vegetative stage	Minor	Low
8	Cock's comb	*Celosia argentea* L.	Amaranthaceae	Caryophyllales	Vegetative stage	Minor	Low
9	Scorpion weed	*Heliotropium indicum* L.	Boraginaceae	Boraginales	Vegetative stage	Minor	Low
10	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Asterales	Vegetative stage	Minor	Low

Some pictures of diseases of sesame are presented below;

Plate-7: Sesame leaf spot

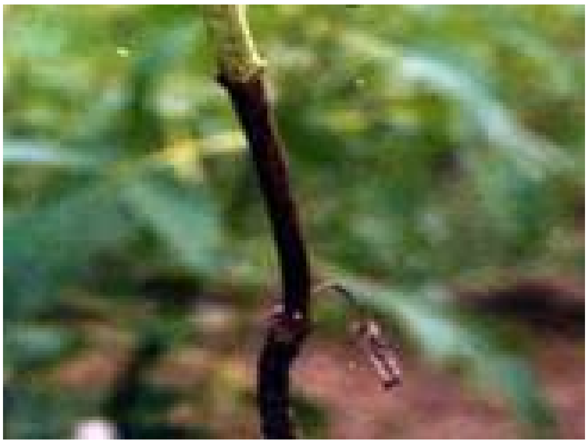


Plate-8: Stem and root rot of sesame

Plate-9: Bacterial leaf blight of sesame

Plate10: Powdery mildew affected sesame leaf

6.2.4. Management options for sesame pests in Bangladesh

Insect and mite pest management: The most effective and commonly practiced management options against the insect pests of sesame were spraying of insecticides in the field. Irrigation was done for controlling soil dwelling insect namely cutworm and removal of harmful insects and infested fruits and parts of plants was also done. It was also reported that Integrated Pest Management (IPM) was also followed for controlling insect pests of sesame. 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 sesame were spraying of fungicidesin the field, seed treatment with fungicides for preventing seed borne diseases, and removal of diseased plants or partsof plants. Other management practices for controlling diseases of sesame were removal of weeds and spraying of insecticides in the sesame fields for disease transmitting vector control.

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

6.3. Pests of sesame in the exporting countries

The pests associated with fresh sesameand 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.

Sixty (60) species of pests were recorded for sesame in the world of which 34 species were insect pests and 2 species were mite pests; the species of disease causing fungi were 9, bacteria 1, nematode 2, and virus & viroids were 2. On the other hand, 10 species of weeds for sesame were recorded in the world.

Table 5 depicted the lists of pests associated with the sesame that also occur India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailandand the absence or presence of these pests in Bangladesh.

6.4. Quaratine pests of sesame for Bangladesh

Fifteen (15) species of quarantine pests of sesame for Bangladesh were identified those were present in India, Vietnam, China, Taiwan, Japan, Korea, Malaysia and Thailand, but not in Bangladesh. Among these 15 species of quarantine pests, 10 were insect pests, 1 fungus, 1 bacterium, 1 nematode species, 1 virus and 1 weed species (Table 6).

The quarantine insect pests arecottony mealybug (*Phenacoccus solenopsis* Tinsley), two-spotted sesame bug (*Eysarcoris guttiger* (Thunberg)); sesame Jassid (*Orosius orientalis);* Desert locust (*Schistocerca gregaria);* death's head hawkmoth (*Acherontia atropos* Linnaeus); beet webworm (*Loxostege sticticalis* Linnaeus); tiger moth (*Amsacta moorei* Butler); cassava hornworm (*Erinnyis ello* (Linnaeus, 1758)); pulse beetle (*Callosobruchus analis* Fabricius) and simsim flea beetle (*Alocypha bimaculata* Jacoby).

On the other hand, four (4) disease causing pathogens have been identified as quarantine pests of sesame for Bangladesh. Among these, one quarantine fungus named Black root rot (*Chalara elegans*);one quarantine bacteria namely Yellow disease phytoplasmas (*Candidatus Phytoplasma asteris)*; one species of nematode namelyPigeon pea cyst nematode (*Heterodera cajani Koshy*);one viruses namely*Cucumber Peanut mottle virus*. One species of quarantine weed has been identified for Bangladesh named Parthenium weed (*Parthenium hysterophorus*)(Table 6).

Table 5. Pests associated with sesame in the world and identification of quarantine organisms

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
Arthropod pests							
Insect pests							
1	Cottony mealybug	*Phenacoccus solenopsis* Tinsley	Pseudococcidae	Hemiptera	No	Yes	CABI/EPPO, 2012; EPPO, 2014
2	Green sting bug	*Nezara viridula*	Pentatomidae	Hemiptera	Yes	No	Ohno & Alam, 1992; CABI/EPPO, 1998; APPPC, 1987; Ali, 1988
3	Hawk moth	*Ambulyx substrigilis* (Westwood)	Sphingidae	Lepidoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
4	Hairy caterpillar	*Spilarctia obliqua* (Walker)	Arctiidae	Lepidoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
5	Leaf and pod caterpillar	*Antigastra catalaunalis* (Dup.)	Pyralidae	Lepidoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
6	Mirid bug	*Cyrtopeltis tenuis* (Reuter)	Miridae	Hemiptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
7	Semilooper	*Plusia orchalcea* (Fab.)	Noctuidae	Lepidoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
8	Green grasshopper	*Atractomorpha crenulata* Fab.	Acrididae	Orthoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
9	Black weevil	*Cyrtozemia cognata* Marshall	Curculionidae	Coleoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
10	Leaf beetle	*Monolepta signata* Oliv.	Chrysomelidae	Coleoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
11	Grey weevil	*Myllocerus maculosus* Desb.	Curculionidae	Coleoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
12	Jassid	*Empoasca terminalis* Dist.	Jassidae	Homoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
13	Sesame pod bug	*Eusarcocoris ventralis* Westwood	Pentatomidae	Hemiptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
14	Thrips	*Frankliniella schultzei* (Trybom)	Thripidae	Thysanoptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
15	White fly	*Bemisia tabaci* (Genn.)	Aleyrodidae	Diptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
16	Gall fly	*Asphondylia sesami* Felt	Cecidomyiidae	Diptera	Yes	No	Biswas, G. C. and Das, G.P., 2011
17	Tomato bug	*Nesidiocoris tenuis*	Miridae	Hemiptera	Yes	No	UK CAB International, 1971; APPPC, 1987
18	Green peach aphid	*Myzus persicae* Sulzer	Aphididae	Hemiptera	Yes	No	CIE, 1979; APPPC, 1987
19	Two spotted sesame bug	Eysarcoris guttiger (Thunberg)	Pentatomidae	Hemiptera	No	Yes	Waterhouse, 1993
20	Sesame Jassid	*Orosius orientalis*	Cicadellidae	Hemiptera	No	Yes	CABI, 2015
21	Desert locust	*Schistocerca gregaria*	Acrididae	Orthoptera	No	Yes	Dirsh &, 1974
22	Melon thrips	*Thrips palmi* Karny	Thripidae	Thysanoptera	Yes	No	Bhatti, 1980; Palmer, 1992; CABI/EPPO, 1998; CABI & EPPO, 1998; EPPO, 2014
23	Death's head hawkmoth	*Acherontia atropos* Linnaeus	Sphingidae	Lepidoptera	No	Yes	CABI, 2017
24	Small death's head hawkmoth	*Acherontia styx* (Westwood, 1847)	Sphingidae	Lepidoptera	Yes	No	Rothschild & Jordan, 1903

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
25	Black cutworm	*Agrotis ipsilon* (Hufnagel, 1766)	Noctuidae	Lepidoptera	Yes	No	Alam & Ahmad, 1975; Islam et al., 1991; APPPC, 1987
26	Turnip moth	*Agrotis segetum* Denis & Schiffermüller	Noctuidae	Lepidoptera	Yes	No	CIE, 1987; APPPC, 1987; EPPO, 2014
27	Beet Webworm	*Loxostege sticticalis* Linnaeus	Crambidae	Lepidoptera	No	Yes	Sun & Chen, 1995
28	Sesame webworm	*Antigastra catalaunalis* Duponchel	Crambidae	Lepidoptera	Yes	No	CABI, 2012
29	Tiger moth	*Amsacta moorei* Butler	Arctiidae	Lepidoptera	No	Yes	CABI, 2008
30	Dried currant moth	*Cadra cautella* Walker	Pyralidae	Lepidoptera	Yes	No	Roesler, 1973
31	Cassava hornworm	*Erinnyis ello* (Linnaeus, 1758)	Sphingidae	Lepidoptera	No	Yes	CABI/EPPO, 2002; EPPO, 2014
32	Pulse beetle	*Callosobruchus analis* Fabricius	Bruchidae	Coleoptera	No	Yes	CABI, 2011
33	Khapra beetle	*Trogoderma granarium* Everts	Dermestidae	Coleoptera	Yes	No	Banks &, 1977; EPPO, 2014
34	Simsim flea beetle	*Alocypha bimaculata* Jacoby	Chrysomelidae	Coleoptera	No	Yes	CABI, 2008
Mite pest							
35	two-spotted spider mite	*Tetranychus urticae* Koch	Tetranychidae	Acarina	Yes	No	Mir, 1990; IIE, 1996
36	Mite	*Brevipalpus phoenicis* (Geijsker)	Tenuipalpidae	Acarina	Yes	No	Biswas, G. C. and Das, G.P., 2011
Disease causing organisms							
Fungi							
37	Choanephora fruit rot	*Choanephora sesamearum*	Choanephoraceae	Mucorales	Yes	No	Meah & Mian, 1981; CABI/EPPO, 2008
38	Cottony soft rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales	Yes	No	Prova et al., 2014; Ahmed & Akhond, 2015; Rahman *et al.,* 2015
39	Sclerotium rot	*Athelia rolfsii*	Atheliaceae	Polyporales	Yes	No	Reddy *et al.,* 1992; UK CAB International, 1992
40	Aspergillus ear rot	*Aspergillus flavus*	Trichocomaceae	Eurotiales	Yes	No	Mandeel, 2005
41	Black root rot	*Chalara elegans*	Helotiaceae	Helotiales	No	Yes	CABI, 2015; CABI/EPPO, 2006; EPPO, 2014
42	Charcoal rot	*Macrophomina phaseolina*	Botryosphaeriaceae	Botryosphaeriales	Yes	No	Bakr & Ahmed, 1991; UK CAB International, 1985
43	Fusarium wilt	*Fusarioxysporum f.sp. vasinfectum*	Nectriaceae	Hypocreales	Yes	No	UK CAB International, 1982
44	Alternaria leaf spot	*Alternaria alternata*	Pleosporaceae	Pleosporales	Yes	No	CABI, 2017
45	Powdery mildew	*Podosphaera xanthii*	Erysiphaceae	Erysiphales	Yes	No	Amano, 1986
Causal organism: Bacteria							
46	Yellow disease	*Candidatus Phytoplasma asteris*	Acholeplasmatac	Acholeplas	No	Yes	EPPO, 2014

SN	Common Name	Scientific name	Family	Order	Presence in Bangladesh	Quarantine status	References
	phytoplasmas		eae	matales			
Causal organism: Nematode							
47	Pigeon pea cyst nematode	*Heterodera cajani*	Heteroderidae	Tylenchida	No	Yes	CABI/EPPO, 2002; EPPO, 2014
48	Reniform nematode	*Rotylenchulus reniformis*	Hoplolaimidae		Yes	No	CABI/EPPO, 2001; EPPO, 2014
Virus							
49	Cowpea aphid-borne mosaic	Cowpea aphid-borne mosaic virus (CABMV)	Potyviridae	RNA viruses	Yes	No	CABI/EPPO, 2010; Dalhal & Albrechtsen, 1996
50	Peanut mottle	Peanut mottle	Potyviridae	RNA viruses	No	Yes	CABI, 2016
Weed							
Grasses							
51	Bermuda grass	*Cynodon dactylon*	Poacegae	Poales	Yes	No	-
52	Nutsedge	*Cyperus esculentus*	Cyperaceae	Poales	Yes	No	-
53	Pigweed	*Amaranthus acanthochiton*	Amaranthaceae	Caryophyllales	Yes	No	-
54	Spiny pigweed	*Amaranthus spinosus*	Amaranthaceae	Caryophyllales	Yes	No	-
55	Goose grass	*Eleusine indica* (L.) Gaertner	Poaceae	Cyperales	Yes	No	Holm et al., 1979
56	Crab grass	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	Cyperales	Yes	No	Moody, 1989; Clayton et al., 2014
Broad leaf							
57	Black nightshade	*Solanum nigrum* L.	Solanaceae	Solanales	Yes	No	CABI, 2015
58	Cock's comb	*Celosia argentea* L.	Amaranthaceae	Caryophyllales	Yes	No	Moody, 1989; Holm et al., 1991
59	Scorpion weed	*Heliotropium indicum* L.	Boraginaceae	Boraginales	Yes	No	Holm et al., 1977
60	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Asterales	Yes (Restricted distributiohn)	No	Shabbir 2006; Shabbir et al. 2011; Anwar et al. 2012

Table 6. Quarantine pests for Bangladesh likely to be associated with sesameimported from sesame exporting countries

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect pests					
1	Cottony mealybug	*Phenacoccus solenopsis* Tinsley	China, India, Indonesia, Iran, Iraq, Japan, Pakistan, Sri Lanka, Thailand, Turkey, Vietnam, Egypt, Canada, USA, Argentina, Brazil, Australia	Transportation air / sea, Migrated over bird	CABI/EPPO, 2012; EPPO, 2014
2	Two spotted sesame bug	Eysarcoris guttiger (Thunberg)	Japan, Malaysia, Myanmar	Fruits, Seeds	Waterhouse, 1993
3	Sesame Jassid	*Orosius orientalis*	India, Iran, Israel, Korea, Japan, Myanmar, Taiwan, Turkey, Egypt, Australia	Fruits	CABI, 2015
4	Desert locust	*Schistocerca gregaria*	China, India, Iran, Iraq, Israel, Jordan, Oman, Pakistan, Philippines, Saudi Arabia, Turkey, Yemen, Egypt, South Africa, France	Fruits, Seeds	Dirsh &, 1974
5	Death's head hawkmoth	*Acherontia atropos* Linnaeus	Iran, Israel, Lebanon, Saudi Arabia, Egypt, France, Germany, Italy,		CABI, 2017
6	Beet Webworm	*Loxostege sticticalis* Linnaeus	China, Kazakhstan, Mongolla, Canada, Italy, Russian Federation	Fruits, Seeds	Sun & Chen, 1995
7	Tiger moth	*Amsacta moorei* Butler	China, India, Pakistan, Sri Lanka, Senegal	Seeds	CABI, 2008
8	Cassava hornworm	*Erinnyis ello* (Linnaeus, 1758)	Canada, USA, Argentina, Brazil, Papua New Guinea	Fruits, Seeds	CABI/EPPO, 2002; EPPO, 2014
9	Pulse beetle	*Callosobruchus analis* Fabricius	India, Indonesia, Malaysia, Myanmar, Pakistan, Sri Lanka, South Africa, Brazil, Germany, Russian Federation	Fruits, Seeds	CABI, 2011
10	Simsim flea beetle	*Alocypha bimaculata* Jacoby	Africa	Seeds	CABI, 2008
Disease causing organisms					
Fungi					
11	Black root rot	*Chalara elegans*	Chain, India, Japan, Pakistan, Philippines, Taiwan, Turkey, USA, Brazil,	Fruits, Leaves, Roots	CABI, 2015; CABI/EPPO, 2006; EPPO, 2014
Bacteria					
12	Yellow disease phytoplasmas	*Candidatus Phytoplasma asteris*	China, India, Malaysia, Myanmar, Japan, Thailand, Turkey, USA	Leaves, fruits, seeds	EPPO, 2014
Nematode					
13	Pigeon pea cyst nematode	*Heterodera cajani* Koshy	India, Myanmar, Pakistan, Egypt	Seeds, Livestock	CABI/EPPO, 2002; EPPO, 2014

Virus					
14	Peanut mottle	*Peanut mottle virus*	China, India, Indonesia, Iran, Israel, Japan, Korea, Malaysia, Philippines, Thailand, Egypt, South Africa, USA, Argentina, Australia	Seeds	CABI, 2016
Weeds					
15	Parthenium weed	*Parthenium hysterophorus*	India	Seed, equipment	

REFERENCES

Ahmed AU, Akhond MAY, 2015. First report of Sclerotinia rot caused by *Sclerotinia sclerotiorum* on Lens culinaris in Bangladesh. New Disease Reports, 31:23. http://www.ndrs.org.uk/article.php?id=031023

Amano K, 1986. Host range and geographical distribution of the powdery mildew fungi. Tokyo, Japan; Japan Scientific Societies Press, 741 pp.

