Government of the People's Republic of Bangladesh
Ministry of Agriculture
Department of Agricultural Extension (DAE)
Tuber Crops Development Project (TCDP)
Khamarbari, Farmgate, Dhaka-1215

Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh
Tuber Crops Development Project (TCDP) of DAE

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Bangladesh

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FORWARD

The Tuber Crops Development Project (TCDP) under Department of Agricultural Extension (DAE), Ministry of Agriculture, Peoples Republic of Bangladesh conducted the study for the **"Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh"** according to the provision of contract agreement signed between TCDP-DAE and Development Technical Consultants Pvt. Limited (DTCL) on 05 January 2022. The PRA study is a five-month assignment commencing from 05 January 2022 under the TCDP-DAE.

The overall objectives of this PRA study are to identify the pests and/or pathways of quarantine concern for a specified area of sweet potato 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 30 upazila under 30 major sweet potato growing districts of Bangladesh. The study covered the interview of 600 sweet potato growers; 30 FGDs of which each was conducted in each of 30 district; 45 KIIs and visits of sweet potato fields through physical inspection under sampled districts. The consultants also reviewed secondary sources of information related to PRA of sweet potato.

The study findings evidenced that the 21 insect pests, 19 disease causing pathogen, one rodent and 17 weeds likely to be associated with the sweet potato in Bangladesh. The study also revealed that a total number of 33 pest species of quarantine importance had been identified, of which 18 insect pests, 3 mite pests, 5 fungi, two bacteria, two nematode and one viral disease and two weed that could be introduced into Bangladesh through importation of commercially produced sweet potato. 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 33, 18 quarantine pests associated with the pathway risk were assessed. Out of 18 potential hazard organisms, 15 hazard organisms were identified with high-risk potential and 3 were moderate and 15 uncertain species was found which likely to be associated with host plants during importation from exporting countries. The findings also suggested the risk management options for the quarantine pests of sweet potato in line with the pre and post harvest management and phytosanitary measures.

The findings of the PRA study had been presented in the National Level Workshop organized by the TCDP 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 TCDP 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 sweet potato 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 sweet potato.

Mukhlasure Rahaman
Project Director
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PREFACE

This report intends to respond to the requirement of the client according to the provision of contract agreement signed between Project Director of Tuber Crops Development Project (TCDP) under the Department of Agricultural Extension (DAE) and the Development Technical Consultants Pvt. Limited (DTCL) for **"Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh"** under 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 05 January 2022 under the TCDP-DAE.

Consultancy services for "Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh" was provided by the Development Technical Consultants Pvt. Ltd. (DTCL), Bangladesh. The study team consists of five senior level experts including field and office level support staffs. The major objectives of the study are to listing of major and minor pests of sweet potato, 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 TCDP officials along with other experts and representatives through several discussion meetings. This report had been presented in the national level workshop for further comments and suggestions. The consultants finally revised and prepared this report of the PRA study based on comments and suggestions of the client and experts.

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ACKNOWLEDGEMENTS

It is indeed a great honor for us that Tuber Crops Development Project (TCDP) under Department of Agricultural Extension (DAE) has entrusted Development Technical Consultant Pvt. Ltd. (DTCL) to carry out the “**Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh”**. The Report has been prepared based on the past five-months**,** commencing from 05 January 2022, activities of the survey study in major 30 sweet potato 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 TCDP-DAE. The principal author is Prof. Dr. Md. Ahsan Ullah, Team Leader with inputs from Prof. Dr. Md. Razzab Ali, Prof. Dr. Md. Ismail Hossain Mian, Dr. B. A. A. Mustafi and Mr. Sumon Saha of the PRA study team.

The authors are grateful to all persons involved in the PRA study. Special thanks to Dr. Mukhlasure Rahaman, Project Director, Tuber Crops Development Project (TCDP); Dr. Md. Azhar Ali, Consultant (PRA); Ferdowsi Easmin, Deputy Project Director, TCDP for their valuable cooperation, guidance and suggestions to the study team in line with the activities performed during study and report preparation. The active support of Dr. M. M. Amir Hossain, Managing Director of DTCL and Kbd. Md. Habibur Rahman, Executive Director of DTCL as well as Mr. Md. Mahabub Alam during study period also acknowledged with thanks.

Dr. Md. Ahsan Ullah
Team Leader

ACRONYMS

AEZ	:	Agro-Ecological Zone
BADC	:	Bangladesh Agriculture Development Corporation
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BSMRAU	:	Bangabandhu Sheikh Mujibur Rahman Agricultural University
CABI	:	Center for Agriculture and Bioscience International
DAE	:	Department of Agricultural Extension
DG	:	Director General
Dr.	:	Doctor
DTCL	:	Development Technical Consultants Private Limited
e.g.	:	For example
EPPO	:	European and Mediterranean Plant Protection Organization
et al.	:	and associates
EU	:	European Union
FAO	:	Food and Agriculture Organization
FAOSTAT	:	Food and Agriculture Organization Statistics
FGD	:	Focus Group Discussion
GoB	:	Government of Bangladesh
IPPC	:	International Plant Protection Convention
IPM	:	Integrated Pest Management
ISPM	:	International Standard for Phytosanitary Measures
J.	:	Journal
KII	:	Key Informant Interview
MD	:	Managing Director
NGO	:	Non-Government Organization
No.	:	Number
NPPO	:	National Plant Protection Organization
^{o}C	:	Degree Celsius
PD	:	Project Director
PFA	:	Pest Free Area
PPW	:	Plant Protection Wing
PQW	:	Plant Quarantine Wing
PRA	:	Pest Risk Analysis
Prof.	:	Professor
Pvt.	:	Private
RH	:	Relative Humidity
SAU	:	Sher-e-Bangla Agricultural University
SCA	:	Seed Certification Agency
SID	:	Statistics and Informatics Division
USA	:	United States of America
USDA	:	United States Department of Agriculture
%	:	Percentage

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EXECUTIVE SUMMARY

The study "Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh" documents the pests of sweet potato available in Bangladesh and the risks associated with the import pathway of sweet potato from the exporting countries namely Japan, Thailand, India, China, Indonesia, Vietnam, and any other exporting countries of the world into Bangladesh.

The findings evidenced that the 58 pests of sweet potato were recorded in Bangladesh, of which 21 insect pests; 19 diseases causing pathogens that included 7 diseases caused by fungi, 2 caused by bacteria, 5 caused by nematode and 5 diseases caused by viruses, one rodent and the remaining 17 were weeds. The insect pests of sweet potato as reported in Bangladesh were tobacco whitefly (*Bemisia tabaci*), pineapple mealybug (*Dysmicoccus brevipes*), striped mealybug (*Ferrisia virgata*), potato aphid (*Macrosiphum euphorbiae*), green peach aphid (*Myzus persicae*), chilli thrips (*Scirtothrips dorsalis*), convolvulus hawk moth (*Agrius convolvuli*), black cutworm (*Agrotis ipsilon*), turnip moth (*Agrotis segetum*), tobacco budworm (*Heliothis virescens*), taro hawk moth (*Hippotion celerio*), green semi-looper (*Argyrogramma signata*), sweet potato stem/vine borer (*Omphisa anastomosalis*), fall armyworm (*Spodoptera frugiperda*), taro caterpillar (*Spodoptera litura*), black hairy caterpillar (*Estigmene chinensis*), sweet potato hairy caterpillar (*Pericallia recini (*Fabricius), jute hairy caterpillar (*Spilarctia obliqua* (Walker), sweet potato weevil (*Cylas formincarius*), tortoise beetle (*Aspidomorpha dorsata* Fabricius) and sweet potato beetle (*Carphurus* sp). Among these insect pests, sweet potato weevil was designated as major pests of sweet potato that was more damaging than other insect pests. In contrary, other 19 insect pests were designated as minor pests of sweet potato causing low level of infestation. Among sweet potato diseases, the incidences of fungal diseases as reported in Bangladesh were sclerotium rot (*Athelia rolfsii*), choanephora fruit rot (*Choanephora cucurbitarum*), diplodia tuber rot (*Lasiodiplodia theobromae*), charcoal rot of bean (*Marcophomina phaseolina*), cottony soft rot (*Sclerotinia sclerotiorum*), sweet potato leaf spot (*Phaeoisariopsis bataticola; Cercospora batatae*) and soft rot (*Rhizopus nigiricans*). Among these fungal diseases, the charcoal rot of bean was designated as major disease that caused medium level of damage on sweet potato vine, while remaining six (6) diseases were designated with minor significance and caused low level of damage. While the incidences of bacterial diseases of sweet potato as reported in Bangladesh were bacterial root rot of sweet potato (*Pectobacterium carotovorym* subsp. *carotovorum*) and sweet potato Witches' Broom (*Sweet potato little leaf phytoplasma*). Both of these were designated at minor diseases causing low level of damage. In contrary, the incidences of diseases of sweet potato caused by nematode as reported in Bangladesh were potato tuber nematode (*Ditylenchus destructor*), common spiral nematode (*Helicotylenchus dihystera*), peanut root-knot nematode (*Meloidogyne arenaria*), root lesion nematode (*Pratylenchus penetrans*) and reniform nematode (*Rotylenchulus reniformis*). All of these nematode diseases of sweet potato were designated as minor pests causing low level of damage. The incidences of viral diseases of sweet potato as reported in Bangladesh were sweet potato latent virus (*Sweet potato latent virus*), sweet potato leaf curl virus (*Sweet potato leaf curl virus*), mild mottle of sweet potato (*Sweet potato mild mottle virus*), sweet potato feathery mottle virus (*Sweet potato feathery mottle virus*) and chlorotic fleck virus (*Sweet potato chlorotic fleck virus* (SPCFV)). All of these viral diseases were designated with minor significance and causes low level of damage. While the incidences of weeds in sweet potato field as recorded in Bangladesh were bermuda grass (*Cynodon dactylon* (L.) Pers.), nut grass (*Cyperus rotundus*), red tassel flower (*Emilia sonchifolia*), bitter vine (*Mikania micrantha*), Alligator weed (*Alternanthera philoxeroides*), Celosia (*Celosia argentea*), wandering jew (*Commelina benghalensis*), Southern crabgrass (*Digitaria ciliaris*), barnyard grass (*Echinochloa crus-galli*), goose grass (*Eleusine indica*), chinese sprangle top (*Leptochloa chinensis*), green foxtail (*Setaria viridis*), dove weed (*Murdannia nudiflora*), prostrate knotweed (*Polygonum aviculare*), marsh pepper (*Polygonum hydropiper*), black nightshade (*Solanum nigrum*) and Parthenium weed (*Parthenium hysterophorus*). Among these weeds, Bermuda grass and nut grass were designated with major significance and cause medium to high level of damage in the sweet potato field.

Information on pests associated with sweet potato in the exporting countries-Japan, Thailand, India, China, Vietnam, Philippines, Indonesia, or any other countries-revealed that pests of quarantine importance exist. The study that included 18 insect pests, 3 mite pests, 10 disease causing pathogens including 5 fungi, 2 bacteria, 2 nematode, and 1 virus; and 2 weed. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced sweet potato. Pests of quarantine importance included insect pests namely the quarantine insect pests are Cirtus Locust (*Chondracris rosea),* Winter cherry bug (*Acanthocoris sordidus),* Tomato/Potato psyllid *(Bactericera cockerelli),* Barnacle Scale (*Ceroplastes cirripediformis),* Spiked Mealybug (*Nipaecoccus nipae*), Sweet potato butterfly (*Acraea acerate),* Pink-spotted Hawk moth (*Agrius Cingulatus).* Sweet Potato Leaf miner *(Bedellia somnulentella),* Southern Armyworm (*Spodoptera eridania),* Cotton Leaf worm (*Spodoptera littoralis*), Impatiens hawkmoth (*Theretra oldenlandiae),* Spotted Tortoise Beetle (*Asidimorpha miliaris),* Chafer Beetle (*Apogonia cribricollis),* Cocoa Weevil (*Araecerus fasciculatus),* Sweet Potato Leaf weevil (*Blosyrus impomoeae),* Flea Beetle (*Chaetocnema confinis),* West Indian Sweet Potato Weevil (*Euscepes postfasciatus)* and Green Weevil (*Hypomeces squamosus).*The quarantine mite pests of sweet potato for Bangladesh are Tomato Russet Mite (*Aculops lycopersici*), Carmine Spider Mite (*Tetranychus cinnabarinus*) and Red spider mite (*Tetranychus evansi*).

Ten (10) disease causing pathogens have been identified as quarantine pests of sweet potato for Bangladesh. Among these, 5 quarantine fungi named hite Rust of Sweet Potato (*Albugo ipomoeae-panduratae),* Ceratocystis Blight *(Ceratocystis fimbriata),* Leaf & Stem Scab *(Elsinoe batatas),* Fusarium Wilt of Sweet Potato (*Fusarium oxysporum f.sp. batatas*) and Scurf of Sweet Potato (*Monilochaetes infuscans*); 2 quarantine bacteria namely Crown Gall (*Rhizobium radiobacter*) and Gall *(Rhizobium rhizogenes); 2* species of nematode namely Sting nematode (*Belonolaimus longicaudatus*) and Pacara Earpod tree root-knot nematode *(Meloidogyne enterolobii);* 1 virus namely *Sweet Potato Chlorotic Stunt Virus*. 2 species of quarantine weed have been identified Bangladesh named *Parthenium weed (Parthenium hysterophorus)* and Scarlet Pimpernel (*Angallis arvensis*)

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 33, 18 quarantine pests associated with the pathway risk were assessed. Out of 18 potential hazard organisms, 15 hazard organisms were identified with high risk potential and 3 were moderate and 15 uncertain species was found which likely to be associated with host plants during importation from exporting countries, but *Pyrenochaeta terrestris* (pink root rot Cirtus Locust (*Chondracris rosea),* Winter cherry bug (*Acanthocoris sordidus),* Barnacle

Scale (*Ceroplastes cirripediformis),* Sweet potato butterfly (*Acraea acerate),* Pink-spotted Hawk moth (*Agrius Cingulatus).* Southern Armyworm (*Spodoptera eridania),* Impatiens hawkmoth (*Theretra oldenlandiae),* Spotted Tortoise Beetle (*Asidimorpha miliaris),* Chafer Beetle (*Apogonia cribricollis),* Cocoa Weevil (*Araecerus fasciculatus),* Sweet Potato Leaf weevil (*Blosyrus impomoeae),* Flea Beetle (*Chaetocnema confinis),* West Indian Sweet Potato Weevil (*Euscepes postfasciatus),* Green Weevil (*Hypomeces squamosus)* and Carmine Spider Mite (*Tetranychus cinnabarinus*), remained as uncertain hazards due to lack of its detail information. 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 spices 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 I

BACKGROUND OF PEST RISK ANALYSIS

1.1. Introduction

According to the agreement signed between the Project Director (PD) of **"Tuber Crops Development Project"** under Department of Agricultural Extension (DAE) and the Development Technical Consultants Pvt. Ltd. (DTCL) for "Pest Risk Analysis (PRA) of Sweet Potato (*Ipomoea batatas*) in Bangladesh", this report intends to fulfill the requirement of the contract obligation to identify the pests of sweet potato and pathways of quarantine concern and identify their risk, endangered areas and risk assessment with management options. The project is implementing by the DAE under the Ministry of Agriculture (MOA) with the financial support of the Government of Bangladesh.

1.2 Background of the study

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

Now more than 300 Destructive Insects and Pests are prevailing in the world where Bangladesh is exclusively free from most of these pests. But we are afraid of maintaining such situations because Bangladesh has to import a huge quantity (about 1 crore MT.) of plants and plant products every year. So, we are at the highest risk of entering those destructive pests because these pests are usually brought in along with imported Agricultural commodities. On the contrary Bangladesh has successfully entered into the highly competitive international export market. We are earning a good amount of valuable foreign currency through exporting 10-12 lakhs metric tons of agricultural products. So, to safeguard our agriculture from entering IAS by imported commodities and maintain and develop our market access by fulfilling the importing countries requirement conducting PRA is most essential. Considering this situation, the project will conduct PRA on Sweet Potato (*Ipomea batatas*). The background review and analysis of the Aroid has been furnished below:

1.2.1 Sweet Potato in Bangladesh

Sweet potato (*Ipomea batatas*. (L.) Lam.) is very important crop in tropical and sub-tropical countries of the world including Africa, India, Bangladesh, China, Japan, the Pacific Island, Tropical America and the Southern part of the United States of America. Approximately 92% of the worlds sweet potato produced in Asia and the Pacific Island and 89% of this grown in China (Horton 1988b). Sweet potato is an introduced crop in Bangladesh during the second half of the 19th century (Rashid *et al.,* 1982). The crop belonging to the family Convolvulaceae in an important root crop in Bangladesh and commonly known as "Misti Alu" (Rabbi, 1995). Sweet potato is a major root crop which is grown for both export and local consumption. It is also the third most important root crop grown in eastern Africa after cassava and potato (FAO 2011).

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Solanales
Family: Convolvulaceae
Genus: Ipomoea
Species: *Ipomoea batatas*

EPPO Code: IPOBA

1.2.2. Area and Production of Sweet Potato in Bangladesh

Reported by Dhaka Tribune (2021), around 43,779 tons of sweet potatoes were produced from 2,954 hectares of land from all eight districts under the Rajshahi division from the recent harvesting season. These newly harvested potatoes are playing as a supplementary role to meet up the food production gap and demand amidst Covid-19 pandemic.

The official data published by Department of Agricultural Extension (DAE) had taken a new target to bring around 2,372 hectares of land under the cash crop farming in the district. In the recent Rabi season, the massive production of sweet crop leads to an increase in demand for the crop in the food market. Currently at the market, this crop is being sold at Tk. 800-900 per mound in the local wholesale market and Tk. 25 to 30 per kilogram in the railing market. Since the crop can be abundantly cultivated at a minimum cost and labor, it is becoming quite known among the farmers. In particular, the char regions as there are sandy lands and riverbeds making it appropriate for its cultivation. Thereby, sweet potato is becoming a substitute for rice and can help reduce dependence on rice as people become habituated with the consumption this crop.

Prior to the Covid-19 pandemic, Bangladesh has been cultivating sweet potato over 8 primary districts and 64 upozila around the country in over various acres of land and metric tons. The table below shows the data of the amount produced in all over Bangladesh:

Table-1.1: Area and Production of Sweet Potato by Region from 2006 to 2011

Area in acres and production in metric ton								
Division	**2016-17**		**2017-18**		**2018-19**		**2019-20**	
	Area	**Prod**	**Area**	**Prod**	**Area**	**Prod**	**Area**	**Prod**
Barishal	10693	35100	10414	36508	10814	34065	14150	45262
Chattogram	23574	81823	20938	72236	17043	59643	18149.88	65096.50
Dhaka	10565	55795	10058	53923	9871	52097	9365	49031
Khulna	1859	7987	1825	7822	2302	10295	1738	7460
Mymensingh	5729	32196	5528	31423	6221	34268	6194	32714
Rajshahi	4950	22823	4580	20012	4652	20594	5084	20825
Rangpur	4721	20021	4325	17756	4267	17770	4261	18204
Sylhet	1513	6957	1576	7136	1699	7149	1706.5	7126.7
Total	**63604**	**262702**	**59244**	**24816**	**56869**	**235881**	**60647.38**	**245719.20**

Source: *BBS (2021)*

On an average the yield rate of sweet potato in the fiscal year of 2018-2019 had been estimated to around 223.48 mounds per acre (20.614 metric tons per hectare in comparison to 221.29 mounds (20.411 metric tons per hectare) of 2017-2018. Whereas the total production of sweet potato in the fiscal year of 2018-2019 had been estimated to 96, 55,082 metric tons in comparison to 97,44,412 metric tons of the year 2017-2018.

1.3. Rationale for the Study

Pest Risk Analysis provides the rationale for phytosanitary measures for a specified PRA area. It evaluates scientific evidence to determine whether an organism is 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 suggestion 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 harbor organisms that are pests. Lists of such organisms are compiled during the initiation stage. Specific organisms will 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 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.

1.4. The Impact of PRA

The US Department of Agriculture (USDA) Animal and Plant Health Inspection Service first introduced the plant pest risk analysis to ascertain the potential risks associated with causal agent of flag smut diseases. On the contrary the quarantine was established in 1919 to prohibit the introduction of the fungus *Urocystis agropyri* (*Urocystis tritici* Koemickle) contained in seeds and or other plant parts originating from other countries that have reported flag smut diseases of wheat. At that time no other options for wheat growers to control mechanisms such as resistant variety, use of HYV seeds, effective control of seeds treatment, advanced techniques of control flag smut. But due to continuous effort of the scientist, researchers and growers all together have achieved a greater understanding of effective and practical measures to mitigate flag smut diseases. In 1932 flag smut diseases had essentially been eradicated from USA through use of resistance variety, seed treatment and strictly implementation of quarantine measures. They considered three components of disease triangle- Host, Pathogen and Environment. Now-a- days the researchers and scientists believed on four principles for the prevention of diseases and these are (a) exclusion, (b) eradication, (c) protection, (d) development of resistance/defense mechanisms.

Each and every year Bangladesh import the major flowers, fruits, vegetables, spices and ornamental plants from China, Thailand, Japan, Malaysia, Pakistan, Indonesia and India. Therefore, there is every possibility to come foreign pest (Quarantine pests) associated with this imported sweet potato and their seeds.

1.5. Scope of the Risk Analysis

The scope of pest risk analysis is to find out the potential hazard organisms like insect and mite pests, diseases and other pests associated with sweet potato imported from different exporting countries such as Japan, Thailand, India, China, the Philippines, Malaysia, Vietnam, etc. (Tuber Crops Development Project, DAE, 2022). Risk in this context is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.

1.6. Objectives of the PRA study

The overall objective of PRA by the Tuber Crops Development Project (TCDP) is to conduct Pest Risk Analysis on sweet potato and categorize the risk as high, medium, low and minimum as well as to determine of an organism as a pest; to create list of regulated pests of sweet potato for the purpose of import regulation and to recommend appropriate pest risk management and assessment options.

The **Specific Objectives** of the Pest Risk Analysis of Sweet Potato in Bangladesh are:

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

CHAPTER II

PROCESS AND METHODOLOGY OF PEST RISK ANALYSIS

2.1. Undertaking of Pest Risk Analysis (PRA)

The PRA team 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 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. A PRA process may be triggered in the following situations:

- a request is made to consider a pathway that may require phytosanitary measures;
- a pest is identified that may justify phytosanitary measures;
- a decision is made to review or revise phytosanitary measures or policies; and
- a request is made to determine whether an organism is a pest.

The initiation stage involves four steps:

- determination whether an organism is a pest;
- defining the PRA area;
- evaluating any previous PRA; and
- conclusion.

When the PRA process has been triggered by a request to consider a pathway, the above steps are preceded by assembling a list of organisms of possible regulatory concern because they are likely to be associated with a pathway. At this stage, information is necessary to identify the organism and its potential economic impact, which includes environmental impact. Other useful information on the organism may include its geographical distribution, host plants, habitats and association with commodities. For pathways, information about the commodity, including modes of transport, and its intended end use, is essential.

PRA STAGE 2: PEST RISK ASSESSMENT

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

- pest categorization
- assessment of the probability of introduction and spread
- assessment of potential economic consequences (including environmental impacts).

In most cases, these steps will be 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 stages of Pest Risk Analysis Framework have been presented in Figure-2.1 through the flow chart at a glance:

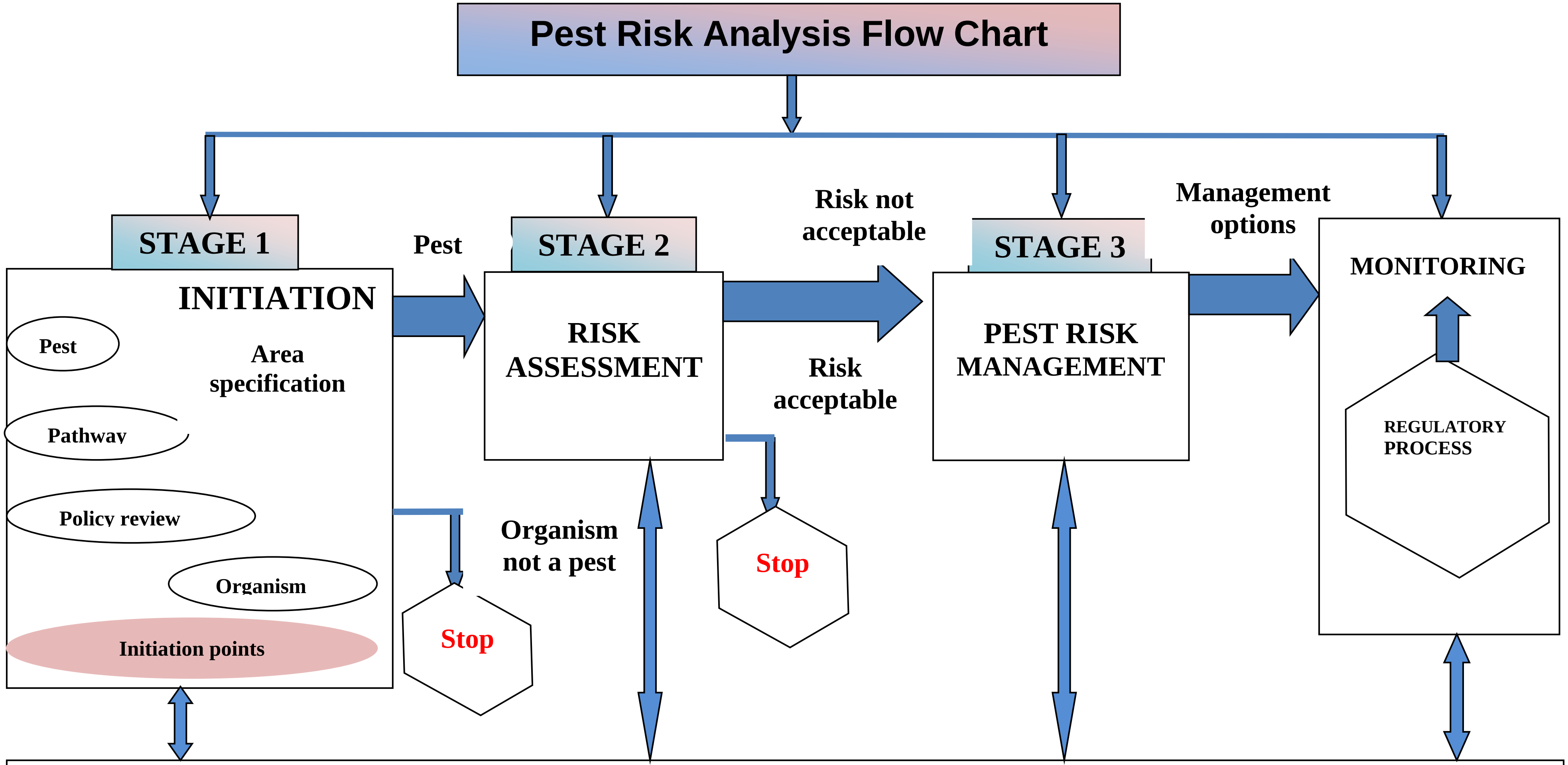
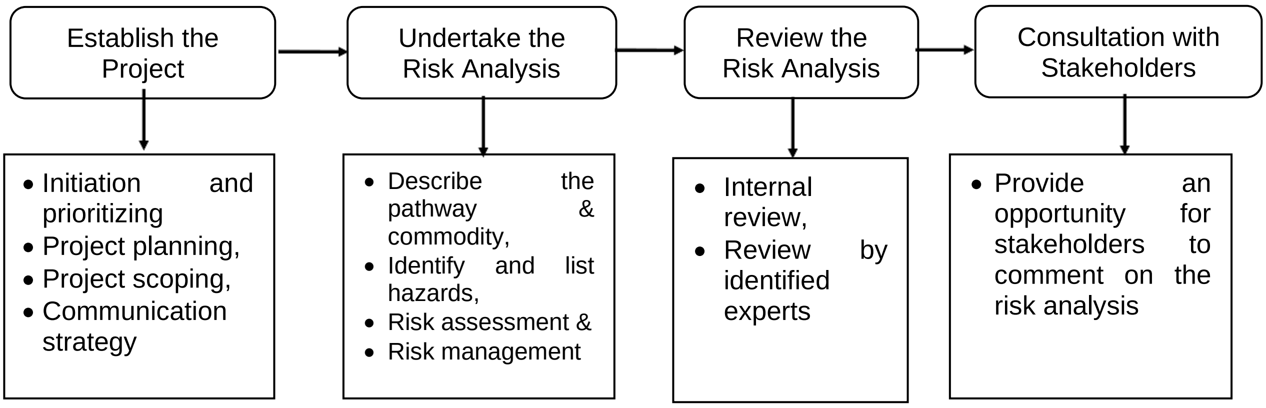


Figure-1: INFORMATION GATHERING, DOCUMENTATION AND RISK COMMUNICATION

2.2. Risk Analysis Process and Methodology

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

Figure-2.2: A summary of the risk analysis development process



2.2.1. Commodity and Pathway Description

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

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

2.2.2 Hazard Identification

Hazard identification is the essential step conducted prior to a risk assessment. Unwanted organisms or diseases which could be introduced by risk goods into Bangladesh and potentially capable of causing unwanted harm, must be identified. This process begins with the collation of a list of organisms that might be associated with the commodity in the country of origin. This list is further refined and species removed or added to the list depending on the strength of the association and the information available about its biology and life cycle. Each pest or pathogen is assessed mainly on its biological characteristics and its likely interaction with the Bangladesh environment and climate.

2.2.3. 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.

<u>A risk assessment consists of four inter-related steps</u>:

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

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

2.2.4. Assessment of Uncertainties

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

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

2.2.5. Analysis of Measures to Mitigate Biosecurity Risks

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

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

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

2.2.6. Risk Evaluation

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

2.2.7. Option Evaluation

a) Identify possible options, including measures identified by international standard setting bodies, where they are available.
b) Evaluate the likelihood of the entry, exposure, establishment or spread of the hazard according to the option(s) that might be applied.

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

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

2.2.8. Review and Consultation

The critique provided by the reviewers where appropriate, is incorporated into the risk analysis to ensure it is based on the most up-to-date and credible information available. If suggestions arising from the critique are not adopted the rationale must be fully explained and documented. Once a risk analysis has been peer reviewed and the critiques addressed, the risk analysis is then published and released for public consultation.

2.3. Import Risk Analysis

The section provides information on the commodity and pathway that is relevant to the analysis of biosecurity risks and common to all organisms or diseases potentially associated with the pathway and commodity. Organism or disease-specific information is provided in subsequent chapters.

2.3.1. Commodity Description

Sweet potatoes, sometimes spelled as one word, sweet potatoes, (*Ipomoea batatas*), are a herbaceous vine and part of the morning glory family. A long season root vegetable, they are native to warm, tropical regions and originated in Central and South America, where they have been cultivated for thousands of years.

Sweet potatoes, however, are not yams as botanically they are quite different. Yams, which originated in Africa and Asia, belong to another cultivar group (Dioscorea). Yams have dry, rough, scaly skin and are starchy tubers few would ever describe as having a “sweet” taste. In contrast, sweet potatoes have smooth skin of varying colors, moist flesh, and a sweet flavor due to postharvest curing (which turns starch to sugar). They are also very rich in fiber, beta carotene, and chockful of vitamins A, C, and other antioxidants and nutrients.

Size is a differentiator as well: yams can grow to enormous dimensions, weighing more than 90 pounds and measuring several feet in length; sweet potatoes tend to be slender, tapered, and petite in comparison.

Sweet potato is a perennial plant mainly grown as an annual. The roots are adventitious, mostly located within the top 25 cm of the soil. Some of the roots produce elongated starchy tubers that vary largely in shape, colour and texture depending on the variety. The flesh of the tubers can be white, yellow, orange and purple whereas their skin can be red, purple, brown or white. The stems are creeping slender vines, up to 4 m long. The leaves are green or purplish, cordate, palmately veined, borne on long petioles. Sweet potato flowers are white or pale violet, axillary, sympetalous, solitary or in cymes. The fruits are round, 1-4 seeded pods containing flattened seeds (Ecocrop, 2010; Duke, 1983).

(a) Cultivation and Climatic requirements of sweet potato: The climate of Bangladesh is favorable for growing most of the horticulture crops especially sweet potato. It is a tropical and subtropical plant which can adapt to more temperate climates providing the average temperature does not drop below 20°C and minimum temperatures stay above 15°C. In other words, it can be cultivated between the 30 and 40° latitudes in both hemispheres.

(b) Temperature: For the cultivation of sweet potatoes, a range of temperature between 15 to 33°C is required during the vegetative cycle, with the optimum temperature being between 20 to 25°C. The highest yields are obtained when temperatures are high during the day (25 to 30°C) and low by night (15 to 20°C); low temperatures during the night favour the formation of tubers, and high temperatures by day favour vegetative development. (Note: tubers development only occurs within a temperature range of 20 to 30°C, optimum 25°C and generally stops below 10°C).

(c) Light: Sweet potato is a short-day plant, that needs light for maximum development. However, the growth of the tubers appears not to be influenced by photoperiod alone. It is probable that temperature and fluctuations in temperature, together with short days favour the growth of tubers and limit the growth of foliage (Youg, 1962).

(d) Altitude: In tropical regions it is possible to cultivate sweet potato from sea level to 2500 m; for example, in Bolivia, Peru and Colombia it is cultivated from sea level to 2300 m. (Del Carpio, 1969).

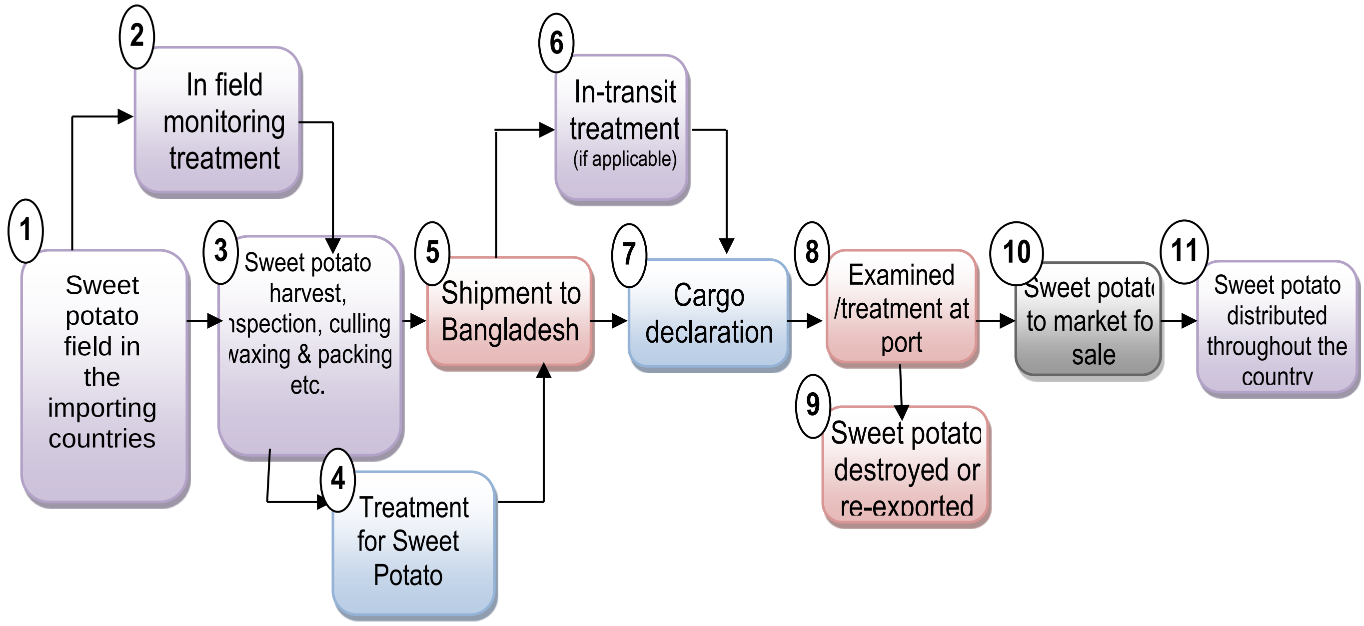
(e) Moisture: Moisture has a decisive influence on sweet potato growth and production. In this context it is relevant to note the water content of the leaf is (86%), stem (88.4%) and tuber (70.6%). At planting it is important to have moist soils in order to achieve good germination. The soil must also be kept moist during the growth period (60-120 days), though at harvesting the humidity must be low in order to prevent the tubers rotting (Carballo, 1979). Conditions that favour the development of the vegetative part of the plant include an 80% relative humidity and moist soils.

(f) Soils: Sweet potato can be cultivated in a wide range of soils, with the best results obtained in ferralitic, brown humic and calcimorphologic soils. Ideally the soil should be friable, have a depth of more than 25 cm. and have good superficial and internal drainage. The chemical properties of the soil are less limiting than structural properties in obtaining good yields. For example, in sandy soils poor in nutrients good yields can be obtained whereas in rich soils the vegetation often becomes luxuriant and the roots large and irregular. The sweet potato also prefers lightly acid or neutral soils, with the optimum pH being between 5.5 and 6.5. Soils which are excessively acid or alkaline often encourage bacterial infections and negatively influence yields (Cairo, 1980).

2.3.2. Description of the Import Pathway

For the purpose of this risk analysis, sweet potato is presumed to be from anywhere in importing/exporting counties particularly Saudi Arabia, Malaysia, China, India, Pakistan etc. To comply with existing Bangladesh's import requirements for sweet potato, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests (insect pests, diseases and weeds) are not associated with the product. Commodity would then be sea or land or air freighted to Bangladesh where it will go to a holding facility before being distributed to dealers, distributors, markets, sellers and farmers for cultivation of the imported/exported sweet potato.

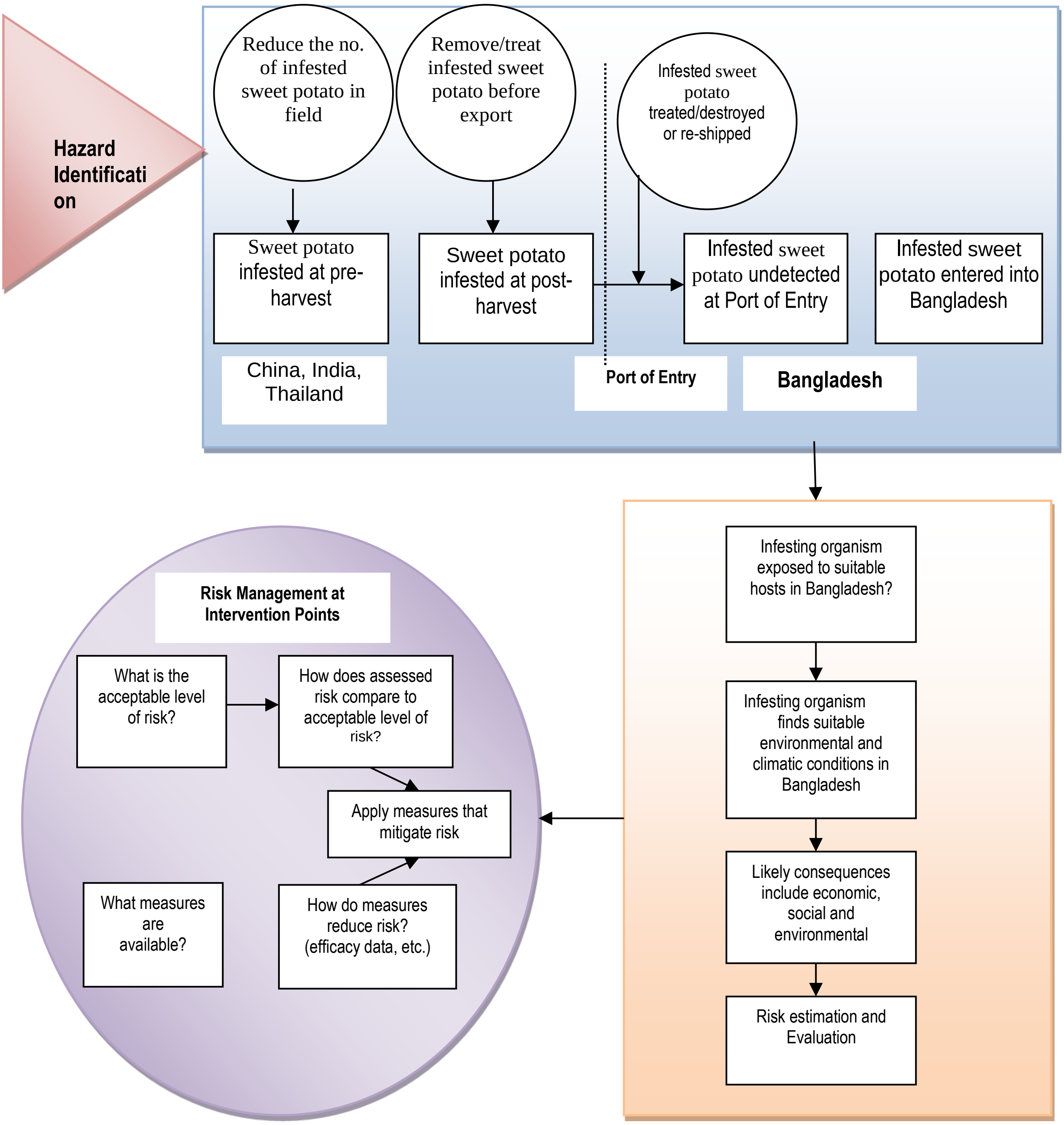
Figure-2.3: Linear Pathway Diagram



- Sweet potatoes in Japan, Thailand, China, India, Pakistan, etc., are grown in the field;
- Monitoring of insect pests, diseases and other exotic pests is undertaken, with appropriate controls applied;
- Sweet potato is harvested, inspected and the best quality sweet potato washed, pre-treated and packed in boxes;
- Post-harvest disinfestations including are undertaken either before or during transport of the sweet potato to Bangladesh;
- Transport to Bangladesh is by land, air or sea freighted;
- Each shipment must be accompanied by the appropriate certification, e.g., a phytosanitary certificate attesting to identity the tubers, any treatments completed, or other information required to help mitigate risks;
- Sweet potatoes are examined at the border and or port of entry to ensure compliance;
- Any sweet potato not complying with Bangladesh biosecurity requirements (e.g. found harboring pest organisms) are either treated re-shipped or destroyed;
- Sweet potatoes are stored before being distributed to market for sale; and
- Dealers and sellers of sweet potato stock and they are bought by consumers within the local area they are sold in.

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

Figure-2.4: Pathway and likelihood of Entry Assessment



2.4. Approach and Methodology

2.4.1. Approaches

A wide range of efforts such as inception of assignment with PD-TCDP and DAE/BARI/BADC/ SCA personnel at local and national level, and others, numerous field visits, interview with DAE/BARI/BADC/SCA officials, farmers at their areas, discussion with the officials of TCDP, relevant officials from government and private sector were made to understand the key methodological and contextual issues regarding the study.

To ease the whole study process constant and continuous communication with PD and DAE officials and with knowledgeable and influential leaders were maintained by the consulting firm throughout the study. This section describes the technical aspect of the methodology and sampling strategies of the study in detail as well as collection of primary data from sweet potato farmers and other relevant stakeholders. In line with this, the section also provides a comprehensive description of the methodology for ensuring Quality Assurance and Quality Control (QAQC) measures for conducting data collection, data management and analysis.

The methodology for the present PRA study used system-wide approach, which is both detailed and participatory. This approach involves wide-ranging and sequenced discussion with TCDP-DAE and BARI/BADC professionals and officials related to identification of insect pests, diseases and other associated problems such as weeds, rodent pests etc. of sweet potato, quarantine concern of these pests, their risk and management options. The study will involve the use of:

(i) Collection and review of literatures, secondary documents, reports, etc.;
(ii) Face-to-face interview of sweet potato farmers using questionnaire;
(iii) Focus group discussions (FGD) with sweet potato farmers and other stakeholders;
(iv) Key Informant Interviews (KII) with officials of DAE/BARI/BADC, etc.; and
(v) Field visits and physical observation of sweet potato fields, etc.

2.4.2 Review of literature and Secondary Data

Detailed review of existing documents on concept, and methodology for the identification of pests likely to be associated with a pathway, identification of potential entry and its potential loss, economic and environmental impacts from the findings in designing the present study, implementing risk analysis, analyzing the data, and preparing the report.

- The PRA team collected relevant literatures from the Tuber Crops Development Project (TCDP) as well as Plant Quarantine Wing (PQW) under the Department of Agricultural Extension (DAE) and Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural Development Corporation (BADC), Bangladesh Bureau Statistics (BBS), etc. offices as well as through internet browsing;
- The review of all relevant documents, journals and information from secondary sources was done by the study team as well as developed and finalized the methodology study instruments;
- The study team made a list the main factors such as identification of pests and/or pathway of quarantine concerns for a specified area of sweet potato and evaluate their risk, endangered areas and management, etc.; and
- The PRA team also analyzed the impact and implications of control measures for different pests of sweet potato emphasized on quarantine aspects.

2.4.3 Sources of data

- The study was conducted to collect the stipulated primary data. Prior to collect the primary data, the relevant secondary information on the study including documents/reports were obtained from the DAE and BARI/BBS/BADC, etc. offices and subsequently reviewed;

- To develop the study instruments accurately and to reveal the inherent characteristics of various dimensions of the study and its contribution to the economy, the secondary data were carefully scanned, reviewed and collated with the study; and
- For generating the desired primary data, the sample study was conducted through a face-to-face interview of sweet potato farmers at field level using an appropriate sampling design and study instrument/questionnaire.

2.4.4. Methodology

2.4.4.1. Meetings with client

The PRA study team undertook the field visit of sweet potato and initiated several meetings with the client (PD-TCDP) and reached a consensus of the approach and methodology, tools, outputs and timeline of the study. Through these meeting indicators for the present PRA study, tools/questionnaires, monitoring and supervision plan, plans for data triangulation and validation, data analysis, report outlines, etc. were finalized.

2.4.4.2. Stakeholders involved with the study

The farmers involved with sweet potato cultivation in the sampled areas were the prime participants under this study. In addition to them, key officials of TCDP-DAE, PQW & PPW-DAE from head office and field level; scientists and relevant officials from BARI/BADC at field level were also participated at different stages of PRA activities.

2.4.4.3. Major activities of PRA Process

(a) Listing of pests of sweet potato: The study identified the insect pests, diseases, weeds and other associated pests of sweet potato through the field survey, focus group discussion, Key Informant Interview and direct field visit aiming to make a list following the framework for pest risk analysis adopted by the IPPC in International Standard for Phytosanitary Measures (ISPMs) and other related ISPMs. In addition, the study team also made a list of pests of sweet potato known as quarantine pests those were not seen earlier in Bangladesh.

(b) Comparison of PRA related secondary information

- The study team collected and gathered the PRA related secondary documents and information regarding sweet potato available in the TCDP, PQW & PPW of DAE, and other sources like CD-ROM search, internet browsing using the websites of CAB International, EPPO bulletin, etc.;
- The subject specialists of PRA team reviewed and minutely synthesized the collected documents and information aiming to compare the present tasks of PRA in relevant with the identification, risk assessment and management options of sweet potato pests; and
- The formulated information regarding PRA of sweet potato were compared with the findings of the current PRA study.

(c) Comparison of PRA related information with sweet potato exporting/importing countries

- The PRA team also collected PRA related documents and information for sweet potato available in the sweet potato exporting/importing countries aiming to authenticate and validate the findings of the quarantine pests and any new but destructive alien species or any other PRA related activities. Through these activities, study team made the list of insect pests, diseases, weeds with other associated pests of sweet potato including their quarantine aspects.

2.4.4.4. PRA areas

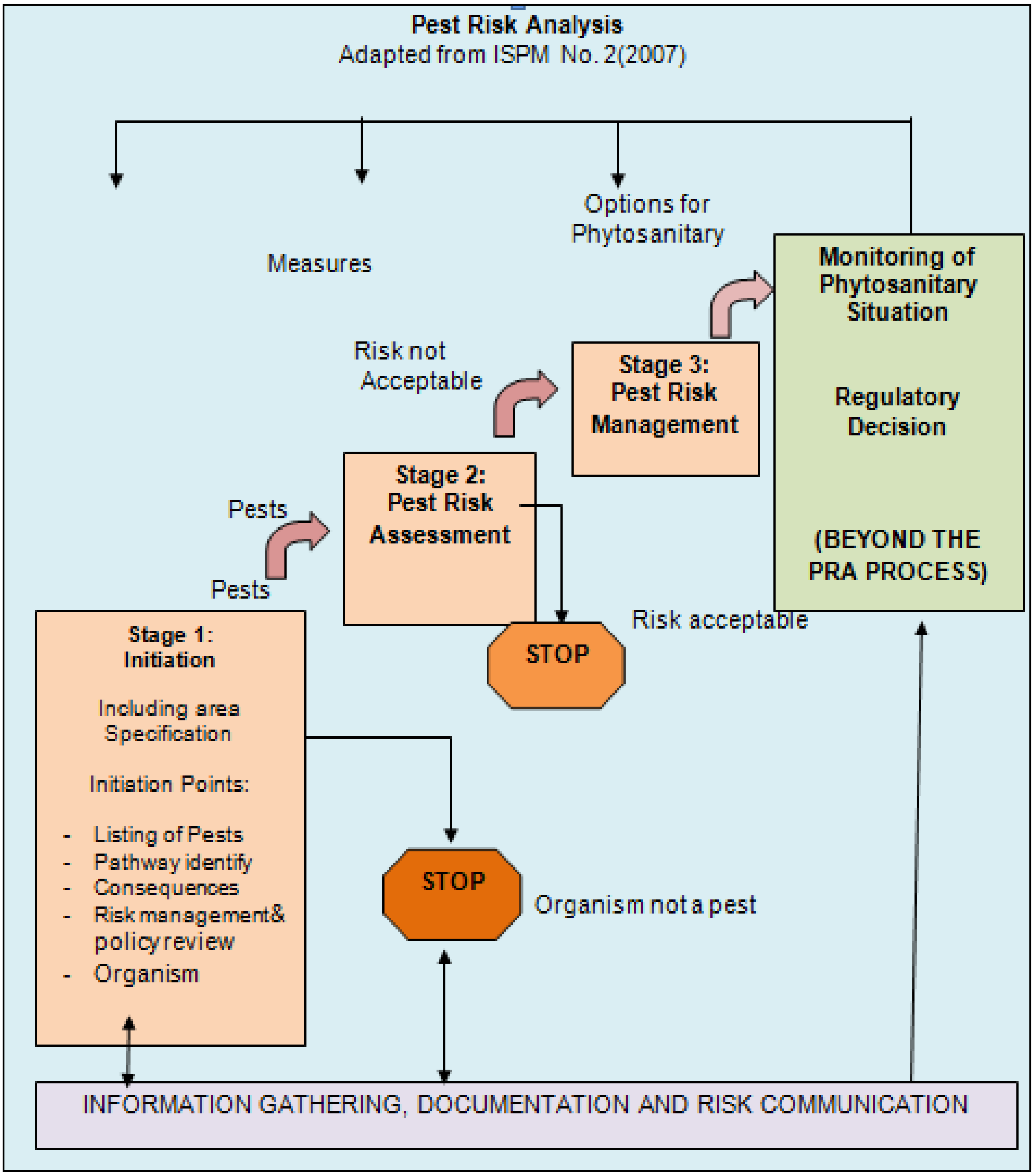
According to the ToR, thirty (30) administrative districts of Bangladesh were considered as the sample districts for PRA areas of sweet potato in Bangladesh. The PRA districts and upazilla are given below:

Table-2.1: Sample districts of major sweet potato growing areas in Bangladesh

Sl. No.	District	Upazila	Remarks
1	Manikgonj	Singair	• Selected 2 agriculture blocks per upazilla in consultation with respective Upazila Agriculture Officer (UAO) based on the sweet potato cultivation under Tuber Crops Development Project (TCDP); • Selected at least 10 sweet potato farmers per agriculture block and conducted face-to-face interview administering through a pre-designed questionnaire; • A total of 20 sweet potato farmers per upazilla were interviewed for collecting primary information; • Thus, a total of 600 sweet potato farmers were interviewed under 60 agriculture blocks from 30 upazila under 30 administrative districts of Bangladesh.
2	Tangail	Bhuapur	
3	Barishal	Ujirpur	
4	Bhola	Sadar	
5	Patuakhali	Mirjagonj	
6	Faridpur	Char Bhadrashon	
7	Jhenaidah	Kaligonj	
8	Kushtia	Bheramara	
9	Gaibandha	Gobindagonj	
10	Kurigram	Phulbar	
11	Nilphamari	Dimla	
12	Panchagarh	Debigonj	
13	Jamalpur	Madargonj	
14	Rajshahi	Bagha	
15	Nogaon	Badalgachi	
16	Pabna	Ishwardi	
17	Bogra	Saria kandi	
18	B.Baria	Bancharampur	
19	Mowlovibazar	Kulaura	
20	Sunamgonj	Jamalgonj	
21	Noakhali	Subornochar	
22	Laxmipur	Ramgoti U	
23	Rajbari	Goalondo	
24	Sariyatpur	Jagira	
25	Madaripur	Sadar	
26	Dhaka	Dhamrai	
27	Norail	Sadar	
28	Satkhira	Kolaroa	
29	Munshigonj	Tungibari	
30	Keshoregonj	Hossainpur	

2.4.5. 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 coconut. The process and methodology for undertaking import risk analyses are shown in Figure-2.5.



2.4.6. Methodology of Primary Data Collection

2.4.6.1. Study Design

The study design included development of methodology emphasized on sampling framework, development of data collection tools, deployment of manpower, systematic monitoring and supervision of data collection activities. The PRA team started fieldwork only after approval of the study design and tools by the client.

2.4.6.1.1. Sample Design

Two types of analysis were made to gather information about the study and these are quantitative and qualitative.

(i) Quantitative Analysis

The quantitative survey was conducted administering a structured questionnaire in the sampled areas and the primary data were collected from sweet potato farmers aiming to get quantitative information in order to identify the insect pests, diseases, weeds and other associated pest problems, and quarantine aspects of sweet potato pests; their risk regarding entry, establishment, spread etc.; economic impact on the production and trades of sweet potato as well as potential management options, etc.

Thus, it is appropriate to determine a representative sample size. For such purpose we adopt a sound statistical formula with Finite Population Correction (FPC) recommended by Daniel (1999) as given below;

$$n = \frac{Z^2 \times P \times Q}{e^2}$$

Where,

n′ = Sample size with finite population correction,
P = Probability of a dichotomous event (If the prevalence is 20%, P=0.2)
Q = 1-P,
Z = Z statistic for a level of confidence,
N = Population size,
e = Precision or allowable margin of error (If the precision is 2%, then e=0.02)

According to ToR, 30 districts for sweet potato were the sample districts. For sweet potato, a total of 30 upazilas were the study area. Thereafter, 2 agricultural blocks were covered under each upazilla and 10 sweet potato farmers were interviewed under each block. Thus, 600 sweet potato farmers were interviewed from a total of 30 selected sample districts of Bangladesh.

Sample size at field level

The ToR provided the information about the area coverage for the study and recommended the major 30 sweet potato growing districts considering one upazila from each district. Thus, 30 upazila were considered under 30 administrative districts. The ToR also recommended that 2 agricultural blocks were considered for each upazilla and 10 sweet potato farmers need to be interviewed from each block. Thus, 20 farmers were considered for each upazilla. It indicates that 600 sweet potato farmers in 30 upazilas were considered as respondent for study. The study team considered the respondent as sample unit. Since the team had no information on necessary parameters viz. population size and standard deviation. Thus, using 95% confidence level with 4% margin of error to obtain a representative sample size by calculating using the statistical formula without Finite Population Correction (FPC) recommended by Daniel (1999). Therefore, the ‘Study Team’ preferred the appropriate formula fit for without Finite Population Correction (FPC) recommended by Daniel (1999) for calculating sample size at the field level as given below:

$$n = \frac{Z^2 \times P \times Q}{e^2}$$

Assumptions:

Z=1.96 (The value of the standard variation at 95% confidence level)
P=0.5
Q= (1-P) =0.5
e= 0.04 (Allowable margin of error at 4%)

Therefore, using this formula the sample size (n) for respondents has been calculated as follows:

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.04^2}$$

n = 600.25 ~ 600

Therefore, the sample size was 600 sweet potato farmers. The participants were selected by using stratified sampling technique for selected blocks under sampled upazilla of 30 selected districts and simple random sampling technique within each block of sampled upazila.

However, in order to reach such respondents, study team adopted multistage sampling procedure. At the first stage, study team selected districts under the study areas. Accordingly, 30 major sweet potato growing districts of Bangladesh were considered as area coverage. At the second stage, study team selected upazila under the study districts. Finally, at the third stage, the respondents were selected from each agriculture block under each sampled upazilla through simple random sampling technique. In order to reach stipulated respondents at sampled block, upazila and districts, a list of sweet potato growers were collected from the respective Upazila Agriculture Office under DAE before the interview. Such initiative was aimed at identifying targeted sweet potato farmers in the agriculture blocks.

(ii) Qualitative Analysis

Qualitative techniques were used primarily to collect in depth/perceptual information on selected indicators related to the study. Thus, the study team adopted "**Stakeholders Analysis**" for this study and these are as follows:

a) Focus Group Discussion (FGD);
b) Key Informant Interviews (KII);
c) Review of secondary documents; and
d) Physical Observation of Sweet Potato Field.

The methods of qualitative analysis used in this study are discussed below:

(a) Focus Group Discussion (FGD): A total of 30 FGD sessions were conducted considering one FGD for each of 30 sampled upazla under 30 sample districts. About 8 to 10 sweet potato farmers, traders, SAAO-DAE, etc. were participated in each FGD session. Thus, at least a total of 300 respondents were participated in 30 FGDs. Each FGD session was arranged by the field staff of the study team in a suitable place where the participants took part easily in the meetings.

(b) Key Informant Interview (KII): The key informant interviews (KIIs) were conducted with the officials of DAE at headquarter (HQ) and field level (district & upazila) who were involved with implementation of TCDP activities regarding sweet potato cultivation, import-exports and other relevant aspects. In addition, the officials of BADC/BARI and other relevant organizations were also participated in the KIIs.

(c) Field Visit and Physical Observation: In addition of respondent survey, FGD and KII, the expert team of the study also physically visited the sweet potato field at sample basis under the project upazila and districts. The study team members observed the physical status of the insect pests, diseases, weeds and other associated pest problems of sweet potato at field condition. The senior officials of TCDP-DAE also accompanied during field visit done by the PRA study team.

(d) Laboratory Investigation: The collected samples for insect pests, diseases and weeds from the field of sweet potato were carried out to the Dhaka office and evidences were proved by in-depth investigations done by the experts of PRA team.

2.4.6.2. Development of Indicators for PRA Study

Based on the study objectives, the team of experts prepared a list of major indicators aiming to conduct the pest risk analysis of sweet potato in Bangladesh. Subsequently, the study team shared these indicators with the TCDP-DAE officials and finalized these indicators. The following variables/indicators were considered to conduct this study:

- Demographic : Name, Age, Sex
- Social : Education, Profession
- Study related indicators:
- Farm size, kinds and variety of sweet potato cultivated
- Major and minor insect pests, diseases and weeds of sweet potato;
- Pests of sweet potato likely to be associated with pathway;
- Regulated pests of sweet potato;
- Potentials for entry, establishment and spread of regulated pests;
- Potential quarantine insect pests, diseases and other associated pests;
- Probability of survival during transport or storage & transfer of hosts;
- Probability of pest surviving existing pest management procedures;
- Availability of suitable hosts, alternate hosts and vectors in the PRA areas;
- Potential risk, economic, environmental impacts and loss by these pests;
- Possible sources of entry and pathways of the newly introduced and unknown pests;
- Possible pathways of spreading of quarantine pests of these crops within Bangladesh;
- Effective management options for controlling of regulated pests of sweet potato;
- Potential options in preventing the entry and spread of quarantine and regulated pests;
- Suggestions for strengthening of phytosanitary and quarantine aspects for sweet potato in Bangladesh.

2.4.6.3. Development of Study Tools/Instruments

According to the sample design, a total of 600 sweet potato farmers were selected for face-to face interview and the selection of respondents were made on a multistage sampling technique for sampled districts, upazila and block. Thereafter, the farmers were selected using simple random sampling technique among the sweet potato farmers who were involved with sweet potato cultivation within the selected block under the sampled upazila and district.

(a) Respondents' Survey: The face-to-face interviews were conducted with the participation of 600 sweet potato farmers using a pre-designed questionnaire (**Appendix-1)** encompassing the following indicators:

- Land use pattern by the sweet potato growers;
- Variety of sweet potato cultivated;
- Occurrence of major and minor insect pests and diseases of sweet potato in field and storage;
- Occurrence of major and minor weeds and vertebrate pests such as rodents and birds of sweet potato in field and storage;
- Severity of insect pests, diseases, weeds and other associated pests of sweet potato;
- Vulnerable stage of the crop plants to insect pests, diseases, weeds and other pests;
- Economic loss caused by these pests;

- Potential unknown insect pests, diseases, weeds and other pests that were not seen earlier;
- Possible sources of entry and pathways of the newly introduced and unknown pests;
- Possible pathways of spreading of unknown pests of sweet potato crop within Bangladesh;
- Effective measures practiced by the farmers in controlling the insect pests, diseases, weeds and other associated pests;
- Suggestions for preventing the spread of unknown pests.

(b) Focus Group Discussion (FGD): The farmers who were associated with the cultivation of sweet potato as well as traders and Sub-Assistant Agriculture Officers (SAAO) of the respective agriculture block under DAE were participated in the FGD session. Each FGD was conducted at a venue that was convenient for the participants and allowed them to speak freely. The FGDs were conducted to collect the information using pre-designed FGD guidelines **(Appendix-2)** encompassing the following indicators:

- major insect pests, diseases and weeds and other associated pests occurring in the sweet potato fields;
- potential economic loss caused by the pests;
- potential control options of these insect pests, diseases, weeds and other associated pest problems in the field;
- pests of sweet potatoes those were seen recent years but not earlier;
- possible sources and pathways of these pests; and
- suggestions for preventing the spreading of unknown and newly introduced but potentially damaging pests of sweet potato in Bangladesh.

(c) Key Informant Interview (KII): The officials of DAE working at field level (UAE/AEO and SAAO) and at headquarter level were interviewed using a semi-designed questionnaire (**Appendix-3)** to gather information about the issues such as:

- Potential insect pests, diseases weeds and other damaging pests of sweet potato;
- Best options for controlling potential insect pests, diseases and other associated pests in the field and storage;
- Source of seed sweet potato imported in Bangladesh;
- quarantine pests of sweet potato identified in Bangladesh;
- possible sources of quarantine pests identified in Bangladesh;
- possible entry and pathways of unknown and newly introduced quarantine pests of sweet potato in Bangladesh;
- suggestions for preventing the entry and spread of quarantine pests of sweet potato in Bangladesh; and
- suggestions for improving phytosanitary measures for quarantine pests of sweet potato in Bangladesh.

(e) Field Visit/Physical Observation

The standing sweet potato fields will be physically visited in the selected districts of the study area aiming to observe the incidence and severity of sweet potato pests, symptoms caused by these pests, intensity of risks etc. caused by the insect pests, diseases and other associated pest problems such as weeds, rodents and vertebrate pests. The physical observations were conducted through a pre-designed observation checklist**.**

2.4.6.4. Phases of Data Collection

The growing seasons of sweet potato cultivation was varied in major sweet potato growing districts of Bangladesh particularly between northern and southern districts. Therefore, two phases of field level data collection were considered based on tuberization and harvesting stages of sweet potato in different sampled districts that are described below:

First/Early Phase: Considering the early stage of sweet potato, the field level data collection was started in 14 north-western districts of Bangladesh on first week of February, 2022. The districts selected for first stage data collection were Gaibandha, Kurigram, Nilphamari, Panchagarh, Rajshahi and Nogaon, Bogura, Pabna, Jhenaidah, Kushtia, Jamalpur, Kishoreganj, Mowlovibazar Sunamganj districts will be covered.

Second/Late Phase: The second/late phase of data collection was started on third week of March, 2022 in middle and south-eastern districts of Bangladesh. The districts selected for second stage data collection were Dhaka, Tangail, Manikganj, Munshiganj, Brahmanbaria, Noakhali, Laxmipur, Faridpur, Rajbari, Sariatpur, Madaripur, Norail, Satkhira, Barishal, Bhola, Patuakhali.

2.4.6.5. Recruitment and Training of Field Staff

Recruitment of field staff: A total of 20 enumerators and 6 supervisors were recruited preferably having Master's degree in Entomology, Plant Pathology and Agronomy as well as having enough experience in data collection. Two enumerators were recruited for three adjacent sample districts and one supervisor was recruited for 5 adjacent sample districts.

Training of the field staff: A two-day training course was organized for the data collection team. The first day was devoted for delivering the background of the PRA study, data collection methodology and introduction to insects and mite pests, diseases and weeds of sweet potato available at field and storage condition with the help of field guide prepared by experts. The second day was devoted on study tools and practicing on how to fill-in the questionnaire, group discussions. The third-day was devoted sharing experiences with each other and experts. The expert members of the PRA team provided the training.