Bakr MA, Ahmed F, 1991. Additional sources of resistance to wilt and root rot of chickpea in Bangladesh. International Chickpea Newsletter, No. 25:28-29; 3 ref.

Biswas, G.C. and Das, G. P. (2011). Insect and mite pests diversity in the oilseed crops ecosystems in Bangladesh. Oilseed Research Centre. BARI, Gazipur, Bangladesh. *Bangladesh J. Zool.* **39**(2): 235-244.

Bradbury JF, 1986. Guide to Plant Pathogenic Bacteria. Wallingford, UK: CAB International.

CABI/EPPO, 2001. *Rotylenchulus reniformis*. Distribution Maps of Plant Diseases, No. 845, edition 1. Wallingford, UK: CAB International.

CABI/EPPO, 2002. *Heterodera cajani*. Distribution Maps of Plant Diseases, No. 850. Wallingford, UK: CAB International.

CABI/EPPO, 2003. *Pratylenchus penetrans*. Distribution Maps of Plant Diseases, No. 888. Wallingford, UK: CAB International.

CABI/EPPO, 2006. *Thielaviopsis basicola.* Distribution Maps of Plant Diseases, No. 218. Wallingford, UK: CAB International.

CABI/EPPO, 2008. *Choanephora cucurbitarum*. [Distribution map]. Distribution Maps of Plant Diseases, October (Edition 1). Wallingford, UK: CABI, Map 1034.

CABI/EPPO, 2010. Cowpea aphid-borne mosaic virus. [Distribution map]. Distribution Maps of Plant Diseases, No.April. Wallingford, UK: CABI, Map 1075 (Edition 1).

Dahal G, Albrechtsen SE, 1996. Some studies on cowpea aphid-borne mosaic and pea seed-borne mosaic potyviruses in Nepal. International Journal of Pest Management, 42(4):337-344; 33 ref.

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

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

Mandeel QA, 2005. Fungal contamination of some imported spices. Mycopathologia, 159(2):291-298. http://springerlink.metapress.com/link.asp?id=102966

Meah MB, Mian MAW, 1981. Pathogenicity of *Choanephora cucurbitarum* on chilli (*Capsicum annuum*) and possibility of its chemical control. Acta Phytopathologica Academiae Scientiarum Hungaricp, 16(1/2):1-7

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

Prova A, Akanda MAM, Islam S, Sultana F, Islam MT, Hossain MM, 2014. First report of stem and pod blight of hyacinth bean caused by *Sclerotinia sclerotiorum* in Bangladesh. Journal of Plant Pathology, 96(3):607. http://sipav.org/main/jpp/index.php/jpp/article/view/3193/1865

Rahman MME, Dey TK, Hossain DM, Nonaka M, Harada N, 2015. First report of white mould caused by *Sclerotinia sclerotiorum* on jackfruit. Australasian Plant Disease Notes, 10(1):10. http://rd.springer.com/article/10.1007/s13314-014-0155-9/fulltext.html

Reddy LJ, Nigam SN, Subrahmanyam P, Reddy AGS, McDonald D, Gibbons RW, Pentaiah V, 1992. Registration of 'ICGV 87160' peanut. Crop Science, 32(4):1075; 2 ref.

UK CAB International, 1982. *Fusarium oxysporum f.sp. vasinfectum*. [Distribution map]. Distribution Maps of Plant Diseases, October (Edition 4). Wallingford, UK: CAB International, Map 362.

UK CAB International, 1985. *Macrophomina phaseolina*. [Distribution map]. Distribution Maps of Plant Diseases, August (Edition 1). Wallingford, UK: CAB International, Map 566.

UK CAB International, 1992. *Corticium rolfsii*. [Distribution map]. Distribution Maps of Plant Diseases, April (Edition 4). Wallingford, UK: CAB International, Map 311.

CHAPTER 7

RISK ASSESSMENT

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 sesame idenfied for Bangladesh has been analyzed details as follows:

7.1. ARTHROPOD: INSECT AND MITE PESTS

Pest-1: Cotton mealybug, *Phenacoccus solenopsis* Tinsley

7.1.1. Hazard identification

Scientific Name: *Phenacoccus solenopsis* Tinsley
Synonyms:

Phenacoccus cevalliae Cockerell 1902

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

Common names: Cotton mealybug

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: PHENSO.

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

7.1.2. 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. Suresh and Kavitha (2008b) concluded that maximum temperature and sunshine hours had a positive influence, whereas relative humidity and rainfall had a negative influence on the mealybug.

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

7.1.3. 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.

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

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

7.1.4. Distribution

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

7.1.5. Hazard Identification Conclusion

Considering the facts that *P. solenopsis* -

- is not known to be present in Bangladesh [EPPO, 2014; CABI, 2016];
- In Asia, *P. solenopsis* is present in China, India, Japan, Taiwan, Thailand and Vietnam, from which countries sesame is imported to Bangladesh.
- *P. solenopsis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

ranging from 0-45°C, throughout the year (Sharma, 2007).The transport, storage and transfer duration from exporting countries to our countries is about 20 days, so the duration is favorable for its survival and the storage environment is also favorable for its survival. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • The pathway appear good for this pest to enter into Bangladesh and establishment because pest or symptoms not visible to the naked eye but usually visible under light microscope so it is very difficult to detect them. The adults, eggs, nymphs and pupae may transported through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • The species may be dispersed internationally over vast areas by transporting infested plants into new areas by air or sea cargo. Local and regional movement is primarily by wind, irrigation water and by attachment to other insects and birds. The solenopsis mealybug is an important invasive pest that has seriously damaged cotton [*Gossypium spp*.] in India and Pakistan and poses a severe threat to cotton production in China. • The first instars or crawlers are the main dispersal stage of the solenopsis mealybug. The waxy strands covering the body serve a variety of functions including allowing the specimens to be transported by wind or water to new locations. The crawlers are commonly dispersed by wind for distances ranging from a few meters to several kilometers. • Infested host material that is transported from one area to another is an important source of distribution for the mealybug. The waxy test covering the body can adhere to passing animals or the clothes of people, allowing individuals specimens to be transported extended distances from the original infestation site before becoming dislodged in new, previously uninfested sites. • Commercial trade involving infested plants may often be the cause for spread of the invasive species over vast distances. Movement of equipment from an infested area to a non-infested area may also be involved in the accidental spread of the mealybugs. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *P. solenopsis* is a major pest of several crops like sesame, okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc. • *P. solenopsis* is also attacked several minor crops and fruits like potato, maize, chili, pumpkin, mango. • Also, it is a pest of commercial crops including a variety of vegetables, grapes, jute, mesta and tobacco. • Almost all the major and minor hosts are important crops and fruit in our country. • These climatic requirements for growth and development of *P. solenopsis* ismore or less similar with the climatic condition of **Bangladesh.**	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.1.7. 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. • Because it is a major pest of several crops like okra, cotton, sunflower, china-rose, tobacco, sesame, tomato, aubergine etc which are also important crops in Bangladesh. • *P. solenopsis* is also minor pest of potato, maize, chili, pumpkin, mango etc and these crops are also common in our country. • Also, it is a pest of commercial crops including a variety of vegetables, grapes [*Vitis vinifera*], jute [*Corchorus* spp.], mesta [*Hibiscus cannabinus*] and tobacco which are also important cash crops in our country. **b. Economic impact and yield loss** • Based on the range of climates and high number of hosts available on which the solenopsis mealybug can survive and the damage inflicted on the host plants, this species poses the serious threat of expanding its range. • Once the species has established on a host plant within a region, it has the capability of rapid growth resulting in significant damage to the crop. Sharma (2007) documented a seasonal outbreak of *P. solenopsis* on okra in 2007, which developed into a heavy infestation on the crop by the end of the season and resulted in a 90% loss of seeds. • Economic crop losses of an estimated 14% occurred in Pakistan in 2005 and in Punjab, India in 2005-2006 and 2006-2007 (Hodgson *et al.,* 2008; Dhawan et al., 2009a) due to this pest attacked. In the 2005 growing season, this invasive pest was responsible for a 44% reduction in seed-cotton yields in Pakistan (Dhawan *et al.,* 2009b). • The intense attack by the mealybug on Bt cotton resulted in significant economic losses to growers in the Punjab region (Dutt, 2007). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • As a result of *P. solenopsis* dispersal, reproductive and survival capacity, this invasive pest has the potential to damage or kill native plant species that could result in their displacement by other more aggressive species. Wang *et al*. (2009) projected that *P. solenopsis* could infest regions within 17 provinces of China and posed a pest risk analysis value of 0.856 to the area. Dhawan *et al.* (2009a) inferred that meteorological parameters influenced the presence and population size of the mealybug, with humidity and rainfall producing a negative effect. • The widespread infestation of the mealybug throughout the cotton growing regions often requires expensive and numerous applications of insecticides to produce and protect the crop. Because of the crop losses and damaged cotton bringing lower prices, many farmers in some areas are reported to be interested in cultivating other crops. As a result, the additional pest control requirements often lead to a reduced profit margin that affects the standard of living of producers and homeowners. *P. solenopsis* attacks and damages numerous ornamental plants,	**Yes and High**

therefore it has the potential to affect the aesthetic appearance of the infested areas, reducing tourism trade to the region.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table1.3 – Calculation of risk rating

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

Calculated Risk Rating – High

7.1.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In countries where *P. solenopsis* is not already present, the enforcement of strict phytosanitary regulations as required *P. solenopsis*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.1.10. References:

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/

Beshr SM, Badr SA, Ahmad AA, Mohamed GH, 2016. New record of host plants of invasive mealybug *Phenacoccus solenopsis* Tinsley (Tinsley, 1898), (Hemiptera: Pseudococcidae) in Alexandria and Behaira governorates. Journal of Entomology, 13(4):155-160. http://scialert.net/fulltext/?doi=je.2016.155.160&org=10

CABI. 2016. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

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

Dhawan AK, Singh K, Anand A, Sarika S, 2009. 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.

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

Fuchs TW, Stewart JW, Minzenmayer R, Rose M, 1991. First record of *Phenacoccus solenopsis* Tinsley in cultivated cotton in the United States. Southwestern Entomologist, 16(3):215-221.

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/

Hodges A, Hodges G, Buss L, Osborne L, 2008. Mealybugs & Mealybug Look-Alikes of the Southeastern United States. North Central IPM Center., USA: USDA-CSREES Integrated Pest Management Centers, 113 pp. www.ncipmc.org/alerts/phmb/mealybugs.pdf

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

Jansen MG, 2004. An updated list of scale insects (Hemiptera, Coccoidea) from imported interceptions and greenhouses in the Netherlands. In: Proceedings of the X International Symposium on Scale Insect Studies, 19th-23rd April 2004. 147-165 pp.

Kaydan MB, Çaliskan AF, Ulusoy MR, 2013. New record of invasive mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in Turkey. Bulletin OEPP/EPPO Bulletin, 43(1):169-171. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2338

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

Nguyen TC, Huynh TMC, 2008. The mealybug *Phenacoccus solenopsis* Tinsley damage on ornamental plants at HCM city and surrounding areas. BVTV, 37(3):3-4.

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

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. New records of Coccoidea in India. 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, 155.

Tanaka H, Tabata J, 2014. A new record of *Phenacoccus solenopsis* Tinsley, 1898 from Kyushu district, Japan. Japanese Journal of Entomology, 17(3):119-120.

Pest-2: Two spotted sesame bug, *Eysarcoris guttiger* (Thunberg)

7.2.1. Hazard identification

Scientific Name: *Eysarcoris guttiger* (Thunberg)

Synonyms:

Eusarcocoris guttiger
Eusarcoris guttiger
Stollia guttiger

Common names: Two spotted sesame bug

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Suborder: Heteroptera
Family: Pentatomidae
Genus: *Eysarcoris*
Species: *Eysarcoris guttiger*

EPPO Code: EUSAGU.
Bangladesh status: Not present in Bangladesh [Waterhouse, 1993]

7.2.2. Biology

Any records of biology about *Eysarcoris guttiger* are poorly present.

7.2.3. Hosts

Host range of *E. guttiger* are sesame and soabean.

7.2.4. Distribution

- **Asia**: Japan, Malaysia (Waterhouse, 1993) and Myanmar (Waterhouse, 1993).

7.2.5. Hazard Identification Conclusion

Considering the facts that *E. guttiger*-

- is not known to be present in Bangladesh [Waterhouse, 1993];
- In Asia, *E. guttiger* is present in Japan and Malaysia from where sesame is imported into Bangladesh;
- *E. guttiger* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.2.6. 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-No, • There is no document of newly establishment of *E. guttiger* in any countries in recent years. Though this pest already present in Japan, Malaysia and	

Myanmar. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *E. guttiger*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • This pest present in Asian countries like Japan and Malaysia from where sesame is imported to Bangladesh. Though the exact pathway of dispersal of *E. guttiger* is not known, *E. guttiger* can enter into Bangladesh from those exporting countries. **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 *E. guttiger* is available in Bangladesh. • The climatic requirement of *E. guttiger* also more or less similar in Bangladesh, because Japan, Malaysia, Myanmar and Bangladesh are remain in the same climatic zone. • So, there have possibility to establish *E. guttiger* in Bangladesh.	**Moderate**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.2.7. 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 • Though the biology, climatic requirement of *E. guttiger* is hardly known and Bangladesh has more or less same climatic condition with Japan, Malaysia and Myanmar. So *E. guttiger* can be a serious pest in Bangladesh. **b. Economic impact and yield loss** • Due to lack of available information about the economic impact of this pest of sesame, it can not be determined **c. Environmental Impact** • There is no report about environmental impact of *E. guitter*.	**Low**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	**Yes &Low**

7.2.8. 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 – Low

7.2.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In that countries where *E. guttiger* is not already present, the enforcement of strict phytosanitary regulations as required *E. guttiger*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.2.10. References

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-3: Sesame Jassid, *Orosius orientalis*

7.1. Hazard identification

Scientific Name: *Orosius orientalis*
Synonyms:

Eutettix orientalis Matsumura
Nesophrosyne orientalis (Matsumura)
Orosius albicinctus Distant
Thamnotettix filigranua Haupt

Common names: Sesame Jassid

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Suborder: Auchenorrhyncha
Superfamily: Cicadelloidea
Family: Cicadellidae
Genus: *Orosius*
Species: *Orosius orientalis*

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

7.2. Biology

Any records of biology about *Orosius orientalis* are poorly present.