2.4.6.6. Method of Data Collection

Direct personal interview approach was adopted for data collection with the participation of sweet potato farmers. Each enumerator personally contacted with the farmers in consultation with the respective Upazila Agricultural Officer (UAO) and, thereafter, collected desired information from the farmers by explaining the objectives of study. The supervisor deployed in the sampled areas supervised and monitored the activities of enumerators as well as checked the filled-in questionnaires done by the enumerators. In addition, supervisors conducted the FGDs and field level KIIs designed for sampled upazila.

2.4.6.7. Data Management and Analysis

Soon after received the filled-in questionnaires from the field, the data entry was done in the pre-designed data sheet using the most suitable computer software. Thereafter, cleaning activities were done by the Data Analyst followed by Data processing and analysis using standard computer software (MS Access, SPSS, MS Excel, etc.).

2.4.7. Interpretation of Results and Report Preparation

The collected information on pests of sweet potato, their risk and management options were analyzed and interpreted. The most vulnerable stages of plant growth as well as parts of plants affected by the pests of sweet potato were also determined based on both primary and secondary data. Finally, a checklist/list was prepared based on locally available pests of sweet potato in Bangladesh as well as quarantine pests of sweet potato for Bangladesh as recorded in exporting countries of sweet potato.

CHAPTER III

REVIEW OF MANAGEMENT OPTIONS

3.1. Introduction

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

3.2. Insect, Diseases and Mite Pest Management of Sweet Potato

Sweet potato (Ipomea batatas. (L.) Lam.) is very important crop in tropical and sub-tropical countries of the world including Africa, India, Bangladesh, China, Japan, the Pacific Island, Tropical America and the Southern part of the United States of America. Although there are few very important pests in common such as Sweet Potato Weevil, Jute hairy caterpillar Tomato/Potato psyllid epilachna beetles, Spiked Mealybug, Cotton Leaf worm, Aphids, Tomato Russet Mite, Ceratocystis Blight, Sting nematode and Pacara Earpod tree root-knot nematode. The timing of control tactics is critical for many of these pests-miss the window and the crop can be severely affected. Some growers choose to spray weekly thinking this lead to good control, but not only does this lead instead to wasted resources and ineffective controls, excessive sprays also lead to secondary pest outbreaks and the development of resistance by pests to some chemical controls.

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

3.2.1. Sweet Potato Weevil

Because of its concealed feeding habits, *C. formicarius* can be difficult to control with conventional insecticide applications. However, because of its limited or almost non-existent flying activity, which implies that the insect is carried from place to place via movement of the plant material, host specificity to the genus Ipomoea, and characteristic mode of entry and damage to the plant, this pest is amenable to suppression by crop rotation, clean cultivation, mulching and similar simple cultural practices. Among various control measures attempted, modification of cultural practices has the greatest potential in combating the sweet potato weevil at very little cost.

Management

a) Cultural Control

Cultural pest control involves changing or modifying cultivation practices which directly or indirectly reduce the pest population. Cultural practices, such as crop rotation, intercropping, mulching, sanitation, etc., were the earliest control measures advocated for reducing sweet potato weevil damage.

Crop Rotation

Rotations of crops, such as growing sweet potatoes in a field only once every 5 years (TAC, 1954), avoiding planting of sweet potatoes in the same area for two successive years (Holdaway, 1941) or planting rice between two sweet potato crops (Franssen, 1935) have long been suggested.

Intercropping

In Taiwan, sweet potato was planted between two rows of each of 68 crop species and weevil infestations of the roots were monitored. Intercropping with chickpea (*Cicer arietinum*), coriander (*Coriandrum sativum*), pumpkin (*Cucurbita moschata*), radish (*Raphanus sativus*), fennel (*Foeniculum vulgare*), blackgram (*Vigna mungo*) and yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis*) reduced weevil infestations considerably. However, intercropping with blackgram, fennel, pumpkin, and yardlong bean also reduced sweet potato yields (AVRDC, 1988). Similarly, Singh *et al.* (1984) observed reduced weevil damage when sweet potato was intercropped with proso millet (*Panicum miliaceum*) and sesame (*Sesamum indicum*).

Mulching

Soil cracks are the major route of weevil access to roots. The enlargement of roots, especially in cultivars which set roots near the soil surface, and soil moisture stress can produce cracks and increase exposure of roots to the weevil. The absence of cracks denies the weevil access to the roots. For example, in Taiwan, less damage by *C. formicarius* occurs during the rainy season when soil cracks are minimal (AVRDC, unpublished data). This is presumed to be due to the absence of soil cracks due to adequate soil moisture in the wet season as opposed to the dry season. Prevention of soil cracking by hilling the area around the plant or irrigating frequently, are also suggested as an important method of reducing weevil damage (Sherman and Tamashiro, 1954). The physical cover made by mulching materials further reduced access of roots to the weevil even if the soil cracked.

Sanitation

Sanitation practices or clean cultivation, especially for the control of an insect that has limited flying activity, may help protect the crop from insect infestation. These practices played an important role in pest control until the introduction and widespread use of chemical insecticides. A variety of sanitation methods have been recommended for weevil control, and in some locations, they are even legally enforced (Karr, 1984).

Destruction of Crop Residues

Destroying any crop residues left in the field after harvest is important because weevils survive in roots and stems and infest succeeding or neighbouring sweet potato plantings (Eddy *et al.,* 1943). Crop rotation, in most cases, serves this purpose. However, in areas where sweet potato is a staple food and is planted year-round, rotation is not always possible.

Clean Cuttings

C. formicarius lays eggs in the vines, especially older portions in the absence of storage roots or when the roots are inaccessible (AVRDC, unpublished data). Planting of infested vines may spread the weevil infestation. Therefore, the use of weevil-free sweet potato cuttings is often advised (Holdaway, 1941). Weevil-free cuttings can be produced by dipping them in a suitable insecticide solution before planting.

Control of Alternative Hosts

Several species of Ipomoea in addition to sweet potato, and a few related convolvulaceous plants are also alternative hosts of *C. formicarius*. Sutherland (1986b) listed 30 such species and four additional ones were recently found to harbour the weevil in Taiwan (AVRDC, 1989). The presence of alternative hosts, most of which are perennial, is important in the infestation of sweet potato weevil. Removal of these hosts growing in the vicinity of sweet potato plantings is recommended as a control measure (Wood, 1976).

Host-Plant Resistance

Not a single sweet potato cultivar has been bred using previously identified sources of resistance, which is grown in any appreciable area to control Cylas species. Moderate levels of resistance have only been obtained in localized growing areas. Efforts to find resistant cultivars have been thwarted by the differences in weevil infestation among trials, locations, seasons, and at times among replicates of a single accession in a trial, among plants in the same plot, and even among storage roots within one plant (Talekar, 1982, 1987a).

b) Chemical Control

Numerous chemical insecticides have been tested for the control of *C. formicarius* despite the hidden mode of the insect's life cycle, which may thwart efforts to control this weevil by conventional insecticides. Sutherland (1986a) listed 59 different insecticides, including botanicals of unknown chemical composition, that were tested against sweet potato weevil. These chemicals, most of which were applied as post-planting foliar sprays, resulted in varying levels of control.

Pre-plant application

Pre-plant insecticide applications have been used to exterminate weevils from the planting material (vine cuttings) before planting. Insecticides with adequate water solubility are presumably transported through the vine and kill the weevils in that plant part. This type of treatment is usually more economical than post-plant insecticide applications, and if combined with proper sanitation and other measures to prevent immigration of weevils from infested plants, may result in satisfactory control of the weevil (Talekar, 1983).

Post-plant application

Control of the weevil is difficult with conventional spraying, dusting, fumigation or side-dressing of insecticide granules with presently available insecticides, once weevils are present within the crown or the tuberous root. Control achieved by post-plant applications appears to be due to mortality of weevil adults searching for feeding or oviposition sites. Movement of adult weevils may facilitate the contact between the toxicant and the insect, thereby resulting in insect mortality. Several researchers have obtained satisfactory control of the weevil by spraying vines or soil around stems (Rajamma and Padmaja, 1983). This method of control, however, requires frequent applications in order to kill adults that might migrate from other areas. This view concurs with that of Sakae (1988) in Japan. Frequent spraying of insecticides, however, is not cost-effective due to the low market price for sweet potato in developing countries.

Sex pheromone

The existence of a female sex pheromone in sweet potato weevil was demonstrated (AVRDC, 1976;) and Heath et al. (1986) isolated, identified and synthesized the chemical (Z)-3-dodecen-1-ol(E)-2-butenoate. This chemical has great potential for attracting male sweet potato weevils (Jansson et al., 1992) and reducing the weevil populations in the field (Braun and van de Fliert, 1999).

c) Biological Control

The fungus *Beauveria bassiana* is produced in large quantities and used intensively for the control of the sweet potato weevil in Cuba, where sprays of the fungus have largely replaced the use of insecticides (Castellon *et al.,* 1992). Synthetic sex pheromone can be used to attract male *C. formicarius* to traps containing *B. bassiana*, in which the weevils become auto-infected and subsequently spread infection to both sexes in field populations (Yasuda, 1999).

Among the three predators, only *Pheidole megacephala* is reported to be an effective biological control agent of *C. formicarius* in Cuba (Castiñeiras *et al.,* 1982). This predator was more effective than chemical insecticides at controlling sweet potato weevil. Root yields in plots where *P. megacephala* was released to control weevils were 21.5 t/ha compared with only 7.8 t/ha in plots that relied solely on chemical insecticides (Morales, 1988).

d) Integrated Pest Management

No specific control measures, used singly, can provide adequate control of *C. formicarius* where sweet potato is grown throughout the year and the weevil is endemic. However, a combination of tactics can give satisfactory control of the pest. With the exception of biological control and applications of insecticides, all other control measures are fully compatible. Biological control agents are quickly eliminated by chemical insecticides.

The International Potato Center has tested in Cuba, a strategy for implementing the integrated management of the sweet potato weevil on a large scale in close collaboration with the Instituto de Investigaçion de Viandes Tropicales (INIVIT), its Cuban counterpart. In a 3-year period, the programme was implemented on more than 30,000 ha. Damage was reduced from 40-50% to 4-8% and the number of insecticide sprays was reduced from 10-12 per season to none in 1996 (except for localized applications around pheromone traps) (Alcázar *et al.,* 1997).

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3.2.2 Jute hairy caterpillar

The indiscriminate use of synthetic insecticides for this pest has not proved satisfactory, having led to resistance to the active ingredients among the target population, as well as causing damage to the environment. There are a number of natural enemies but these are insufficient to maintain control. Investigations are being made into the use of a viral bio-control agent known as SpobNPV. In a field trial using jute, there was a 69, 79 and 93% reduction in the larval population at 3, 4 and 7 days after spraying.

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3.2.3 Tomato/Potato psyllid

Management of *B. cockerelli* has extensively been discussed by Trumble (2012).

Monitoring *B. cockerelli* is essential for its effective management. Early season management of this insect is crucial to minimize damage and psyllid reproduction in the field. The adult populations are commonly sampled using sweep nets or vacuum devices, but egg and nymphal sampling requires visual examination of foliage. The adults can also be sampled with yellow water-pan traps. Typically, psyllid populations are highest at field edges initially, but, if not controlled, the insects will eventually spread throughout the crop (Workneh *et al.,* 2012).

B. cockerelli control is currently dominated by insecticide applications (Guenthner *et al.,* 2012), but psyllids have been shown to develop insecticide resistance due to the high fecundity and short generation times Therefore, alternative strategies should be considered to limit the impact of the potato psyllid and its associated diseases. Even with conventional insecticides, *B. cockerelli* tends to be difficult to manage.

The most valuable and effective strategies to manage zebra chip would likely be those that discourage vector feeding, such as use of plants that are resistant to psyllid feeding or less preferred by the psyllid. Unfortunately, no potato variety has so far been shown to exhibit sufficient resistance or tolerance to zebra chip or potato psyllid (Munyaneza *et al.,* 2011). However, some conventional and biorational pesticides, including plant and mineral oils and kaolin, have shown some substantial deterrence and repellency to potato psyllid feeding and oviposition (Peng *et al.,* 2011) could be useful tools in integrated pest management programs to manage zebra chip and its psyllid vector.

Good insecticide coverage or translaminar activity is important because psyllids are commonly found on the underside of the leaves. Also, the different life stages require use of specific insecticides as it has been shown that chemicals controlling adults do not necessarily controls nymphs or eggs. Because several generations often overlap, caution should be taken when selecting and applying insecticides targeted against the potato psyllid in relation to which life stages are present in the crop and timing of insecticide applications.

Several predators and parasites of *B. cockerelli* are known, though there is little documentation of their effectiveness. In some areas such as southern Texas, early planted potato crops are more susceptible to psyllid injury than crops planted mid- to late season (Munyaneza et al., 2012).

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3.2.4 Spiked Mealybug

Chemical Control

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

Infestations of *N. nipae* were eliminated in sweet potato plantations by chemically controlling Azteca ants which maintained and protected the mealybug colonies (Raj, 1977).

Biological Control

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

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3.2.5 Cotton Leaf worm

Biological Control

Numerous studies have been carried out on possible biological control of *S. littoralis*. Parasitoids (braconids, encyrtids, tachinids and ichneumonids) and predators have been extensively documented. Parasitic nematodes such as *Neoaplectana carpocapsae* have also been evaluated. However, direct use of these biocontrol agents has not been commercailized. Treatment with *Bacillus thuringiensis* has been used (Navon *et al.,* 1983), but only some strains are effective as *S. littoralis* is resistant to many strains (Salama *et al.,* 1989).

Chemical Control

The chemical control of *S. littoralis* has been extensively reported, especially in relation to cotton in Egypt. Numerous organophosphorus, synthetic pyrethroids and other insecticides have been used, with appearance of resistance and cross resistance in many cases (Abo-El-Ghar *et al.,* 1986). However, compulsory limitation of the application of synthetic pyrethroids to one per year on cotton in Egypt has stopped the appearance of new resistance (Sawicki, 1986).

Chemicals used against species of Spodoptera also include insect growth regulators. There is interest, especially in India, in various antifeedant compounds or extracts, and in natural products, such as azadirachtin and neem extracts.

IPM

Integrated pest management techniques, favouring beneficial arthropods, are applied against *S. littoralis* on cotton in Egypt. These involve hand collection of egg masses, use of microbial pesticides and insect growth regulators and slow-release pheromone formulations for mating disruption. If these measures are taken, relatively few applications of conventional insecticides are necessary. Pheromones have also been used for mass trapping using a lure and kill strategy (McVeigh and Bettany, 1987) and for monitoring populations. Souka (1980) experimented with irradiation for sterile-insect release, but this technique has not been widely applied in the field.

Phytosanitary Measures

For planting material, EPPO recommends (OEPP/EPPO, 1990) absence of the pests from the place of production during the last 3 months, or treatment of the consignment. For cut flowers, pre-export inspection is considered sufficient.

Cold storage of chrysanthemum and carnation cuttings for at least 10 days at a temperature not exceeding 1.7°C will kill all stages of *S. littoralis,* but may damage the plants. Storage at slightly higher temperatures or shorter durations does not eradicate *S. littoralis*, but differences in response to cold have been observed both between strains and within developmental stages of the pest (Miller, 1976). Irradiation has been investigated as a treatment for cut flowers (Navon *et al.,* 1988). For cut chrysanthemum flowers, Wang and Lin (1984) suggest enclosing buds in perforated polythene bags to exclude the pest and dipping the cut stems in insecticide solutions.

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3.2.6 Aphids

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

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

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

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

3.2.7 Whiteflies

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

3.2.8 Tomato Russet Mite

Chemical Control

Approaches have changed from repeated application of broad spectrum insecticides to focused treatment of young plants to prevent establishment of *A. lycopersici* early in the growing season (Baradaran-Anaraki and Daneshvar, 1992).

Of several acaricides tested against *A. lycopersici* in the field in Australia, dicofol, SLJ0312 (an experimental compound), cyhexatin, azocyclotin and sulprofos were found to be effective (Kay and Shepherd, 1988). Dicofol was recommended to control or prevent infestation of the mite. Royalty and Perring (1987) found avermectin B1 to be more toxic to *A. lycopersici* than dicofol, and selective doses of avermectin B1 gave good control of the pest without reducing numbers of the beneficial tydeid mite *Homeopronematus anconai.* Perring (1996) provides a short overview of the control of *A. lycopersici*.

Biological Control

Chemical methods have progressively been supplemented, especially in greenhouse situations, by increasingly well understood biological control strategies involving predatory phytoseid, stigmaeid and tydeid mites (Atanasov *et al.,* 1995).

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3.2.9 Ceratocystis Blight

Host-Plant Resistance

Host-plant resistance has been used successfully with Mangifera (Rossetto *et al.,* 1997), Theobroma (Simmonds, 1994), Ipomoea (Martin, 1954), Coffea (Castilla, 1982) and Crotalaria (Ribeiro *et al.,* 1977). Species and varieties of citrus also vary in susceptibility to Colombian strains of the fungus (Paez-Redondo and Castano-Zapata, 2001).

Cultural Control and Sanitary Measures

Sanitation is also effective for disease control. For example, disinfecting machetes and pruning tools between plants may help control the disease in Platanus (Walter et al., 1952) and Prunus (Teviotdale and Harper, 1991). Heat treatment of Ipomoea roots used in propagation has been suggested (Daines *et al.,* 1962).

Chemical Control

Fungicides are used with some success to treat tapping panels of Hevea (Chee, 1970) and in Ipomoea fields (Martin, 1971) or as post-harvest dips of Ipomoea roots (Yang *et al.,* 2000). Fungicides injected into the stems of Platanus species may provide some protection (Minervini *et al.,* 2001). Fungicides are also used to control the disease in Ficus (Hirota *et al.,* 1984).

Biological Control

No biological control methods currently exist.

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3.2.10. Sting nematode

Chemical treatment of soil using liquid or granular nematicides is usually highly effective due to the porous nature of the sandy soils that the nematode favours. Various non-hosts have been used as cover crops or in rotation to reduce populations of the nematode (Smart and Nguyen, 1991) and organic soil amendments may also have a beneficial effect. Soil solarization has also been tested in strawberry fields (Overman *et al.,* 1987). Biological control has been attempted: Pasteuria penetrans suppressed *B. longicaudatus* populations after 1 year (Giblin-Davis, 1990).

References

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3.2.11. Pacara Earpod tree root-knot nematode

Basically, taking into account the banning of most chemical nematicides, growing resistant crops or non-host plants currently represents the best method for reducing *M. enterolobii* populations. However, the list of non-host plants for this species is very limited. In addition, resistance genes active against the major tropical root-knot nematode species (i.e., *M. incognita, M. javanica* and *M. arenaria*) do not control *M. enterolobii,* for example, in the case the Mi-1, N and Rk genes from tomato, pepper and cowpea, respectively. Therefore, some efforts have been devoted in recent years to the identification of new sources of resistance to *M. enterolobii*, with some success in perennial crops. A decade ago, a screening experiment using high and durable inoculum pressure indicated that Ma genes in Myrobolan plum, known to control the main tropical root-knot nematode species, also control resistance to *M. enterolobii* (Rubio-Cabetas *et al.,* 1999). In peach, commercial rootstocks carrying the RMia resistance gene were shown resistant to the nematode in greenhouse evaluation tests (Nyczepir *et al.,* 2008.). In guava trees, whose cultivation may suffer high damage in cases of heavy infestations, resistance has recently been identified in Psidium spp. accessions (Freitas *et al.,* 2014). Recently, the discovery of resistance of *Psidium cattleianum* to this nematode has increased its selective use as rootstock for guava (Macan and Cardoso, 2020). Oat, wheat and sorghum cultivars have been shown resistant to this nematode and can be recommended for crop rotation in areas infested with *M. enterolobii* (De Brida *et al.,* 2018). Clearly, search for new sources of resistance to *M. enterolobii,* especially in vegetables and annual crops, and their introgression into cultivars of agronomic interest, currently represent a major challenge to plant breeders worldwide.

Another alternative to chemical nematicides is based on the use of biocontrol agents, and several organisms have been investigated for their antagonistic effects against *M. enterolobii*. However, although some show promise, the results of all these studies require validation in various field conditions before a biological agent active against *M. enterolobii* may be commercially released.

References

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3.3. Phytosanitary measures

3.3.1. Post-Harvest Procedures

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

3.3.2. Visual Inspection

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

- In-field monitoring during the growing season;
- Harvesting;
- Post-harvesting sorting and grading;

- Packaging seedlings for treatment;
- Packaging of flowers for export; and
- Visual phytosanitary inspection.

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

3.4. Application of phytosanitary measures

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

- Surveillance for pest freedom;
- 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; and
- Treatment on arrival in Bangladesh.

3.4.1. General conditions for sweet potato

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

3.5. Pre-shipment requirements

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

Treatment of the consignment

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

Documentation

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

3.5.1. Phytosanitary certification

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

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

The sweet potato have:

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

AND, ONE OR MORE OF THE FOLLOWING:

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

AND;

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

3.5.2. 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 sweet potato 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 Bangladesh’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.”

3.5.3. Transit requirements

The sweet potato 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.

3.5.4. 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.

3.5.5. Testing for Regulated Pests

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

3.5.6. 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; and
- 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.

3.5.7. Bio-security Clearance

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

3.5.8 Feedback on Non-compliance

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

CHAPTER IV

IDENTIFICATION OF SWEET POTATO PESTS

4.1. Introduction

The pest risk assessment was done with the aim to determine Bangladesh's phytosanitary measure regarding the sweet potato imported from any exporting countries of Japan, India, China, Thailand, Malaysia and Vietnam into Bangladesh.

4.2. Pests of Sweet Potato Recorded in Bangladesh

The study for "Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh" was done in 30 major sweet potato growing districts of Bangladesh. From the field survey and review of secondary documents, the precise findings of the study in-line with the presence of insect and mite pests, diseases and weed pests have been presented below:

4.2.1. Insect and mite pests of coconut in Bangladesh

The findings depicted in Table-4.1, a total of 21 arthropod pests of sweet potato, of which all were insect pests as reported in Bangladesh. The incidences of insect pests as recorded in Bangladesh were tobacco whitefly (*Bemisia tabaci*), pineapple mealybug (*Dysmicoccus brevipes*), striped mealybug (*Ferrisia virgata*), potato aphid (*Macrosiphum euphorbiae*), green peach aphid (*Myzus persicae*), chilli thrips (*Scirtothrips dorsalis*), convolvulus hawk moth (*Agrius convolvuli*), black cutworm (*Agrotis ipsilon*), turnip moth (*Agrotis segetum*), tobacco budworm (*Heliothis virescens*), taro hawk moth (*Hippotion celerio*), green semi-looper (*Argyrogramma signata*), sweet potato stem/vine borer (*Omphisa anastomosalis*), fall armyworm (*Spodoptera frugiperda*), taro caterpillar (*Spodoptera litura*), black hairy caterpillar (*Estigmene chinensis*), sweet potato hairy caterpillar (*Pericallia recini (*Fabricius)), jute hairy caterpillar (*Spilarctia obliqua* (Walker)), sweet potato weevil (*Cylas formincarius*), tortoise beetle (*Aspidomorpha dorsata* Fabricius) and sweet potato beetle (*Carphurus* sp.).

Among these insect pests as reported in Bangladesh, sweet potato weevil was designated as major pests of sweet potato as well as they was reported as more damaging than other insect pests. Among the major insect pests, sweet potato weevil caused damages of sweet potato tubers with severe infestation at storage condition, though it also causes damage at field condition. On the contrary, other 20 insect pests were designated as minor pests of sweet potato, which cause damage of sweet potato by feeding foliage, vine, tubers, etc. at field and storage condition with low infestation severity. Usually, Bangladesh's sweet potato growers always used chemical insecticides at low level of frequency through which these insect pests were suppressed in every season. Whereas, farmers and traders always face difficulties to control the infestation of sweet potato weevil at storage condition of tubers, because the larvae and adults of sweet potato weevil remain hidden inside the sweet potato tubers and cause damage by feeding the internal portion of tubers (Table-4.1).

Table-4.1: Insect pests of sweet potato as reported in Bangladesh, their introduction, plant parts affected, pest status and infestation severity

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity
1	Tobacco whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera	Leaf	Minor	Low
2	Pineapple mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Leaf, vine, tuber	Minor	Low

SN	Common Name	Scientific name	Family	Order	Plant parts affected	Pest status	Infestation severity
3	Striped mealybug	*Ferrisia virgata*	Pseudococcidae	Hemiptera	Leaf, vine, tuber	Minor	Low
4	Potato aphid	*Macrosiphum euphorbiae*	Aphididae	Hemiptera	Leaf, vine, flower	Minor	Low
5	Green peach aphid	*Myzus persicae*	Aphidoidea	Hemiptera	Leaf, vine, flower	Minor	Low
6	Chilli thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Leaf & twig	Minor	Low
7	Convolvulus hawk moth	*Agrius convolvuli*	Sphingidae	Lepidoptera	Leaf & twig	Minor	Low
8	Black cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Seedling	Minor	Medium
9	Turnip moth	*Agrotis segetum*	Noctuidae	Lepidoptera	Leaf & twig	Minor	Low
10	Tobacco budworm	*Heliothis virescens*	Noctuidae	Lepidoptera	Leaf, vine	Minor	Low
11	Taro hawk moth	*Hippotion Celerio*	Sphingidae	Lepidoptera	Leaf & twig	Minor	Low
12	Green semi-looper	*Argyrogramma signata*	Noctuidae	Lepidoptera	Leaf & twig	Minor	Low
13	Sweet potato vine borer	*Omphisa anastomosalis*	*Crambidae*	*Lepidoptera*	Stem/vine	Minor	Low
14	Fall armyworm	*Spodoptera Frugiperda*	Noctuidae	Lepidoptera	Leaf	Minor	Low
15	Taro caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera	Leaf	Minor	Low
16	Black hairy caterpillar	*Estigmene chinensis* Hope	Arctiidae	Lepidoptera	Leaf	Minor	Low
17	Sweet potato hairy Caterpillar	*Pericallia recini* (Fabricius)	Arctiidae	Lepidoptera	Leat	Minor	Low
18	Jute hairy caterpillar	*Spilarctia obliqua* (Walker)	Arctiidae	Lepidoptera	Leaf	Major	Medium
19	Sweet potato weevil	*Cylas formincarius*	Apioniadae	Coleoptera	Leaf, root	Major	High
20	Tortoise beetle	*Aspidomorpha dorsata* Fabricius	Chrysomelidae	Coleoptera	Leaf	Minor	Low
21	Sweet potato Beetle	*Carphurus* sp.	Melachiidae	Coleoptera	Leaf	Minor	Low

4.2.2. Diseases of sweet potato as reported in Bangladesh

The findings depicted in Table-4.2, a total of 19 species of disease-causing pathogens of sweet potato were reported in Bangladesh, of which seven (7) diseases were caused by fungi, two (2) diseases caused by bacteria, five (5) diseases caused by nematode and the remaining five (5) diseases caused by virus.

The incidences of fungal diseases of sweet potato as reported in Bangladesh were sclerotium rot (*Athelia rolfsii*), choanephora fruit rot (*Choanephora cucurbitarum*), diplodia tuber rot (*Lasiodiplodia theobromae*), charcoal rot of bean (*Marcophomina phaseolina*), cottony soft rot (*Sclerotinia sclerotiorum*), sweet potato leaf spot (*Phaeoisariopsis bataticola; Cercospora batatae*) and soft rot (*Rhizopus nigiricans*). Among these fungal diseases, the charcoal rot of bean was designated as major disease that caused medium level of damage on sweet potato vine, while remaining six (6) diseases were designated with minor significance and caused low level of damage on leaf, tuber, etc. of sweet potato (Table-4.2).

The incidences of bacterial diseases of sweet potato as reported in Bangladesh were bacterial root rot of sweet potato (*Pectobacterium carotovorym* subsp. *carotovorum*) and sweet potato Witches' Broom (*Sweet potato little leaf phytoplasma*). Both of these were designated at minor diseases of sweet potato causing low level of damage on leaf and tuber (Table-4.2).

In contrary, the incidences of diseases of sweet potato caused by nematode as reported in Bangladesh were potato tuber nematode (*Ditylenchus destructor*), common spiral nematode (*Helicotylenchus dihystera*), peanut root-knot nematode (*Meloidogyne arenaria*), root lesion nematode (*Pratylenchus penetrans*) and reniform nematode (*Rotylenchulus reniformis*). All of these nematode diseases of sweet potato were designated as minor pests causing low level of damage on roots of sweet potato (Table-4.2).

The incidences of viral diseases of sweet potato as reported in Bangladesh were sweet potato latent virus (*Sweet potato latent virus*), sweet potato leaf curl virus (*Sweet potato leaf curl virus* mild mottle of sweet potato (*Sweet potato mild mottle virus*), sweet potato feathery mottle virus (*Sweet potato feathery mottle virus*) and chlorotic fleck virus (*Sweet potato chlorotic fleck virus* (SPCFV)). All of these viral diseases of sweet potato were designated with minor significance and causes low level of damage on leaf of sweet potato (Table-4.2). Most of cases, the damages caused by these diseases were controlled by the growers through routine application of fungicides and other pesticides in the field of sweet potato.

Table-4.2. Diseases of sweet potato as reported in Bangladesh, their introduction, plant parts affected, disease status and damage severity

Sl. No.	Common name	Scientific name	Family	Order	Plant parts affected	Pest status	Damage severity
Causal Organism: Fungi							
1	Sclerotium rot	*Athelia rolfsii*	Atheliaceae	Polyporales	Tuber, leaf	Minor	Low
2	Choanephora fruit rot	*Choanephora cucurbitarum*	Choanephoraceae	Mucorales	Tuber, leaf	Minor	Low
3	Diplodia tuber rot	*Lasiodiplodia theobromae*	Botryosphaeriaceae	Botryosphaeriales	Tuber	Minor	Low
4	Charcoal rot of bean	*Marcophomina phaseolina*	Botryosphaeriales	Botryosphaeriaceae	Vine	Major	Medium
5	Cottony soft rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales			
6	Sweet potato leaf spot	*Phaeoisariopsis bataticola; Cercospora batatae*	Mycosphaerellaceae	Capnodiales	Leaf	Minor	Low
7	Soft rot	*Rhizopus nigiricans*	Mucoraceae	Mucorales	Tuber	Minor	Low

Sl. No.	Common name	Scientific name	Family	Order	Plant parts affected	Pest status	Damage severity
Causal Organism: Bacteria							
8	Bacterial root rot of sweet potato	*Pectobacterium carotovorym* subsp. *Carotovorum*	Enterobacteriaceae	Enterobacteriales	Leaf, tuber	Minor	Low
Causal Organism: Phytoplasma/Bacteria							
9	Sweet potato Witches' Broom	*Sweet potato little leaf* (SPLL) *phytoplasma*	Acholeplasmataceae	Acholeplasmatales	Leaf	Minor	Low
Causal Organism: Nematode							
10	Potato tuber nematode	*Ditylenchus destructor*	Anguinidae	Tylenchida	Root	Minor	Low
11	Common spiral nematode	*Helicotylenchus dihystera*	Hoplolaimidae	Tylenchida	Root	Minor	Low
12	Peanut root-knot nematode	*Meloidogyne arenaria*	Meloidogynidae	Tylenchida	Root	Minor	Low
13	Root lesion nematode	*Pratylenchus penetrans*	Pratylenchidae	Tylenchida	Root	Minor	Low
14	Reniform nematode	*Rotylenchulus reniformis*	Hoplolaimidae	Tylenchida	Root	Minor	Low
Causal Organism: Virus							
15	Sweet potato latent virus	*Sweet potato latent virus*	Potyviridae	Patatavirales	Leaf	Minor	Low
16	Sweet potato leaf curl virus	*Sweet potato leaf curl virus*	Geminiviridae	Geplafuvirales	Leaf	Minor	Low
17	Mild mottle of sweet potato	*Sweet potato mild mottle virus*	Potyviridae	Patatavirales	Leaf	Minor	Low
18	Sweet potato feathery mottle virus	*Sweet potato feathery mottle virus*	Potyviridae	Patatavirales	Leaf	Minor	Low
19	Chlorotic fleck virus	*Sweet potato chlorotic fleck virus* (SPCFV)	Betaflexiviridae	Tymovirales	Leaf	Minor	Low

4.2.3. Weeds of sweet potato as reported in Bangladesh

The findings depicted in Table-4.3 illustrate a total of 17 weeds of sweet potato were reported in Bangladesh. The incidences of weeds in sweet potato field as recorded in Bangladesh were bermuda grass (*Cynodon dactylon* (L.) Pers.), nut grass (*Cyperus rotundus*), red tassel flower (*Emilia sonchifolia*), bitter vine (*Mikania micrantha*), Alligator weed (*Alternanthera philoxeroides*), Celosia (*Celosia argentea*), wandering jew (*Commelina benghalensis*), Southern crabgrass (*Digitaria ciliaris*), barnyard grass (*Echinochloa crus-galli*), goose grass (*Eleusine indica*), chinese sprangle top (*Leptochloa chinensis*), green foxtail (*Setaria viridis*), dove weed (*Murdannia nudiflora*), prostrate knotweed (*Polygonum aviculare*), marsh pepper (*Polygonum hydropiper*), black nightshade (*Solanum nigrum*) and Parthenium weed (*Parthenium hysterophorus*).

Among these weeds of sweet potato, Bermuda grass and nut grass were designated with major significance and cause medium to high level of damage in the sweet potato field (Table-4.3). In contrary, the remaining weeds were designated with minor significance and cause damage low level in the field of sweet potato. Most of cases, the damages caused by these diseases were controlled by the growers through routine practice of intercultural operation.

Table-4.3. Weeds of sweet potato reported in Bangladesh, their introduction, plant stage affected, pest and infestation severity

Sl. No.	Common Name	Scientific Name	Family	Order	Plant stage affected	Pest status	Infestation severity
1	Bermuda grass	*Cynodon dactylon* (L.) Pers.	Poaceae	Cyperales	Vegetative stage	Major	Medium to high
2	Nut grass	Cyperus rotundus	Cyperaceae	Poales	Vegetative stage	Major	Medium to high
3	Red tassel flower	*Emilia sonchifolia*	Asteraceae	Asterales	Vegetative stage	Minor	Low
4	Bitter vine	*Mikania micrantha*	Asteraceae	Asterales	Vegetative stage	Minor	Low
5	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Caryophyllales	Vegetative stage	Minor	Low
6	Celosia	*Celosia argentea*	Amaranthaceae	Caryophyllales	Vegetative stage	Minor	Low
7	Wandering jew	*Commelina benghalensis*	Commelinaceae	Commelinales	Vegetative stage	Minor	Low
8	Southern crabgrass	*Digitaria ciliaris*	Poaceae	Cyperales	Vegetative stage	Minor	Low
9	Barnyard grass	*Echinochloa crus-galli*	Poaceae	Cyperales	Vegetative stage	Minor	Low
10	Goose grass	*Eleusine indica*	Poaceae	Cyperales	Vegetative stage	Minor	Low
11	Chinese sprangle top	*Leptochloa chinensis*	Poaceae	Cyperales	Vegetative stage	Minor	Low
12	Green foxtail	*Setaria viridis*	Poaceae	Cyperales	Vegetative stage	Minor	Low
13	Dove weeds	*Murdannia nudiflora*	Commelinaceae	Commelinales	Vegetative stage	Minor	Low
14	Prostrate knotweed	*Polygonum aviculare*	Polygonaceae	Polygonales	Vegetative stage	Minor	Low
15	Marsh pepper	*Polygonum hydropiper*	Polygonaceae	Polygonales	Vegetative stage	Minor	Low
16	Black nightshade	*Solanum nigrum*	Solanaceae	Solanales	Vegetative stage	Minor	Low
17	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Asterales	Vegetative stage	Minor	Low

4.2.4. Rodent of sweet potato as reported in Bangladesh

The findings depicted in Table-4.4 illustrate a total of 1 rodent of sweet potato were reported in Bangladesh. The incidences of rodents in sweet potato field as recorded in Bangladesh was.

Table-4.4. Rodent of sweet potato reported in Bangladesh, their introduction, plant stage affected, pest and infestation severity

Sl. No.	Common name	Scientific name	Family	Order	Plant stage affected	Pest status	Infestation severity
1	Bush rat; Pacific rat	*Rattus exulans* (Peale, 1848)	Muridae	Rodentia	Tuber	Major	Medium to high

4.3. Management options for pests of sweet potato in Bangladesh

4.3.1. Insect Pest Management: The most effective and commonly applied management options against the insect pests of sweet potato were spraying of insecticides in the field. It was also reported that Integrated Pest Management (IPM) options were also followed for controlling insect pests of sweet potato at field condition.

4.3.2. Disease Management: The most effective and commonly used management options against the diseases of sweet potato were spraying of fungicides in the field, and removal of diseased plants or parts of plants. Other management practices for controlling diseases of sweet potato were removal of weeds and spraying of insecticides in sweet potato fields for controlling disease transmitting vectors.

4.3.3. Weed Management: The most effective and commonly practiced management options against weeds of sweet potato were the removal of weeds during land preparations and weeding during intercultural operations. Other options were earthing up at the base of plants, and use of herbicides.

4.3.4 Rodent Management: Control methods have often been directed against the rat species that cause most damage. For example, in the Philippines, in mixed populations, problems with *R. exulans* surface once the major species (e.g. *R. rattus mindanensis*, *R. argentiventer*, *R. norvegicus* or *R. tiomanicus*) are controlled. Fortunately, the same control methods generally work for all species. Various modifications of sustained baiting and a modified form of continuous baiting in crops, using principally the first-generation multiple-dose anti-coagulants, have been recommended for use in the Philippines (PCARRD, 1985) and elsewhere. Second-generation anticoagulant poisons are used widely for invasive rat control in the Pacific (including eradication attempts involving *R. exulans*), but possible consequences of any ongoing control should always be considered. These consequences include primary or secondary poisoning of species that are targeted for protection or other non-target species. Secondary poisoning of other vertebrate pests such as cats, and the development of resistance to these poisons by Pacific rats, should also be considered.

4.4. Pests of Sweet Potato in the World including Exporting Countries and Bangladesh

The pests associated with sweet potato in the world were categorized and listed below based on their scientific name, taxonomic position, common name, plant parts affected, geographical distribution and their quarantine status for Bangladesh.

A total of ninety-one (91) species of pests were recorded for sweet potato in the world including exporting countries of sweet potato into Bangladesh, of which 41 species were arthropod pests that include 39 species of insect pests and 2 species of mite pests. While a total of 30 species of disease-causing pathogens were recorded that included 12 fungi, 4 bacteria, 7 nematodes, and 6 viruses. On the other hand, 20 species of weeds and one species of rodent for sweet potato were also recorded in the world.

The findings depicted in Table-4.4 illustrated the insect and mite pests, diseases and weeds associated with sweet potato as reported in the world including Bangladesh, Japan, China, India, Indonesia, Thailand, Malaysia, etc. as well as identification of quarantine pests for Bangladesh.

Table-4.4: Pests associated with sweet potato in the world and identification of quarantine pests for Bangladesh

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
A. Arthropod Pests									
Insect pests									
1	Cirtus Locust	*Chondracris rosea*	Acrididae	Orthoptera	Major	No	Yes	China, Japan, Malaysia, Thailand	Sun JiangHua *et al.* (2006); Mungai (1992); Waterhouse (1993)
2	Winter cherry bug	*Acanthocoris sordidus*	Coreidae	Hemiptera	Major	No	Yes	Japan, Taiwan	Imura (2003); CABI (2021)
3	Tomato/ Potato psyllid	*Bactericera cockerelli*	Triozidae	Hemiptera	Major	No	Yes	Australia, New Zealand, United States	EPPO (2021); Seebens *et al.* (2017)
4	Tobacco Whitefly	*Bemisia Tabaci*	Aleyrodidae	Hemiptera	Minor	Yes	No	Bangladesh, China, India, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	EPPO (2021); Wang *et al.* (2018); Manmohan Dhkal *et al.* (2021); Seebens *et al.* (2017)
5	Barnacle Scale	*Ceroplastes cirripediformis*	Coccidae	Hemiptera	Minor	No	Yes	India	Sunil Joshi *et al.* (2021)
6	Pineapple Mealybug	*Dysmicoccus brevipes*	Pseudococcidae	Hemiptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Williams (2004); Palma-Jiménez and Blanco-Meneses (2017); Srinivasnaik *et al.* (2016); Williams (2004); Seebens *et al.* (2017); Palma-Jiménez and Blanco-Meneses (2017)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
7	Striped Mealybug	*Ferrisia virgata*	Pseudococcidae	Hemiptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia, Singapore, Thailand	Williams (2004); Kaydan and Gullan (2012); Vidya *et al.* (2015); Waterhouse (1993); Kinjo *et al.* (1996); Bader and Al-Jboory (2020)
8	Spiked Mealybug	*Nipaecoccus nipae*	Pseudococcidae	Hemiptera	Major	No	Yes	China, India, Indonesia, Thailand	CABI and EPPO (2005); CABI (Undated a);
9	Potato Aphid	*Macrosiphum euphorbiae*	Aphididae	Hemiptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia,	APPPC (1987); Tao (1999); Sunil Joshi and Sangma (2015); Maharani *et al.* (2018); Imura (2003); NHM (Undated);
10	Green Peach Aphid	*Myzus persicae*	Aphidoidea	Hemiptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Thailand	APPPC (1987); Zhu *et al.* (2017); Sunil Joshi and Sangma (2015); Waterhouse (1993); Fenton *et al.* (2010)
11	Chilli Thrips	*Scirtothrips dorsalis*	Thripidae	Thysanoptera	Minor	Yes	No	Bangladesh, China, India, Japan, Malaysia, Thailand,	EPPO (2021); Mirab-Balou *et al.* (2014); Chinthangkhomba and Varatharajan (2016); Toda *et al.* (2014); Hamaseh Aliakbarpour and Md Rawi (2011);
12	Sweet potato butterfly	*Acraea acerate*	*Nymphalidae*	Lepidoptera	Major	No	Yes	Ethiopia, Kenya, Nigeria	Girma (1993); Smit *et al.* (1997)
13	Pink-spotted Hawk moth	*Agrius cingulatus*	Sphingidae	Lepidoptera	Major	No	Yes	United States	CABI Data Mining (Undated)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
14	Convolvulus Hawk moth	*Agrius convolvuli*	Sphingidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Japan, Malaysia, Saudi Arabia, Singapore, Thailand	CABI/EPPO (2012);
15	Black Cutworm	*Agrotis Ipsilon*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia, Singapore, Thailand	Islam *et al.* (1991); APPPC (1987); Mohammad Munib (2018); Hirai (1991); Waterhouse (1993)
16	Turnip Moth	*Agrotis Segetum*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia,	EPPO (2021)
17	Sweet Potato Leaf miner	*Bedellia somnulentella*	Lyonetiidae	Lepidoptera	Major	No	Yes	China, Japan, Indonesia, Thailand,	Lin (1984); CABI (Undated)
18	Tobacco Budworm	*Heliothis virescens*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	CABI and EPPO (2010); Ali and Sharma (2003)
19	Taro hawk moth	*Hippotion Celerio*	Sphingidae	Lepidoptera	Minor	Yes	No	Bahrain, Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	CARCASSON (1967); Pittaway (1983); APPPC (1987);
20	Green Semi-looper	*Argyrogramma signata*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, India,	APPPC (1987); Waterhouse (1993)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Malaysia, Thailand	
21	Sweet Potato Stem Borer	*Omphisa anastomosalis*	*Crambidae*	*Lepidoptera*	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Das (1994); EPPO (2021); CTCRI (1983); Zimmerman (1958); Ho (1970); Waterhouse (1993)
22	Southern Armyworm	*Spodoptera eridania*	Noctuidae	Lepidoptera	Minor	No	Yes	Natherlands, United States, Brazil,	NPPO of the Netherlands (2013); EPPO (2021);
23	Fall armyworm	*Spodoptera Frugiperda*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Thailand	FAO (2019); ICAR-NBAIR (2018); IPPC (2019g); Jamil *et al.* (2020); Ratna *et al*. (2019); EPPO (2021)
24	Cotton Leaf worm	*Spodoptera littoralis*	Noctuidae	Lepidoptera	Major	No	Yes	Bahrain, China, India, Saudi Arabia,	EPPO (2021); Chen BoSheng *et al.* (2016); Prasad and Bhattacharya (1975)
25	Taro Caterpillar	*Spodoptera litura*	Noctuidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Japan, Malaysia, Nepal, Singapore, Thailand	EPPO (2021); Wang XueGui *et al.* (2018); Singh *et al.* (2018); Murata *et al.* (2006); AVA (2001); Ruttanaphan *et al.* (2018)
26	Impatiens hawkmoth	*Theretra oldenlandiae*	Sphingidae	Lepidoptera	Major	No	Yes	China, India, Indonesia, Japan, Malaysia, Nepal	Chu and Wang (1980); Bell and Scott (1937), CABI (Undated); Inoue (1961)
27	Black hairy caterpillar	*Estigmene chinensis* Hope	Arctiidae	Lepidoptera	Minor	Yes	No	Bangladesh, India	APPPC (1987); Gurule and Nikam (2013)
28	Sweet potato hairy	*Pericallia recini (Fabricius)*	Arctiidae	Lepidoptera	Minor	Yes	No	Bangladesh, India	APPPC (1987); Gurule and Nikam (2013)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
	caterpillar								
29	Jute hairy caterpillar	*Spilarctia obliqua (Walker)*	Arctiidae	Lepidoptera	Minor	Yes	No	Bangladesh, China, India, Nepal	Uddin *et al.* (2013); Selvaraj *et al.* (2015)
30	Spotted Tortoise Beetle	*Asidimorpha miliaris*	Chrysomelidae	Coleoptera	Major	No	Yes	India, Indonesia, Malaysia, Singapore, Thailand	Waterhouse (1993); AVA (2001)
31	Chafer Beetle	*Apogonia cribricollis*	Scarabaeidae	Coleoptera	Minor	No	Yes	Indonesia, Malasia, Singapure	EPPO (2021); Waterhouse (1993)
32	Cocoa Weevil	*Araecerus fasciculatus*	Anthribidae	Coleoptera	Major	No	Yes	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Li DanDan *et al.* (2018); Mphuru (1974); Seebens *et al.* (2017); Waterhouse (1993);
33	Sweet Potato Leaf weevil	*Blosyrus impomoeae*	Curulionidae	Coleoptera	Minor	No	Yes	India	EPPO (2021)
34	Flea Beetle	*Chaetocnema confinis*	Chrysomelidae	Coleoptera	Minor	No	Yes	India, Japan, Thailand	CABI and EPPO (2009); Jolivet (1979)
35	Sweet Potato Weevil	*Cylas formincarius*	Apionidae	Coleoptera	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	EPPO (2021); Seebens *et al.* (2017); Waterhouse (1993)
36	West Indian Sweet Potato Weevil	*Euscepes postfasciatus*	Curculionidae	Coleoptera	Major	No	Yes	Japan	Kohama and Sugiyama (2000)
37	Green Weevil	*Hypomeces squamosus*	Curulionidae	Coleoptera	Minor	No	Yes	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	CABI (Undated a), Mazumder *et al.* (2015); Waterhouse (1993); Kôno (1930)
38	Tortoise beetle	*Aspidomorpha dorsata* Fabricius	Chrysomelidae	Coleoptera	Minor	Yes	No	Bangladesh	DAE (2019)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
39	Sweet potato beetle	*Carphurus sp.*	Melachiidae	Coleoptera	Minor	Yes	No	Bangladesh	DAE (2019)
Mite pest									
40	Tomato Russet Mite	*Aculops lycopersici*	Eriophyidae	Acariformes	Major	No	Yes	China, Japan, Saudi Arabia, Sri Lanka	EPPO (2021); Seebens *et al.* (2017)
41	Carmine Spider Mite	*Tetranychus cinnabarinus*	Tetranychidae	Acariformes	Major	No	Yes	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Liu and Li (1993); CABI (Undated a); Waterhouse (1993); Yanagida *et al.* (1996); Waterhouse (1993)
B. Diseases of sweet potato									
Causal organism: Fungi									
42	White Rust of Sweet Potato	*Albugo ipomoeae-panduratae*	Albuginaceae	Peronosporales	Minor	No	Yes	India	Rashtra Vardhana (2017)
43	Sclerotium Rot	*Athelia rolfsii*	Atheliaceae	Polyporales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	UK, CAB International (1992); AVA (2001); Lim and Sijam (1989); Takahashi and Tsukiboshi (2012); Naito *et al.* (1993); Sunita Chandel and Gupta (2016)
44	Ceratocystis Blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	Minor	No	Yes	China, India, Indonesia, Japan, Malaysia, Thailand	Li *et al.* (2019); EPPO (2021); Engelbrecht and Harrington (2005);
45	Choanephora fruit rot	*Choanephora cucurbitarum*	Choanephoraceae	Mucorales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	CABI and EPPO (2008); AVA (2001); Siddhartha Das *et al.* (2017); Sun *et al.* (2018)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
46	Leaf & Stem Scab	*Elsinoe batatas*	Elsionaceae	Myriangiales	Major	No	Yes	China, Indonesia, Japan, Malaysia, Singapore, Thailand	EPPO (2021)
47	Fusarium Wilt of Sweet Potato	*Fusarium oxysporum f.sp. batatas*	Nectriaceae	Hypocreales	Major	No	Yes	China, Japan, India	CABI (Undated a); Holliday (1970); Tombe and Sitepu (1986); Holliday (1970)
48	Diplodia Pod Rot of Cocoa	*Lasiodiplodia theobromae*	Botryosphaeriaceae	Botryosphaeriales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	Briste *et al.* (2019); Zhang *et al.* (2021); Rashtra Vardhana (2017); CABI and EPPO (2010); Sato *et al.* (2008); Ammar and El-Naggar (2011)
49	Charcoal rot of bean	*Marcophomina phaseolina*	Botryosphaeriales	Botryosphaeriaceae	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal,	Bakr and Ahmed (1991); Cai Lin *et al*. (2021); Lokesh *et al.* (2020); UK, CAB International (1985); Kanapathipillai and Hashim (1981)
50	Scurf of Sweet Potato	*Monilochaetes infuscans*	Chaetosphaeriaceae	Chaetosphaeriales	Major	No	Yes	China, Japan, Korea	EPPO (2021); UK, CAB International (1981);
51	Cottony Soft Rot	*Sclerotinia sclerotiorum*	Sclerotiniaceae	Helotiales	Minor	Yes	No	Bangladesh, China, India, Japan, Nepal, Singapore, Thailand	Islam *et al.* (2020); Wang FanFan *et al.* (2020); Rathi *et al.* (2018); Sakamoto *et al.* (2019); CABI and EPPO (2005)
52	Sweet potato leaf spot	*Phaeoisariopsis bataticola; Cercospora batatae*	Mycosphaerellaceae	Capnodiales	Minor	Yes	No	Bangladesh, India	EPPO (2021)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
53	Soft rot	*Rhizopus nigiricans*	Mucoraceae	Mucorales	Minor	Yes	No	Bangladesh, China, India, Japan,	Helal *et al.* (2018); Cheng *et al.* (2017); Rashtra Vardhana (2017); CABI (Undated b)
Causal organism: Bacteria									
54	Bacterial Root Rot of Sweet Potato	*Pectobacterium carotovorym subsp. Carotovorum*	Enterobacteriaceae	Enterobacteriales	Major	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia, Singapore, Thailand	Hossain (1994); Huang *et al.* (2017); Karwasra and Parashar (1988); Sulikanti Agusni and Rumawas (1978); Kobayashi *et al.* (1990); Golkhandan *et al.* (2013); Tawfik *et al.* (1981); AVA (2001),
55	Crown Gall	*Rhizobium radiobacter*	Rhizobiaceae	Rhizobiales	Major	No	Yes	China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia	EPPO (2021); Furuya *et al.* (2004); Lamichhane *et al.* (2009)
56	Gall	*Rhizobium rhizogenes*	Rhizobiaceae	Rhizobiales	Major	No	Yes	China, India, Indonesia, Japan, Malaysia	Bradbury (1986); Verma and Thapa (2005); Sawada *et al.* (1990);
57	Sweet Potato Witches' Broom	*Sweet potato little leaf phytoplasma*	Acholeplasmataceae	Acholeplasmatales	Major	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia	EPPO (2021); CABI and EPPO (2001);
Causal Organism: Nematode									
58	Sting nematode	*Belonolaimus longicaudatus*	Belonolaimidae	Metazoa	Minor	No	Yes	India, Pakistan, Saudi Arabia, Turkey	Pathan *et al.*, 2004; Abu-Gharbieh & Al-Azzeh, 2004
59	Potato Tuber Nematode	*Ditylenchus destructor*	Anguinidae	Tylenchida	Minor	Yes	No	Bangladesh, China, Indonesia, Japan, Saudi Arabia	DAE (2019); Mao YanZhi et al. (2020);

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
									EPPO (2021); CABI/EPPO (2013)
60	Common Spiral nematode	*Helicotylenchus dihystera*	Hoplolaimidae	Tylenchida	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	CABI and EPPO (2010); Ali and Sharma (2003); AVA (2001)
61	Peanut root-knot nematode	*Meloidogyne arenaria*	Meloidogynidae	Tylenchida	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Thailand	CABI and EPPO (2003); Zeng JianMin *et al.* (2018); Poornima *et al.* (2017); El-Sherbiny (2011);
62	Pacara Earpod tree root-knot nematode	*Meloidogyne enterolobii*	Meloidogynidae	Tylenchida	Minor	No	Yes	China, India, Singapore, Thailand	Xiao *et al.* (2018); EPPO (2021); Kumar and Rawat (2018);
63	Nematode, Northern Root Lesion	*Pratylenchus penetrans*	*Pratylenchidae*	Tylenchida	Minor	Yes	No	Bangladesh, China, India, Japan, Saudi Arabia, Singapore,	DAE (2019); EPPO (2021); CABI and EPPO (2003);
64	Reniform nematode	*Rotylenchulus reniformis*	*Hoplolaimidae*	Tylenchida	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia, Singapore, Thailand	EPPO (2021); Zhang *et al.* (2019); Aasia Rashid *et al.* (2014); El-Sherbiny (2011);
Causal Organism: Virus									
65	Sweet Potato Chlorotic Stunt Virus	*Sweet Potato Chlorotic Stunt Virus*	Closteroviridae		Minor	No	Yes	China, Korea	EPPO (2021); Yun *et al.* (2002)
66	Sweet Potato Latent Virus	*Sweet Potato Latent Virus*	Potyviridae		Minor	Yes	No	Bangladesh, China, Japan, Korea	DAE (2019); CABI (Undated); Marinho and Dusi (1995)

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
67	Sweet Potato Leaf Curl Virus	*Sweet Potato Leaf Curl Virus*	Geminiviridae		Minor	Yes	No	Bangladesh, India, Korea	DAE (2019): Geetanjali *et al.* (2013); Kil *et al.* (2014)
68	Mild Mottle of Sweet Potato	*Sweet potato mild mottle virus*	Potyviridae		Minor	Yes	No	Bangladesh, China, Indonesia, Japan	DAE (2019); Zhang LiMing et al. (2005); CABI and EPPO (2009)
69	Sweet potato feathery mottle virus	*Sweet potato feathery mottle virus*	Potyviridae		Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan	DAE (2019); Zhao FuMei *et al.* (2020); Prasanth and Hegde (2008)
70	Chlorotic fleck virus	*Sweet potato chlorotic fleck virus (SPCFV)*	Betaflexiviridae	Tymovirales	Minor	Yes	No	Bangladesh, China	Deng *et al.* (2014);
C. Weeds of Sweet Potato									
71	Bermuda grass	*Cynodon dactylon* (L.) Pers.	Poaceae	Cyperales	Major	Yes	No	Bangladesh, China, India, Indonesia, Japan, Nepal, Thailand	EPPO (2021); Waterhouse (1993)
72	Nut grass	Cyperus rotundus	Cyperaceae	Poales	Major	Yes	No	Bangladesh, China, India, Indonesia, Japan, Nepal, Thailand	EPPO (2021); Waterhouse (1993)
73	Alligator Weed	*Alternanthera philoxeroides*	Amaranthaceae	Caryophyllales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Nepal, Thailand	EPPO (2021); Waterhouse (1993)
74	Palmer Amaranth	*Amaranthus palmeri*	Amaranthaceae	Caryophyllales	Minor	No	Yes	China, India, Japan	EPPO (2021); GRIIS (2019)
75	Celosia	*Celosia argentea*	Amaranthaceae	Caryophyllales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia,	Holm *et al.* (1991); Chen *et al.* (2016); Nayak and Satapathy (2015);

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Nepal, Singapore, Thailand	Waterhouse (1993); Seebens *et al.* (2017)
76	Common Ragweed	*Ambrosia artemisiifolia*	Asteraceae	Asterales	Minor	No	Yes	China, India, Japan	EPPO (2021); Seebens *et al.* (2017)
77	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Asterales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Thailand	EPPO (2021); Seebens *et al.* (2017)
78	Red tassel flower	*Emilia sonchifolia*	Asteraceae	Asterales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	Holm *et al.* (1997); Yang *et al.* (2012); USDA-ARS (2018); Wibowo and Iskandar (2013); Chong *et al.* (2009)
79	Bitter Vine	*Mikania micrantha*	Asteraceae	Asterales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Malaysia, Nepal, Singapore, Thailand	EPPO (2021); Tang *et al.* (2020); Swapna Vijayan and Joy (2016); Seebens *et al.* (2017)
80	Scarlet Pimpernel	*Angallis arvensis*	Primulales	Primulales	Minor	No	Yes	Bhutan, China, India, Japan, Nepal, Saudi Arabia,	Parker (1992); Tang (1991); Holm *et al.* (1991); Ishimine *et al.* (1982); Dangol (1987)
81	Wandering jew	*Commelina benghalensis*	Commelinaceae	Commelinales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	EPPO (2021); Ciba Geigy (1982); Devi *et al.* (2015); Waterhouse (1993); Wilson (1981)
82	Southern Crabgrass	*Digitaria ciliaris*	Poaceae	Cyperales	Minor	Yes	No	Bahrain, Bangladesh, China, India,	Clayton *et al.* (2014); He YunHe and

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
								Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	Qiang Sheng (2014); Holm *et al.* (1979); Waterhouse (1993);
83	Barnyard Grass	*Echinochloa crus-galli*	Poaceae	Cyperales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Thailand	USDA-ARS (2014); He YunHe and Qiang Sheng (2014); Nayak and Satapathy (2015); Waterhouse (1993); USDA-ARS (2014)
84	Goose Grass	*Eleusine indica*	Poaceae	Cyperales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia, Singapore, Thailand	Holm *et al.* (1979); Song *et al.* (2019); Duary and Mukherjee (2013); USDA-ARS (2014); Hakim *et al.* (2013); Chaudhary *et al.* (1981)
85	Chinese Sprangle top	*Leptochloa chinensis*	Poaceae	Cyperales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, , Thailand	DAE (2019); He YunHe and Qiang Sheng (2014); Munirathnam and Kumar (2014); EPPO (2021); Hakim *et al.* (2013)
86	Green Foxtail	*Setaria viridis*	Poaceae	Cyperales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Saudi Arabia, Thailand	Holm *et al.* (1979); Song *et al.* (2019); Chaudhary *et al.* (1981); Teerawatsakul *et al.* (1987)
87	Dove weeds	*Murdannia nudiflora*	Commelinaceae	Commelinales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Thailand	CABI (Undated); Flora of China Editorial Committee (2017); Duary and Mukherjee (2013); USDA-ARS (2017);

SN	Common Name	Scientific name	Family	Order	Pest status	Presence in Bangladesh	Quarantine status	Distribution	References
									Nakamura (2015); Govaerts (2017)
88	Prostrate Knotweed	*Polygonum aviculare*	Polygonaceae	Polygonales	Minor	Yes	No	Bangladesh, China, India, Japan, Nepal, Saudi Arabia	Holm *et al.* (1997); Liu *et al.* (2016);
89	Marsh Pepper	*Polygonum hydropiper*	Polygonaceae	Polygonales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal	Holm *et al.* (1997);
90	Black Nightshade	*Solanum nigrum*	Solanaceae	Solanales	Minor	Yes	No	Bangladesh, China, India, Indonesia, Japan, Malaysia, Saudi Arabia, Thailand	CABI (Undated a); Chaudhary and Zawawi (1983)
D. Rodent									
91	Pacific rat	*Rattus exulans*	Muridae	Rodentia	Major	Yes	No	Bangladesh, China, India, Japan, Malaysia,	Seebens *et al.* (2017); CABI 2022

4.5. Quarantine Pests of Sweet Potato for Bangladesh

Thirty-three (33) species of quarantine pests of sweet potato for Bangladesh were identified those were recorded in India, China, Japan, Thailand, Mayanmar, Indonesia, and other countries of the world, but not in Bangladesh. Among these 33 species of quarantine pests, 18 were insect pests, 3 species were mite pests, 5 fungi, 2 bacteria, 2 nematode species, 1 viruses and weed were two species (Table 4.5).

The quarantine insect pests are Cirtus Locust (*Chondracris rosea),* Winter cherry bug (*Acanthocoris sordidus),* Tomato/Potato psyllid *(Bactericera cockerelli),* Barnacle Scale (*Ceroplastes cirripediformis),* Spiked Mealybug (*Nipaecoccus nipae*), Sweet potato butterfly (*Acraea acerate),* Pink-spotted Hawk moth (*Agrius Cingulatus).* Sweet Potato Leaf miner *(Bedellia somnulentella),* Southern Armyworm (*Spodoptera eridania),* Cotton Leaf worm (*Spodoptera littoralis*), Impatiens hawkmoth (*Theretra oldenlandiae),* Spotted Tortoise Beetle (*Asidimorpha miliaris),* Chafer Beetle (*Apogonia cribricollis),* Cocoa Weevil (*Araecerus fasciculatus),* Sweet Potato Leaf weevil (*Blosyrus impomoeae),* Flea Beetle (*Chaetocnema confinis),* West Indian Sweet Potato Weevil (*Euscepes postfasciatus)* and Green Weevil (*Hypomeces squamosus).* The quarantine mite pests of sweet potato for Bangladesh are Tomato Russet Mite (*Aculops lycopersici*), Carmine Spider Mite (*Tetranychus cinnabarinus*) and Red spider mite (*Tetranychus evansi*).

On the other hand, ten (10) disease causing pathogens have been identified as quarantine pests of sweet potato for Bangladesh. Among these, 5 quarantine fungus named White Rust of Sweet Potato (*Albugo ipomoeae-panduratae),* Ceratocystis Blight *(Ceratocystis fimbriata),* Leaf & Stem Scab *(Elsinoe batatas),* Fusarium Wilt of Sweet Potato (*Fusarium oxysporum f.sp. batatas*) and Scurf of Sweet Potato (*Monilochaetes infuscans*); 2 quarantine bacteria namely Crown Gall (*Rhizobium radiobacter*) and Gall *(Rhizobium rhizogenes); 2* species of nematode namely Sting nematode (*Belonolaimus longicaudatus*) and Pacara Earpod tree root-knot nematode *(Meloidogyne enterolobii);* 1 virus namely *Sweet Potato Chlorotic Stunt Virus*. 2 species of quarantine weed has been identified Bangladesh named Parthenium weed *(Parthenium hysterophorus),* and Scarlet Pimpernel (*Angallis arvensis*) (Table 4.5).