7. Hosts

Orosius orientalis is polyphagous insect. It has wide range of hosts. Among these, sesame, groundnut, chickpea, cotton and sweet potato are main hosts for *O. orientalis.*

7.4. Distribution

- **Asia**: India (Rakesh et al., 2009; Choudhary & Prasad, 2007; Kamala et al., 2002), Iran (Parvin, 1992), Israel (Ishihara &, 1983), Japan (Ishihara &, 1983), Korea (APPPC, 1987), Tiwan (Ishihara &, 1983), Myanmar (Waterhouse, 1993), Turkey (Lodos & Kalkandelan, 1985).
- **Africa**: Egypt (Ishihara &, 1983).
- **Oceania:** Australia (Tre¸bicki et al., 2010).

7.5. Hazard Identification Conclusion

Considering the facts that *O. orientalis*-

- is not known to be present in Bangladesh [CABI, 2015];
- In Asia, *O. orientalis*is present in India, Japan, Korea and Taiwan from where sesame is imported to Bangladesh.
- *O. orientalis*also present in Iran, Israel, Myanmar, Turkey, Egypt and Australia. (CABI, 2015).
- *O. orientalis*is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis

7.6. 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 • *O. orientalis* has been established in India and Australia in recent years (CABI, 2015). **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *O. orientalis*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • This pest present in Asian countries like India, Japan, Korea and Taiwan from where sesame is imported to Bangladesh. Though the exact pathway of dispersal of *O. orientalis* is not known, *O. orientalis* can enter into Bangladesh from those exporting countries. **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 *O. orientalis* is available in Bangladesh*.* • The climatic requirement of *O. orientalis* also more or less similar in Bangladesh, because India, Japan, Korea, Taiwan, Myanmar and	**Moderate**

Bangladesh are remain in the same climatic zone. • So, there have possibility to establish *O. orientalis* 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 hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • Though the biology and climatic requirement of *O. orientalis* is hardly known and Bangladesh has more or less same climatic condition with India, Japan, Korea, Tiwan and Myanmar. So *O. orientalis* can be a serious pest in Bangladesh. **b. Economic impact and yield loss** • "Yellows" diseases in wine grapes are typically caused by *O. orientalis* (Conti, 1985). • In Australia, phytoplasmas vectored by *O. orientalis* cause a range of economically important diseases including legume little leaf, tomato big bud, lucerne witches broom, potato purple top wilt, Australian lucerne and is a possible vector of Australian grapevine yellows (Grylls, 1979). • *O. orientalis* also transmits Tobacco yellow dwarf virus (TYDV genus Mastrevirus, family Geminiviridae) to beans, causing bean summer death disease and to tobacco, causing tobacco yellow dwarf disease (Hill, 1941). **c. Environmental Impact** • There is no report about environmental impact of *O. orientalis*.	**Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 3.3 – Calculation of risk rating

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

Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating – Moderate

7.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In that countries where *o. orientalis*is not already present, the enforcement of strict phytosanitary regulations as required *O. orientalis*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.10. References

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

CABI. 2015. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Choudhary CS, Prasad SM, 2007. Influence of weather parameters and vector population on incidence and development of sesamum phyllody. Indian Phytopathology, 60(2):198-201.

Conti, M. 1985. Transmission of plant viruses by leafhoppers and planthoppers. In the leafhoppers and Planthoppers. pp.:289-309. Eds. L. R. Nault and J. G. Rodriguez. New York: John Wiley & Sons, Inc.

Grylls, N. E. (1979). Leafhopper vectors in Australia. In Leafhopper Vectors and Plant Disease Agents (Ed. K Maramorosch and K F Harris.). Academic Press New York, 179-214.

Hill, A. V. (1941). Yellow dwarf of tobacco in Australia, II. Transmission by the jassid *Thamnotettix argentata* (Evans). Journal of Council of Scientific and Industrial Research, 14(3), 181-186.

Ishihara T, 1983. Biotaxonomy of Cicadelloidea in Japan. In: Knight WJ, Pant NC, Robertson TS, Wilson MR, ed. Proceedings of the 1st International Workshop on Biotaxonomy, Classification and Biology of Leafhoppers and Planthoppers (Auchenorrhyncha) of Economic Importance, London, 4-7 October 1982 Commonwealth Institute of Entomology London UK, 457-467

Kamala G, Ramasubbarao V, Rajasekhar P, 2002. New records of leafhoppers associated with rice ecosystems of Andhra Pradesh, India. Pest Management and Economic Zoology, 10(1):51-56.

Lodos N, Kalkandelen A, 1985. Preliminary list of Auchenorrhyncha with notes on distribution and importance of species in Turkey. XVII Family Cicadellidae: Deltocephalinp: Grypotini, Goniagnathini and Opsini (Part I). Turkiye Bitki Koruma Dergisi, 9(2):79-90

Parvin A, 1992. Some biological features of Empoasca decipiens Paoli on sesame in Varamin. Journal of Entomological Society of Iran, 11(1/2):11-18 (Ar), 3-4 (En)

Rakesh Kumar, Shamshad Ali, Umesh Chandra, 2009. Seasonal incidence of insect-pests of Sesamum indicum. Annals of Plant Protection Sciences, 17(2):487-488. http://www.indianjournals.com/ijor.aspx?target=ijor:apps&type=home

Tre¸bicki P, Harding RM, Rodoni B, Baxter G, Powell KS, 2010. Seasonal activity and abundance of Orosius orientalis (Hemiptera: Cicadellidae) at agricultural sites in Southeastern Australia. Journal of Applied Entomology, 134(2):91-97. http://www.blackwell-synergy.com/loi/jen

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-4: Desert locust, *Schistocerca gregaria*

7.4.1. Hazard identification

Scientific Name: *Schistocerca gregaria*
Synonyms:

Acridium flaviventre Burmeister 1838
Acridium peregrina
Acridium peregrinum Olivier, 1804
Acridium sellatum Walker, 1870
Acridium tataricum Latreille, 1804
Gryllus gregarius Forskål, 1775
Gryllus rufescens Thunberg, 1815
Schistocerca americana gregaria (Forskål, 1775)
Schistocerca flaviventris (Burmeister 1838)
Schistocerca peregrina

Common names: Desert locust

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Orthoptera
Family: Acrididae
Genus: *Schistocerca*
Species: *Schistocerca gregaria*

EPPO Code: SHICGR.
Bangladesh status: Not present in Bangladesh [CABI, 2012]

7.4.2. Biology

Any records of biology about *Schistocerca gregaria*are poorly present.

7.4.3. Hosts

Wide range of hosts for *S. gregaria* are present including sesame, white siris, pigeon pea, citrus, cotton, barly, cassava, date palm, sugarcane, sorghum, wheat, grape and maize.

7.4.4. Distribution

- **Asia**: Afghanistan (Dirsh &, 1974), China (Chen YongLin, 2002), India (Sinha & Jagdish, 2001), Iran (Dirsh &, 1974), Iraq (Dirsh &, 1974), Israel (Dirsh &, 1974), Jordan (Dirsh &, 1974), Kuwait (Dirsh &, 1974), Pakistan (Dirsh &, 1974), Philippines (CAB ABSTRACTS Data Mining 2001), Turkey (Dirsh &, 1974), Yemen (Dirsh &, 1974).

- **Africa**: Egypt (Dirsh &, 1974), South Africa (Dirsh &, 1974).
- **South America:** Venezuela (CAB ABSTRACTS Data Mining 2001).
- **Europe:** France (CAB ABSTRACTS Data Mining 2001), Spain (Dirsh &, 1974).

7.4.5. Hazard Identification Conclusion

Considering the facts that *S. gregaria* -

- is not known to be present in Bangladesh [CABI, 2012];
- is present in China and India, from which countries sesame is imported to Bangladesh.
- *S. gregaria* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis

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

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

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years- Yes • In Asia, *S. gregaria* has been introduced in India and China (CABI, 2012) in the recent years. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *S. gregaria*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • Nymphal bands and swarms can travel up to 1-5 and 100 km/day, respectively (Pedgley, 1981). A swarm can consist of billions of locussts, with up to 80 million/km^2, and can cover an area of >1000 km^2 (Steedman, 1988). • *S. gregaria* laid eggs in moist soil in egg pods (70-80 eggs per pod) (Steedman, 1988). • So, this pest can enter into Bangladesh via various ornamental plants and also can enter via flight. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • Though this pest is a polyphagous pest and climatic condition of Bangladesh is more or less similar with its required climatic condition of this pest. So *S. gregaria* can establish into Bangladesh.	**Moderate**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.4.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Though the climatic condition and the host range both are suitable for *S. gregaria* present in Bangladesh. So *S. gregaria* can become a serious pest of Bangladesh. **b. Economic impact and yield loss** • The 1988 infestation could have destroyed $29 million worth of Tunisian grain; protecting the 552000ha of grain at risk would cost $8 million-$17 million per year (Potter & Showler, 1991). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • Use of BHC, a chlorinat4ed hydrocarbon, was quickly discontinued of environmental and human safety concerns (Potter & Showler, 1991).	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table4.3 – Calculation of risk rating

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

Calculated Risk Rating – High

7.4.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In countries where *S. gregaria*is not already present, the enforcement of strict phytosanitary regulations as required*S. gregaria*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.4.10. References

CABI. 2012. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Chen YongLin, 2002. Watch out for the outbreaks of desert locusts. Entomological Knowledge, 39(5):335-339.

Dirsh VM, 1974. Genus Schistocerca (Acridomorpha, Insecta). Genus Schistocerca (Acridomorpha, Insecta). The Hague, The Netherlands: Dr. W. Junk B.V., 238 pp.

Pedgley, D. (1981). *Desert Locust Forecasting Manual*, Vol.1. Centre for Overseas Pest Research, London, 265 pp.

Potter, C. S. & Showler, A. T. (1991). The desert locust: agricultural and environmental impacts. In *Tunisia: The Political Economy of Reform,* ed. I. W. Zartman, Lynne Rienner, London, pp. 153-66.

Sinha PP, Jagdish Prasad, 2001. Locust invasion in Madhya Pradesh during 1993. Insect Environment, 6(4):178-179.

Steedman, A. (1988). *Locust Handbook*. Overseas Development Natural Resources Institute, London, 180 pp.

Pest-5: Death's head hawkmoth, *Acherontia atropos* Linnaeus

7.5.1. Hazard identification

Scientific Name: *Acherontia atropos*Linnaeus
Synonyms:
Acherontia sculda Kirby, 1877
Atropos solani Oken, 1815
Sphinx atropos Linnaeus

Common names: Death's head hawkmoth

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Sphingidae
Genus: *Acherontia*
Species: *Acherontia atropos*

EPPO Code: ACHEAT.

Bangladesh status: Not present in Bangladesh [CABI, 2011]

7.5.2. Biology

Acherontia atropos is a large hawk moth with a wingspan of 90–130 mm (about 3.5 to 5 inches), being the largest moth in some of the regions in which it occurs. The adult has the typical streamlined wings and body of the hawk moth family. The moth lays its eggs singly on the underside of leaves and the initial larvae are green or grey-blue. The first instar larva are relatively small, around 120-130 mm and has a black anal horn.with a slightly forked tip. Small pale tubercles form on the surface of the body and horn. During the second instar the horn shortens and turns into a pale-yellow color. In the third instar, 7 lateral stripes form and are a signal that the hawkmoth caterpillar is fully developed. During this phase the caterpillar turns more yellow from its greenish color. During the fourth instar, the yellow tone becomes even more vivd than before and the horn recurves more. The fifth and final instar, the tubercles are lost and only the horn remains which is now strongly recurved. The stripes are now vividly blue and form V-shapes along the back. Once fully mature, the larvae burrow underground and create a small chamber where they pupate.

7.5.3. Hosts

A. atropos is considered a specialist phytophagous species. Its host range is wide. The death's head hawkmoth was observed on chinaberry, tobacco, sesame, teak etc.

7.5.4. Distribution

- **Asia:** India (Present), Indonesia (APPPC, 1987; Waterhouse, 1993), Japan (Kalshoven & LGE, Laan PA van der (Reviser translator), 1981), Malaysia (Waterhouse, 1993), Myanmar (Waterhouse, 1993), Thailand (Waterhouse, 1993), Vietnam (Waterhouse, 1993).

7.5.5. Hazard Identification Conclusion

Considering the facts that *A. atropos*-

- is not known to be present in Bangladesh [CABI, 2011];
- is potentially economic important to Bangladesh because it is an important pest of sesame in Asia including India, Japan, Malaysia and Thailand (Waterhouse, 1993) from where sesame is imported to Bangladesh.
- *A. atropos* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.5.6. 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-No**, • There is no evidence for establishment of *A. atropos* in any countries in recent years. • But *A. atropos* present in India, Indonesia, Japan, Malaysia, Myanmar, Thailand and Vietnam. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information it is difficult to determine the possibility of surviving of *A. atropos*during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - No** • The pathway of *A. atropos* for dispersal and enter into Bangladesh is hardly known because of unavailable information about this pest. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • Though this pest is present in India, Japan and Malaysia etc. which climatic condition more or less similar with Bangladesh. So the climatic requirements for growth and development of*A. atropos*is similar with the climatic condition of **Bangladesh**.	**Low**
• 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	Low

establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	

7.5.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • *A. atropos* is a serious pest in India, Japan, Malaysia, Thailand and Vietnam from where sesame is imported into Bangladesh. • The host plants and climate requirement of *A. atropos* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Due to lack of sufficient information about *A. atropos*, it is quite possible to determine the economic impact and yield loss of sesame. **c. Environmental Impact** • Environmental impact of *A. atropos* is unknown due to lack of information.	**Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 5.3 – Calculation of risk rating

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

Calculated Risk Rating – Low

7.5.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In countries where *A. atropos*is not already present, the enforcement of strict phytosanitary regulations as required for *A. atropos*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

Particular attention is needed for consignments from countries where certain *A. atropos* are present.

7.5.10 References

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

CABI. 2011. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Kalshoven LGE, Laan PA van der (Reviser and translator), 1981. Pests of crops in Indonesia (revised). Jakarta, Indonesia: Ichtiar Baru, 701 pp.

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-6: Beet Webworm, *Loxostege sticticalis* Linnaeus

7.6.1. Hazard identification

Scientific Name: *Loxostege sticticalis* Linnaeus
Synonyms:
Botys sticticalis Linnaeus
Eurycreon sticticalis Linnaeus
Margaritia sticticalis Linnaeus
Parasitochroa sticticalis Linnaeus
Phalaena sticticalis Linnaeus
Phlyctaenodes sticticalis Linnaeus
Pyrausta sticticalis Linnaeus
Common names: Beet Webworm

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Crambidae
Genus: *Loxostege*
Species: *Loxostege sticticalis*
EPPO Code: LOXOST.

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

7.6.2. Biology

Any records of biology about *Loxostege sticticalis* are poorly present.

7.6.3. Hosts

Host ranges of *L. sticticalis* are wide such as sesame, onion, groundnut, oats, sugarbeet, mustard, cabbage, hemp, watermelon, cucumber, carrot, soyabean, cotton, sunflower, lettuce, tobacco, pea, radish, sorghum, wheat, maize etc.

7.6.4. Distribution

- **Asia:** China (Sun & Chen, 1995), Kazakhistan (Shek & Telepa, 1981), Tajikistan (Sukhoruchenko *et al*., 1991).
- **North America:** Canada (Allyson, 1976; Struble & Lilly, 1977).
- **Europe:** Italy (Caporale, 1970), Netharlands (de & Vos Rutten, 1996), Russian Federation (Makarova & Doronina, 1985; Knor, 1990).

7.6.5. Hazard Identification Conclusion

Considering the facts that *L. sticticalis*-

- is not known to be present in Bangladesh [CABI, 2014];
- *L. sticticalis* is present in China from where sesame is imported to Bangladesh.
- *L. sticticalis*is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.6.6. 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- No • There is no document of newly establishment of *L. sticticalis* in any countries in recent years. Though this pest already present in Japan, Malaysia and Myanmar. **b. Posibility of survival during transport, storage and transfer? Yes** • Larvae in diapause can tolerant very low winter temperatures down to -40^{o}C (Li et al., 2006). • So, *L. sticticalis* has posibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • Adults can fly continuously for 24 h and have flown a maximum distance >100 km in a 24-h tethered-flight test (Luo and Li 1992). • Moths can migrate ≈ 300-500 km (Sun and Chen 1995). **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 *L. sticticalis* is fairly common in Bangladesh. • And also climatic requirement of *L. sticticalis* are more or less similar with Bangladesh. • So, there are suitable environment for establishment of *L. sticticalis* in Bangladesh.	**Moderate**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.6.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	**Consequence potential**
a. Is this a serious pest of Bangladesh? - Yes. • *L. sticticalisi* present in China from where sesame is imported to Bangladesh. Besides this this moth has high migratory power by flight. So, *L. sticticalis* will be a serious pest for Bangladesh. **b. Economic impact and yield loss** • In China, the species has intermittent outbreaks over a wide region of northern, northeastern, and northwestern China, with three extended periods of serious outbreaks reported since 1953 (Sun and Chen, 1995, Luo et al., 1996, Luo and Qu, 2005, Huang et al., 2008). • In 1997, there was an outbreak of first-generation larvae in Zhangjiakou city of Hebei province, where the total area of crop damage reached 600,000 ha, and economic loss reached 240 million yuan RMB (Luo et al., 1998). • In 2003, there was an outbreak of second-generation larvae in Shanxi, Shaanxi, Hebei, and Heilongjiang provinces and Inner Mongolia where the total area of crop damage reached 1.3 million ha (Luo, 2004). • Abundant diapausing larvae were the source of 6.67 million ha of crop damage in the next generation (Luo and Qu, 2005). **c. Environmental Impact** • There is no report about environmental impact of *L. sticticalis.*	**Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 6.3 – Calculation of risk rating

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

Calculated Risk Rating – Moderate

7.6.9. Risk Management Measures

- Avoid importation of sesame from that countries, where this pest is available.

- In that countries where *L. sticticalis*is not already present, the enforcement of strict phytosanitary regulations as required *L. sticticalis*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.6.10. References

Allyson S, 1976. North American larvae of the genus Loxostege Hubner (Lepidoptera: Pyralidae: Pyraustinae). Canadian Entomologist, 108(1):89-104

CABI. 2014. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Caporale F, 1970. Contribution to knowledge of Pyrausta (Parasitochroa) sticticalis L. (Lep. Ryralidae). Bollettino dell' Instituto di Entomologia della Universita degli studi di Bologna, 1968-9, 29:207-240.

Huang, S. Z., X. F. Jiang, C. L. Lei, and L. Z. Luo. 2008. Correlation analysis between periodic outbreaks of *Loxostege sticticalis* (Lepidoptera: Pyralidae) and solar activity. Acta Ecol. Sin. 28: 4824-4829.

Knor IB, 1990. Loxostege sticticalis in the Asian part of the USSR. Zashchita Rastenii, 11:52-56.

Li, C. X., L. Z. Luo, and X. L. Pan. 2006. Cold-hardiness in the diapause and non-diapause larvae of meadow moth, *Loxostege sticticalis* L. Plant Protect. 32: 41-44.

Luo, L. Z. 2004. The first generation of meadow moth will be outbreak in China. Plant Protect. 30: 86-88.

Luo, L. Z., and G. B. Li. 1992. Variation of the flight ability and behavior of adult meadow moth, *Loxostege sticticalis* at different ages. Transactions of the Ecological Society of Chinese Youths. pp. 303Ð308. **In** Ecology Research Society of China and IPM Institute of Chinese Agricultural University (eds). Chinese Science and Technology Press, Beijing, China.

Luo, L. Z., and X. F. Qu. 2005. Analysis of the occurrence characters of beet webworm, *Loxostege sticticalis* L in-naeus in 2004 and occurrence tendency of its 1st generation in 2005. Plant Protect. 31: 69-71.

Luo, L. Z., G. B. Li, and Y. Z. Cao. 1996. The third outbreak duration of meadow worm has come. Plant Protect. 22: 50-51.

Luo, L. Z., H. J. Zhang, and A. G. Kang. 1998. Cause for outbreak of the meadow moth, *Loxostege sticticalis* in Zhangjiakou region of Hebei province during 1997 production season. J. Nat. Disasters 7: 158-164.

Makarova LA, Doronina GM, 1985. Prerequistes of automation of the prediction of the population dynamics of the meadow moth. Puti Avtomatizatsii Fitosanitarnoi Diagnostiki [edited by Novozhilov, K.V.] Leningrad, USSR; Vsesoyuznyi Nauchno-issledovatel'skii Institut Zashchity Rastenii, 31-42

Shek GKh, Telepa NG, 1981. The meadow moth in Kazakhstan. Zashchita Rastenii, 6:23-24.

Struble DL, Lilly CE, 1977. An attractant for the beet webworm, Loxostege sticticalis (Lepidoptera: Pyralidae). Canadian Entomologist, 109(2):261-266

Sukhoruchenko GI, Kapitan AI, Serebrennikova NI, 1991. Optimization of the range of control measures used against soyabean pests. Ekologicheskie osnovy primeneniya insektoakaritsidov St. Petersburg, Russia: VIZR, 103-110.

Sun, Y. J., and R. L. Chen. 1995. Studies on migration, oc-currence by region and life history of meadow moth (*Loxostege sticticali* L.) in China. *Acta Agric. Boreali-Sin*.10: 86-91.

Vos RD, Rutten ALM, 1996. Migrating Lepidoptera in 1995 (fifty-sixth report). Entomologische Berichten, 56(12):177-191.

Pest-7: Tiger moth, *Amsacta moorei*

7.7.1. Hazard identification

Scientific Name: *Amsacta moorei*
Synonyms:
Amsacta moorei sara (Swinhoe)
Creatonotus moorei (Butler)

Common names: Tiger moth

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepodoptera
Family: Arctiidae
Genus: *Amsacta*
Species: *Amsacta moorei*
EPPO Code: AMSAMO.

Bangladesh status: Not present in Bangladesh [CABI, 2008]

7.7.2. Biology

Any records of biology about *Amsacta moorei* are poorly present.

7.7. Hosts

The host range of *A. moorei* includes sesame, groundnut, pigeon pea, watermelon, sunn hemp, guar, soyabean, black gram, mung bean, cow pea etc.

7.7.4. Distribution

Africa: Senegal (Ndoye, 1979).
Asia: China (You et al., 1983), India (Netam et al., 2007; Sarma et al., 2005; Surjeet Kumar, 2003), Pakistan (Hampson, 1894; Lefroy, 1907), and Sri Lanka (APPPC, 1987).

7.7.5. Hazard Identification Conclusion

Considering the facts that *A. moorei* -
- is not known to be present in Bangladesh [CABI, 2008];
- is potentially economic important to Bangladesh because it is an important pest of sesame in Asia including China and India [CABI, 2008] from where sesame is imported to Bangladesh.
- *A. moorei* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.7.6. 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-No • There is no report of establishment of *A. moorei* in recent years. This pest already present in China, India from which countries sesame is imported in Bangladesh. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *A. moorei*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No** • Due to lack of information about *A. moorei,* dispersal mechanism and pathway of disperse of this pest is quite difficult to determine. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The host ranges of *A. moorei* are fairly common in Bangladesh and the climatic requirement for this pest also more or less similar with Bangladesh. • This pest present in India and also present in some South Asian couintries. • So, there is possibility for establishment of *A. moorei* in Bangladesh.	**Low**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.7.7. Determine the Consequence establishment of this pest in Bangladesh

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

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • *A. moorei* can be a serious pest for Bangladesh. Because the host ranges for this pest are available in Bangladesh. **b. Economic impact and yield loss** • Crop losses caused by *A. moorei* during different years vary from minor damage to complete crop failure in the endemic areas but no attempt has so far been made to estimate losses caused by this species to different crops. **c. Environmental Impact**	**Yes and High**

• Arctiidae is a family which apparently reacts very markedly to climatic influences (Lefroy, 1909), pest outbreaks, and hence heavy crop losses, are likely to occur in years of substantial and frequent or intermittent rains during the first 25-30 days after start of moth emergence, i.e. from end June to July.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 7.3 – Calculation of risk rating

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

Calculated Risk Rating – Moderate

7.7.9. Risk Management Measures

- Avoid importation of seeds of sesame from countries, where this pest is available.
- In countries where *A. moorei*is not already present, the enforcement of strict phytosanitary regulations as required for *A. moorei*, may help to reduce the risk of this tiger moth 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. Particular attention is needed for consignments from countries where certain *A. moorei* are present.

7.7.10. References

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

CABI. 2008. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Hampson GF, 1894. The Fauna of British India including Cylone and Burma. London, UK: Taylor and Francis.

Lefroy HM, 1907. The more important insects injurious to Indian agriculture. In: Memoirs of the Department of Agriculture in India. Calcutta, India: Thacker, Spink and Company, 1(2):113-252.

Ndoye M, unda. Pests of cowpea and their control in Senegal. 113-115.

Netam PK, Ganguli RN, Dubey AK, 2007. Insect pest succession in okra. Environment and Ecology, 25(1):177-180.

Sarma AK, Singh MP, Singh KI, 2005. Studies on insect-pests of castor in the agro-ecosystem of Manipur. Journal of Applied Zoological Researches, 16(2):164-165.

Surjeet Kumar, 2003. Insect pests of kala zira, Bunium persicum (Boiss) Fedtsch, and field evaluation of some insecticides against them. Pest Management and Economic Zoology, 11(1):65-68.

You LS, Xiong SL, Cao KC, 1983. New records of Apanteles Forster (Hymenoptera: Braconidae) from China. Acta Entomologica Sinica, 26(4):469.

Pest-8: Cassava hornworm, *Erinnyis ello* (Linnaeus, 1758)

7.8.1. Hazard identification

Scientific Name: *Erinnyis ello* (Linnaeus, 1758)
Synonyms:

Anceryx ello (Linnaeus) Walker, 1856
Dilophonota ello (Linnaeus) Burmeister, 1856
Erinnyis cinifera Zikán, 1934
Erinnyis ello encantada Kenbauch, 1962
Sphinx ello Linnaeus, 1758

Common names: Cassava hornworm

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Sphingidae
Genus: *Erinnyis*
Species: *Erinnyis ello*

EPPO Code: ERINEL.

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

7.8.2. Biology

Errinyis ello is a very large sphinx moth (FW length 38–41 mm; wingspan 7.5–8.5 cm) with streaky light gray-tan or gray-brown forewings and bright red-orange hindwings that occurs as a very rare migrant in the Pacific Northwest. The forewing is very narrow, tapering to a sharp point at the apex, and has a toothed outer margin. It is sexually dimorphic. Males have gray finely streaked forewings with a longitudinal black stripe that extends from the mid-base to the apex, and a dark brown or black stripe on the median dorsal thorax. Females (illustrated) have both uniformly light gray wings and thorax without conspicuous dark markings. The hindwings are bright red-orange or burnt orange with dark gray to black outer margin and pale gray near the anal angle. The head and thorax are gray-tan. The dorsal abdomen is marked by black and gray bands on each segment that are bisected by a gray median band. The antenna is whitish, club-like. Larvae are distinctive due to a red and black eyespot on the dorsum of the first abdominal segment. Many color variations can be found including the common green as well as tan, purplish, and brown-gray mottled. The larvae have a caudal horn that becomes progressively smaller in each instar.

7.8.3. Hosts

The host range of *E. ello* are sesame, rubber, cassava, guava etc.

7.8.4. Distribution

- **North America**: Canada (CABI/EPPO, 2002; EPPO, 2014), USA (CABI/EPPO, 2002; EPPO, 2014).
- **South America:** Argentina (CABI/EPPO, 2002; EPPO, 2014), Brazil (CABI/EPPO, 2002; EPPO, 2014; Darrault & Schlindwein, 2002), Venezuela (CABI/EPPO, 2002; EPPO, 2014).

7.8.5. Hazard Identification Conclusion

Considering the facts that *E. ello*-

- is not known to be present in Bangladesh [CABI/EPPO, 2002; EPPO, 2014];
- *E. ello* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.8.6. 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-No, • There is no document of newly establishment of *E. ello* in any countries in recent years. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *E. ello*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – No** • Though this pest is present in only America, so it possess low possibility to enter into Bangladesh through sesame importation. Beside this due to lack of information about their dispersal mechanism, it is quite difficult to determine their establishment. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– No** • Due to lack of information about the biology of *E. ello*, we can not determine the climatic requirement of this pest. Though the host range is available in Bangladesh, it is quite possible to establish this pest in Bangladesh.	**Low**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.8.7. 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? - No • *E. ello* is only present in America and Bangladesh import sesame seeds from American countries. So it is hardly possible to become a serious pest in Bangladesh. **b. Economic impact and yield loss** • Due to lack of available information about the economic impact of this pest of sesame, it can not be determined. **c. Environmental Impact** • There is no report about environmental impact of *E. ello*.	**Low**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.8.8. 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 – Low

7.8.9. Risk Management Measures

- Avoid importation of sesame from countries, where this pest is available.
- In that countries where *E. ello* is not already present, the enforcement of strict phytosanitary regulations as required *E. ello*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.8.10. References:

CABI/EPPO, 2002. Erinnyis ello. Distribution Maps of Plant Pests, No. 628. Wallingford, UK: CAB International.

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

Darrault RO, Schlindwein C, 2002. Hawkmoths (Lepidoptera, Sphingidae) in the Tabuleiro Paraibano, northeastern Brazil: abundance, richness and relations to sphingophilous

plants. (Esfingídeos (Lepidoptera, Sphingidae) no Tabuleiro Paraibano, nordeste do Brasil: abundância, riqueza e relação com plantas esfingófilas.) Revista Brasileira de Zoologia, 19(2):429-443.

Pest-9: Pulse beetle, *Callosobruchus analis* Fabricius

7.9.1. Hazard identification

Scientific Name: *Callosobruchus analis* Fabricius
Synonyms:

Bruchus analis Fabricius
Bruchus ciceri Rondani
Bruchus glaber Allibert
Bruchus jekelii Allibert
Bruchus obliquus Allibert
Callosobruchus glaber (Allibert)
Callosobruchus jekelii (Allibert)

Common names: Pulse beetle
Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Family: Bruchidae
Genus: *Callosobruchus*
Species: *Callosobruchus analis*

EPPO Code: CALSAN.