Table-4.5: Quarantine pests for Bangladesh likely to be associated with sweet potato imported from tuber/Vine 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	Cirtus Locust	*Chondracris rosea*	China, Japan, Malaysia, Thailand	Tuber, Vine	CABI/EPPO, 2021
2	Winter cherry bug	*Acanthocoris sordidus*	Japan, Taiwan	Tuber, Vine	CABI (2021)
3	Tomato/Potato psyllid	*Bactericera cockerelli*	Australia, New Zealand, United States	Tuber, Vine	EPPO (2021)
4	Barnacle Scale	*Ceroplastes cirripediformis*	India	Vine	Sunil Joshi *et al.* (2021)
5	Spiked Mealybug	*Nipaecoccus nipae*	China, India, Indonesia, Thailand	Tuber, leaves, seedlings	CABI and EPPO (2005)
6	Sweet potato butterfly	*Acraea acerate*	Ethiopia, Kenya, Nigeria	leaves	Girma (1993)
7	Pink-spotted Hawk moth	*Agrius Cingulatus*	USA	Flower, Leaf	CABI Data Mining (Undated)
8	Sweet Potato Leaf miner	*Bedellia somnulentella*	China, Japan, Indonesia, Thailand	Leaf	CABI (Undated)
9	Southern Armyworm	*Spodoptera eridania*	Natherlands, United States, Brazil,	Leaf, seedlings, Tuber	EPPO (2021)
10	Cotton Leaf worm	*Spodoptera littoralis*	Bahrain, China, India, Saudi Arabia,	Leaf, Vine,	EPPO (2021)
11	Impatiens hawkmoth	*Theretra oldenlandiae*	China, India, Indonesia, Japan, Malaysia, Nepal	Leaf, inflorescence	CABI (Undated)
12	Spotted Tortoise Beetle	*Asidimorpha miliaris*	India, Indonesia, Malaysia, Singapore, Thailand	Leaf, Vine	AVA (2001)
13	Chafer Beetle	*Apogonia cribricollis*	Indonesia, Malasia, Singapure	Leaf, Vine	EPPO (2021)
14	Cocoa Weevil	*Araecerus fasciculatus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Tuber, vine	Waterhouse (1993)
15	Sweet Potato Leaf weevil	*Blosyrus impomoeae*	India	Leaf, Vine	EPPO (2021)
16	Flea Beetle	*Chaetocnema confinis*	India, Japan, Thailand	Tuber, Leaf	CABI and EPPO (2009); Jolivet (1979)

Sl. No.	Common name	Scientific Name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
17	West Indian Sweet Potato Weevil	*Euscepes postfasciatus*	Japan	Tuber, Leaf	Kohama and Sugiyama (2000)
18	Green Weevil	*Hypomeces squamosus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Tuber, Leaf	CABI (Undated a)
Mite pest					
19	Tomato Russet Mite	*Aculops lycopersici*	China, Japan, Saudi Arabia, Sri Lanka	Leaf, vine, tuber	EPPO (2021)
20	Carmine Spider Mite	*Tetranychus cinnabarinus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Leaf, vine, tuber	EPPO (2021)
21	Red spider mite	*Tetranychus evansi*	Japan, China, Taiwan	Leaf, vine, tuber	EPPO (2022)
Disease causing organisms					
Fungi					
22	White Rust of Sweet Potato	*Albugo ipomoeae-panduratae*	India	Leaf, Tuber	Rashtra Vardhana (2017)
23	Ceratocystis Blight	*Ceratocystis fimbriata*	China, India, Indonesia, Japan, Malaysia, Thailand	Leaf	EPPO (2021)
24	Leaf & Stem Scab	*Elsinoe batatas*	China, Indonesia, Japan, Malaysia, Singapore, Thailand	Leaf, vine, tuber	EPPO (2021)
25	Fusarium Wilt of Sweet Potato	*Fusarium oxysporum f.sp. batatas*	China, Japan, India	Seedling, tuber	CABI (Undated a)
26	Scurf of Sweet Potato	*Monilochaetes infuscans*	China, Japan, Korea	Leaf, tuber	EPPO (2021)
Bacteria					
27	Crown Gall	*Rhizobium radiobacter*	China, India, Indonesia, Japan, Malaysia, Nepal, Saudi Arabia	Tuber, leaf	EPPO (2021)
28	Gall	*Rhizobium rhizogenes*	China, India, Indonesia, Japan, Malaysia	Tuber, leaf	EPPO (2021)
Nematode					
29	Sting nematode	*Belonolaimus longicaudatus*	India, Pakistan, Saudi Arabia, Turkey	Tuber	Khan *et al.* (2007)
30	Pacara Earpod tree root-knot nematode	*Meloidogyne enterolobii*	China, India, Singapore, Thailand	Tuber	EPPO (2021)
Virus					
31	Sweet Potato Chlorotic Stunt Virus	*Sweet Potato Chlorotic Stunt Virus*	China, Korea	Tuber, leaf	EPPO (2021);
Weeds					
32	Parthenium weed	*Parthenium hysterophorus*	Bhutan, India, Indonesia, Israel, Japan, Jordan,	Transport, equipment	EPPO, 2014

Sl. No.	Common name	Scientific Name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
			Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam, South Africa, USA,		
33	Scarlet Pimpernel	*Angallis arvensis*	Bhutan, China, India, Japan, Nepal, Saudi Arabia,	Transport, equipment	EPPO (2021);

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CHAPTER V

RISK ASSESSMENT

The risk analysis of quarantine pests included 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 of quarantine pests of sweet potato 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 sweet potato identified for Bangladesh has been analyzed details as follows:

5.A . Arthopod: Insect and mites pests

5.1.	Tomato/Potato psyllid (*Bactericera cockerelli*)

5.1.1. Hazard identification

Scientific Name: *Bactericera cockerelli (*Šulc*)*
Synonyms: *Paratrioza cockerelli* (Šulc) 1909
Common names: Tomato/potato psyllid
Taxonomic tree

- Domain: Eukaryota
- Kingdom: Metazoa
  - Phylum: Arthropoda
    - Subphylum: Uniramia
      - Class: Insecta
        - Order: Hemiptera
          - Suborder: Sternorrhyncha
            - Unknown: Psylloidea
              - Family: Triozidae
                - Genus: Bactericera
                  - Species: *Bactericera cockerelli*

EPPO Code: PARZCO (*Paratrioza cockerelli*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2021]

5.1.2. Biology

In an effort to identify and develop a sex pheromone and other attractants that can be used to develop improved integrated pest management programs for *B. cockerelli*, its reproductive biology and the role of chemical signals in sex attraction were studied by Guédot *et al.* (2010; 2012). It was determined for the first time that the potato psyllid possesses a female-produced pheromone that attracts males (Guédot *et al.,* 2010). Guédot *et al*. (2012) also showed that adult potato psyllids reach reproductive maturity within 48 hours post-eclosion, with females being mature on the day of eclosion and males at one day post-eclosion. In addition, oviposition generally began two days after mating but was delayed when females mated within two days post-eclosion.

Optimum psyllid development occurs at approximately 27°C, whereas oviposition, hatching, and survival are reduced at 32°C and cease at 35°C (List, 1939; Pletsch, 1947; Butler and Trumble, 2012). A single generation may be completed in three to five weeks, depending on temperature. The number of generations varies considerably among regions, usually ranging from three to seven. However, once psyllids colonize an area, prolonged oviposition causes the generations to overlap, making it difficult to distinguish between generations (Pletsch, 1947; Wallis, 1955; Munyaneza *et al.,* 2009a). Both adults and nymphs are very cold tolerant, with nymphs surviving temporary exposure to temperatures of -15°C and 50% of adults surviving exposure to -10°C for over 24 hours (Henne *et al.,* 2010a).

5.1.3. Hosts

B. cockerelli is found primarily on plants within the family Solanaceae. The psyllid attacks, reproduces and develops on a variety of cultivated and weedy plant species (Essig, 1917; Knowlton and Thomas, 1934; Pletsch, 1947; Jensen, 1954; Wallis, 1955), including crop plants such as potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), tomato (*Solanum lycopersicon*), pepper (*Capsicum annuum*), eggplant (*Solanum melongena*) and tobacco (*Nicotiana tabacum*) as well as non-crop species such as nightshade (*Solanum* spp.), groundcherry (*Physalis* spp.) and matrimony vine (*Lycium* spp.).

Adults have been collected from plants in numerous families, including Pinaceae, Salicaceae, Polygonaceae, Chenopodiaceae, Brassicaceae, Asteraceae, Fabaceae, Malvaceae, Amaranthaceae, Lamiaceae, Poaceae, Menthaceae and Convolvulaceae, but this is not the complete host range of this psyllid (Pletch, 1947; Wallis, 1955; Cranshaw, 1993). Beside solanaceous species, *B. cockerelli* has been shown to reproduce and develop on some Convolvulaceae species, including field bindweed (*Convolvulus arvensis*) and sweet potato (*Ipomoea batatas*) (Puketapu and Roskruge, 2011; Munyaneza, unpublished data).

5.1.4. Distribution

B. cockerelli is native to North America and occurs mainly in the Great Plains region of the United States, from Colorado, New Mexico, Arizona and Nevada, north to Utah. More recently, its range has expanded to include Wyoming, Idaho, Montana, California, Oregon, Washington, Alberta and Saskatchewan (Ferguson *et al.,* 2003). This insect pest is common in southern and western Texas and has also been documented in Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Minnesota and as far west as California and British Columbia.

B. cockerelli also occurs in Mexico and Central America, including Guatemala and Honduras (Munyaneza et al., 2014), and most recently was reported from Nicaragua (Munyaneza et al., 2013a). *B. cockerelli* is also suspected to be present in neighbouring countries, including El Salvador (Bextine *et al.,* 2013a). There are no early records of *B. cockerelli* in Central America, and it is possible that Central America, as well as the northern portions of its current North American range, represents a newly-colonized area.

B. cockerelli is also widespread in New Zealand (Teulon *et al.,* 2009).

North America: Canada (CABI and EPPO 2015); Mexico (Tuthill, 1945), United States (EPPO, 2022),
Oceania: Australia (EPPO, 2022), New Zealand (EPPO, 2022), Botswana (CABI/EPPO, 2014), Cote d'Molre (CABI/EPPO, 2014), Kenya (CABI/EPPO, 2014), South Africa (Schoeman & Mohlala, 2013), Tanzania (CABI/EPPO, 2014), Zambia (CABI/EPPO, 2014).

5.1.5. Hazard Identification Conclusion

Considering the facts that *Bactericera cockerelli*:

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially less economic important to Bangladesh because it is an important pest of sweet potato United States, southern Canada, Mexico, Central America and New Zealand (Munyaneza, 2012) from where sweet potato are not imported to Bangladesh.
  - This insect was introduced into New Zealand, where it was recently found established in tomato glasshouses and several outdoors solanaceous crops (Thomas *et al.,* 2011). It is not clear on how the insect arrived in New Zealand, but it was most likely transported with plant material, possibly as eggs (Thomas *et al.,* 2011). Entry on fruits of host species (e.g. tomato, pepper, eggplant) is possible, especially when they are associated with green parts (e.g. truss tomato). Entry on potato tuber is more unlikely.
  - *B. cockerelli* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.1.1: Which of these descriptions best fit of this pest?

<table>
<tr><th>Description</th><th>Establishment Potential</th></tr>
<tr><td>
a. Has this pest been established in several new countries in recent years-Yes,
• B. cockerelli is a serious and economically important pest of potatoes, tomatoes and other solanaceous crops in the western United States, southern Canada, Mexico, Central America and New Zealand (Munyaneza, 2012). Suitable host plants are widespread in almost any part the world and, given its current distribution in the Americas and New Zealand, it is thought that B. cockerelli could establish and overwinter outdoors in areas with warm climate and mild winters. It could also establish under protected conditions in many regions.
• B. cockerelli has been recorded in Canada; Mexico, United States, Australia, New Zealand (EPPO, 2022), from where Bangladesh does not import tuber and vine.
b. Possibility of survival during transport, storage and transfer? Yes
• Bactericera cockerelli can survive as nymphs for up to 90 days but usually takes only 14–21 days before developing into adults. Eggs hatch within a few days of being laid. The entire duration of the lifecycle is 4–5 weeks, but this varies considerably depending on hosts and temperature (UNL 2009).
• Optimum psyllid development occurs at approximately 27°C, whereas oviposition, hatching, and survival are reduced at 32°C and cease at 35°C (Butler and Trumble, 2012). A single generation may be completed in three to five weeks, depending on temperature. The number of generations varies considerably among regions, usually ranging from three to seven. However, once psyllids colonize an area, prolonged oviposition causes the generations to overlap, making it difficult to distinguish between generations (Munyaneza et al., 2009a). Both adults and nymphs are very cold tolerant, with nymphs surviving temporary exposure to temperatures of -15°C and 50% of adults surviving exposure to -10°C for over 24 hours (Henne et al., 2010a).
• Long distance transport of different life stages of this insect pest is possible, particularly by commercial trade of plant material for propagation and produce in the family Solanaceae, which constitute major hosts for B. cockerelli. Based on the discovery of at least four haplotypes of potato psyllid in North and Central America, seasonal dispersal of this insect into potato crops was recently reviewed and discussed by Nelson et al. (2014).
• The optimum temperature for the development and survival of B. cockerelli is 27°C. Temperatures below 16°C or above 32°C are reported to adversely affect the development and survival of this pest (Ferguson et al. 2003).
• The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival.
• For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature B. cockerelli can survive.
• Besides, psyllids can migrate long distances, and flights of up to 83 km have been recorded (HTWG 2007). Similar long flights are likely to be undertaken by B. cockerelli.
c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes,
• Nursery stock represents a higher risk than fruit, as nursery stock of host species supports all life stages of the psyllid. Adult female B. cockerelli lay their eggs on the leaves of host plants and nymphs are commonly found on the underside of leaves (Horticulture New Zealand 2009). Therefore, propagative material from “Ca. L. psyllaurous”-affected areas may harbour infected B. cockerelli eggs, nymphs and/or adults.
</td><td>YES
and
Moderate</td></tr>
</table>

• *Bactericera cockerelli* feeds on a wide range of plants, which includes species in 20 plant families, but the psyllid only breeds on species in the Solanaceae, Convolvulaceae and Lamiaceae (Wallis 1955). • It would be possible for infected psyllids to enter Bangladesh via trade in commodities, such as fresh fruit and nursery stock, of any of these species but is more likely to be associated with host species. • *Bactericera cockerelli* eggs are quite small and may be difficult to detect during routine visual inspection. Godfrey and Haviland (2008) states that the eggs are best seen with the use of a hand lens. • For *B. cockerelli* host plants are similar in Bangladesh. • Though in case of sweet potato there is no relation with North America and Oceania countries. But in future if we import sweet potato or planting materials from such countries, it became a great problem for us. • For this reason, the pathway appears good for this pest to enter Bangladesh and establishment. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • The host range of *B. cockerelli* is common in Bangladesh and the climate in Bangladesh is also suitable for establishment of *B. cockerelli* in Bangladesh.	
• NOT AS ABOVE OR BELOW	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.1.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.1.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • *B. cockerelli* is found primarily on plants within the family Solanaceae. The psyllid attacks, reproduces and develops on a variety of cultivated and weedy plant species including crop plants such as potato *(Solanum tuberosum),* sweet potato *(Ipomoea batatas),* tomato *(Solanum lycopersicon),* pepper *(Capsicum annuum),* eggplant *(Solanum melongena) and* tobacco *(Nicotiana tabacum) as well as non-crop species such as* nightshade *(Solanum spp.),* groundcherry *(Physalis spp.) and* matrimony vine *(Lycium spp.).* • Adults have been collected from plants in numerous families, including Pinaceae, Salicaceae, Polygonaceae, Chenopodiaceae, Brassicaceae, Asteraceae, Fabaceae, Malvaceae, Amaranthaceae, Lamiaceae, Poaceae, Menthaceae and Convolvulaceae, but this is not the complete host range of this psyllid. Beside solanaceous species, *B. cockerelli* has been shown to reproduce and develop on some Convolvulaceae species, including field bindweed *(Convolvulus arvensis)* and sweet potato *(Ipomoea batatas)* (Puketapu and Roskruge, 2011; Munyaneza, unpublished data). • Though the host plants and climate requirement of *B. cockerelli* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Detailed information on the economic impact of *B. cockerelli* is provided by Munyaneza (2012). Historically, the extensive damage to solanaceous crops that was observed during the outbreak years of the early 1900s is thought to have been due to *B. cockerelli's* association with a physiological disorder in plants referred to as 'psyllid yellows' (Richards	**Yes and High**

and Blood, 1933), presumably caused by a toxin that is transmitted during the insect's feeding activities, especially nymphs (Eyer and Crawford, 1933; Eyer, 1937). • However, the nature of this toxin has not yet been identified. 'Psyllid yellows' is characterized by yellowing and curling of foliage, stunting or death of plants and a loss in yield (Richards and Blood, 1933; Eyer, 1937). Infected tomato plants produce few or no marketable fruits (List, 1939; Daniels, 1954). In potatoes, psyllid yellows result in yellowing or purpling of foliage, the early death of plants and low yields of marketable tubers (Eyer, 1937; Pletsch, 1947; Daniels, 1954; Wallis, 1955). In areas of outbreaks of psyllid yellows, the disorder was often present in 100% of plants in affected fields, with yield losses exceeding 50% in some areas (Pletsch, 1947). • In recent years, potato, tomato, and pepper growers in a number of geographic areas have suffered extensive economic losses associated with outbreaks of potato psyllid (Munyaneza, 2010). This increased damage is due to a previously undescribed species of the bacterium liberibacter, tentatively named 'Candidatus Liberibacter solanacearum' (syn. Ca. L. psyllaurous) (Liefting *et al.,* 2009), now known to be vectored by potato psyllid. Potato psyllids acquire and spread the pathogen by feeding on infected plants (Munyaneza *et al.,* 2007a, b). The bacterium is also transmitted transovarially in the psyllid (Hansen *et al.,* 2008), which contributes to the spread of the disease between geographic regions by dispersing psyllids. It also helps maintain the bacterium in geographic regions during the insect's overwintering period. • Symptoms associated with liberibacter in tomatoes and pepper include chlorosis and purpling of leaves, leaf scorching, stunting or death of plants, and production of small, poor-quality fruit (Crosslin *et al.,* 2010). During the outbreaks of 2001-2003, tomato growers in coastal California and Baja California suffered losses exceeding 50-80% of the crop (Trumble, 2009). In potatoes, foliar symptoms closely resemble those caused by psyllid yellows and purple top diseases (Sengoda *et al.,* 2009). However, tubers from liberibacter-infected plants develop a defect referred to as 'zebra chip', which is not induced by the potential toxin causing psyllid yellows (Sengoda *et al.,* 2009). Tubers show a striped pattern of necrosis, which is particularly noticeable when the tuber is processed for chips or fries (Miles *et al.,* 2010). Chips or fries from affected plants are not marketable. The defect was of sporadic importance until 2004, when it began to cause millions of dollars in losses to potato growers in the United States, Central America and Mexico. The potato industry in Texas estimates that zebra chip could affect over 35% of the potato acreage in Texas, with potential losses annually to growers exceeding 25 million dollars (CNAS, 2006). Finally, quarantine issues have begun to emerge in potato psyllid-affected regions, because some countries now require that shipments of solanaceous crops from certain growing regions be tested for the pathogen before the shipments are allowed entry (Munyaneza, 2012). **c. Environmental Impact** • *B. cockerelli* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And this chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.1.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.1.9. Risk Management Measures

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

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5.2 Spiked Mealybug, *Nipaecoccus Nipae* (Maskell, 1893)

5.2.1. Hazard identification

Scientific Name: *Nipaecoccus nipae* (Maskell, 1893)
Synonyms: *Ceroputo nipae* (Maskell), Lindinger, 1904
Dactylopius dubia Maxwell-Lefroy, 1903
Dactylopius nipae Maskell, 1893
Common names: Spiked mealybug, coconut mealybug

Taxonomic tree

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

EPPO Code: NIPANI (*Nipaecoccus nipae*)
Bangladesh status: Not present in Bangladesh [CABI and EPPO (2005)]

5.2.2 Identification Characteristics

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

5.2.2. Biology

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

5.2.3. Hosts

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

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

5.2.4. Distribution

N. nipae is found in Europe, Asia, Africa, North, Central and South America and Oceania (Ben-Dov, 1994; CABI/EPPO, 2005).
Asia: China (Ben-Dov, 1994), India (Josephrajkumar *et al.,* 2012), Indonesia (CABI/EPPO, 2005), South Korea (CABI/EPPO, 2005), Philippines (Caasi-Lit *et al.,* 2012), Thailand (Waterhouse, 1993), Turkey (CABI/EPPO, 2005).
Africa: Morocco (CABI/EPPO, 2005), South Africa (CABI/EPPO, 2005)
North America: Mexico and USA (CABI/EPPO, 2005)

South Amrica: Brazil, Chile, Argentina, Peru, Colombia (Ben-Dov, 1994; CABI/EPPO, 2005)
Europe: Belgium, Italy, Portugal, Russian federation, Spain, UK (Ben-Dov, 1994; CABI/ EPPO, 2005)
Ocenia: Fiji (Hodgson & Agowska, 2011)

5.2.5. Hazard Identification Conclusion

Considering the facts that *N. nipae*:

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

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

Table-5.2.1: Which of these descriptions best fit of this pest?

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

5.2.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.2.2: Which of these descriptions best fit of this pest?

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

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

Establishment Potential X Consequence Potential = Risk

Table-5.2.3: Calculation of risk rating

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

Calculated Risk Rating-Moderate

5.2.9. Risk Management Measures

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

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5.3	Sweet Potato Leaf miner (*Bedellia somnulentella*)

5.3.1. Hazard identification

Scientific Name: *Bedellia somnulentella* (Zeller)
Synonyms: *Bedellia ipomoeae* Bradley
Common names: Sweet potato leafminer
Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Lyonetiidae
Genus: Bedellia
Species: *Bedellia somnulentella*
EPPO Code: BEDESO *(Bedellia somnulentella)*
Bangladesh status: Not present in Bangladesh [CABI, 2022]

5.3.2. Biology

The microlepidoptera, *Bedellia somnulentella* (Zeller), is an important pest of sweet potato, *Ipomoea batatas* (L.) Lam. Damage by *B. somnulentella* occurs in the larval stage and when consuming the foliar mesophyll of *I. batatas* make the leaves brown, wrinkled, and reducing the photosynthetic area and the yield. The detection and management of this pest depends on knowing its biological cycle and identifying its natural enemies.

Egg: The eggs are oval, flattened against the leaf surface; translucent, greenish white with granulate surface which turns yellowish when about to hatch.

Larva: The emerging larvae are distinctly segmented with a rather pointed heads and abdomens. A mature larva measures 5.5 mm long. The larva has a yellowish body with paired pink spots on the dorsolateral sides of the thorax which later disappear and are replaced by red tubercles in all segments.

Pupa: The pupae measuring 3.5 mm appear green at first with mottled red markings. Later the red markings disappear and they turn dark brown with lateral projections on the abdomen.

Adult: The adults are very small moths, 3.5-4.0 mm long with grayish to brown bodies and light brown scales.

The eggs are laid singly or in groups usually on the lower surface of the leaf near the midrib, veins or at the base of the leaf blade. Incubation lasts 5-6 days. The insect undergoes five larval instars. During the fifth instar, the larva undergoes a short pre-pupal period, comes out of the mine and produces numerous silken threads which fix and support the pupa on the lower surface of the leaf. Pupation lasts 3-6 days. A female adult is capable of laying 1-67 eggs during the 1-2-day oviposition period.

The developmental period of *B. somnulentella* was 32.5 ± 0. 21 d with a viability of 75, 84, 100, and 84% for the egg, larva, prepupa, and pupa stages, respectively. The identification of this pest on the plants is possible from the third instar and in the pupal and adult stages. The parasitoid *Conura* sp. (Hymenoptera: Chalcididae) was identified parasitizing pupae of *B. somnulentella* and could be considered a potential natural enemy for the integrated management of this pest.

5.3.3. Hosts

Apart from sweet potato, leaf miners can also survive on Ipomoea triloba, I. aquatica and I. purpurea.

5.3.4. Distribution

Originally from Asia, where its food plants are found, it has reached a nearly cosmopolitan distribution and has been recorded from Russia, Ukraine, Georgia, southern Kazakhstan, Kirgizia, Uzbekistan, nearly all of Europe, the Middle East, Africa, India, Japan, North America, Australia, New Zealand and Oceania.

Africa: Egypt (Awadallah *et al.* 1976); Nigeria (NHM, 1974); South Africa ((NHM, 1974);

Asia: China (Lin, 1984); Indonesia (CABI, Undated a); Japan (CABI, Undated a); Thailand (CABI, Undated a)

Europe: Austria (Razowski and Karsholt, 1996); Denmark; Finland; France; Germany; Spain, United Kingdom (Razowski and Karsholt, 1996)

North America: Canada (CABI (Undated a)); United States (Seebens *et al.* 2017),

Oceania: Australia Wood (1976), New Zealand (Kuruko, 1964).

South America: Brazil (Santos *et al.* 2018)

5.3.5. Hazard Identification Conclusion

Considering the facts that *Bedellia somnulentella*:

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially economic important to Bangladesh because it is an important pest of sweet potato of China (Lin, 1984); Indonesia (CABI, Undated a); Japan (CABI, Undated a); Thailand (CABI, Undated a) from where sweet potato imported to Bangladesh.
- The larvae are small caterpillars which feed on the green tissue inside the leaf, leaving the transparent upper and lower membranes (epidermis) intact. The young larvae enter the leaf and form serpentine mines (narrow, grey-brown or silvery tracks). As the larva matures, it consumes a broader patch of the leaf, forming blotch mines. Later holes are produced as the mined tissues are destroyed. The lower surface of the infested leaves become dirty with small grains of blackish frass and show silken webbings containing the

small pupae. During high infestation, the leaves become brown. A serious outbreak can cut down the effective leaf surface for plant food production resulting in reduced storage root yield.

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

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

Table-5.3.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years-Yes**, • Originally from Asia, where its food plants are found, it has reached a nearly cosmopolitan distribution and has been recorded from Russia, Ukraine, Georgia, southern Kazakhstan, Kirgizia, Uzbekistan, nearly all of Europe, the Middle East, Africa, India, Japan, North America, Australia, New Zealand and Oceania. **b. Possibility of survival during transport, storage and transfer? Yes** • The eggs are laid singly or in groups usually on the lower surface of the leaf near the midrib, veins or at the base of the leaf blade. Incubation lasts 5-6 days. The insect undergoes five larval instars. During the fifth instar, the larva undergoes a short pre-pupal period, comes out of the mine and produces numerous silken threads which fix and support the pupa on the lower surface of the leaf. Pupation lasts 3-6 days. A female adult is capable of laying 1-67 eggs during the 1-2-day oviposition period. • The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival. • For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature *B. somnulentella* can survive. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes** • The larvae are small caterpillars which feed on the green tissue inside the leaf, leaving the transparent upper and lower membranes (epidermis) intact. young larvae enter the leaf and form serpentine mines (narrow, grey-brown or silvery tracks). As the larva matures, it consumes a broader patch of the leaf, forming blotch mines. Later holes are produced as the mined tissues are destroyed. The lower surface of the infested leaves become dirty with small grains of blackish frass and show silken webbings containing the small pupae. During high infestation, the leaves become brown. A serious outbreak can cut down the effective leaf surface for plant food production resulting in reduced storage root yield. • For *B. somnulentella* host plants are similar in Bangladesh. • For this reason, the pathway appears good for this pest to enter Bangladesh and establishment. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • The host range of *B. somnulentella* is common in Bangladesh and the climate in Bangladesh is also suitable for establishment of *B. somnulentella* in Bangladesh.	**YES and Moderate**
• **NOT AS ABOVE OR BELOW**	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.3.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.3.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • The microlepidoptera, *Bedellia somnulentella* (Zeller), is an important pest of sweet potato, *Ipomoea batatas* (L.) Lam. Damage by *B. somnulentella* occurs in the larval stage and when consuming the foliar mesophyll of I. batatas make the leaves brown, wrinkled, and reducing the photosynthetic area and the yield. • Though the host plants and climate requirement of *B. somnulentella* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Infestation in the field is usually low. However, sporadic heavy outbreaks may occur, particularly during or after a prolonged dry period. **c. Environmental Impact** • *B. somnulentella* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And these chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	**Yes and Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.3.3: 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

5.3.9. Risk Management Measures

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

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5.4	Cotton Leaf worm, *Spodoptera littoralis* (Boisduval)

5.4.1. Hazard identification

Scientific Name: *Spodoptera littoralis* (Boisduval)
Synonyms: *Hadena littoralis (*Boisduval)
Noctua gossypii
Prodenia littoralis (Boisduval)
Prodenia retina (Freyer)
*Prodenia testaceoides (*Guenee)
Common names: Egyptian cotton leafworm
Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Noctuidae
Genus: Spodoptera
Species: *Spodoptera littoralis*
EPPO Code: SPODLI (*Spodoptera littoralis*)
Bangladesh status: Not present in Bangladesh [CABI and EPPO (2022)]

5.4.2 Identification characteristics

- Eggs are whitish-yellow and are laid in masses on the lower surface of young leaves. They are covered with hair scales from the female's abdomen.
- Six larval instars occur. Feeding damage is similar to *S. litura* with initial larval feeding resulting in leaf skeletonization. Larvae are hairless and blackish-grey to dark green when recently hatched, as they mature they become reddish-brown or whitish-yellow. Caterpillars have dark and light longitudinal bands and two dark, semi-circular spots on their back. When recently hatched, larvae begin feeding on the underside of leaves, but as they mature they move towards the upper surface of leaves. Larvae may also feed on fruits, pods and stems of plants. They can grow up to 1.5 to 1.75 inches in length. They pupate 0.5 inches below the surface of the soil in a clay cocoon. When the pupae form, they are green with a reddish abdomen but they turn dark reddish-brown pretty quickly.
- Adults are gray-brown and marked by grey to reddish-brown forewings with paler lines along the veins. The tip of the forewing (apex) is light brown, with a distinct white marking shaped like an "A" and a white, three-branched fork-like pattern. Hind wings are whitish, glossy with grayish-brown margins and veins as well as fringe hairs.

5.4.3. Biology

Female moths lay most of their egg masses (20-1000 eggs) on the lower surface of younger leaves or upper parts of the plant (Khalifa *et al.,* 1982). On cotton, the first three larval instars feed mainly on the lower surface of the leaves, whereas later instars feed on both surfaces.

The larvae feed mainly in the dark, although this behaviour pattern may be less noticeable in early instars (Hassan *et al.,* 1960). Pinhey (1975) recorded that >50% of the nocturnal larval population consisted of early instar larvae. In summer the majority of fifth- and sixth-instar larvae leave the plants during mid-morning until sunset, returning to climb the plant at night (Baker and Miller, 1974). Third- and fourth-instars rest on the plant and remain stationary unless overcrowded.

On pupation the fully grown larva pushes the loose surface of the soil downwards until it reaches more solid ground 3-5 cm deep. It then creates a clay 'cell' or cocoon in which it usually pupates within 5-6 hours (Pinhey, 1975).

Emergence of adult moths occurs at night and they have a life span of 5-10 days (Shalama and Shoukry, 1972). The reproductive capacity, egg facility and life span of moths are affected by the difference in ages between males and females. The highest ratio of egg fertility was obtained by mating between 4-day-old males with fresh females (Nasr and Nassif, 1978). There is also a correlation between the host plant and the longevity and fecundity of *S. littoralis* (Dimetry and Nadia, 1972). The majority of adults mate on the first night of emergence, copulation lasting for 20 minutes to 2 hours. Approximately 50% of mated females lay their eggs on the same night of mating, before sunrise (Hassan et al., 1960). Adults fly at night, mostly between 20.00 and midnight (Nasr *et al.,* 1981). Flight activity is governed by atmospheric conditions, increases in relative humidity and decreases in air temperature inducing flight (Hassan *et al.,* 1960). The flight range during a 4-hour-period can be up to 1.5 km (Salama and Shoukry, 1972).

The moths have chemoreceptors on the ventral surface of the tarsi and the distal portion of the proboscis. These are highly sensitive and respond to a certain number of sugars mainly present in nectar. Pheromones (comprising of tetradecadien-1-ol acetates) have been isolated and successfully used in traps (Kehat and Gordon, 1975; Campion, 1977).

The minimum constant temperature for normal development in all stages is 13-14°C. Resistance to cold generally increases through the larval stages and is greatest in the pupal stage (Miller, 1977). At 18°C, egg, larval and pupal stages last 9, 34 and 27 days, respectively. At 36°C, egg, larval and pupal stages last 2, 10 and 8 days, respectively. Data on survival and development at different temperatures are provided by Ocete Rubio (1984). Information on development on different host crops is given by Badr *et al.* (1983). Studies in Egypt indicate that there are seven overlapping generations of *S. littoralis* when feeding on cotton, and that there are three peak infestation periods (Khalifa *et al.,* 1982).

5.4.4. Hosts

S. littoralis is polyphagous and attacks 40 families, containing at least 87 species of economic importance (Salama *et al.,* 1970). It is recorded feeding on a wide range of economically important plants, mostly vegetables including Among their host are: okra, onion, pigweed, peanut, cabbage, cauliflower, pepper, citrus, taro, tea, cucurbits, carrot, fig, sweet potato, geranium, soybean, cotton, sunflower, tomato, lettuce, apple, alfalfa, tobacco, avocado, pine, pea, poplar, plum, pear, oak, potato, eggplant, spinach, clover, wheat, and corn.

a) Major host: *Abelmoschus esculentus* (okra), *Allium cepa* (onion), *Amaranthus* (amaranth), *Arachis hypogaea* (groundnut), *Beta vulgaris* (beetroot), *Beta vulgaris* var. *saccharifera* (sugarbeet), *Brassica oleracea* (cabbages, cauliflowers), *Camellia sinensis* (tea), *Chrysanthemum indicum* (chrysanthemum), *Citrullus lanatus* (watermelon), Citrus, *Corchorus olitorius* (jute), *Daucus carota* (carrot), *Ficus carica* (common fig), *Glycine max* (soyabean), *Gossypium* (cotton), *Helianthus annuus* (sunflower), *Ipomoea batatas* (sweet potato), *Oryza sativa* (rice), *Psidium guajava* (guava), *Raphanus sativus* (radish), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Triticum aestivum* (wheat), *Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea), *Zea mays* (maize).

5.4.5. Distribution

The northernly distribution limit of *S. littoralis* in Europe corresponds to the climatic zone in which winter frosts are infrequent. It occurs throughout Africa and extends eastwards into Turkey and north into eastern Spain, southern France and northern Italy. However, this boundary is probably the extent of migrant activity only because although the pest overwinters in southern Spain, it does not do so in northern Italy or France. In southern Greece, pupae have been observed in the soil after November and the species overwinters in this stage in Crete. Low winter temperatures are therefore an important limiting factor affecting the northerly distribution, especially in a species with no known diapause (Miller, 1976; Sidibe and Lauge, 1977).

Asia: Bahrain (EPPO, 2022), China (Chen BoSheng *et al.* 2016)), India (Prasad and Bhattacharya, 1975)), Pakistan (EPPO, 2022), Saudi Arabia (EPPO, 2022), United Arab Emirates (EPPO, 2022), Turkey (EPPO, 2022).
Africa: Egypt (EPPO, 2022), Kenya (EPPO, 2022), Nigeria (EPPO, 2022), South Africa (EPPO, 2022)

5.4.6. Hazard Identification Conclusion

Considering the facts that *S. littoralis*:

- is not known to be present in Bangladesh [EPPO, 2022];
- will be potentially economic important to Bangladesh because it is a major pest of several vegetable like okra, onion, pigweed, peanut, cabbage, cauliflower, pepper, citrus, taro, tea, cucurbits, carrot, fig, geranium, soybean, cotton, sunflower, tomato, lettuce, apple, alfalfa, tobacco, avocado, pine, pea, poplar, plum, pear, oak, potato, eggplant, spinach, clover, wheat, corn, etc. which are also important crops in our country.
- The degree of polyphagy of *S. littoralis* its numerous economically important host-plants, and the rapid escalation of international trade in fresh plant material and produce, mean that this species presents a high risk of introduction.
- EPPO has listed *S. littoralis* as an A2 quarantine pest (OEPP/EPPO, 1981). CPPC, NAPPO and OIRSA also consider it to be of quarantine significance. It is a potential pest of areas where the average annual minimal temperature is not below -10°C. *S. littoralis* is already fairly widespread in Mediterranean countries and does not present a phytosanitary risk there. The most significant phytosanitary risk for *S. littoralis* is the possible introduction into glasshouses in most parts of Europe, where it could damage many ornamental and vegetable crops. Although control with insecticides is possible, there have been many cases of resistance and the lack of available biological control methods means that introduction of *S. littoralis* into glasshouses could necessitate insecticide treatments that could interfere with existing biological control of other pests (EPPO, 1997).
- *S. littoralis* first appeared in UK glasshouses in considerable numbers in 1963. It was found that the eggs were being introduced on imported cuttings, especially chrysanthemums and carnations.
- *S. littoralis* is a quarantine pest for Bangladesh and considered to be a potential hazard organism in this risk analysis.

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

Table-5.4.1: 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 recent years *N. nipae* been established in different country especially in Asian countries like China (Chen BoSheng *et al.* 2016), Oman (EPPO, 2022), Pakistan (EPPO, 2022), Saudi Arabia (EPPO, 2022), United Arab Emirates (EPPO, 2022). **b. Possibility of survival during transport, storage and transfer? No** • The minimum constant temperature for normal development in all stages is 13-14°C. Resistance to cold generally increases through the larval stages and is greatest in the pupal stage (Miller, 1977). At 18°C, egg, larval and pupal stages last 9, 34 and 27 days, respectively. At 36°C, egg, larval and pupal stages last 2, 10 and 8 days, respectively. Data on survival and development at different temperatures are provided by Ocete Rubio (1984). Information on development on different host crops is given by Badr *et al. (*1983). Studies in Egypt indicate that there are seven overlapping generations of *S. littoralis* when feeding on cotton, and that there are three peak infestation periods (Khalifa *et al.,* 1982). • The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival. • For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature *S. littoralis* can survive. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes,** • The pathway appears good for this pest to enter into Bangladesh and establishment because the adults, eggs, nymphs and pupae may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • Immature and adult female *S. littoralis* are readily carried on plants and plant produce and may be injurious when introduced to new geographical areas where they have no natural enemies. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • *S. littoralis* is polyphagous and attacks 40 families, containing at least 87 species of economic importance (Salama *et al.,* 1970). It is recorded feeding on a wide range of economically important plants, mostly vegetables including Among their host are: okra, onion, pigweed, peanut, cabbage, cauliflower, pepper, citrus, taro, tea, cucurbits, carrot, fig, sweet potato, geranium, soybean, cotton, sunflower, tomato, lettuce, apple, alfalfa, tobacco, avocado, pine, pea, poplar, plum, pear, oak, potato, eggplant, spinach, clover, wheat, and corn. • These climatic conditions of these countries where this pest has already established are more or less similar with the climatic condition of Bangladesh.	**YES and High**
• **NOT AS ABOVE OR BELOW**	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.4.8. Determine the Consequence establishment of this pest in Bangladesh

Table-5.4.2: Which of these descriptions best fit of this pest?

<table>
<tr><th>Description</th><th>Consequence Potential</th></tr>
<tr><td>

a. Is this a serious pest of Bangladesh? - Yes.

- Because it is a major pest of several economically important plants, mostly vegetables, including *Abelmoschus esculentus* (okra), *Allium cepa* (onion), *Amaranthus* (amaranth), *Arachis hypogaea* (groundnut), *Beta vulgaris* (beetroot), *Beta vulgaris* var. *saccharifera* (sugarbeet), *Brassica oleracea* (cabbages, cauliflowers), *Camellia sinensis* (tea), *Chrysanthemum indicum* (chrysanthemum), *Citrullus lanatus* (watermelon), Citrus, *Corchorus olitorius* (jute), *Daucus carota* (carrot), *Ficus carica* (common fig), *Glycine max* (soyabean), *Gossypium* (cotton), *Helianthus annuus* (sunflower), *Ipomoea batatas* (sweet potato), *Oryza sativa* (rice), *Psidium guajava* (guava), *Raphanus sativus* (radish), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Triticum aestivum* (wheat), *Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea), *Zea mays* (maize). etc. which are also important crops in our country.

b. Economic impact and yield loss

- *S. littoralis* is one of the most destructive agricultural lepidopterous pests within its subtropical and tropical range. It can attack numerous economically important crops throughout the year (EPPO, 1997). On cotton, the pest may cause considerable damage by feeding on the leaves, fruiting points, flower buds and occasionally on bolls. When groundnuts are infested, larvae first select young folded leaves for feeding, but in severe attacks, leaves of any age are stripped off. Sometimes, even the ripening kernels in the pods in the soil may be attacked. Pods of cowpeas and the seeds they contain are also often badly damaged. In tomatoes, larvae bore into the fruit, which is thus rendered unsuitable for consumption. Numerous other crops are attacked, mainly on their leaves.
- In Europe, damage caused by *S. littoralis* was minimal until about 1937. In 1949, there was a catastrophic population explosion in southern Spain, which affected lucerne, potatoes and other vegetable crops. At present, this noctuid is of great economic importance in Cyprus, Israel, Malta, Morocco and Spain (except the north). In Italy, it is especially important on protected crops of ornamentals and vegetables (Inserra and Calabretta, 1985; Nucifora, 1985). In Greece, *S. littoralis* causes slight damage in Crete on lucerne *and clover only.*
- In North Africa, tomato, Capsicum, cotton, maize and other vegetables are affected. In Egypt, it is one of the most serious cotton pests.

c. Environmental Impact

- The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water.
- The excessive use of toxic chemical insecticides has a negative impact to our environment, natural life, wild life, even aquatic life and disrupting the natural control system in the field.

</td><td>

Yes and High

</td></tr>
<tr><td>• Not as above or below</td><td>Moderate</td></tr>
<tr><td>• This is a not likely to be an important pest of common crops grown in Bangladesh.</td><td>Low</td></tr>
</table>

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

Establishment Potential X Consequence Potential = Risk

Table-5.4.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.4.10. Risk Management Measures

- Avoid importation of vine and tuber of sweet potato from countries, where this pest is available.
- In countries where *S. littoralis* is not already present, the enforcement of strict phytosanitary regulations as required for *S. littoralis* may help to reduce the risk of this insect 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 *S. littoralis* are present.

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ARTHROPOD: MITE PESTS

5.5	Tomato Russet Mite, *Aculops lycopersici* (Tryon, 1917)

5.5.1. Hazard identification

Scientific Name: *Aculops lycopersici* (Tryon, 1917)
Synonyms: *Aceria lycopersici*
Aculops destructor
Aculops lycopersicae
Aculus destructor (Keifer, 1940)
Aculus lycopersici (Tryon, 1917)
Common names: tomato russet mite
Taxonomic tree
Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Chelicerata
Class: Arachnida
Subclass: Acari
Superorder: Acariformes
Suborder: Prostigmata
Family: Eriophyidae
Genus: Aculops
Species: *Aculops lycopersici*
EPPO Code: VASALY *(Aculops lycopersici)*
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022]

5.5.2. Biology

In field situations, airborne adults of *A. lycopersici* begin to infest tomatoes perennial alternate hosts shortly after transplanting (Ramalho, 1978). Females begin to oviposit soon after becoming established on the host, giving rise to a succession of generations (up to seven per growing season) that can develop from egg to adult in as little as 6 or 7 days each under optimum conditions of 26.5°C and 30% RH (Abou-Awad, 1979). Consequently, populations increase rapidly to very high densities with catastrophic impact on the vitality of the host, especially under dry weather conditions (Holdaway, 1941). When the primary host dies, some of the mites are dispersed by wind to nearby alternative hosts where they form overwintering aggregations. In greenhouses, the sources of infestation of young plants are surviving populations of mites on remnants of previous crops of infected plants or mites newly introduced on young plants. Perring (1996) summarized information on the biology of *A. lycopersici*.

A. lycopersici has been implicated as a vector of the fungal pathogen *Hirsutella thompsonii* (Cabrera and McCoy, 1984).

5.5.3. Hosts

A. lycopersici is most often reported as a pest of tomatoes, but utilizes a wide range of Solanaceae, including several crop plants, as secondary hosts. The mites require perennial alternate hosts in order to survive during winter and, as a result of the catastrophic injury they cause to tomato plants, after death of their primary hosts.

a) Major Host: *Ipomoea batatas* (sweet potato), *Nicotiana tabacum* (tobacco), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato)

5.5.4. Distribution

A. lycopersici probably now occurs in all countries where tomatoes, potato, brinjal and related solanaceous crops are grown.

- **Asia**: Azerbaijan (EPPO, 2022), China (EPPO, 2022), Iran (EPPO, 2022), Israel (EPPO, 2022), Japan (Seebens *et al.* 2017), Jordan (EPPO, 2022), Saudi Arabia (EPPO, 2022), South Korea (Kim *et al.* 2002), Sri Lanka (EPPO, 2022), Turkey (Akyazİ, 2012), Yemen (Negm and Alsharhi, 2018).
- **Africa:** Egypt (EPPO, 2022), Ethiopia (EPPO, 2022), Morocco (EPPO, 2022), South Africa (EPPO, 2022), Zimbabwe (EPPO, 2022)
- **North America:** Canada (Macnay, 1953), Mexico (Undurraga and Dybas, 1988), USA (EPPO, 2022).
- **South America:** Argentina, Brazil, Chile, Uruguay (EPPO, 2022)
- **Europe:** Bulgaria (EPPO, 2022), Finland; France; Greece; Hungary, Italy, Spain, United Kingdom (EPPO, 2022)
- **Oceania:** Australia (EPPO, 2022); New Zealand (EPPO, 2022)

5.5.5. Hazard Identification Conclusion

Considering the facts that *A. lycopersici* -

- is not known to be present in Bangladesh [CABI/EPPO, 2022];
- will be potentially economic important to Bangladesh because it is a major pest of several vegetable plants like sweet potato, tomato, potato, brinjal etc. which are also important crops in our country.
- *A. lycopersici* may cause serious reductions in yield in sweet potato crops, especially when young plants are exposed to attack. Losses of up to 65% have been reported in situations where young plants have become heavily infested shortly after transplantation (Oliveira *et al.,* 1982).
- In Asia, *A. lycopersici* is present in China, Japan, Saudi Arabia, Korea Sri Lanka, and Thailand from where sweet potato are imported.
- *A. lycopersici* is a quarantine pest for Bangladesh and considered to be a potential hazard organism in this risk analysis.

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

Table-5.5.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. Has this pest been established in several new countries in recent years-Yes, • Establishment of *A. lycopersici* has been recorded in recent years in Zambia, Armenia, Azerbaijan, Jordan, South Korea, Yemen, Croatia, Portugal, Russia, United Kingdom and Chile. **b. Possibility of survival during transport, storage and transfer? Yes** • *A. lycopersici* can survive at 15°C temperature then the duration of the life cycle become long. • Females begin to oviposit soon after becoming established on the host, giving rise to a succession of generations (up to seven per growing season) that can develop from egg to adult in as little as 6 or 7 days each under optimum conditions of 26.5°C and 30% RH.	**YES and HIGH**

• The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival. • For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature *A. lycopersici* can survive. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? – Yes** • The pathway appears good for this pest to enter into Bangladesh and establishment because the mites may transport through flowers, inflorescence, fruits, leaves, roots and stems. Different type of vegetables, fruits, crops, seeds, flowers, plant parts are imported in our country from different country in where the pest is already established. So, this insect can enter in our country through any of this imported material. • Though the neighboring country has present *A. lycopersici* at sweet potato plant and Bangladesh can import sweet potato from this country, so it seems the good pathway for this pest to enter Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? -Yes** • The host range of *A. lycopersici* are fairly common in Bangladesh. • The favorable temperature is 24.2° C for *A. lycopersici*, which is more or less similar in Bangladesh. • So, the host ranges of *A. lycopersici* are fairly common in Bangladesh and the climate is more or less similar for establishment of this pest in Bangladesh.	
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.5.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.5.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? -Yes • Because it is a major pest of several economically important plants, mostly vegetables, including *Ipomoea batatas* (sweet potato), *Nicotiana tabacum* (tobacco), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), etc. Besides this, Though the climatic condition and the host range for *A. lycopersici* are similar in Bangladesh, so it can be a serious pest in Bangladesh. **b. Economic impact and yield loss** • *A. lycopersici* may cause serious reductions in yield in tomato crops, especially when young plants are exposed to attack. Losses of up to 65% have been reported in situations where young plants have become heavily infested shortly after transplantation (Oliveira *et al.,* 1982). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • The excessive use of toxic chemical insecticides has a negative impact to our environment, natural life, wild life, even aquatic life and disrupting the natural control system in the field.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.5.3: 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-High

5.5.9. Risk Management Measures

- Avoid importation of vine and tuber of sweet potato from countries, where this pest is available;
- In countries where *A. lycopersici* is not already present, the enforcement of strict phytosanitary regulations as required for *A. lycopersici* may help to reduce the risk of this insect becoming established; and
- 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. lycopersici* are present.

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5.6	Red spider mite: *Tetranychus evansi*

5.6.1 Hazard Identification

Scientific name: *Tetranychus evansi* Baker & Pritchard, 1960

Synonyms: No synonyms recorded, but *Tetranychus takafujii* Ehara & Ohashi, 2002, is suspected to be the same species.

Common names: Red tomato spider-mite (English)
Cassava stem mussel scale;
White mussel scale

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Class: Arachnida
Order: Acarina
Family: Tetranychidae
Genus: *Tetranychus*
Species: *Tetranychus evansi*

EPPO Code: TETREV. This pest has been included in EPPO A2 list: No. 349
Bangladesh status: Not present in Bangladesh [EPPO, 2022].

5.6.2 Biology

Arrhenotokous parthenogenesis is the rule for Tetranychid mites. Unfertilised eggs develop into haploid males while diploid females are produced biparentally from fertilized eggs. The sex-ratio is about 70% females.

Tetranychus evansi reproduction is continuous throughout the year. No diapause has been observed even in the coldest parts of its distribution area or for *T. takafujii* in Tokyo Bay (Ohashi *et al.*, 2003). This could limit the distribution to areas with moderately cold winters.

Qureshi *et al.* (1969), Moraes & McMurtry (1987) and Bonato (1999) have studied the life-history of the mite. The theoretical minimal growing temperature varies from 10.3°C to 13.7°C depending on authors and stages. The optimal temperature is 34°C and the maximal 38°C. The duration of development from egg to adult ranges from 46 days at 15°C to 8-13 days at 25°C and 6 days at 35°C. The number of eggs laid by females varies from 80 with extreme low and high temperatures to a range of 120-250, depending on the authors, for optimal temperatures. This mite has one of the highest rates of population increase among *Tetranychus* species (~0.4) which leads to heavily infested plants at the end of a favourable growing season. This phenomenon causes spectacular outbreaks and high mite populations can kill host plants. Dispersal behaviour is associated with outbreaks, in which mites form large aggregates at the top of the infested plants and are blown with the wind.

5.6.3 Hosts

T. evansi is polyphagous. It has been reported on 31 plant families (Spider Mites Web Database, Migeon & Dorkeld, 2007). Major hosts are within the *Solanaceae.*

Cultivated hosts

The primary cultivated solanaceous hosts are tomato (*Lycopersicon esculentum*) (Silva, 1954; Migeon, 2007), aubergine (*Solanum melongena*) (Moraes *et al.*, 1987a; Leite *et al.*, 2003), potato (*S. tuberosum*) (Escudero & Ferragut, 2005), sweet potato (*Ipomea batatas*) (Moutia, 1958), tobacco (*Nicotiana tabacum*) (Blair, 1989) and to a lesser degree peppers and chillies

(*Capsicum annuum*) (Silva, 1954). Bean (*Phaseolus vulgaris*) is a cultivated non-solanaceous host (Gutierrez & Etienne, 1986).

The EWG regarded the following crops as secondary, or minor, hosts since there are very few records in the literature of *T. evansi* occurring on them, *Abelmoschus esculentus* (Tuttle *et al.* 1977), beetroot (*Beta vulgaris*) (Aucejo *et al.*, 2003), *Phacelia* sp. (Qureshi *et al.* 1969), cotton (*Gossypium hirsutum*) (Wene, 1956), castor bean (*Ricinus communis*) (Ho *et al.* 2004), peanuts (*Arachis hypogea* and *A. prostrata*) (Moutia 1958, Chiavegato & Reis 1969, Feres & Hirose 1986), watermelon (*Citrullus lanatus*) (Ferragut, pers. comm. 2007), and *Rosa* spp. (Qureshi *et al.* 1969).

Weeds

The preferred host for *T. evansi* is the widespread weed *Solanum nigrum* (Migeon, 2007). Other weed hosts include *Amaranthus blitoides*, *Chenopodium* spp. (El Jaouani, 1988), *Convolvulus arvensis*, *Conyza* spp., *Diplotaxis erucoides*, *Hordeum murinum, Lavatera trimestris*, *Sonchus* spp. (Ferragut & Escudero, 1999; Aucejo, Foo, Gimeno, *et al.*, 2003). INRA Spider Mites Web database (Migeon & Dorkeld, 2007) provides a more extensive lists of hosts / plants on which *T. evansi* has been recorded.

5.6.4 Geographical distribution

T. evansi is suspected to originate from South America. It has been unintentionally introduced to other parts of the world.
Because the pest can easily be confused with other *Tetranychus* species, there is uncertainty on the pest distribution, e.g. it could be present on crops but considered to be another *Tetranychus* species, or present but disregarded on non-crop plants. The geographic distribution of *T. evansi* is given below:

EPPO region: **France** (Pyrénées-Orientales, Alpes Maritimes, Var), Greece (EPPO, 2007), Israel (EPPO, 2006a), **Italy** (Liguria, EPPO 2006b), Jordan (Palevsky, pers. comm. 2007), Portugal (from Algarve to Lisbon including Madeira), Spain (Canary Islands, Baleares Islands, along the Mediterranean coast, Atlantic coast of Andalusia).

Asia: China (EPPO, 2022), Israel (CABI/EPPO, 2006), Japan (EPPO, 2022), Jordan (Palevsky, pers. comm. 2007), **Taiwan** (including Kinmen and Lienchang Islands). If *T. takafujii* is shown to be a synonym of *T. evansi*, then the pest would also be known to occur in **Japan** (EPPO, 2006).

Africa: Democratic Republic of Congo, Congo, Gambia, Kenya, Malawi, Mauritius (including Rodrigues island), Morocco, Mozambique, Namibia, Niger (pers. comm. Migeon, 2007), Reunion Island, Senegal, Seychelles, Somalia, South Africa, Tunisia, Zambia, Zimbabwe. Detections of *T. evansi* on consignments of plant products from Gambia, suggest that *T. evansi* may also be present in Gambia (MacLeod, pers. comm. 2007).

North America: USA (Arizona, California, Florida, Texas, Hawaii).

Central America and Caribbean: Puerto Rico, Virgin Islands

South America: **Brazil**, Argentina

Oceania: Asutralia (EPPO, 2022); New Zealand (EPPO, 2022)

5.6.5 Hazard Identification Conclusion

Considering the facts that *T. evansi*:

- is not known to be present in Bangladesh [EPPO, 2022].
- is potentially economic important to Bangladesh because it is an important pest of different important vegetables including sweet potato in Asia including Japan, China, Taiwan (EPPO, 2022) from where sweet potato are imported to Bangladesh.

- Local movement is mainly linked to wind currents. In international trade, *T. evansi* may be carried on Solanaceous plants for planting (except tubers and seeds) and this is the hypothesis used to explain the introduction of the pest e.g. in Africa. The mites are less likely to infest fruits, these only present a risk where peduncles are present (aubergines, vine tomatoes, fresh beans, and to a lesser degree, chillies and peppers).
- *T. evansi* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.6.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-5.6.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. Has this pest been established in several new countries in recent years?-Yes, • *T. evansi* is suspected to originate from South America. It has been unintentionally introduced to other parts of the world. However, this pest is widely distributed in many Asian countries including Japan, China, Taiwan (CABI, 2022). • *T. evansi* is a tropical species of New World origin. There is no mention in the literature of the history of its spread, but it has undoubtedly reached countries outside the New World as a result of human transport of infested planting materials. **b. Possibility of survival during transport, storage and transfer? -Yes** • The mites are less likely to infest fruits, these only present a risk where peduncles are present (cucurbits, aubergines, vine, tomatoes, fresh beans, and to a lesser degree, chillies and peppers). • The duration of development from egg to adult ranges from 46 days at 15°C to 8-13 days at 25°C and 6 days at 35°C. Within this period the eggs and mites can easily survive on fruit/tuber surfaces of vegetables. Secondly, sweet potato is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, this pest is rated with High risk potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? -No,** • Internationally, *T. evansi* is liable to be carried on any plants for planting or on roses, and nursery stocks, which are the main means of dispersal of this pest [EPPO, 2006]. There is no possibility of this pest to appear on seeds and less possibility to appear on the tubers. **c. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? -Yes** • The preferred host (*Ipomea batatas*) and at least three major cultivated hosts (aubergines, tomatoes and potatoes) and rose are widely distributed in many Asian countries including Japan, China (CABI, 2022), among of these are common in **Bangladesh**. • *T. evansi* is a warmth-loving pest. A study by Bonato (1999) showed that the optimal temperature for population growth is 34°C. The shortest developmental time (6.3 days) occurs at 36°C. At 25°C, the life cycle is completed in 13.5 days. • These climatic requirements for growth and development of *T. evansi* are more or less similar with the climatic condition during summer season of **Bangladesh**.	**Yes and moderate**
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

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

Table-5.6.2: Which of these descriptions best fit of this pest?

<table>
<tr><th>Description</th><th>Consequence Potential</th></tr>
<tr><td>

a. Is this a serious pest of Bangladesh? -Yes.

- If infested plants for planting are introduced in protected cultivation where no plant protection products are used, *T. evansi* has the potential to cause economic damage although we do not know about the susceptibility of cultivars used.
- In African countries where *T. evansi* is established, it has been reported as a serious pest in particular of tomato. Of the thirteen known spider mite species on Reunion, *T. evansi* is one of the most destructive pests on crops (Gutierrez & Etienne, 1986). In Southern Africa *T. evansi* is considered as the most important dry season acarine pest of tomatoes (Fiaboe, 2007). Severe damage is also recorded on aubergine (Migeon, pers. comm. 2007). Infested tomato plants turn yellow, green then brown. Plants generally show a bleached yellow-orange or russeted appearance. Infested plants may be killed very rapidly (Jeppson *et al.*, 1975). In Zimbabwe, up to 90% yield losses have been recorded from field trials. However, it should be noted that with improved use of plant protection products, the damage on crops could be significantly reduced (Knapp *et al* 2003).
- This is a **fairly serious pest** of several important other crops rather than flowers for Bangladesh.

b. Economic Impact and Yield Loss

- *Tetranychus evansi* is regarded as an important pest of tomato and other solanaceous crops. In East and South Africa, it has been considered the most important dry season pest of tomatoes (Knapp, 2002) since it was first recorded in 1979 and yield losses are noted. In Western Africa, it damages tomatoes and aubergines (Duverney & Ngueye-Ndiaye, 2005).
- *Tetranychus evansi* is one of four species of red spider mites causing damage in vegetable crops in eastern Spain (Escudero and Ferragut, 2005), although there is no specific data on economic impact caused by *T. evansi* alone (Ferragut, pers. com. 2007). In Spain, damage has only been recorded in outdoor crops such as aubergine, potato and tomato (Ferragut, pers com. 2007) the same situation occurs in Israel on aubergine and potato.
- The most severe damage in Israel occurs on aubergine (Palevsky pers. com. 2007). Few outbreaks are recorded under protected conditions, even in areas where the pest is present outdoors on weeds.
- An outbreak in organic farming production unit was detected in southern France on tomato in protected cultivation in October 2007 (Migeon, pers. com. 2007). This illustrates the potential of the pest to cause damage in protected organic farming cultivation.

c. Environmental Impact

- Acaricides are commonly used against *T. evansi* and other spider mites on Solanaceous crops. Mite populations have developed resistance, in particular in Zimbabwe during the 1980s but current use of non organo-phosphorous acaricides is effective at controlling populations although it does not allow integrated crop protection or organic production.
- The pesticide resistance invariably leads to an increase in the use of insecticides as whitefly control becomes increasingly more difficult. This in turn can produce an ever increasing spiral in the levels of insecticide resistance and insecticide use, having a direct impact on the environment.

</td><td>Yes
and
High</td></tr>
<tr><td>• Not as above or below</td><td>Moderate</td></tr>
<tr><td>• This is a not likely to be an important pest of common crops grown in Bangladesh.</td><td>Low</td></tr>
</table>

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

Establishment Potential X Consequence Potential = Risk

Table-5.6.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.6.9. Risk Management Measures

a. Measures related to consignments

- **Visual inspection:** Visual detection of mites is possible but confusion with other mites (such as *T. urticae (syn. cinnabarinus), T. turkestani, T. ludeni, T. neocaledonicus, T. lombardini)* is possible. Mites and eggs in low numbers would be difficult to detect.
- **Treatment of the consignment:** Chemical treatments (combining treatments targeting adults and eggs) may be recommended, but their efficacy has to be verified by inspection.

b. Measures related to the crop or to places of production

- Pest Free Area for *T. evansi*
- Pest Free Place of Production:

(i) Mites are expected to spread more than five kilometres.

(ii) Having a five km buffer zone free from host plants is not a realistic option but a place of production freedom should consist in:

- Isolation: no other host plants in the immediate vicinity of the place of production (minimum 5 m recommended by Clark, 2001)
- Hygienic measures to prevent the pest to enter the greenhouse.
- Treatment of the crop during the production (the active ingredients which have resulted in more than 90% of mortality in adult females are: hexythiazox, propargite, dicofol, acrinatrin, fenbutatin oxide, dicofol+hexythiazox, fenpyroximate and dicofol.)
- Two inspections of the consignment prior to export

c. Other possible measures

- Surveillance in the importing country was not considered as a possible measure.

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5.B. Diseases: Fungi

5.7.	**White Rust of Sweet Potato (*Albugo ipomoeae-panduratae*)**

5.7.1. Hazard identification

Scientific Name: *Albugo ipomoeae-panduratae* (Schwein.) Swingle
Synonyms Name: *Aecidium ipomoeae* Thüm., (1875)
Cystopus ipomoeae-panduratae (Schwein.) Swingle, (1889)
Puccinia ipomoeae-panduratae (Schwein.) P. Syd. & Syd., (1904)
Trochodium ipomoeae (Thüm.) Syd. & P. Syd., (1920)
Uromyces ipomoeae (Thüm.) Berk., (1882)
Common names: White rust of sweet potato
Taxonomic tree
Domain: Eukaryota
Kingdom: Chromista
Phylum: Oomycota
Class: Oomycetes
Order: Peronosporales
Family: Albuginaceae
Genus: Albugo
Species: *Albugo ipomoeae-panduratae*
EPPO Code: ALBUIP (*Albugo ipomoeae-panduratae*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2021]

5.7.2. Morphology

The sporangia of white rust of sweet potato is Hyaline, cylindrical to rectangular with rounded terminal region, 12–20 × 12–18 µm. Walls display equatorial thickening. Sporangiophores are Hyaline, club-shaped, 30-40 × 12-15 µm, curled at base. Oospores are Spherical, yellowish-brown, 25-40 µm, papillate or with ridges. And Pustules (sori) of white rust of sweet potato are White or light yellow, disposed in concentric rings, with various sizes and shapes (Saharan and Verma, 1992).

5.7.3. Hosts

The host range for *Albugo ipomoeae-panduratae* is wide. The list of host are- *Arabis alpinarabis caucasica* (snow-in-summer), *Arabis hirsuta* (hairy rock-cress (UK)), *Armoracia rusticana* (horseradish), *Brassica juncea* (mustard), *Brassica juncea var. juncea* (Indian mustard), *Brassica napus var. napus* (rape), *Brassica nigra* (black mustard), *Brassica oleracea var. botrytis* (cauliflower), *Brassica oleracea var. capitata* (cabbage), *Brassica oleracea var. gemmifera* (Brussels sprouts), *Brassica oleracea var. viridis* (collards), *Brassica rapa* (field mustard), *Brassica rapa subsp. chinensis* (Chinese cabbage*), Brassica rapa* subsp. *pekinensis*, *Brassica rapa* subsp. *rapa* (turnip), *Capsella bursa-pastoris* (shepherd's purse), *Cleome viscosa* (Asian spiderflower), *Daucus carota* (carrot), *Eruca vesicaria* (purple-vein rocket), *Erysimum cheiranthoides* (Treacle mustard), *Erysimum cheiri* (wallflower), *Eutrema wasabi* (Wasabi), *Hirschfeldia incana* (shortpod mustard), *Ipomoea batatas* (Sweet potato), *Ipomoea aquatica* (swamp morning-glory), *Lepidium campestre* (Field cress), *Lepidium latifolium* (perennial pepperweed), *Lepidium sativum* (garden cress), *Lepidium virginicum* (Virginian peppercress), *Lobularia maritima* (sweet alyssum), *Nasturtium officinale* (watercress), *Raphanus raphanistrum* (wild radish), *Raphanus sativus* (radish), *Rorippa amphibia* (great yellowcress), *Rorippa islandica* (yellow marshcress*), Rorippa sylvestris* (creeping yellowcress), *Sinapis alba* (white mustard), *Sinapis arvensis* (wild mustard), *Sisymbrium altissimum* (Tall rocket), *Sisymbrium irio*, *Sisymbrium officinale* (Hedge mustard), *Sisymbrium orientale* (eastern rocket (UK)), *Spergula arvensis* (corn spurry), *Thlaspi arvense* (field pennycress),*Tropaeolum majus* (common nasturtium).

5.7.4. Distribution

Asia: Brunei (Greathead and Greathead, 1992), India (Rashtra Vardhana, 2017), China (Xie *et al.*, 2022), Japan (Sato *et al.*, 2009)
North America: Cuba (Schotman,1989), Dominica (Schotman, 1989), Dominican Republic, (Schotman, 1989), Hatia (Schotman, 1989), Jamaica (Schotman, 1989), Puerto Rico (Schotman, 1989) and United Status (Schotman, 1989).
South America: Guyana (Schotman, 1989), Brazil (Pagani *et al.*, 2012).

5.7.5. Symptoms

Saharan and Verma (1992) and Guzman and Heil (2013) have described symptoms on host plants caused by *A. candida* infection. Symptoms are generally present on above-ground parts of host plants and are of two kinds. The white rust phase (asexual phase) is in the form of raised, milky-white or creamish-coloured single (or coalescing) or concentrically arranged pustules that are closed at first but rupture later and turn powdery-white. The pustules may be present on any above-ground part of the plant including the seedlings but are more common on the underside of leaves. The white rust phase alone results in no or only incipient hypertrophy and hyperplasia of the host tissue and is associated with only limited development of the sexual phase inside the leaf tissue. The leaf area opposite the white rust pustule often bulges out slightly and appears mildly chlorotic but shows chlorophyll retention in the form of a green island as the leaf ages.