Bangladesh status: Not present in Bangladesh [CABI, 2011]

7.9.2. Biology

Any records of biology about *Amsacta moorei* are poorly present.

7.10.3. Hosts

There are wide ranges of host of *C. analis.* Among them chickpea, soyabean, beans, sesame, cowpea, moth beans, black gram, mung bean etc. are the main host for *C. analis.*

7.9.4. Distribution

- **Asia:** India (Chitra & Sinha, 2008), Indonesia (Haines, 1989), Malaysia (Southgate, 1978), Myanmar (APPPC, 1987), Pakistan (Rasul et al., 1989), Sri Lanka (Southgate, 1978).
- **Africa:** South Africa (Southgate, 1978), Sudan (Southgate, 1978).
- **South America:** Brazil (Costa et al., 2007).
- **Europe:** Germany (Bahr, 1976), Russian Federation (Bel'skaya & Popova, 1978)

7.9.5. Hazard Identification Conclusion

Considering the facts that *C. analis* -

- is not known to be present in Bangladesh [CABI, 2011];
- is potentially economic important to Bangladesh because it is an important pest of India and Malaysia [CABI, 2011] from where sesame is imported to Bangladesh.
- *C. analis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.9.6. Determine likelihood of pest establishing 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-No • There is no report of establishment of *C. analis* in recent years. This pest already present in India and Malaysia from which countries sesame is imported in Bangladesh. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information the possibility of surviving of *C. analis* during transport, storage and transfer is unknown. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No** • The pathway of *C. analis* to enter into Bangladesh and establishemt of this pest is undetermined due to lack of information. **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 *C. analis* is fairly common in Bangladesh. • Though *C. analis* is present in India, and the climatic condition of India is more or less similar with Bangladesh. So, it is possible to establish *C. analis* into Bangladesh.	**Low**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.9.7. Determine the Consequence establishment 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 • Though *C.analis* is present in India from which country sesame is imported to Baqngladesh and host range also available in Bangladesh. So, this pest will be a serious pest of Bangladesh. **b. Economic impact and yield loss** • Due to lack of available information about the economic impact of this pest of sesame, it can not be determined. **c. Environmental Impact** • There is no report about environmental impact of *C. analis.*	**Low**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.9.8. 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 – Low

7.9.9. Risk Management Measures

- Avoid importation of sesame from that countries, where this pest is available.
- In that countries where *C. analis*is not already present, the enforcement of strict phytosanitary regulations as required *C. analis*, may help to reduce the risk of this pest 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 this pest (OEPP/EPPO, 1990).

7.9.10. References

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

Bahr I, 1976. On the occurrence of bruchids in imports and leguminous seeds in the interior. Nachrichtenblatt fur den Pflanzenschutz in der DDR, 30(11):216-220

Bel'skaya NM, Popova LG, 1978. Injurious insects in cargoes from India. Zashchita Rastenii, No. 2:42-43

CABI. 2011. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Chitra Srivastava, Sinha SN, 2008. Susceptibility of Callosobruchus sp. collected from various NSP Centres to insecticides. Annals of Plant Protection Sciences, 16(2):337-340. http://www.indianjournals.com/ijor.aspx?target=ijor:apps&type=home

Costa VA, Guzzo ÉC, Lourenção AL, Tavares MAGC, Vendramim JD, 2007. Occurrence of Dinarmus basalis in Callosobruchus analis in stored soybean in São Paulo, Brazil. Scientia Agricola, 64(3):301-302. http://www.scielo.br/sa

Haines CP, 1989. Observations on Callosobruchus analis (F.) in Indonesia, including a key to storage Callosobruchus spp. (Col., Bruchidae). Journal of Stored Products Research, 25(1):9-16

Rasul G, Ali A, Ulfat M, 1989. Varietal resistance in pulses to mung dhora (Callosobruchus analis F.). Journal of Agricultural Research (Lahore), 27(1):61-64

Southgate BJ, 1978. New junior synonyms of Callosobruchus analis (F.) and Callosobruchus dolichosi (Gyll.) (Coleoptera: Bruchidae) with notes on distribution. Journal of Stored Products Research, 14(1):61-63

Pest-10: Simsim flea beetle, *Alocypha bimaculata* Jacoby

7.10.1. Hazard identification

Scientific Name: *Alocypha bimaculata*
Synonyms:
Aphthona bimaculata Jac.
Common names: Simsim flea beetle

Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Chrysomelidae
Genus: *Alocypha*
Species: *Alocypha bimaculata*
EPPO Code: APHTBI.

Bangladesh status: Not present in Bangladesh [CABI, 2008]

7.10.2. Biology

Adults are small (1/10 inch long), shiny, dark brown or black beetles with large hind legs that allow them to jump when disturbed. Some species may have white or yellow stripes on their wing cases. Larvae are small, cream-colored worms (1/8 – 1/3 inch long). They live underground and feed on the roots and tubers of young plants as well as on germinating seeds.

7.10.3. Hosts

The only one host is sesame.

7.10.4. Distribution

Africa: Africa (CABI, 2008).

7.10.5. Hazard Identification Conclusion

Considering the facts that *A. bimaculata* -
- is not known to be present in Bangladesh [CABI, 2008];
- *A. bimaculata* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.10.6. 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- No • There are no studies about the newly establishment of *A. bimaculata* in any other countries in the world. **b. Posibility of survival during transport, storage and transfer? No** • Due to lack of information about the biology of *A. bimaculata*, we can not determine the possibility of survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - No** • Though this pest is present in only Africa, so it possesses low possibility to enter into Bangladesh through sesame importation. Beside this due to lack of information about their dispersal mechanism, it is quite difficult to determine their establishment. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • Sesame is the only host of *A. bimaculata* in Africa and sesame is also common crop in Bangladesh. The climatic condition of Bangladesh in summer season is more or less similar with Africa.	**Low**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.10.7. 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? - No • *A. bimaculata* is only present in Africa and Bangladesh does not import sesame from Africa. So it is hardly possible to become a serious pest in Bangladesh. **b. Economic impact and yield loss** • Due to lack of available information about the economic impact of this pest of sesame, it can not be determined. **c. Environmental Impact** • There is no report about environmental impact of *A. bimaculata.*	**Low**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

7.10.8. 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 – Low

7.10.9. Risk Management Measures

- Avoid importation of sesame from that countries, where this pest is available.
- 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 *A. bimaculata*are present.

7.10.10. References

CABI. 2008. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Pest-11: Black root rot, *Chalara elegans* Nag Raj & W.B. Kendr.

7.11.1. Hazard Identification

Scientific name: *Chalara elegans* Nag Raj & W.B. Kendr.

Synonyms: *Thielaviopsis basicola* (Berk. & Broome) Ferraris
Torula basicola Berk. & Broome
Trichocladium basicola (Berk. & Broome) J.W. Carmichael

Common names: Black root rot, black root rot and stubby root: chicor;

Taxonomic tree
Domain: Eukaryota
Kingdom: Fungi
Phylum: Ascomycota
Subphylum: Pezizomycotina
Class: Leotiomycetes
Subclass: Leotiomycetidae
Order: Helotiales
Family: Helotiaceae
Genus: Chalara
Species: *Chalara elegans*
EPPO Code: THIEBA.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2006; EPPO, 2014]

7.11.2. Biology

Black root rot is caused by the soil-dwelling fungus *Chalara elegans*. It is widespread and common, and is pathogenic on a wide range of ornamental plant species. The fungus infects the cortical and epidermal tissues of the root system. Once established, it produces two types of spores — tough, black, thick-walled chlamydospores, which give the infected roots their black appearance; and short-lived conidiospores. The conidiospores are responsible for rapid local spread of the fungus from plant to plant. Chlamydospores are long-term survival spores that can persist for months or even years on surfaces, in pots and containers, infected plant material or growing media dust and debris.

Spores can be spread by water splash and by insects such as shore and sciarid flies. The fungus can survive and grow in a wide range of conditions but infections are most severe when the root zone is waterlogged or poorly aerated, with root zone temperatures between 15°C and 20°C, and a pH of between 5.7 and 5.9. *Chalara elegans* produces two different spore types, both of which are produced in huge numbers:

- The larger, more robust chlamydospores can remain dormant in the soil and on dry contaminated surfaces for long periods of time (at least 3-5 years) between crops. Chlamydospores are highly resistant to chemical sterilants and are much more difficult to kill than spores of Pythium and Phytophthora.
- The smaller less robust endospores are usually produced a little earlier than the chlamydospores. They can readily become airborne and are recoverable from dust and nursery drainage water.

7.11.3. Hosts

a) **Major hosts:** *Arachis hypogaea* (groundnut), Citrus, *Citrus aurantiifolia* (lime), *Citrus limon* (lemon), *Citrus sinensis* (navel orange), Citrus x paradisi (grapefruit), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita maxima* (giant pumpkin), *Cucurbita moschata* (pumpkin), *Cucurbita pepo* (marrow), *Daucus carota* (carrot), *Glycine max* (soyabean), *Gossypium* (cotton), *Lagenaria siceraria* (bottle gourd), *Lathyrus odoratus* (sweet pea), *Lens culinaris* subsp. *culinaris* (lentil), *Momordica charantia* (bitter gourd), *Pisum sativum* (pea), *Prunus domestica* (plum), ***Sesamum indicum* (sesame),***Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea), etc.

b) **Minor hosts:** *Solanum tuberosum* (potato), *Solanum melongena* (aubergine), *Solanum lycopersicum* (tomato), *Saccharum officinarum* (sugarcane), *Nicotiana tabacum* (tobacco), *Ipomoea batatas* (sweet potato), *Coriandrum sativum* (coriander)

7.11.4. Distribution

- **Asia:** China, Indonesia, Pakistan (CABI/EPPO, 2006; EPPO, 2014), India, Philippines, Japan (EPPO, 2014), Singapore (AVA, 2001; EPPO, 2014),
- **Africa:** Egypt, South Africa (EPPO, 2014; Nkuekam *et al.,* 2013)
- **North America:** Canada and USA (Farr *et al.,* 1989; EPPO, 2014).
- **Central Amrica:** Cuba, Jamaica (EPPO, 2014)
- **South America:** Brazil (Farr *et al.,* 1989; EPPO, 2014)
- **Oceania:** Australia (Restricted distribution) and New Zealand (EPPO, 2014)
- **EU:** Italy, Spain, Sweden, Swizerland, UK, France.

7.11.5. Hazard identification conclusion

Considering the facts that *C. elegans* -

- is not known to be present in Bangladesh [CABI/EPPO, 2006; EPPO, 2014]
- potentially economic important to Bangladesh because it is an important pest of many cultivated plants including most characteristically field crops: Sweet gourd, carrot, cucumber, sweet pea, etc; fruit crops like lime, lemon, navel orange, etc; pulse crops like lentil, cowpea, mung bean, etc; oil crops like soyabean. Sesame etc. Many tree crops of the EPPO region are potential hosts.
- It is a serious pest of India, China, Japan from where a large amount of fruits, oil, field and horticultural crops are imported to Bangladesh.
- The disease can spread in irrigation water and substrate by insects such as shore flies and fungus gnats and also can spread long distance via infected plants. The fungus can survive in the soil or it can survive as a saprophyte on plant debris. It overwinters as chlamydospores.
- *C. elegans* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.11.6. 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, • This pest has been established worldwide especially in Asain countries like India, Japan, China, Pakistan, Taiwan and Turkey from where sesame has imported to our country. **b. Posibility of survival of this pest during transport, storage and transfer? – Yes** • Various environmental factors impact upon the diseases severity including; media pH (5.5 best), moisture levels (aim for 36% or lower), and temperature (under 12°C or over 32°C). These should all be considered as part of an integrated program to manage the disease but are quite inadequate by themselves. • The transport duration of sesame from exporting countries to our country is about 20 days. So, the transport duration is favourable for its survival. • On the other hand, the storage condition is more or less favourable for its growth, survival and reproduction. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • The spores are soilborne, airborne within the nursery and its immediate surrounds and waterborne in drainage water. The chlamydospore is particularly rugged and able to survive for long periods (particularly in a desiccated state) on contaminated surfaces such as pots, flats, benches, floors, roads, growing surfaces, machinery and tools. Fungus gnats and shore flies have been identified as carriers of *C. elegans* spores. Shore fly larvae feed on algae living on media surfaces and the adults imbibe liquids and leave faecal spots on foliage. Fungus gnat larvae feed on	**Yes and High**

fungi, algae and the roots and lower stems of seedlings, cuttings and a range of other nursery and hydroponic crops. Adult shore flies can pick up Chalara while feeding and deposit it during defecation on leaf surfaces. Both insects are winged and carry infection from bench to bench and area to area. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • *C. elegans* is the most serious insect pest of fruits, vegetables, pulse and oil crops in Asain countries mainly India, China, Japan, Philippines and Taiwan from where sesame are transported to Bangladesh. Groundnut, lime, lemon, melon, cucumber, soyabean, cotton bottle gourd, sweet pea,, lentil, bitter gourd are the major hosts of *C. elegans.* All the hosts are major crops in our country. The climatic condition ot the countries where the pest is already estabilished is more or less similar with Bangladesh.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.11.7. Determine the Consequence establishment 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. • It is an important pest of many cultivated plants including most characteristically fruits, field crops, vegetables, pulse crops and oil crops: *Arachis hypogaea* (groundnut), Citrus, *Citrus aurantiifolia* (lime), *Citrus limon* (lemon), *Citrus sinensis* (navel orange), Citrus x paradisi (grapefruit), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita maxima* (giant pumpkin), *Cucurbita moschata* (pumpkin), *Cucurbita pepo* (marrow), *Daucus carota* (carrot), *Glycine max* (soyabean), *Gossypium* (cotton), *Lagenaria siceraria* (bottle gourd), *Lathyrus odoratus* (sweet pea), *Lens culinaris* subsp. *culinaris* (lentil), *Momordica charantia* (bitter gourd), *Pisum sativum* (pea), *Prunus domestica* (plum), ***Sesamum indicum* (sesame),***Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea), etc. So, if the pest enter into our country become a serious pest for most of the crops. **b. Economic Impact and Yield Loss** • Black root rot delays development of the crop and in effect 'steals time' from the crop. If conditions later in the season are warm then the crop may not compensate and yield well. Severe Black root rot can lead to delays in maturity of up to four weeks and yield reductions as high as 40 per cent. • *C. elegans* was first detected in cotton in 1989 in north-western NSW (Allen 1990) and since then the pathogen has quickly spread to all cotton growing areas of NSW. By 2004, *C. elegans* reached all cotton growing regions in NSW and Queensland, and the disease was declared an Australian pandemic (Nehl *et al.* 2004). The 2015–2016 cotton pathology surveys showed that in NSW, 46.8 per cent of the farms and 76.8 per cent of the	**Yes and High**

fields surveyed had plants infected with Black root rot, while in Queensland 50 per cent of the farms and 30 per cent of the fields survey had plants infected with Black root rot. • In Queensland, traditionally Black root rot prevalence is relatively low however over the past few seasons the disease has become a lot more prevalent being recorded during the annual industry cotton pathology surveys. Since 2004–2005, Black root rot has not been detected in Theodore and Emerald. However in the 2015–2016 surveys, Black root rot was observed on roots of cotton from one field in Moura. **c. Environmental Impact** • A range of fungicides has been evaluated but none are registered in Australia for this use in ornamental crops and so unfortunately they cannot be reported on here. The use of fungicides has two distinct advantages: ✓ decreasing symptom expression (they do not eliminate the fungus however). ✓ decreasing the inoculum build-up in the nursery, essential in improving the success of sanitation procedures (it is a numbers game). • But the use of execss amount of chemical fungicides have different negative impact on our environment like disruption of natural control system, development of bio-type, resistence, resurgence and secondary pest outbreak.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 11.3 – Calculating risk rating

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

Calculated Risk Rating – High

7.11.9. Risk Management Measures

- Avoid importation of sesame and other crops from countries, where this pest is available.
- In countries where *C. elegans* not already present, the enforcement of strict phytosanitary regulations as required for *C. elegans* may help to reduce the risk of this pest becoming established.
- Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990).

Particular attention is needed for consignments from countries where certain *C. elegans* present.

7.11.10. References

CABI/EPPO, 2006. *Thielaviopsis basicola.* Distribution Maps of Plant Diseases, No. 218. Wallingford, UK: CAB International.

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

Farr DF, Bills GF, Chamuris GP, Rossman AY, 1989. Fungi on Plants and Plant Products in the United States. St. Paul, Minnesota, USA: APS Press, 1252 pp.

Lloyd AB, Lockwood JL, 1963. Effect of soil temperature, host variety, and fungus strain on Thielaviopsis root rot of pea. Phytopathology, 53:329-331.

Merrill LE, Sanderson KC, Williams JC, Reed RB, 1986. Response of Ilex cultivars to media and pH on the incidence of black root rot caused by *Thielaviopsis basicola* (Berk. & Br.) Ferraris. Journal of the American Horticultural Society, 111:102-105.

Nkuekam GK, Wingfield MJ, Roux J, 2013. Ceratocystis species, including two new taxa, from Eucalyptus trees in South Africa. Australasian Plant Pathology, 42(3):283-311. http://rd.springer.com/article/10.1007/s13313-012-0192-9

O'Brien RG, Davis RD, 1994. Lettuce black root rot a disease caused by *Chalara elegans*. Australasian Plant Pathology, 23(3):106-111

Papavizas GC, Adams PB, 1969. Survival of root-infecting fungi in soil. XII. Germination and survival of endoconidia and chlamydospores of Thielaviopsis basicola in fallow soil and in soil adjacent to germinating bean seed. Phytopathology, 59:371-378.

Pest-12: Yellow disease phytoplasmas, *Candidatus Phytoplasma asteris*

5.3.12.1. Hazard Identification

Scientific name: *Candidatus Phytoplasma asteris*

Synonyms:

Aconitum proliferation
Aconitum virescence
Alberta aster yellows
Alfalfa stunt
Alstroemeria decline
American aster yellows
Anemone virescence
Apple sessile leaf
Apricot chlorotic leaf roll

Common names: Yellow disease phytoplasmas

Taxonomic tree

Domain: Bacteria
Phylum: Firmicutes
Class: Mollicutes
Order: Acholeplasmatales
Family: Acholeplasmataceae
Genus: Phytoplasma
Species: *Candidatus Phytoplasma asteris*

EPPO Code: PHYP01.

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

7.12.2. Biology

AY group phytoplasmas are graft- but not seed-transmissible and spread naturally by insect vectors. Several leafhoppers, including *Macrosteles fascifrons* [*M. quadrilineatus*], *M. laevis*, *M. striiformis*, *M. quadripunctulatus*, *M. sexnotatus*, *M. viridigriseus*, *Euscelis plebeja*, *E. lineolatus*, *E. incisus*, *Euscelidius variegatus*, *Aphrodes bicinctus*, *Hishimonoides sellatiformis*, *Scaphytopius acutus*, *Dalbulus elimatus*, *Colladonus montanus*and *C. geminatus*, are reported to transmit them. However, *M. quadrilineatus* is reported to be the principal vector. These leafhopper species are polyphagous and can transmit the pathogens to a wide range of host plants (Lee *et al.,* 1998b, 2004; Weintraub and Beanland, 2006).
AY group phytoplasmas are also readily transmissible by dodder (*Cuscuta* spp.). More than 50 strains of AY phytoplasma group have been transmitted by means of dodder from naturally infected plants to the experimental plant *Catharanthus roseus* and are maintained in this host by periodic grafting (Gundersen *et al.,* 1996; Seemüller *et al.,* 1998; Marcone *et al.,* 2000).

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

7.12.3. Hosts

AY group phytoplasmas appear to have a wide host range. The vast majority of strains in the AY group infect herbaceous dicotyledonous plant hosts. However, a number of strains that belong to subgroups 16SrI-A, 16SrI-B and 16SrI-C are capable of infecting monocotyledonous plants (e.g., maize, onion, gladiolus, oat, wheat and grass). Some strains in subgroups 16SrI-A, 16SrI-B, 16SrI-D, 16SrI-E, 16SrI-F and 16SrI-Q can induce disease in woody plants (e.g., grey dogwood, sandalwood, blueberry, mulberry, peach, cherry, olive, grapevine and paulownia). For many of the plant hosts which have previously been reported to be affected by AY diseases on the basis of symptomatology and/or microscopic examinations (see McCoy *et al.,* 1989), the identity of the infecting phytoplasmas has never been determined with molecular techniques, or proved to be different from that of other established AY phytoplasma strains (Schneider *et al.,* 1997; Marcone *et al.,* 2000).

a) Major hosts:*Allium cepa* (onion), *Brassica napus var. napus* (rape), *Brassica oleracea var. capitata* (cabbage), *Brassica oleracea var. italica* (broccoli), *Brassica rapa subsp. rapa* (turnip), *Daucus carota* (carrot), ***Sesamum indicum* (sesame),***Spinacia oleracea* (spinach), *Zea mays* (maize)

b) Minor hosts:*Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Bougainvillea spectabilis* (Bougainvilla), *ajanus cajan* (pigeon pea), *Coriandrum sativum* (coriander), *Cucurbita moschata* (pumpkin), *Hibiscus rosa-sinensis* (China-rose), *Mangifera indica* (mango)

7.12.4. Distribution

AY phytoplasma group is the most widespread phytoplasma group. However, there are significant differences in the geographic distribution of the various subgroups (Lee *et al.,* 1998a, b; Seemüller *et al.,* 1998; Marcone *et al.,* 2000; Lee *et al.,* 2004; Jomantiene *et al.,* 2011a). Subgroups 16SrI-A, 16SrI-B and 16SrI-C are known to occur worldwide whereas subgroups 16SrI-L and 16SrI-M appear to be restricted to the European continent. Subgroups 16SrI-D, 16SrI-E and 16SrI-F seem to show pronounced host specificity. Each of them has been identified in only one host. This host specificity may be responsible for a restricted geographic distribution (Lee *et al.,* 2004). The current information about distribution is likely to be just a temporary picture subject to change with further research. There are several reports of phytoplasmas diseases of weed, and ornamental and vegetable crop plants from Europe as well as from North America which have previously been described, mostly on the basis of symptomatology and microscopical examination. The identity of phytoplasmas occurring in these plants has not been determined.

- **Asia:** China (Restricted distribution) (Nakamura *et al.,* 1996; EPPO, 2014); India (Schneider *et al.,* 1993; Baiswar *et al.,* 2010; EPPO, 2014), Indonesia (Boa *et al.,* 2010), Japan (Namba *et al.,* 1993; Nakamura *et al.,* 1996; Okuda *et al.,* 1997; EPPO, 2014), Malaysia (Khew *et al.,* 1991; Naderali *et al.,* 2013; Neda *et al.,* 2014; Neda *et al.,* 2015), Myanmar (Win *et al.,* 2014), Thailand (Schneider *et al.,* 1993).
- **Africa:** South Africa, Zambia (EPPO, 2014)
- **North America:** USA and Canada (Lee *et al.,* 1993a; Lee *et al.,* 1993b; Gundersen *et al.,* 1996; Seemüller *et al.,* 1998; EPPO, 2014; Mollov *et al.,* 2014),
- **South America:** Brazil (Bedendo *et al.,* 1997), Colombia (EPPO, 2014)
- **Europe:** France, Germany, Greece, Hungary, Poland, Spain and UK (Nisbet *et al.,* 2014; Vibio *et al.,* 1996; Keane *et al.,* 1996; Reeder & Arocha, 2008; EPPO, 2014)
- **Oceania:** Australia (EPPO, 2014).

7.12.5. Hazard identification conclusion

Considering the facts that *Candidatus Phytoplasma asteris* -

- is not known to be present in Bangladesh [CABI/EPPO, 2015; EPPO, 2014];
- is potentially economic important to Bangladesh because it is an important pest of various fruits, vegetables, pulses, flowers and oil seed crops in Asia including China, India, Thailand, **Japan** [CABI/EPPO, 2015] from where sesame seeds are imported to Bangladesh.
- AY group phytoplasmas affect plants by causing extensive abnormalities in plant growth and development, suggestive of profound disturbance in plant hormone balance.

Symptoms typical on herbaceous plant hosts include yellowing of the leaves, stunting, proliferation of auxiliary shoots resulting in a witches'-broom appearance, bunchy appearance of growth at the ends of stems, virescence of flowers and sterility, phyllody, shortening of internodes, elongation and etiolation of internodes, small and deformed leaves.

- Can become established in Bangladesh through imports of the sesame seeds. Some of the major host plants of *Candidatus Phytoplasma asteris*, such as onion, cabbage, carrot, sesame, maize, mango, tomato, aubergine, sweet pepper, cucumber, melons, etc are widely grown in the Asia region, in both field and protected conditions. Economic damage has been reported from countries where the pathogen occurs. According to the EPPO study on pest risks associated with the import of sesame seeds, the climatic similarity between the area where *Candidatus Phytoplasma asteris* occurs and Bangladesh region is same. As experience has shown that control and eradication of this pathogen is complex and costly, the introduction of *Candidatus Phytoplasma asteris* in Bangladesh should be avoided.
- *Candidatus Phytoplasma asteris* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.12.6. Determine likelihood of pest establishing in Bangladesh 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. The pathogen is already estabilished in India, China, Thailand, Japan, Indonesia from where sesame seeds are imported into our country. **b. Posibility of survival during transport, storage and transfer of this pest? - Yes** • *M. quadrilineatus* is reported to be the principal vector. These leafhopper species are polyphagous and can transmit the pathogens to a wide range of host plants (Lee *et al.,* 1998b, 2004; Weintraub and Beanland, 2006). • The transport duration of sesame seeds from exporting countries to our country is about 20 days. So, the duration is favourable for both ot the vector and pathogen. • The storage condition is also favourable for its growth, survival and development. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Pest or symptoms usually invisible. Besides this, the pathogen may be enter into our country through seeds, fruits and other planting materials. Moreover, the vector insect is already estabilished into our country. So, the pathway appears good for this pest to enter into our country. • Natural dispersal: Abiotic factors are not involved in natural spread of 'Candidatus Phytoplasma asteris'. • Vector transmission: 'Candidatus Phytoplasma asteris' is naturally transmitted by a wide range of leafhoppers. However, Macrosteles fascifrons [M. quadrilineatus] is reported to be the principal vector (Lee *et*	**YES and HIGH**

al., 1998b, 2004; Weintraub and Beanland, 2006). • Accidental introduction: Like other phytoplasmas, 'Candidatus Phytoplasma asteris' is not seed-transmissible. However, it may be introduced into new areas where it may have never existed before by importing vegetative propagating materials that carry the pathogen undetected. • Intentional introduction: The use of infected vegetative propagating material is responsible for long-distance movement of the pathogen and intentional introduction into new areas. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The major hosts range of *Candidatus Phytoplasma asteris* are *Allium cepa* (onion), *Brassica napus var. napus* (rape), *Brassica oleracea var. capitata* (cabbage), *Brassica oleracea var. italica* (broccoli), *Brassica rapa subsp. rapa* (turnip), *Daucus carota* (carrot), ***Sesamum indicum* (sesame),***Spinacia oleracea* (spinach), *Zea mays* (maize), which are mostly common in Bangladesh. • The minor hosts range are *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Bougainvillea spectabilis* (Bougainvilla), *ajanus cajan* (pigeon pea), *Coriandrum sativum* (coriander), *Cucurbita moschata* (pumpkin), *Hibiscus rosa-sinensis* (China-rose), *Mangifera indica* (mango) which also common in our country. • Besides this, the climatic condition where the pathogen is already estabilished is more or less similar with the climatic conditions of Bangaldesh. So, the pathogen can easily estabilished into our country.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

7.12.7. 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. • *Candidatus Phytoplasma asteris* has quarantine significance for Bangladesh. Its introduction and rapid spread in 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** • Aster yellows (AY) group phytoplasmas affect plants by causing a general reduction in quantity and quality of yield. The most severely affected hosts	**Yes and High**

are carrot, lettuce, onion, spinach and several ornamental crops, including aster, gladiolus, hydrangea, chrysanthemum and purple coneflower. Disease incidence may vary from year to year depending on the population trend of the vectors in the field. Infection rates varying from 20 to 30% were observed in lettuce and ranunculus fields in southern Italy (Marcone *et al.,* 1995; Parrella *et al.,* 2008). In Oklahoma, USA, according to Errampalli et al. (1991), AY group phytoplasma infections occurred in 80% of lettuce plants and 28% of carrots. In Ohio, disease incidence of 100% has been recorded in lettuce fields (Zhang *et al.,* 2004). • A major outbreak of AY disease occurred in 2000 in Texas that affected several vegetable crops. Among them, carrot was most severely damaged with infection rates that ranged from to 50 to near 100% (Lee *et al.,* 2003). A severe AY disease of chrysanthemum which induced losses of 70 to 80% of the crop has been reported from China (Min *et al.,* 2008) whereas losses of 90% were recorded in AY-affected aubergines in Bangladesh (Kelly *et al.,* 2009). Infection rates of 60 and 99% were recorded in Hungary for AY-affected sugarbeet plants and India for AY-affected *Jatropha curcas* plants, respectively (Mumford *et al.,* 2000; Kumar *et al.,* 2010b). However, there are also several reports on sporadic occurrence and generally low incidence of AY group phytoplasmas in vegetable and ornamental crops (Smith *et al.,* 1988; Vibio *et al.,* 1995; Bertaccini *et al.,* 1998). Cassava witches' broom, a disease affecting cassava in South East Asia (Vietnam, Thailand, Cambodia, Laos, China and the Philippines) is caused by 16SrI phytoplasma. The disease has resulted in significant reductions in cassava root starch content and up to 80% yield loss in parts of Vietnam (Anon., 2014). • Diseases caused by *'Ca. P. australiense'* impact economically important food and ornamental crops. Researchers have documented vineyard losses as high as 13%. Severely affected grape vines can produce up to 54% less fruit than healthy grape vines (CABI, 2007; NPAG, 2007). Papaya dieback is responsible for annual plant losses of 10% and up to 100% during epiphytotics (epidemic among plants of a single kind over a wide area) in central and southern Queensland plantations (Glennie and Chapman, 1976; Guthrie *et al.,* 1998). Australian lucerne yellows has caused a reduction in seed yield, which has led to the cutting or plowing-under of seed crops, resulting in estimated losses of $7 million annually (Pilkington et al., 1999). • The economic impact that '*Ca. P. australiense'* could have on new host *Solanum tuberosum* is potentially significant. The total economic value of New Zealand's potato industry in 2011 was estimated to be $382 million NZD ($300 million USD), with about a quarter of that coming from exports (Potatoes New Zealand, n.d.). **c. Environmental impact** • To prevent the infection of the pathogen and control of the vector farmers used different types of chemical pesticides. Excess amount of chemical pesticides have negative effect on environment like development of bio-type, development of resistence, resurgence and secondary pest outbreak.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table 12.3 – Calculating risk rating

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

Calculated Risk Rating – High

7.12.9. Risk Management Measures

- Avoid importation of sesame seeds from countries, where this pest is available.
- In countries where *Candidatus Phytoplasma asteris* not already present, the enforcement of strict phytosanitary regulations as required for *Candidatus Phytoplasma asteris* may help to reduce the risk of this pest 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 *Candidatus Phytoplasma asteris* present.