Conspicuous hypertrophy and hyperplasia occur in parts of the host where the sexual phase of the pathogen develops preferentially. Parts of the inflorescence axes, along with flowers and siliques, swell and curl in various ways resulting in galls known as the 'stagsheads'. These structures are vaguely reminiscent of the heads of stags with antlers, the antlers being represented by pedicles of flowers and siliques. In some cases, isolated flowers and siliques also become malformed. Seeds abort in malformed siliques and contribute to dockage upon harvesting. Terminal parts of the vegetative shoots also sometimes swell and malform. In some cases, parts of the leaves may also curl and twist, but such symptoms are always associated with copious development of the sexual phase in the host tissue. Stem and silique blisters are another symptom of the disease caused by *A. candida*. Rarely, the roots may also develop galls (Guzman and Heil, 2013).

Plant tissues infected with *A. candida* are also often colonized with a mealy growth of Peronospora parasitica resulting in a disease complex. Field observations indicate that in such cases, most, if not all, hypertrophy of the infected tissue is due to *A. candida* (Guzman and Heil, 2013).

Hazard Identification Conclusion

Considering the facts that *Albugo ipomoeae-panduratae* -

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially less economic important to Bangladesh because it is an important pest of sweet potato in United States, southern Canada, Mexico, Central America and New Zealand (Munyaneza, 2012) from where sweet potato are not imported to Bangladesh.

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

Table-5.7.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years-Yes** • In recent years, *Albugo ipomoeae-panduratae* been established in different country especially in Asian countries like China (Xie *et al.*, 2022) and Japan (Sato *et al.*, 2009). **b. Possibility of survival during transport, storage and transfer? Yes** • Mycelium is capable of overwintering in the infected crowns and lateral roots (57, 99, 266). Remaining dormant during the winter, it resumes activity and grows into the new shoots the host produces in the spring. • Lakra and Saharan (128) observed that sporangia of *A. candida* can survive for 4.5 days at 15°C on detached infected *B. juncea* leaves, but lose their viability after 18 h if separated and incubated without host tissues. However, sporangia can be stored for 105 days at -40°C as a dry powdered mass. • Verma and Petrie (251) found that oospores can remain viable for over 20 years under dry storage conditions. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - No** • The natural spread of the pathogen is very slow and over extremely short distances. The main path of distribution is by means of infected cuttings which may be obtained from infected but symptomless mother plants. **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 *Albugo ipomoeae-panduratae* is wide. The list of host are- mustard, cabbage, carrot, Sweet potato, radish, etc. Many of these hosts are fairly common in Bangladesh. • These climatic requirements for proper growth and development of this fungus also more or less similar with the climatic conditions of Bangladesh.	**Yes and Moderate**
• **NOT AS ABOVE OR BELOW**	Moderate
• Its hosts are not common in Bangladesh and climate is similar to places it is established.	Low

5.7.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.7.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes • *Albugo ipomoeae-panduratae* 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** • Yield losses in rapeseed in north central Alberta were 1-2% in 1971 (8), while in Manitoba losses of 30-60% were reported in severe white rust infected fields (Bernier, 1972). Petrie and Vanterpool (1974) reported yield losses of up to 60% due to A. candida staghead infection in rapeseed in Saskatchewan. • In Canada, Petrie (1973) reported loss estimates from hypertrophied inflorescences in 8. campestris of 1.68, 4.13 and 2.43 million dollars respectively for 1970-72. In western Australia, Barbetti (1981) estimated annual yield losses of 5 - 10% due to stagheads in rapeseed. • Mixed infections of Albugo and Peronospora in *B. juncea* cause yield losses of 17-32% in India (Bains and Jhooty, 1979). Saharan, *et al.* (1984) estimated yield losses of 23 - 54.5% in late sown Indian mustard cv. RH-30. **c. Environmental Impact** • *Albugo ipomoeae-panduratae* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical pesticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And these chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.7.3: 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-High

5.7.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available.
- In countries where *Albugo ipomoeae-panduratae* is not already present, the enforcement of strict phytosanitary regulations as required for *Albugo ipomoeae-panduratae* may help to reduce the risk of this insect 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 *Albugo ipomoeae-panduratae* are present.

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5.8	**Ceratocystis Blight (*Ceratocystis fimbriata*)**

5.8.1. Hazard identification

Scientific Name: *Ceratocystis fimbriata* Ellis & Halst.

Synonyms Name: *Ceratostomella fimbriata* (Ellis & Halst.) J.A. Elliott
Endoconidiophora fimbriata (Ellis & Halst.) R.W. Davidson
Ophiostoma fimbriatum (Ellis & Halst.) Nannf.
Rostrella coffeae Zimm.
Sphaeronaema fimbriata (Ellis & Halst.) Sacc.

Common names: Ceratocystis blight, black cane rot of Syngonium; black canker of aspen; black rot of sunn hemp; black rot of sweet potato; black rot of taro; blight of mango; cacao wilt; canker of coffee; canker stain of plane tree; Ceratocystis canker; Ceratocystis wilt; Ceratostomella wilt; mallet canker; mallot wound canker; mango blight; mango wilt; mouldy rot of rubber; sweet potato black rot; target canker of aspen; wilt disease of cocoa.

Taxonomic tree

Domain: Eukaryota
Kingdom: Fungi
Phylum: Ascomycota
Subphylum: Pezizomycotina
Class: Sordariomycetes

Subclass: Hypocreomycetidae
Order: Microascales
Family: Ceratocystidaceae
Genus: Ceratocystis
Species: *Ceratocystis fimbriata*

EPPO Code: CERAFI (*Ceratocystis fimbriata*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022]

5.8.2. Biology

C. fimbriata grows readily on most agar media. Mycelium is hyaline at first, later turning dark greenish-brown. Within a few days there are usually abundant conidiophores that produce chains of hyaline conidia, sometimes called endoconidia, characteristic of the anamorph genus Chalara. However, Chalara species are anamorphs of discomycetes, and the genus Thielaviopsis is now used for anamorphs of Ceratocystis species (Paulin *et al*., 2002). Endoconidia are cylindrical and may vary in size from 11 to 16 mm long by 4 to 5 mm wide (all measurements are from Hunt, 1956). Specialized conidiophores give rise to thick-walled, pigmented aleurioconidia (sometimes called chlamydospores), probably a survival spore. Aleurioconidia are typically 9-16 mm long and 6-13 mm wide, borne singly or in short chains. Endoconidia may also darken and become thick walled chlamydospores, thus resembling aleurioconidia. Endoconidia, chlamydospores formed from endoconidia, and aleurioconidia may be produced on and within the substratum.

The teleomorph of the fungus is well adapted to insect dispersal. The fungus has two mating types, and MAT-1 isolates can only produce perithecia when paired with MAT-2 isolates. However, MAT-2 isolates are self-fertile due to uni-directional mating type switching (Harrington and McNew, 1997; Witthuhn *et al*., 2000). Most field isolates are MAT-2 and self-fertile, producing many fruiting bodies (ascomata) on the surface of the host or in culture, often within one week. Ascomata are dark brown to black and globose, 130-200 µm diameter with a long, thin neck up to 800 µm long, through which the ascospores are exuded. The opening at the tip of the neck has 8 to 15 ostiolar hyphae ranging in length from 50 to 90 µm. Ascospores are small, hyaline and hat-shaped, 4.5-8 µm long by 2.5-5.5 µm wide, and accumulate in a sticky matrix at the tip of the ascomatal neck, where they appear as a cream to pink ball or coil.

5.8.3. Hosts

The host range for *C. fimbriata* is wide. The list of hosts is- black wattle (Roux *et al*., 2000), sugar apple (Silveira *et al*., 2006), arabica coffee (Webster and Butler, 1967), taro (Harrington *et al*., 2015, Harrington *et al*., 2011 and Ferreira *et al*., 2010), eucalyptus (Arriel *et al*., 2014 and Li *et al*., 2014), common fig (Harrington *et al.* 2011 and Ferreira *et al*. 2010), candahar (Harrington *et al.,* 2011 and Ferreira *et al*. 2010), sweet potato (Harrington *et al*., 2015 and Ferreira *et al*. 2010), lettuce (Halfeld-Vieira and Nechet, 2006), mango (Zhang *et al*., 2017; Harrington *et al*., 2015, Oliveira *et al*., 2015 and Asad *et al.*, 2014), allspice (Leather, 1966), Almond (Webster and Butler, 1967), pomegranate (Alam *et al*., 2017, Harrington *et al*., 2015 and Xu *et al*., 2011) and cocoa (Engelbrecht and Harrington, 2005).

Several recorded host plants for *C. fimbriata* are not included in the listing because they have not been confirmed. Some of these are probably erroneous reports, including the reports of *C. fimbriata* on soyabean, tobacco, potato, chestnut, cucumber, kidney bean, coconut, pineapple and yam. There is also considerable confusion over the scientific and common names of edible members of the Araceae (for example, Xanthosoma, Colocasia and Alocasia), and it is not always clear which of these genera are referred to in the various reports.

5.8.4. Distribution

Asia: Brunei (EPPO, 2022), Cambodia (EPPO, 2022), China (Li *et al*., 2019, Zhang *et al*., 2017, Seebens *et al.*, 2017 and Harrington *et al*., 2015), India (Somasekhara, 2006, Somasekhara and Wali, 2000 and Kaushik and Toky, 1992), Indonesia (Zimmerman, 1900), Japan (Engelbrecht and Harrington, 2005), Malaysia (EPPO, 2022), Mayanmar (EPPO, 2022), North Korea (EPPO, 2022), Oman (Oliveira *et al*., 2015), Pakistan (Latif *et al*., 2020, Alam *et al*., 2017 and Oliveira *et al*., 2015), Philippines (EPPO, 2022), South Korea (EPPO, 2022), Taiwan (EPPO, 2022), Thailand (EPPO, 2022) and Vietnam (EPPO, 2022).

Africa: Congo (EPPO, 2022), Ghana (EPPO, 2022), Seychelles (EPPO, 2022), South Africa (Wyk *et al*., 2006) and Uganda (Roux *et al.*, 2001).

Europe: France (Grosclaude *et al*., 1991), Italy (Panconesi, 1999), Poland (Przybył, 1980), Portugal (EPPO, 2022), Switzerland (Matasci and Gessler, 1997) and United Kingdom (EPPO, 2022).

North America: Canada (EPPO, 2022), Costa Rica (Engelbrecht and Harrington, 2005), Cuba (Herrera Isla and Grillo Ravelo, 1989), Dominican Republic (EPPO, 2022), Grenada (EPPO, 2022), Guatemala (Tejada, 1983), Haiti (EPPO, 2022), Jamaica (EPPO, 2022), Mexico (EPPO, 2022), Nicaragua (EPPO, 2022), Panama (EPPO, 2022), Puerto Rico (EPPO, 2022), Saint Lucia (EPPO, 2022), Trinidad and Tobago (Engelbrecht and Harrington, 2005) and United States (Seebens *et al*., 2017 and Keith *et al*., 2015).

South America: Brazil (Santos *et al*., 2018, Silva *et al*., 2017 and Melo *et al*., 2016), Colombia (Marin *et al.*, 2003), Ecuador (Engelbrecht and Harrington, 2005), Guyana (EPPO, 2022), Peru (Soberanis *et al*., 1999), Suriname (Baker *et al*., 2003), Uruguay (Wyk *et al*., 2006) and Venezuela (Reyes, 1988).

Oceania: American Samoa (EPPO, 2022), Australia (Walker *et al*., 1988), Fiji (Walker *et al*., 1988), New Zealand (Baker *et al*., 2003), Papua New Guinea (Wyk *et al*., 2006), Samona (Walker *et al*., 1988) and Solomon Islands (EPPO, 2022).

5.8.5. Hazard Identification Conclusion

Considering the facts that *Ceratocystis fimbriata:*

- is not known to be present in Bangladesh [EPPO, 2022];
- As most forms of *C. fimbriata* are easily transmitted in cuttings, unrestricted movement of cuttings or other propagative material is potentially dangerous. It is likely that the fungus has been spread to new countries or regions on cuttings of Populus, Theobroma, Eucalyptus and Syngonium and on storage roots of Ipomoea. Circumstantial evidence points to packing materials as the source of the plane tree pathogen in southern Europe, and the fungus is known to survive for up to 5 years in wood, probably in the form of aleurioconidia.
- *C. fimbriata* is listed as among the highest risk pathogens that could be imported into the USA on eucalyptus logs and chips from South America (Kliejunas *et al.,* 2001). The Platanus form (*C. fimbriata* f. *platani*) is listed as an EPPO A2 quarantine pest (OEPP/EPPO, 1986).
- is potentially less economic important to Bangladesh because it is an important pest of sweet China, India, Indonesia, Japan, Malaysia, Thailand (EPPO, 2022) from where sweet potato is imported to Bangladesh.

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

Table-5.8.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years-Yes**, • The pathogen on Platanus species, f. *platani*, is believed to be specialized to that genus and was probably introduced to Naples, Italy, during World War II on colonized crating material or dunnage from the USA (Baker *et al.,* 2003). The pathogen has spread throughout northern Italy (Pancosi 1999) to Switzerland in 1986 (Matasci and Gessler, 1997) and to southern France.	

• The Syngonium form of the pathogen has been dispersed on cuttings of this plant and has been reported in greenhouses in California, Florida, Hawaii and Australia. • The recent reports of the eucalyptus form of the pathogen in Uganda and the Congo may also be due to introductions on cuttings from Brazil (Baker *et al.,* 2003). • The Ipomoea form of the fungus has probably been spread to many locations on storage roots. For example, the report of *C. fimbriata* in the Azores was on experimental plantings of Ipomoea germplasm imported from the Caribbean. The Ipomoea form is apparently native to Latin America and/or the Caribbean (Baker *et al.,* 2003). **b. Possibility of survival during transport, storage and transfer? Yes** • As most forms of *C. fimbriata* are easily transmitted in cuttings, unrestricted movement of cuttings or other propagative material is potentially dangerous. It is likely that the fungus has been spread to new countries or regions on cuttings of Populus, Theobroma, Eucalyptus and Syngonium and on storage roots of Ipomoea. • Circumstantial evidence points to packing materials as the source of the plane tree pathogen in southern Europe, and the fungus is known to survive for up to 5 years in wood, probably in the form of aleurioconidia. • *C. fimbriata* is listed as among the highest risk pathogens that could be imported into the USA on eucalyptus logs and chips from South America (*Kliejunas et al.,* 2001). The Platanus form (C. *fimbriata* f. *platani*) is listed as an EPPO A2 quarantine pest (OEPP/EPPO, 1986). • The fungus may be dispersed as fragments of mycelium, conidia, aleurioconidia or ascospores. Aleurioconidia are probably the most common survival units because they are thick-walled and durable, and they probably facilitate survival in soil (Accordi, 1989) and in insect frass (Iton, 1960). The fungus may survive in wood fragments in river water (Grosclaude *et al.,* 1991a) and in the soil (Accordi, 1989) for at least 3 months in the winter. • *C. fimbriata* usually grows best at temperatures from 18 to 28°C and is able to produce ascospores within a week. The fungus probably survives adverse conditions as mycelium within the plant host, or as aleurioconidia in the soil or in plant hosts or debris. • The transport duration of sweet potato from exporting countries to our country is about 20 days. So, the duration is favorable for both ot the vector and pathogen. • The storage condition is also favorable for its growth, survival and development. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes** • The fungus spreads readily between adjacent Platanus trees via root grafts (Accordi, 1986). Mangifera trees may be infected through the roots from soilborne inoculum (Rossetto and Ribeiro, 1990), and root crops such as Ipomoea are commonly infected through wounds made by insects and rodents (Clark and Moyer, 1988). Ascopores are probably spread naturally by insects and are not likely to be airborne. • Pruning wounds are common entry points for *C. fimbriata*, and the fungus can be carried on machetes or pruning tools (Walter, 1946, 1952; Teviotdale and Harper, 1991). • Cuttings, roots and corms are used to propagate many other common hosts of *C. fimbriata*, including Theobroma, Ipomoea and Colocasia, and this may facilitate long-distance transport of the fungus. • It is apparent that several host-specialized forms of the fungus have been introduced into many regions. Propagative materials, especially cuttings, are a likely source. Packaging material and dunnage are also likely means of dispersal of the fungus. The Platanus form may have been introduced on packing material to Europe from North America during World War II (Panconesi, 1999) and has caused substantial damage to ornamental Platanus in southern Europe. This form can survive in	**Yes and High**

Platanus wood taken from diseased trees (Grosclaude *et al.,* 1995), which may be an efficient means of introducing the pathogen to new locations. **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 *C. fimbriata* is wide. The list of hosts is- taro, eucalyptus, common fig, sweet potato, lettuce, mango, pomegranate. • Some of these are probably erroneous reports, including the reports of *C. fimbriata* on soyabean, tobacco, potato, chestnut, cucumber, kidney bean, coconut, pineapple and yam. • Beside this, the climatic requirements for proper growth and development of this fungus also more or less similar with the climatic conditions of Bangladesh.	
• NOT AS ABOVE OR BELOW	**High**
• Its hosts are common in Bangladesh and climate is also similar to places it is established.	**High**

5.8.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.8.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes • *C. fimbriata* 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** • In Theobroma plantations, the fungus has killed as many as 50% of the trees in some locations (Idrobo, 1958). The disease in Coffea is particularly important in Colombia (Pontis, 1951), where citrus is another major economic host (Borja *et al*., 1995). • The fungus has also decimated certain clones of Eucalyptus in plantations in Brazil, and recent reports of the disease in Eucalyptus in the Congo and Uganda have indicated serious levels of mortality (Roux *et al*., 2000, 2001a). • Platanus plantings in Italy, France and Switzerland are also seriously affected, and over 10% of the London plane trees in southern Switzerland have been killed since the early 1980s (Matasci and Gessler, 1997). More than 87% of plane trees (*Platanus acerifolia*) were lost during the period 1926-1949 in the community of Gloucester, New Jersey, the earliest recognized epidemic on plane tree in the USA (Walter *et al*., 1952). • By 1952, they had estimated losses in excess of $1,000,000 (in 1952 dollars) in the north-east. Loss from Ceratocystis wilt on Punica in the Bijapur district of India from 1995 to 1998 was estimated at 7.5% of the crop (Somasekhara, 1999). **c. Environmental Impact** • *C. fimbriata* is probably a natural component of many forest ecosystems in the Americas and Asia. On native tree hosts it primarily colonizes wounds but does not move throughout the tree or kill the host. Most mortality of woody hosts appears to be on exotic tree species or native trees in plantations or used as street trees, perhaps because of wounding and movement of the pathogen on tools. The plane tree pathogen, for instance, has been devastating on street trees but is rare in natural forests with little human activity (Walter *et al*., 1952). Even where the fungus has been introduced, the damage is primarily to planted species. Thus, the impact in natural environments has been minimal. However, some plantation species have been abandoned in some regions, such as Gmelina arborea in Pará state in Brazil and Platanus in the south-eastern USA.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.8.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.8.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available.
- In countries where *Ceratocystis fimbriata* is not already present, the enforcement of strict phytosanitary regulations as required for *Ceratocystis fimbriata* may help to reduce the risk of this insect 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 *Ceratocystis fimbriata* are present.

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5.9	Leaf & stem scab (*Elsinoe batatas*)

5.9.1. Hazard identification

Scientific Name: *Elsinoë batatas Viégas & Jenkins*
Synonyms Name: *Sphaceloma batatas Sawada (anamorph)*
Common names: Leaf & stem scab
Taxonomic tree
Domain: Eukaryota
Kingdom: Fungi
Phylum: Ascomycota
Subphylum: Pezizomycotina
Class: Dothideomycetes
Subclass: Dothideomycetidae
Order: Myriangiales
Family: Elsinoaceae
Genus: Elsinoe
Species: *Elsinoe batatas*
EPPO Code: ELSIBA (*Elsinoe batatas*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 1997]

5.9.2. Morphology

The ascomata formed below the epidermis are dark brown to black and solitary to aggregated. They measure up to 150 µm in diameter, composed of pseudoparenchymatic tissues, and contain numerous monoascus locules. The asci are globose or ovoid, 8-spored, thick walled and measure 18-25 x 12-25 µm. The ascospores are hyaline, smooth, transversely 1-3 septate, constricted at the midseptum, and measure 12-18 x 4.5 µm. The acervulus is colourless, 12-16 µm in diameter. The conidiophores are short, simple to rarely branched and measure 10 x 3 µm; the conidia are hyaline, smooth, aseptate, oblong, and measure 4-9 x 2.5-3.5 µm (Sivanesan and Hyde, 1989).

5.9.3. Hosts

Sweet potato is the primary host but the disease has also been found in *Ipomoea aquatica*, *I. gracilis*, and *I. triloba* (Clark and Moyer, 1988).

5.9.4. Distribution

Asia: Brunei (EPPO, 2022), Cambodia (EPPO, 2022), China (EPPO, 2022), Hong kong (EPPO, 2022), Indonesia (EPPO, 2022), Japan (EPPO, 2022), Malaysia (EPPO, 2022), Philippines (Nayga and Gapasin, 1986) and Taiwan (EPPO, 2022)
North America: Mexico (McGuire and Crandall, 1967), Puerto Rico (EPPO, 2022) and United States (EPPO, 2022).
South America: Brazil (EPPO, 2022).
Oceania: Australia (Ramsey *et al*., 1988), Cook Islands (Dingley *et al*., 1981), Fiji (Firman, 1972), New Caledonia (EPPO, 2022), Papua New Guinea (Shaw, 1985), Solomon Islands (EPPO, 2022), Tonga (EPPO, 2022) and Vanuatu (EPPO, 2022).
Africa: Nigeria (EPPO, 2022) and Sierra Leone (EPPO, 2022).

5.9.5. Hazard Identification Conclusion

Considering the facts that *Elsinoe batatas* -

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially less economic important to Bangladesh because it is an important pest of sweet potato in Japan, Malaysia, Taiwan, Mexico, United states China, Indonesia, Hongkong, Japan, Malaysia, Philippines and Taiwan (EPPO, 2022) from where sweet potato are imported to Bangladesh.

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

Table-5.9.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. Has this pest been established in several new countries in recent years-Yes • This pest been established in several new countries like Nigeria and Sierra Leone in recent years. **b. Possibility of survival during transport, storage and transfer? No** • Due to lack of information about their biology, we can't predict about their survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - No** • The disease is transmitted by infected cuttings and through rain splash that carries masses of spores from infected to healthy plant parts of the same plant or to neighbouring plants. The disease is widespread in places with a high incidence of rain, mist and dew or in places where sprinkle irrigation is used (Clark and Moyer, 1988). So, it is not possible to enter into Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • The host range of *Elsinoe batatas* is common in Bangladesh. • Beside this, the climatic requirements for proper growth and development of this fungus also more or less similar with the climatic conditions of Bangladesh.	**Yes and Moderate**
• **NOT AS ABOVE OR BELOW**	Moderate
• Its hosts are common in Bangladesh and climate is not similar to places it is established.	Low

5.9.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.9.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes • The host plants and climate requirement of *Elsinoe batatas* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Leaf and stem scab is the most severe fungal foliar disease of sweet potato throughout South-East Asia and the Pacific. In the Philippines, yield losses of 50% have been measured in the field (Divinagracia and Mailum, 1976). Under controlled conditions, the inoculation of 2-4-week-old plants showed 28% yield loss, while those inoculated at 8 weeks suffered only 4% yield loss (Gapasin, 1984). Infection within the first 2-4 weeks after planting causes greater loss of marketable tubers than later infection (Nayga and Gapasin, 1986). • In Papua New Guinea, scab has reduced yields of sweet potato by 57% (Goodbody, 1983), 19% (34% marketable yield) (Floyd, 1988) and 27% (*P. Kokoa*, Kuk Research Station, Mt Hagen, Papua New Guinea, personal communication, 1990). Tuber number was the most severely affected yield parameter. A significant positive correlation was found between the yield of marketable roots and the percentage of leaf area not affected by scab in Tonga (Van Wijmeersch, 1986) while in Australia, a negative correlation was demonstrated between yield and scab severity which was significant at 55 and 82 days from planting, but not later (Ramsey *et al*., 1988).	**High**

c. Environmental Impact	
• *Elsinoe batatas* will not be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And these chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	
• Not as above or below	Moderate
• This is **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.9.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.9.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available.
- In countries where *Elsinoe batatas* is not already present, the enforcement of strict phytosanitary regulations as required for *Elsinoe batatas* may help to reduce the risk of this insect 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 *Elsinoe batatas* are present.

5.9.10 References

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5.10 Fusarium Wilt of Sweet Potato, (*Fusarium oxysporum f.sp. batatas*)

5.10.1. Hazard identification

Scientific Name: *Fusarium oxysporum f.sp. batatas* (Wollenw.) Snyder & Hansen
Synonyms: *Fusarium batatas (=batatis)* Wollenw.
Fusarium bulbigenum var. batatas Wollenw.
Fusarium hyperoxysporum Wollenw.
Common names: Fusarium Wilt of Sweet Potato, Fusarium wilt and stem rot; Fusarium wilt of yam; soft rot of sweet potato; stem rot of sweet potato; surface rot of sweet potato; wilt of sweet potato

Taxonomic tree

Domain: Eukaryota
- Kingdom: Fungi
  - Phylum: Ascomycota
    - Subphylum: Pezizomycotina
      - Class: Sordariomycetes
        - Subclass: Hypocreomycetidae
          - Order: Hypocreales
            - Family: Nectriaceae
              - Genus: Fusarium
                - Species: *Fusarium oxysporum* f.sp.*batatas*

EPPO Code: FUSABA (*Fusarium oxysporum* f.sp.*batatas*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO (2021)]

5.10.2. Biology

The biology and ecology of *Fusarium oxysporum* f.sp.*batatas* is poorly known.

5.10.3. Hosts

Convolvulaceae (Plants of the bindweed family), *Ipomoea batatas* (sweet potato), *Jacquemontia tamnifolia* (Smallflower morningglory), *Nicotiana tabacum* (tobacco), Vanilla.

5.10.4. Distribution

Asia: China (Fang *et al*., (1995), India (Holliday, 1970), Indonesia (Tombe and Sitepu, 1986), Japan (Holliday, 1970) and Taiwan (Holliday, 1970).
Africa: Malawi (Holliday, 1970) and Egypt (Mousa *et al.*, 2018).
North America: United States (Farr *et al*., 1989)
South Amrica: Brazil (Ribeiro *et al*., 1983), Argentina (Folquer, 1978), Peru (Gamarra and Martin, 1990), Uruguay (Viláró, 1988).

Europe: Spain (Rodríguez-Molina *et al*., 2007)
Ocenia: New Zealand (Holliday, 1970)

5.10.5. Hazard Identification Conclusion

Considering the facts that *Fusarium oxysporum* f.sp.*batatas* -

- is not known to be present in Bangladesh [CABI/EPPO, 2022];
- will be potentially economic important to Bangladesh because it is a major pest of sweet potato, etc. which are also important crops in our country.
- *F. oxysporum.* f. sp. *batatus* is a soil-borne fungus which is responsible for Fusarium wilt of sweet potato, one of the most destructive disease affecting sweet potato world-wide.
- *F. oxysporum.* f. sp. *batatus* is a quarantine pest for Bangladesh and considered to be a potential hazard organism in this risk analysis.

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

Table-5.10.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. **Has this pest been established in several new countries in recent years-Yes**, • In recent years *Fusarium oxysporum* f.sp. *batatas* been established in different countries like Egypt, Spain. **b. Possibility of survival during transport, storage and transfer? No** • Due to lack of information about their biology, we can't predict about their survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes,** • *F. oxysporum* f.sp. *batatas* was isolated from wilted sweet potato plants in recently developed areas for this crop in Japan and was also pathogenic to some cultivars of *I. tricolor*. • The pathogen was also transmitted through diseased tubers. The opt. temp. for disease occurrence was 28°C and of in vitro growth, 30°. • The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival. • For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature *Fusarium oxysporum* f.sp. *batatas* can survive. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established? – Yes** • *F. oxysporum f.sp. batatas* is a major pest of sweet potato. • These climatic conditions of these countries where this pest has already established are more or less similar with the climatic condition of Bangladesh.	**YES and Moderate**
• **NOT AS ABOVE OR BELOW**	**Moderate**
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.10.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.10.2: 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 sweet potato which are also important crops in our country. **b. Economic impact and yield loss** • Before resistant varieties became available, losses in most varieties often exceeded 50%, but with the successful development of resistant varieties Fusarium wilt became a minor problem. In tropical countries where the disease has sometimes only been introduced recently and resistant varieties are not grown, losses can be considerable, but no precise figures have been published (Cook, 1953; Clark and Moyer, 1988). **c. Environmental Impact** • The grower is required to implement chemical applications to save the crop, resulting in increased expenses in production as well as the potential of chemical contamination of soil and water. • The excessive use of toxic chemical insecticides has a negative impact to our environment, natural life, wild life, even aquatic life and disrupting the natural control system in the field.	**Yes and Moderate**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.10.3: 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-Moderate

5.10.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available.
- In countries where *F. oxysporum f.sp. batatas* is not already present, the enforcement of strict phytosanitary regulations as required for *F. oxysporum f.sp. batatas* may help to reduce the risk of this insect 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 *F. oxysporum f.sp. batatas* are present.

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5.11	Scurf of Sweet Potato (*Monilochaetes infuscans*)

5.11.1. Hazard identification

Scientific Name: *Monilochaetes infuscans* Harter
Synonyms: *Bedellia ipomoeae* Bradley
Common names: Scurf of Sweet Potato, manure stain; scurf: sweet potato; soils stain
Taxonomic tree
Domain: Eukaryota
Kingdom: Fungi
Phylum: Ascomycota
Subphylum: Pezizomycotina
Class: Sordariomycetes
Subclass: Sordariomycetidae
Order: Chaetosphaeriales
Family: Chaetosphaeriaceae
Genus: Monilochaetes
Species: *Monilochaetes infuscans*
EPPO Code: MNLCIN *(Monilochaetes infuscans)*
Bangladesh status: Not present in Bangladesh [CABI, 2022]

5.11.2. Morphology

M. pteridophytophila has darker and longer conidiophores [(268)360-565 μm vs. 300 μm high], shorter conidiogenous cells (25-54 μm vs. 70-100 μm) and smaller conidia (20-24 × 10-12 μm vs. 25-38 × 12-16 μm) (Zhang *et al.*, 2021).

A fungus causes the disease. Greyish spots and patches (these may be purplish-brown to black on orange fleshed varieties) occur, with irregular margins, joining together and often covering most of the storage roots. The colour of the infections depends on the variety. However, the infections are only in the 'periderm' of the storage roots; this is the thin 'skin' outside the starchy flesh. Spores are produced on the surface of the infected spots and patches.

Spots, similar to those on the storage roots, may occur on the stems and leaves if infected storage roots are used as a source of planting material.

The fungus is worse in soils with high organic matter, and much less in light sandy soils. Also, scurf is worse during rainy seasons. Spread occurs on infected cuttings, and these can be a source of spores to infect the storage roots. Survival occurs in crop debris for 2-3 years.