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7.12.10. References

Baiswar P, Arocha Y, Chandra S, Ngachan SV, 2010. First report of 'Candidatus Phytoplasma asteris' associated with witches' broom of Crotalaria tetragona in India. Plant Pathology, 59(2):397. http://www.blackwell-synergy.com/loi/ppa

Bedendo IP, Davis RE, Dally EL, 1997. Molecular evidence for the presence of maize bushy stunt phytoplasma in corn in Brazil. Plant Disease, 81(8):957; 4 ref.

Boa E, Arocha Y, Harling R, Tobing C, Kelly P, Reeder R, 2010. First report of group 16SrI, 'Candidatus Phytoplasma asteris' associated with Mimosa pudica yellows in Indonesia. Plant Pathology, 59(2):397. http://www.blackwell-synergy.com/loi/ppa

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

Gundersen DE, Lee IM, 1996. Ultrasensitive detection of phytoplasmas by nested-PCR assays using two universal primer pairs. Phytopathologia Mediterranea, 35(3):144-151; 25 ref.

Jomantiene R, Zhao Yan, Lee IngMing, Davis RE, 2011. Phytoplasmas infecting sour cherry and lilac represent two distinct lineages having close evolutionary affinities with clover phyllody phytoplasma. European Journal of Plant Pathology, 130(1):97-107. http://springerlink.metapress.com/link.asp?id=100265

Khew KL, Davis RE, Ong CA, Lee I-M, Su HJ, Tsai MC, 1991. Detection of a Malaysian mycoplasmalike organism (MLO) and its differentiation from other Asian, European, and North American MLOs by use of cloned chromosomal and extrachromosomal MLO DNA probes. Journal of Plant Protection in the Tropics, 8:167-180.

Lee IngMing, Gundersen-Rindal DE, Davis RE, Bartoszyk IM, 1998. Revised classification scheme of phytoplasmas based on RFLP analyses of 16S rRNA and ribosomal protein gene sequences. International Journal of Systematic Bacteriology, 48(4):1153-1169; 145 ref.

Marcone C, Lee I-M, Davis RE, Ragozzino A, Seemüller E, 2000. Classification of aster yellows-group phytoplasmas based on combined analyses of ribosomal RNA and tuf gene sequences. International Journal of Systematic and Evolutionary Microbiology, 50: 1703-1713
Marcone C, Lee I-M, Davis RE, Ragozzino A, Seemüller E, 2000. Classification of aster yellows-group phytoplasmas based on combined analyses of ribosomal RNA and tuf gene sequences. International Journal of Systematic and Evolutionary Microbiology, 50: 1703-1713
McCoy RE, Caudwell A, Chang CJ, Chen TA, Chiykowski LN, Cousin MT, Dale JL, de Leeuw GTN, Golino DA, Hackett KJ, Kirkpatrick BC, Marwitz R, Petzold H, Sinha RC, Sugiura M, Whitcomb RF, Yang IL, Zhu BM, Seemnller E, 1989. Plant diseases associated with mycoplasma-like organisms. In: Whitcomb RF, Tully, eds. The Mycoplasmas, Vol. V. San Diego, USA: Academic Press, 545-640.

Naderali N, Nejat N, Tan YH, Vadamalai G, 2013. First report of two distinct phytoplasma species, 'Candidatus phytoplasma cynodontis' and 'Candidatus phytoplasma asteris,' simultaneously associated with yellow decline of Wodyetia bifurcata (foxtail palm) in Malaysia. Plant Disease, 97(11):1504-1505. http://apsjournals.apsnet.org/loi/pdis

Nakamura H, Yoshikawa N, Takahashi T, Sahashi N, Kubono T, Shoji T, 1996. Evaluation of primer pairs for the reliable diagnosis of Paulownia witches'-broom disease using a polymerase chain reaction. Plant Disease, 80(3):302-305; 17 ref.

Neda Naderali, Ganesan Vadamalai, Naghmeh Nejat, Ling KL, 2015. First report of phytoplasma (16SrI) associated with yellow decline disease of Royal Palms [Roystonea regia (Kunth) O. F. Cook] in Malaysia. Journal of Phytopathology, 163(2):133-137. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1439-0434

Neda Naderali, Ganesan Vadamalai, Tan YeeHow, Naghmeh Nejat, 2014. Detection and identification of aster yellows phytoplasma associated with lipstick yellow frond disease in Malaysia. Journal of Phytopathology, 162(4):264-268. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1439-0434

Schneider B, Marcone C, Kampmann M, Ragozzino A, Lederer W, Cousin MT, Seemnller E, 1997. Characterization and classification of phytoplasmas from wild and cultivated plants by RFLP and sequence analysis of ribosomal DNA. European Journal of Plant Pathology, 103(8):675-686; 38 ref.

Seemüller E, Schneider B, Maürer R, Ahrens U, Daire X, Kison H, Lorenz KH, Firrao G, Avinent L, Sears BB, Stackebrandt E, 1994. Phylogenetic classification of phytopathogenic mollicutes by sequence analysis of 16S ribosomal DNA. International Journal of Systematic Bacteriology, 44(3):440-446
Seemüller E, Schneider B, Maürer R, Ahrens U, Daire X, Kison H, Lorenz KH, Firrao G, Avinent L, Sears BB, Stackebrandt E, 1994. Phylogenetic classification of phytopathogenic mollicutes by sequence analysis of 16S ribosomal DNA. International Journal of Systematic Bacteriology, 44(3):440-446

Weintraub PG, Beanland L, 2006. Insect vectors of phytoplasmas. Annual Review of Entomology, 51:91-111. http://www.annualreviews.org

Win NangKyuKyu, Kim YoungHwan, Jung HeeYoung, 2014. Bitter gourd little leaf disease associated to 'Candidatus Phytoplasma asteris'. Tropical Plant Pathology, 39(1):82-88. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1982-56762014000100010&lng=en&nrm=iso&tlng=en

Pest-13: Pigeon pea cyst nematode, *Heterodera cajani* Koshy, 1967

7.13.1. Hazard identification

Scientific Name: *Heterodera cajani* Koshy, 1967
Synonyms:
Heterodera vigni Edward & Misra, 1968
Common names: Pigeon pea cyst nematode

Taxonomic tree

- Domain: Eukaryota
  - Kingdom: Metazoa
    - Phylum: Nematoda
      - Order: Tylenchida
        - Family: Heteroderidae
          - Genus: *Heterodera*
            - Species: *Heterodera cajani*

EPPO Code: HETDCJ.

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

7.13.2. Biology

Adult female's body obese, lemon-shaped and white to slightly brown, with a neck and posterior cone-like elevation on which the vulva is situated; turns into a cyst of same size and shape. Posterior part of body protruding outside the root usually with small rounded egg sac attached to it. Cephalic region with two annules, the second larger than the first. Stylet of medium strength, in two equal parts; basal knobs round to slightly anteriorly flattened. Median oesophageal bulb large rounded, with well developed valve plates. The excretory pore is placed posterior behind the median bulb. Oesophageal glands extend over the intestine. Ovaries paired, convoluted. Uterus with several eggs filling most of the body. Vulva a large transverse slit on a cone-shaped elevation of the body. Anus close to vulva. An egg sac is present. Cysts are lemon-shaped, with protruding neck and vulva region, light-brown, thin walled and without a subcrystalline layer. Cuticle surface with a zigzag pattern. Vulval cone is prominent. Vulval slit fairly long, terminal. The end-on view of the vulval cone shows concentric wavy lines of cuticular ridges around the vulval slit and two large fenestrae. Ambifenestrate with the two semifenestrae separated by a vulval bridge and surrounded by a wide 'basin'. Anus indistinct. Bullae present, few. The underbridge is simple, thin. Egg sac size varies between 0.5-2 times the size of cyst (note that other species of the schachtii group have egg sacs not more than one cyst size). Yellow, occasionally purple. Few to 200 eggs (average 54) are found in the egg sacs (Koshy and Swarup, 1971c). Eggs oval, 95-115

(110) µm long, 37-48 (43) µm wide. Egg shell hyaline, without surface markings. Juveniles morphological characteristics of 2nd-, 3rd- and 4th-stage juveniles of *H. cajani*, *H. avenae* and *H. mothi* are described and compared by Taya and Bajaj (1986). Second-stage juveniles (J2): vermiform, tapering at both ends, assuming a slightly arcuate position when relaxed or dead. Cephalic region with 3-4 annules and an indistinct labial disc. Cephalic framework strongly sclerotized. Cuticle distinctly annulated. Lateral field with four incisures forming three bands; middle band distinct and narrower than the outer ones. Stylet strong, 17-23 µm long, with flattened to anteriorly directed knobs; dorsal knob larger than the subventrals. Dorsal oesophageal gland orifice 3-4 µm from the base of the stylet. Median oesophageal bulb oval, muscular, with distinct cuticular thickenings. Oesophageal glands elongate, extending over intestine mostly ventrally; subventral glands larger and extending past the dorsal gland. Nerve ring encircling isthmus a little behind the median bulb. Excretory pore just behind the level of the nerve ring. Hemizonid just anterior to excretory pore. Tail elongate-conoid, usually 35-45 µm long, with a small rounded terminus; hyaline region more than half tail length. Phasmids small, pore-like, about one anal body width behind anus level. Males are common, found in egg masses or in soil. Body ventrally arcuate to open C-shaped when relaxed. Lateral field with four incisures, one-fourth to one-third as wide as body. Cephalic region slightly offset from body contour, with four annules and an indistinct labial disc, framework heavily sclerotized. Median oesophageal bulb oval, muscular, with distinct inner cuticular thickenings. Isthmus short, encircled by nerve ring. Oesophageal glands extending over intestine mostly ventrally and ventro-laterally; dorsal gland nucleus larger and anterior to those of subventral glands. Oesophago-intestinal valve indistinct, about 1-1.5 body widths from centre of median bulb. Hemizonid distinct, 1-2 annules long, about one corresponding body width behind oesophago-intestinal junction. Excretory pore 140-160 µm from anterior end of body, 5-7 annules behind hemizonid. Testis single, anteriorly outstretched. Spicules paired, similar, cephalated, slightly arcuate ventrally, notched terminally, 26-29 µm long. Gubernaculum linear, 8-10 µm long. Tail end bluntly convex-conoid; tail short, less than one anal body width.

7.13.3. Hosts

Of the 105 species of plants belonging to 58 genera in 21 families tested, only 19 (18 in Fabaceae and Sesamum indicum in Pedaliaceae) proved to be hosts. Pigeon pea (*Cajanus cajan*), Lablab purpureus, *Vigna radiata*, cowpea (*V. unguiculata*) and sesame (*Sesamum indicum*) were the most favoured hosts and showed extensive damage from *H. cajani* attack (Koshy and Swarup, 1973). Reports of primary hosts include *C. cajan*, *V. unguiculata*, *Vigna mungo*, *V. radiata*, *V. aconitifolia*, *Phaseolus species*, *Pisum sativum* and *Phyllanthus maderaspatensis* (Evans and Rowe, 1998); *S. indicum* and *Cyamopsis tetragonoloba* from Haryana (India) (Bhatti and Gupta, 1973).

Other host reports are of *L. purpureus*, *S. indicum*, *Sesbania aculeata* [*S. bispinosa*] and *Crotalaria juncea* (Walia et al., 1985); *Cyamopsis tetragonoloba*, *V. radiata* and *V. mungo* (Yadav and Walia, 1988); *Phaseolus vulgaris*, *Sesbania bispinosa* and *V. radiata* as winter host plants (Jain et al., 1994a); species of *Atylosia, Dunbaria, Flemingia* and *Rhynchosia* (Sharma and Nene, 1985); and *V. mungo* (Kalha and Edward, 1979). Three biological races with different host preferences have been distinguished by Siddiqui and Mahmood (1993).

7.13.4. Distribution

- **Asia**: India (CABI/EPPO, 2002; EPPO, 2014), Myanmar (Yi et al., 2005), Pakistan (CABI/EPPO, 2002; EPPO, 2014).
- **Africa**: Egypt (CABI/EPPO, 2002; EPPO, 2014).

7.13.5. Hazard Identification Conclusion

Considering the facts that *Heterodera cajani*-

- is not known to be present in Bangladesh [CABI, 2017];
- is present in India from which country sesame is imported to Bangladesh.
- *H. cajani*is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

7.13.6. 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- Yes • *Heterodera cajani*has been introduced in Myanmar (CABI/EPPO, 2002; EPPO, 2014) in the recent years. **b. Posibility of survival during transport, storage and transfer? Yes** • The life cycle was completed in 16 days at 29°C but during cooler conditions (10-25°C), the life-cycle took 45-80 days to complete (Koshy and Swarup, 1971c). So tis nematode can survive during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • Spread of *H. cajani* by itself is limited. Transportation results mainly from flooding, drainage or transfer of infested seeds and plants, from soil washings, and from soil attached to farm machinery, livestock, tools or people (Mathur, 1986; Sharma, 1998). **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 for *H. cajani* are available in Bangladesh and climatic condition of Bangladesh is also favourable for this nematode.	**High**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.13.7. Determine the Consequence establishment of this pest in Bangladesh

Table 13.2: Which of these descriptions best fit of this pest?

Description	Consequence potential
a. Is this a serious pest of Bangladesh? - Yes. • Though the climatic condition and the host range both are suitable for *H. cajani* present in Bangladesh. So *H. cajan* can become a serious pest of Bangladesh. **b. Economic impact and yield loss** • In India, *H. cajani* is considered to be one of the four most important cyst nematodes and is an economic pest of cowpea and pigeon pea. Although accurate estimates of economic crop loss are not available, yield reduction and decline of plants have been reported by many workers such as Sharma (1991), who recorded yield losses in pigeon pea of over 30%. • *H. cajani* infection suppresses plant growth of pigeon pea by 28% and reduces grain yield by 24%; in mung bean (Vigna radiata), plant growth was suppressed by 42% and grain yield by 68% (Saxena and Reddy, 1987). When *H. cajani* is associated with the fungus Fusarium udum [Gibberella indica] there is a significant increase in wilting (Hasan, 1984). **c. Environmental Impact** • Due to estabilishment of this nematode farmers used different type of nematicide are used by the farmers. Result of alteration soil chemical properties, development of bio-type, reduced soil microorganism activity.	**High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table13.3 – Calculation of risk rating

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

Calculated Risk Rating – High

7.13.9. Risk Management Measures

- Avoid importation of sesame from countries, where this nematode is available.
- In countries where *H. cajani*is not already present, the enforcement of strict phytosanitary regulations as required*H. cajani*, may help to reduce the risk of this nematode 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 this nematode (OEPP/EPPO, 1990).

7.13.10. References

Bhatti DS, Gupta DC, 1973. Guar an additional host of *Heterodera cajani*. Indian Journal of Nematology, 3(2):160.

CABI. 2017. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

CABI/EPPO, 2002. *Heterodera cajani*. Distribution Maps of Plant Diseases, No. 850. Wallingford, UK: CAB International.

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

Evans K, Rowe JA, 1998. Distribution and economic importance. In: Sharma SB, ed. The Cyst Nematodes. Dordrecht, Netherlands: Kluwer Academic Publishers, 1-30.

Hasan A, 1984. Synergism between *Heterodera cajani* and *Fusarium udum* attacking *Cajanus cajani*. Nematologia Mediterranea, 12(1):159-162; 4 ref.

Jain SK, Dave GS, Jain AK, 1994. Host range of cyst nematode *Heterodera cajani* in cold weather. Indian Phytopathology, 47(2):177-178.

Kalha CS, Edward JC, 1979. Studies of pathogenicity, life cycle, histopathology and morphometry of some isolates of *Heterodera cajani* Koshy, 1967 on local and T9 urd (Phaseolus mungo Roxb.) varieties. Allahabad Farmer, 50(4):397-398.

Koshy PK, Swarup G, 1971. On the number of generations of *Heterodera cajani*, the pigeon-pea cyst nematode in a year. Indian Journal of Nematology, 1:88-90.

Koshy PK, Swarup G, 1973. Susceptibility of plants to pigeon-pea cyst nematode, *Heterodera cajani*. Indian Journal of Nematology, 2(1972):1-6.

Mathur VK, 1986. Quarantine: an effective and possible method to control plant parasitic nematodes. In: Swarup G, Dasgupta DR, eds. Plant-Parasitic Nematodes of India, Problems and Progress. New Delhi, India: Indian Agricultural Research Institute, 490-497.

Saxena R, Reddy DDR, 1987. Crop losses in pigeonpea and mungbean by pigeonpea cyst nematode, *Heterodera cajani*. Indian Journal of Nematology, 17(1):91-94; 10 ref.

Sharma SB, 1991. Pearly root of pigeonpeas caused by *Heterodera cajani*. Indian Journal of Nematology, 21(2):169.

Sharma SB, ed., 1998. The Cyst Nematodes. Dordrecht, Netherlands: Kluwer Academic Publishers.

Sharma SB, Nene YL, 1985. Additions to host range of pigeonpea cyst nematode, *Heterodera cajani*. International Pigeonpea Newsletter, No. 4:42.

Siddiqui ZA, Mahmood I, 1993. Occurrence of races of *Heterodera cajani* in Uttar Pradesh, India. Nematologia Mediterranea, 21(2):185-186; 5 ref.

Taya AS, Bajaj HK, 1986. Larval stages of Heterodera avenae Woll.,*H. cajani* Koshy and *H. mothi* Khan and Husain. Indian Journal of Nematology, 16(2):160-162.

Walia KK, Bajaj HK, Gupta DC, 1985. Prevalence of pigion pea cyst nematode, *Heterodera cajani* Koshy, 1967 in Bhiwani district (Haryana) along with a new host record. Haryana Agricultural University Journal of Research, 15:463-464.

Yadav US, Walia RK, 1988. On the biology of pigeonpea cyst nematode, *Heterodera cajani* Koshy, 1967. Indian Journal of Nematology, 18(1):35-39; 13 ref.

Yi Yi Myint, Thein Lwin, Khin Hnin Thwe, Yu Yu Min, Seint San Aye, Myat Lin, Pyone Pyone Kyi, Zin Thu Zar Maung, Po Po Than, 2005. New record on the occurrence of cyst nematode, *Heterodera cajani* Koshy, 1967 on sesame, *Sesamum indicum* in Myanmar. In: Proceedings of the Fourth Agricultural Research Conference in Commemoration of the Ruby Jubilee of Yezin Agricultural University, Yezin Agricultural University, Nay Pyi Taw, Myanmar, 17-18 February 2005 [ed. by Myint Thaung\Kyaw Kyaw Win\Nang Hseng Hom]. Nay Pyi Taw, Myanmar: Yezin Agricultural University, 59-67.

Pest-14: Peanut mottle, *Peanut mottle virus*

7.14.1. Hazard identification

Scientific Name: *Peanut mottle virus*
Synonyms:
Groundnut mottle virus
Peanut mild mosaic virus
Peanut mottle potyvirus
Peanut severe mosaic virus
Common names: Peanut mottle

Taxonomic tree
Domain: Virus
Group: "Positive sense ssRNA viruses"
Group: "RNA viruses"
Family: Potyviridae
Genus: Potyvirus
Species: *Peanut mottle virus*
EPPO Code: PEMOV0.

Bangladesh status: Not present in Bangladesh [CABI, 2016]

7.14.2. Biology

Any records of biology about *Peanut mottle virus*are poorly present.

7.14.3. Hosts

Wide range of hosts for *Peanut mottle virus*are present including sesame, groundnut, soyabean, beans, pea and cowpea etc.

7.14.4. Distribution

- **Asia**: China (Xu et al., 1983; Shih & Hsu, 1979), India (Nigam et al., 1992), Indonesia (Iwaki, 1979), Iran (Elahinia et al., 2008), Japan (Matsumoto et al., 1991), Korea (Koo et al., 2002), Malaysia (VIDE), Philippines (Estrada & Palomar, 1981), Taiwan (Chang, 1993), Thailand (Iwaki et al., 1986).
- **Africa**: Egypt (Abdelsalam et al., 1986; Khalil & Abdelsalam, 1986), South Africa (Pieterson & Garnett, 1990).

- **South America:** Argentina (Truol et al., 1988).
- **North America:** USA (Gudauskas et al., 1993)
- **Oceania:** Australia (Anon, 1973; Anon, 1976).

7.14.5. Hazard Identification Conclusion

Considering the facts that *Peanut mottle virus*-

- is not known to be present in Bangladesh [CABI, 2016];
- is present in China, India, Japan, Korea, Malaysia, Tiwan and Thailand, from which countries sesame is imported to Bangladesh.
- *Peanut mottle virus*is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table 14.1 – Which of these descriptions best fit of this pest?

Description	**Establishment Potential**
a. Has this pest been established in several new countries in recent years- Yes • *Peanut mottle virus*has been introduced in Korea and Zimbabwe (CABI, 2016) in the recent years. **b. Posibility of survival during transport, storage and transfer? No** • Though this virus is seed transmited virus so it can survive under 20°C, which is maintain at the time of transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • Though peanut mottel virus is seed transmitted virus so the pathway is appeared good to enter Bangladesh and establish. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The host range for peanut mottel virus is available in Bangladesh and climatic condition of Bangladesh is also favourable for this virus.	**High**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

7.14.7. 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. • Though the climatic condition and the host range both are suitable for *Peanut mottle virus* present in Bangladesh. So *peanut mottle virus* can become a serious pest of Bangladesh. **b. Economic impact and yield loss** • Due to lack of available information about the economic impact of this pest of sesame, it can not be determined**.**	**Moderate**

c. Environmental Impact • There is no report about environmental impact of *Peanut mottle Virus*.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table14.3 – Calculation of risk rating

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

Calculated Risk Rating – High

7.14.9. Risk Management Measures

- Avoid importation of sesame from countries, where this Virus is available.
- In countries where *Peanut mottle virus*is not already present, the enforcement of strict phytosanitary regulations as required*Peanut mottle virus*, may help to reduce the risk of this virus 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 this virus (OEPP/EPPO, 1990).

7.14.10. References

Abdelsalam AM, Khalil EF, El-Kady MAS, 1986. Purification of an Egyptian isolate of peanut mottle virus. Egyptian Journal of Phytopathology, 18(2):113-121.

Anon, 1973. Annual Report 1972-1973. Brisbane, Australia: Queensland Department of Primary Industries.

Anon, 1976. Phaseolus. Annual Report 1975-1976. Brisbane, Australia: Queensland Department of Primary Industries.

CABI. 2016. Crop Protection Compendium CD ROM. CABI. www.cabicompendium.org/cpc

Chang CA, 1993. Viruses of legume crops in Taiwan. Plant Pathology Bulletin, 2(3):149-160.

Elahinia SA, Shahraeen N, Alipour HRM, Nicknejad M, Pedramfar H, 2008. Identification and determination of some properties of Peanut Mottle Virus using biological and serological methods in Guilan Province. Journal of Agricultural Sciences (Guilan), 1(10):11-21. http://research.guilan.ac.ir/jas/papers/1022.pdf

Estrada EH, Palomar MK, 1981. Effect of rust and mottle virus infection on the growth and yield of groundnut. Annals of Tropical Research, 3(2):117-126.

Gudauskas RT, Burch KB, Jin P, Hagan AK, Weeks JR, 1993. Identification of viruses infecting peanut in Alabama. Peanut Science, 20(2):71-73.

Iwaki M, 1979. Virus and mycoplasma diseases of leguminous crops in Indonesia. Review of Plant Protection Research, 12:88-97.

Iwaki M, Thongmeearkom P, Sarindu N, Deema N, Honda Y, Goto T, Surin P, 1986. Peanut mottle virus isolated from soybean in Thailand. Technical Bulletin of the Tropical Agriculture Research Center, No.21:101-105.

Khalil EM, Abdelsalam AM, 1986. Detection of peanut mottle virus by enzyme-linked immunosorbent assay. Egyptian Journal of Phytopathology, 18(2):123-131.

Koo BongJin, Shin HyeYoung, Sung JungHyun, Kang DongKyon, Chang MooUng, 2002. Bean common mosaic virus and Peanut mottle virus isolated from peanut in Korea. Research in Plant Disease, 8(2):92-100; 23 ref.

Matsumoto JI, Ohki ST, Inouye T, 1991. Incidence of peanut stripe virus in seeds and field plants of peanut in Japan. Annals of the Phytopathological Society of Japan, 57(4):587-590

Nigam SN, Dwivedi SL, Rao YLC, Gibbons RW, 1992. Registration of 'ICGV 87187' peanut. Crop Science, 32(1):278-279; 4 ref.

Pietersen G, Garnett HM, 1990. A survey for the viruses of soybeans (Glycine max) in the Transvaal, South Africa. Phytophylactica, 22(1):35-40.

Shih CL, Hsu SH, 1979. Studies on the peanut mosaic virus from Shantung. Acta Phytopathologica Sinica, 9(2):131-136.

Truol GA, Laguna IG, Rodriguez Pardina P, 1988. Presence of peanut mottle virus on soyabean (Glycine max L. Merr) in Argentina. Fitopatologia, 23(2):75-80.

Xu Z, Yu Z, Lui J, Barnett OW, 1983. A virus causing peanut mild mottle in Hubei Province, China. Plant Disease, 67(9):1029-1032.

Pest-15: Parthenium weed: *Parthenium hysterophorus*

7.15.1. 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.

7.15.2. 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).

7.15.3. 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).

7.15.4. 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.

Exotic distribution

- **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.

7.15.5. 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 fruits, 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.

7.15.6. 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. 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.

YES and HIGH

- 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 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.,* 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

7.15.7. 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. • *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.	**Yes and High**

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 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

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

Establishment Potential X Consequence Potential = Risk

Table 15.3 – Calculating risk rating

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

Calculated Risk Rating – High

7.15.9. 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.

7.15.10. 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.

7.2. 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 sesame pathway to Bangladesh as India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand and other exporting countries, out 16 potential hazard organisms, 7 hazard organisms were identified with highrisk potential, 4 were moderate and 5 were identified with low risk potential.

The overall pest risk potential ratings of 16 quarantine pests of sesame 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	Cottony mealybug	*Phenacoccus solenopsis* Tinsley	Pseudococcidae	Homoptera	High
2	Two spotted sesame bug	*Eysarcoris guttiger* (Thunberg)	Pentatomidae	Hemiptera	Moderate
3	Sesame Jassid	*Orosius orientalis*	Cicadellidae	Homoptera	Moderate
4	Desert locust	*Schistocerca gregaria*	Acrididae	Orthoptera	High
5	Death's head hawkmoth	*Acherontia atropos* Linnaeus	Sphingidae	Lepidoptera	Low
6	Beet Webworm	*Loxostege sticticalis* Linnaeus	Crambidae	Lepidoptera	Moderate
7	Tiger moth	*Amsacta moorei* Butler	Arctiidae	Lepodoptera	Moderate
8	Cassava hornworm	*Erinnyis ello* (Linnaeus, 1758)	Sphingidae	Lepodoptera	Low
9	Pulse beetle	*Callosobruchus analis* Fabricius	Bruchidae	Coleoptera	Low

Sl. No.	Potential Hazard Organism	Common name	Family	Order	Pest Risk Potential
10	Simsim flea beetle	*Alocypha bimaculata* Jacoby	Chrysomelidae	Coleoptera	Low
Fungus					
11	Black root rot	*Chalara elegans*	Helotiaceae	Helotiales	High
Bacteria					
12	Yellow disease phytoplasmas	*Candidatus Phytoplasma asteris*	Acholeplasmataceae	Acholeplasmatales	High
Nematode					
13	Pigeon pea cyst nematode	*Heterodera cajani* Koshy	Heteroderidae	Tylenchida	High
Virus					
14	Peanut mottle	*Peanut mottle virus*	Potyviridae	Group: RNA viruses	High
Weed					
15	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	High

CHAPTER 8

RISKMANAGEMENT

8.1. Risk Management Optionsand 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 sesamefrom India, Vietnam, China, Taiwan, Japan, Korea, Malaysia, Thailand or any other countries of sesameexport (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.

8.1.1. 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 sesame 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 sesame plant debris, or in a living form in surviving fallen fruit. On occasion, diseased seedsare the sources of contamination for the current season crops. Therefore, acrop rotation to minimize soil disease problems is recommended.

iv. **Control of Insects**: Sucking and chewing insects may transmit many diseases. For example the virus diseases are transmitted by the aphids. 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 sesame 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 sesame production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of diseases detected.

8.1.2. Post-harvest Management Options

i. **Sanitization of equipment and material**: All machinery, transport and storage surfaces that the sesameseed will contact should be cleaned and disinfected prior to receiving new sesame 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. **Seed grading**: The class and variety of sesame seeds must be kept separate through harvesting, grading and storage. Grading must be done according to class, variety and disease tolerance. The class of sesame must clearly identifiable and labeled.

8.1.3. 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 sesame seeds**: 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 sesame that reflects the acceptable tolerance level of the country.

iii. **Accept only certified sesame 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 sesame fruit samples; and sealing and labeling of certified seed. Sesame 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 sesame seeds 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.

vi. **Requirement of phytosanitary certification from country of origin:** The phytopathological service of the country of origin should ensure the sesame seeds from which the consignment is derived was not grown in the vicinity of unhealthy sesame crops and was inspected by a duly authorized official/phytopathological service and the sesameseeds 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 sesame should be inspected to detect pests, with export phytosanitary certificate and seed certificate. Sampling of sesame 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.

8.2 Risk Management Conclusions

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

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