5.11.3. Hosts

Ipomoea batatas (sweet potato) and *Ipomoea carnea*

5.11.4. Distribution

Africa: Sierra Leone (EPPO, 2022, Deighton, 1933), South Africa (Thompson *et al*., 1995) and Zimbabwe (Bates, 1963).
Asia: China (Zhang and Huang, 1990); Israel (EPPO, 2022); Japan (EPPO, 2022); North Korea (EPPO, 2022), South Korea (EPPO, 2022), Sri Lanka (EPPO, 2022) and Taiwan (Zhang and Huang, 1990).
Europe: Italy (CABI Undated) and Portugal (EPPO, 2022).
North America: United States (Anon, 1960),
Oceania: Australia (Simmons, 1937), Cook Islands (EPPO, 2022), New Zealand (EPPO, 2022), Papua New Guinea (EPPO, 2022) and Vanuatu (McKenzie and Jackson, 1990).
South America: Argentina (EPPO, 2022) and Brazil (EPPO, 2022)

5.11.5. Hazard Identification Conclusion

Considering the facts that *Monilochaetes infuscans*:

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially economic important to Bangladesh because it is an important pest of sweet potato of China; Israel; Japan; Sri Lanka and Taiwan from where sweet potato imported to Bangladesh.
- *Monilochaetes infuscans* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.11.1: 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**, • It has reached a nearly cosmopolitan distribution and has been recorded from Portugal, Italy, New Zealand and Brazil. **b. Possibility of survival during transport, storage and transfer? Yes** • Spread occurs on infected cuttings, and these can be a source of spores to infect the storage roots. Survival occurs in crop debris for 2-3 years. • The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival.	**YES**

• For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C in which temperature *Monilochaetes infuscans* can survive. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal?-No** • Not enough information is present about this. **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 *Monilochaetes infuscans* is common in Bangladesh and the climate in Bangladesh is also suitable for establishment of *Monilochaetes infuscans* in Bangladesh.	**and Moderate**
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are and climate are similar in Bangladesh to places it is established.	Low

5.11.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.11.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • The *Monilochaetes infuscans*, is an important pest of sweet potato, *Ipomoea batatas* (L.) Lam. It effects on leaves and roots and reduced the yield of sweet potato. • Though the host plants and climate requirement of *Monilochaetes infuscans* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Scurf disease causes cosmetic damage to sweet potatoes and therefore a less marketable product. The disease has no effect on the eating quality of tubers (Sherf and MacNab, 1986). The hepatotoxin Ipomeamarone that might form in sweet potatoes infected by *M. infuscans* is insignificant due to the small amount of tissue affected, and the slow superficial growth of the pathogen (Martin et al., 1976). • Crop losses are only incurred with severe infestations when development of young roots is impaired (Taubenhaus, 1916), when affected tubers crack and shrink during storage (Harter, 1916; Daines, 1955) or because sweet potatoes with scurf disease are predisposed to invasion of spoilage fungi (Poole, 1932). **c. Environmental Impact** • *Monilochaetes infuscans* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And these chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	**Yes and High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.11.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.11.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available;
- In countries where *Monilochaetes infuscans* is not already present, the enforcement of strict phytosanitary regulations as required for *Monilochaetes infuscans* may help to reduce the risk of this insect becoming established; and
- 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 *Monilochaetes infuscans* are present.

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5.C. Diseases: Bacteria

5.12	Crown Gall (*Rhizobium radiobacter*)

5.12.1. Hazard identification

Scientific Name: *Rhizobium radiobacter* (Beijerinck & van Delden 1902) Young et al. 2001
Synonyms Name: *Agrobacterium radiobacter* (Beijerinck & van Delden 1902) Conn 1942
Agrobacterium radiobacter subsp. tumefaciens (Smith & Townsend) De Ley et al. 1966
Agrobacterium sp. biovar 1
Agrobacterium tumefaciens (Smith & Townsend) Conn 1942
Agrobacterium tumefaciens biotype 1
Agrobacterium tumefaciens biovar 1
Bacillus ampelopsorae De Toni & Trevisan 1889
Bacillus radiobacter Beijerinck & van Delden 1902
Bacillus tumefaciens (Smith & Townsend) Holland 1920
Bacterium radiobacter (Beijerinck & van Delden) Löhnis 1904
Bacterium tumefaciens Smith & Townsend 1907
Phytomonas tumefaciens (Smith & Townsend) Bergey et al. 1923
Polymonas tumefaciens (Smith & Townsend) Lieske 1928
Pseudomonas radiobacter (Beij. & v. Deld.) Krasil'nikov 1949
Pseudomonas tumefaciens (Smith & Townsend) Duggar 1909
Rhizobium radiobacter (Beij. & v. Deld.) Pribram 1933

Common names: Crown Gall, bacterial gall; bacterial stem gall; beet crown gall; burr knot; crown gall: beet; crown gall: Rosaceae; crown knot; gall; hairy root: apple; root gall; root knot; rosaceae crown gall.

Taxonomic tree
- Domain: Bacteria
  - Phylum: Proteobacteria
    - Class: Alphaproteobacteria
      - Order: Rhizobiales
        - Family: Rhizobiaceae
          - Genus: Rhizobium
            - Species: *Rhizobium radiobacter*

EPPO Code: AGRBTU (*Agrobacterium tumefaciens*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2021]

5.12.2. Biology

Rhizobium radiobacter is a soil-living, gram-negative, motile rod-shaped bacterium. It is a biotrophic pathogen that can alter the physiology and morphology of its host plant without killing it, resulting in tumourlike structures or galls.

5.12.3. Hosts

Main hosts for *Rhizobium radiobacter* are onion, celery, asparagus, sugar beet, rape, cabbage, cauliflower, broccoli, turnip, pigeon pea, marigold, tea, bell pepper, safflower, pecan, chicory, watermelon, sour orange, lemon, pummel, sweet orange, grape fruit, melon, cucumber, giant pumpkin, marrow, globe artichoke, carrot, yam, white yam, date plum, rubber planr, bourbon cotton, easter cactus, sweet potato, lettuce, lentil, flax, lupins, osage orange, apple, mallow, mango, cassava, Lucerne, maro, black mulberry, tree tobacco, wild tobacco, tobacco, avocado, lima bean, common bean, pines, pepper, pea, stone fruit, American plum, sweet cherry, plum, almond, sour cherry, Canada plumtree, peach, Japanese plum, black cherry, Japanese flowering cherry, pomegranate, radish, rose, rosemary, tomato, mustard, potato, cocoa, clover, blue berries, mung bean, jujube etc. (CABI, 2021).

5.12.4. Distribution

Africa: Algeria (Bouzar *et al*., 1991), Egypt (EPPO, 2022), Ethiopia (EPPO, 2022), Kenya (IPPC-Secretariat, 2005), Libya (EPPO, 2022), Malawi (Bradbury, 1986), Morocco (EPPO, 2022), Mozambique (EPPO, 2022), Seychelles (EPPO, 2022), Somalia (EPPO, 2022), South Africa (Loubser, 1978), Tanzania (EPPO, 2022), Uganda (EPPO, 2022), Zambia (EPPO, 2022) and Zimbabwe (EPPO, 2022).

Asia: Afghanistan (EPPO, 2022), China (Wang *et al*., 2013), India (EPPO, 2022), Indonesia (Suharti, 1976), Israel (EPPO, 2022), Japan (Furuya *et al*., 2004), Jordan (CABI Undated b), Lebanon (EPPO, 2022), Malaysia (EPPO, 2022), Nepal (Lamichhane *et al*., 2009), North Korea (EPPO, 2022), Pakistan (CABI Undated b), Saudi Arabia (EPPO, 2022), South Korea (EPPO, 2022), Sri Lanka (EPPO, 2022), Syria (EPPO, 2022), Taiwan (Bradbury, 1986) and Turkey (EPPO, 2022).

Europe: Austria (EPPO, 2022), Belgium (EPPO, 2022), Czechia (EPPO, 2022), Bulgaria (EPPO, 2022), Cyprus (EPPO, 2022), Czechoslovakia (EPPO, 2022), Denmark (EPPO, 2022), Finland (EPPO, 2022), France (EPPO, 2022), Germany (EPPO, 2022), Greece (EPPO, 2022), Hungary (EPPO, 2022), Italy (EPPO, 2022), Netherlands (EPPO, 2022), Norway (EPPO, 2022), Poland (EPPO, 2022), Portugal (CABI Undated a), Romania (Barbu *et al.*, 2019), Russia (Ignatov *et al*., 2016), Serbia (EPPO, 2022), Spain (EPPO, 2022), Sweden (EPPO, 2022), Switzerland (EPPO, 2022), Ukraine (Bradbury, 1986) and United Kingdom (Weller and O'Neill, 2006).

North America: Bermuda (EPPO, 2022), Canada (EPPO, 2022), Cuba (EPPO, 2022), Jamaica (EPPO, 2022), Mexico (EPPO, 2022) and United States (EPPO, 2022),

Oceania: Australia (EPPO, 2022) and New Zealand (EPPO, 2022).

South Africa: Argentina (Alippi *et al*., 2006), Bolivia (EPPO, 2022), Brazil (EPPO, 2022), Chile (EPPO, 2022), Colombia (Bradbury, 1986), French Guiana (EPPO, 2022), Peru (EPPO, 2022), Uruguay (EPPO, 2022) and Venezuela (EPPO, 2022).

5.12.5. Hazard Identification Conclusion

Considering the facts that *Rhizobium radiobacter* -

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially more economic important to Bangladesh because it is an important pest of sweet potato in India, Japan, Malaysia, Nepal, Saudi Arabia (EPPO, 2022) from where sweet potato are imported to Bangladesh.
- *Rhizobium radiobacter* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.12.1: 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**, • *Rhizobium radiobacter* is a serious and economically important pest of sweet potato and has been introduced in Kenya and Nepal (EPPO, 2022). **b. Possibility of survival during transport, storage and transfer? No** • Due to lack of information about their biology, we can't predict about their survival during transport, storage and transfer. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes,** • Though *Rhizobium radiobacter* is present in the neighbouring country and the countries from which Bangladesh import various agricultural and plant products, so it seems that, the pathway appear good for this pest to enter Bangladesh.	**YES and Moderate**

• Climatic condition of Bangladesh is faviourable for the growth of this pest. **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 *Rhizobium radiobacter* is common in Bangladesh and the climate in Bangladesh is also suitable for establishment of *Rhizobium radiobacter* in Bangladesh.	
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.12.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.12.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • Though the host plants and climate requirement of *Rhizobium radiobacter* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Plants are damaged most by crown gall when they become infected the first year after out-planting. Severely galled young plants are weakened, stunted, unproductive and occasionally die due to girdling and/or development of an inferior root system (Htay and Kerr, 1974). Contradictions abound in the literature, however, about the injurious effects of crown gall on plants. The reports range from benign (or cosmetic), to debilitating, to death-dealing. However, rose growers in New Zealand (DW Dye, MARC, Auckland, personal communication, 1979) and a Euonymous grower in Missouri, USA (D Millikan, University of Missouri, USA, personal communication, 1978) were again able to grow these plants after they began using the biological control agent, R. rhizogenes K84. Nurserymen in Oregon, USA estimate conservatively that use of K84 to prevent crown gall reduces culling of diseased trees and conservatively saves them one million US dollars annually. **c. Environmental Impact** • *Rhizobium radiobacter* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And this chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	**Yes and High**
• Not as above or below	Moderate
• This is likely to be an important pest of common crops grown in Bangladesh.	High

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

Establishment Potential X Consequence Potential = Risk

Table-5.12.3: Calculation of risk rating

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

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

Calculated Risk Rating-High

5.12.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available;
- In countries where *Rhizobium radiobacter* is not already present, the enforcement of strict phytosanitary regulations as required for *Rhizobium radiobacter* may help to reduce the risk of this insect becoming established; and
- 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 *Rhizobium radiobacter* are present.

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5.13	Gall (*Rhizobium rhizogenes*)

5.13.1. Hazard identification

Scientific Name: *Rhizobium rhizogenes* (Riker *et al*. 1930) Young *et al*. 2001
Synonyms Name: *Agrobacterium biovar 2* (Riker *et al*., 1930) Conn 1942
Agrobacterium radiobacter Beijerinck & Van Delden 1902) Kerr *et al*., 1978
Agrobacterium rhizogenes (Riker *et al*. 1930) Conn 1942
Agrobacterium rhizogenes (Riker *et al*.) Conn 1942
Agrobacterium tumefaciens biotype 2
Agrobacterium tumefaciens biovar 2
Bacterium rhizogenes Riker *et al*. 1930
Erwinia rhizogenes (Riker *et al*. 1930) Dowson 1957
Phytomonas rhizogenes Riker *et al*. 1930
Common names: Gall, bacterial gall; bacterial stem gall; beet crown gall; burr knot; crown gall: beet; crown gall: Rosaceae; crown knot; gall; hairy root: apple; root gall; root knot; rosaceae crown gall.
Taxonomic tree
Domain: Bacteria
Phylum: Proteobacteria
Class: Alphaproteobacteria
Order: Rhizobiales
Family: Rhizobiaceae
Genus: Rhizobium
Species: *Rhizobium rhizogenes*
EPPO Code: AGRBRH (*Agrobacterium rhizogenes*)
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2021]

5.13.2. Biology

Some plants and their rhizospheric microorganisms participate in petroleum hydrocarbon remediation through a process known as phytoremediation. Examples of microbes that may participate in these processes include *Agrobacterium tumefaciens* and *A. rhizogenes*, Rhizobium spp., Enterobacter cloaceae, Pseudomonas, and mycorrhizal fungi. Plants function in phytoremediation in two ways, the major one being facilitation of favorable conditions for microbial degradation, specifically by plant root colonizing microbes. The second mechanism involves the plant root itself, which may provide a simple and inexpensive means of accessing contaminants existing in subsurface soils and water. In the rhizosphere, the microbial population is supported by plant nutrients in the form of decaying biomass and root exudates. Plant root exudates also stimulate cometabolic transformations, leading to degradation of some organic contaminants. This, therefore, means that *R. rhizogenes* relies on other means to introduce variation into its genetic material, such as gene transfer using the plasmid. The resulting genetic variation ensures that the bacterium can adapt and survive amid changing surrounding environment and ensure that its host is prepared to tolerate changes as well. Root plant cells would release compounds, which are sensed by the bacterium in the soil, and which triggers it to be attracted to that area. The bacterium then transfers DNA from the plasmid into the host cell and integrates the T-DNA into the plant cell gene structure. After integration, the plant undergoes root architectural changes and produces an abundance of opines, which are beneficial for the growth of *R. rhizogenes.*

5.13.3. Hosts

Main hosts for *R. rhizogenes* are onion, celery, sugar beet, rape, cabbage, cauliflower, broccoli, turnip, pigeon pea, marigold, tea, bell pepper, safflower, pecan, chicory, watermelon, sour orange, lemon, pummel, sweet orange, grape fruit, melon, cucumber, giant pumpkin carrot, yam, white yam, date plum, rubber plant, sweet potato, lettuce, lentil, orange, mango, cassava, tobacco, avocado, common bean, sweet cherry, plum, almond, pomegranate, radish, rose, tomato, mustard, potato, cocoa, clover, blue berries, mung bean, jujube etc. (CABI, 2021).

5.13.4. Distribution

Africa: Algeria (Bouzar *et al*., 1991), Malawi (Bradbury, 1986), and South Africa (Loubser, 1978).
Asia: China (Dai and Gao, 1993), India (Verma and Thapa (2005), Indonesia (CABI Undated a), Japan (Sawada *et al.* 1990), Malaysia (CABI Undated a) and Taiwan (Bradbury, 1986).
Europe: Bulgaria (EPPO, 2022), France (EPPO, 2022), Italy (EPPO, 2022), Portugal (CABI Undated a), Russia (CABI Undated a), Spain (López *et al*., 2008) and Ukraine (Bradbury, 1986).
North America: Canada (CABI Undated a) and United States (Bradbury, 1986),
Oceania: Australia (Bradbury, 1986).
South America: Argentina (Alippi *et al*., 2010), Brazil (CABI Undated a) and Colombia (Bradbury, 1986).

5.13.5. Hazard Identification Conclusion

Considering the facts that *Rhizobium rhizogenes* -

- is not known to be present in Bangladesh [EPPO, 2022];
- is potentially more economic important to Bangladesh because it is an important pest of sweet potato in China, India, (EPPO/CABI, 2022) from where sweet potato are imported to Bangladesh.
- *Rhizobium rhizogenes* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.13.1: 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**, • *Rhizobium rhizogenes* is a serious and economically important pest of sweet potato and has been introduced in India, Spain, Argentina and Italy (EPPO, 2022). • Infectious hairy root disease is caused by *Rhizobium rhizogenes* and it occurs on many dicotyledonous plants. It was first identified as a pathogen of economic importance on apples in the early 20th century **b. Possibility of survival during transport, storage and transfer? Yes** • Galls first appear as small, callus-like outgrowths within 2-4 weeks of infection when temperatures are at or above 20°C. At first the galls cannot be distinguished from wound callus, but galls usually develop more rapidly than callus, producing white to tannish-coloured, more-or-less spherical galls. Gall texture varies from soft and spongy in the early period of formation to hard as they age, depending largely upon the content of disorganized vascular elements. Gall surfaces typically are not covered by an epidermis and can vary in colour. • The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival. • For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature *Rhizobium rhizogenes* can survive. **c. Does the pathway appear good for this pest to enter Bangladesh and establish and dispersal? - Yes,**	**YES and High**

• Though *Rhizobium rhizogenes* is present in the neighbouring country and the countries from which Bangladesh import various agricultural and plant products, so it seams that, the pathway appear good for this pest to enter Bangladesh. • Climatic condition of Bangladesh is faviourable for the growth of this pest. **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 *Rhizobium rhizogenes* is common in Bangladesh and the climate in Bangladesh is also suitable for establishment of *Rhizobium rhizogenes* in Bangladesh.	
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter Bangladesh and establish, and • Its hosts are not common in Bangladesh and climate is not similar to places it is established.	Low

5.13.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.13.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • Though the host plants and climate requirement of *Rhizobium rhizogenes* are similar with Bangladesh, so it will be serious pest for Bangladesh. **b. Economic impact and yield loss** • Accounts of disease loss caused by crown gall are at best estimates as detailed, accurate surveys are rarely conducted, nor are there good survey instruments available for disease forecast and impact. Plants with crown gall disease are primarily a problem for nurserymen who grow woody plants and shrubs for landscapes and fruit production. Losses in the USA amount to millions of dollars annually from the culling of diseased nursery trees. Infected nursery plants may subsequently have reduced vigour through root damage, but thiss has never been accurately quantified. Production also can be reduced for landscape plants such as rose and poplar and for fruit trees, grapevines, caneberries and chrysanthemums (Nesme *et al.,* 1990). **c. Environmental Impact** • *Rhizobium rhizogenes* will be a new pest for Bangladesh and no research present for effective controlling measurement for this pest. As a result, farmers will use chemical insecticides at excess and/or less dose. As a result, pest resistant, resurgence and outbreak will be occurred. And this chemical insecticides damage our environment, kill animals, birds etc. and also damage aquatic ecosystem.	**Yes and High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.13.3: Calculation of risk rating

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

Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

Calculated Risk Rating-High

5.13.9. Risk Management Measures

- Avoid importation of vine and tuber from countries, where this pest is available.
- In countries where *Rhizobium rhizogenes* is not already present, the enforcement of strict phytosanitary regulations as required for *Rhizobium rhizogenes* may help to reduce the risk of this insect 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 *Rhizobium rhizogenes* are present.

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5.D. DISEASE CAUSING PATHOGEN: NEMATODE

5.14	Sting nematode: *Belonolaimus longicaudatus* Rau, 1958

5.14.1 Hazard Identification

Scientific Name: *Belonolaimus longicaudatus* Rau, 1958

Common name: Sting nematode

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Nematoda
Family: Belonolaimidae
Genus: *Belonolaimus*
Species: *Belonolaimus longicaudatus*

EPPO code: BELOLO
Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022].

5.14.2. Biology

B. longicaudatus is a migratory ectoparasite of plant roots. There are three juvenile stages in the soil; the first moult occurs within the egg. The life cycle takes about 28 days and the species is amphimictic. Although an ectoparasite, the exceptionally long spear allows the nematode to feed deep within the root tissue, causing severe damage to the host. The optimum temperature for reproduction is around 30ºC, but the nematode remains active and feeds at up to 39ºC. Light sandy soils are favoured and the nematode is absent in muck or marl soils.

The existence of physiological races has been demonstrated and these have differing host ranges (Smart and Nguyen, 1991). The presence of the nematode may overcome resistance to Fusarium wilt [*Fusarium oxysporum* f.sp. *vasinfectum*] in cotton leading to high crop losses in the field.

5.14.3. Hosts

B. longicaudatus has a wide host range including many grasses, crops and woody hosts. Differences in host range are reported between populations from various states in the USA (Smart and Nguyen, 1991).

a. **Major hosts:** The main host of *B. longicaudatus are Daucus carota* (carrot), *Helianthus annuus* (sunflower), *Lactuca sativa* (lettuce), *Brassica oleracea* (cabbages, cauliflowers), ***Ipomoea batatas* (sweet potato),** *Citrullus lanatus* (watermelon), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Arachis hypogaea* (groundnut), *Glycine max* (soyabean), *Pisum sativum* (pea), *Allium cepa* (onion), *Abelmoschus esculentus* (okra), *Triticum* *aestivum* (wheat), *Zea mays* (maize), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato) etc.

b. **Minor hosts:** The minor or other hosts of this pest include *Ligustrum sinennsis*, *Oriza* sp., *Phragmites australis*, *Ocimun basilicum*, and *Sapium sebiferum, Fragaria* (strawberry), *Citrus sinensis* (navel orange), *Capsicum annuum* (bell pepper) etc.

5.14.4. Distribution

B. longicaudatus is a major pest in southeastern USA and is widespread throughout the Atlantic coastal plain from Virginia to Florida. Outlier populations have been reported from Mexico and Central America. Reports from Bermuda, the Bahamas and Puerto Rico apparently refer to golf courses where infected turf was imported from the USA (Perry and Rhoades, 1982). Early reports of *B. gracilis* from southern USA almost certainly refer to *B. longicaudatus.*

Asia: India (Qaiser Shakeel *et al.* 2009)) Pakistan (Pathan *et al.*, 2004), Saudi Arabia (Abu-Gharbieh & Al-Azzeh, 2004), Turkey (Kepenekci, 2001).
North America: USA (Alabama, Arkansas, California, Delaware, Florida, Georgia, Illinois, Indiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas) (Mundo-Ocampo *et al.,* 1994; Cherry *et al.,* 1997; CABI/EPPO, 2003).
South and Central America: Bahamas, Costa Rica, Puerto Rico (Perry & Rhoades, 1982; CABI/EPPO, 2003).
Oceania: Absent.

EPPO: Absent.

5.14.5. Hazard Identification Conclusion

Considering the facts that *B. longicaudatus* -

- is not known to be present in Bangladesh [CABI/EPPO, 2003].
- is potentially economic important to Bangladesh because it is an important pest of various vegetables like Apiaceae, Asteraceae, Brassicaceae, Cucurbitaceae, Convolvulaceae, Fabaceae, Malvaceae, Poaceae, Solanaceaeous family in Worldwide including Pakistan, Saudi Arabia, Turkey, USA (CABI/EPPO, 2022) from where vegetables and planting matreials are imported to Bangladesh.
- *B. longicaudatus* feeds ectoparasitically near the root tip and along the root resulting in a reduced root system with stubby side branches and terminal galling. Dark lesions may appear on the outer root surface at the point of penetration. Above-ground symptoms include severe stunting, wilting in dry conditions, leaf chlorosis and, in severe cases, death of the plant. The main phytosanitary risk is probably via infected sods of turf exported for golf course establishment. *B. longicaudatus* may be extracted from soil and turf using standard techniques. Because it is a relatively long nematode, centrifugation or immersion sieving methods should enhance recovery rates. The vegetables are imported from other countries through airfreight. Therefore, *B. longicaudatus* can easily enter in Bangladesh and establish.
- *B. longicaudatus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.14.1: 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 • This pest has been established in many countries including India, Pakistan, Saudi Arabia, Turkey, USA (CABI/EPPO, 2022). **b. Posibility of survival during transport, storage and transfer?-Yes** • *B. longicaudatus* is a migratory ectoparasite of plant roots. The life cycle takes about 28 days and the species is amphimictic. Although an ectoparasite, the exceptionally long spear allows the nematode to feed deep within the root tissue, causing severe damage to the host. Therefore, this pest can survive during transport, storage and transfer of planting materials with roots and soils. **c. Does the pathway appear good for this pest to enter into Bangladesh and establish? - No** • *B. longicaudatus* is found in deep sandy soils where it is an ectoparasite of plant roots. In Virginia, USA, the sand content of infested soils ranged from 84 to 94% (Miller, 1972). The nematode is mainly confined to the top 30 cm of soil but may migrate vertically in response to temperature. • The main phytosanitary risk is probably via infected sods of turf exported for golf course establishment. Therefore, the less probability to enter this pest through seeds or fruits of the cucurbits into Bangladesh. **d. Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The host range of *B. longicaudatus* is very wide The main host of B. longicaudatus are *Daucus carota* (carrot), *Helianthus annuus* (sunflower), *Lactuca sativa* (lettuce), *Brassica oleracea* (cabbages, cauliflowers), ***Ipomoea batatas* (sweet potato),** *Citrullus lanatus* (watermelon), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Arachis hypogaea* (groundnut), *Glycine max* (soyabean), *Pisum sativum* (pea), *Allium cepa* (onion), *Abelmoschus esculentus* (okra), *Triticum aestivum* (wheat), *Zea mays* (maize), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato). The numbers of plants attacked belong to the families are Apiaceae, Asteraceae, Brassicaceae, Cucurbitaceae, Convolvulaceae, Fabaceae, Malvaceae, Poaceae, Solanaceaeous. • The optimum temperature for reproduction is around 30ºC, but the nematode remains active and feeds at up to 39ºC. Light sandy soils are favoured and the nematode is absent in muck or marl soils. • The climatic requirements and hosts of *B. longicaudatus* are common in Bangladesh.	**Yes and Moderate**
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

5.14.7. Determine the Consequence establishment of this pest in Bangladesh

Table-5.14.2: Which of these descriptions best fit of this pest?

Description	**Consequence Potential**
a. Is this a serious pest of **Bangladesh? - Yes**. • *B. longicaudatus i*s a major pest in southeastern USA and is widespread throughout the Atlantic coastal plain from Virginia to Florida. • *B. longicaudatus* feeds ectoparasitically near the root tip and along the root resulting in a reduced root system with stubby side branches and terminal galling. Dark lesions may appear on the outer root surface at the point of penetration. Above-ground symptoms include severe stunting, wilting in dry conditions, leaf chlorosis and, in severe cases, death of the plant. • This is a fairly serious pest of several important vegetables and other crops for Bangladesh. **b. Economic Impact and Yield Loss** • If introduced, this pest could lower the yield of several crops of economic importance and may cause plant mortality, but damages depend upon the type of crop and the growth stage affected. • *B. longicaudatus* can cause devastating losses to cotton, particularly when it occurs in association with Fusarium wilt [*Fusarium oxysporum* f.sp. *vasinfectum*]. It also causes severe losses to other crops including groundnut, soyabean, *Phaseolus vulgaris*, beet, crucifers, celery, okra, onion, pea, pepper, potato and maize and to forage and turf grasses, the latter being economically important in amenity grassland such as golf courses. **c. Environmental Impact** • Chemical treatment of soil using liquid or granular nematicides is usually highly effective due to the porous nature of the sandy soils that the nematode favours. But the application of chemical pesticides in the soils leads to soil and water pollutions. Thus, the introduction and establishment of this pest would stimulate the use of chemical pesticides in the field that are toxic and harmful to the soil and environment.	**Yes** **and** **High**
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.14.3: Calculating risk rating

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

Calculated Risk Rating-High

5.14.9. Phytosanitary Measures

- Avoid importation of vegetables (Roots, Seedings, Micropropagated plants) from countries, where this pest is available.
- *B. longicaudatus* may be extracted from soil and turf using standard techniques. Because it is a relatively long nematode, centrifugation or immersion sieving methods should enhance recovery rates.
- A phytosanitary certificate may be required for vegetables with roots, seedlings and micropropagated plants

5.14.10. References

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5.15	Pacara Earpod tree root-knot nematode: *Meloidogyne enterolobii* Yang & Eisenback, 1983

5.15.1 Hazard Identification

Scientific Name: *Meloidogyne enterolobii* Yang & Eisenback, 1983

Common name: Pacara earpod tree root-knot nematode

Other Scientific Name: *Meloidogyne mayaguensis* Rammah & Hirschmann, 1988

Taxonomic tree

Domain: Eukaryota
Kingdom: Metazoa
Phylum: Nematoda
Family: Meloidogynidae
Genus: Meloidogyne
Species: *Meloidogyne enterolobii*

EPPO code: MELGMY

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022].

5.15.2. Biology

M. enterolobii is a sedentary endoparasite. Its life-cycle is very similar to other root-knot nematodes, and can be summarized briefly as follows. The worms hatch in the soil as second-stage, infective juveniles (J2s) and migrate towards the root of their host plant, which they invade in the zone of elongation. There, they migrate intercellularly, first to the root apex and then to the vascular cylinder, where permanent feeding sites (i.e., giant cells) are established. Now sedentary, J2s further undergo three successive moults to develop into adults. The saccate (pyriform) females remain sedentary, producing large egg masses that are extruded in a gelatinous matrix out of the root, while males (if any) migrate out of the plant tissues (Abad *et al.,* 2003). The life-cycle of *M. enterolobii* takes 4-5 weeks under favourable conditions and females produce around 400-600 eggs. The reproduction of *M. enterolobii* is by mitotic parthenogenesis and the somatic chromosome number is 2n = 44-46. Most oocytes advance to metaphase and telophase soon after they have entered the uterus and show no extended prophase stage (Yang and Eisenback, 1983).

5.15.3. Hosts

M. enterolobii is considered to be a highly polyphagous species, with a host range similar to that of Meloidogyne incognita (Yang and Eisenback, 1983). The most frequently recorded hosts include many vegetables, e.g., tomato, pepper and watermelon (Rammah and Hirschmann, 1988) but also guava (Gomes *et al.,* 2011), ornamental plants (Brito *et al.,* 2010) and weeds (Rich *et al.,* 2009). Of particular concern is the ability of *M. enterolobii* to develop on crop genotypes carrying resistance to the major Meloidogyne species, among which are resistant cotton, sweet potato, tomatoes (Mi-1 gene), potato (Mh gene), soyabean (Mir1 gene), bell pepper (N gene), sweet pepper (Tabasco gene) and cowpea (Rkgene) (Cetintas et al., 2008). Very few crop species have been recorded as non-hosts for *M. enterolobii,* including grapefruit, sour orange, garlic and peanut (Brito *et al.,* 2004).

Major hosts: The main host of *M. enterolobii are Cucumis sativus* (cucumber*), Glycine max* (soyabean), *Ipomoea batatas* (sweet potato), *Phaseolus vulgaris* (common bean), *Psidium guajava* (guava), *Solanum lycopersicum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), etc.

5.15.4. Distribution

M. enterolobii is largely distributed in regions with typical tropical climatic conditions, including Asia, Africa, Europe, South and Central America and the Caribbean. It has also been reported from areas of North America exhibiting a warmer climate, e.g., Florida and North Carolina (Ye *et al.,* 2013). Because of its thermal requirements, *M. enterolobii* will probably not survive in colder regions. However, it might be able to establish in Mediterranean climates or in greenhouses (e.g., the nematode was detected on vegetables in greenhouses in Switzerland; Kiewnick *et al.,* 2008). *M. enterolobii* has been intercepted on several occasions in a few European countries in plant materials imported from tropical areas. Recently, it has been reported in several localities of Portugal (Santos *et al.,* 2019).

Asia: China (EPPO, 2022), **I**ndia (Kumar and Rawat, 2018), Singapore, Taiwan, Thailand, Vietnam (EPPO, 2022).
North America: USA (Alabama, Arkansas, California, Delaware, Florida, Georgia, Illinois, Indiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Texas) (CABI and EPPO, 2014).
South and Central America: Brazil (CABI/EPPO, 2022).
Oceania: Absent.

EPPO: Belgium, France, Netherlands, Portugal and Switzerland (EPPO, 2022).

5.15.5. Hazard Identification Conclusion

Considering the facts that *M. enterolobii* -

- is not known to be present in Bangladesh [CABI/EPPO, 2022].
- is potentially economic important to Bangladesh because it is an important pest of various vegetables and fruits like cucumber, soyabean, sweet potato, bean, guava, tomato, brinjal, potato in Worldwide including China, India, Singapore, Taiwan, Thailand, Vietnam (CABI/EPPO, 2022) from where vegetables and planting materials are imported to Bangladesh.
- *Meloidogyne enterolobii* is a highly pathogenic and aggressive invasive species emerging as an economically important species worldwide. As a root-knot nematode species, M. enterolobii can easily be transmitted with soil and plant material. Infested soil and growing media, plants for planting, bulbs and tubers from countries where *M. enterolobii* occurs are the most probable pathways of introduction into different regions. Soil attached to machinery, tools, footwear or plant products is also another possible pathway. The recent interception of this pest in several countries in Europe and the Mediterranean region (Germany, The Netherlands, UK) illustrates that it has the potential to enter different regions. In addition, *M. enterolobii* could survive under glasshouse conditions across regions with a sub-Mediterranean or a continental climate. Once root-knot nematodes have been introduced, it is generally difficult to control or eradicate them. Only in the EPPO region has this nematode been listed as a quarantine pest (EPPO A2 list No.361)
- *M. enterolobii* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.15.1: 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 • *M. enterolobii* and the fact that it has been intercepted approximately 10 times from 1991 to 2007 in the Netherlands (although the identity of the nematode could only be confirmed in 2007). The Dutch NPPO intercepted *M. enterolobii* in 1991 in plants of *Cactus* sp. imported from South Africa; in 1993 and 1994 in plants of *Syngonium* sp. imported from Togo; in 1999 in plants of *Ficus* sp. imported from China; in 2004 in plants of *Ligustrum* sp. imported from China; in 2006 in plants of *Brachychiton* sp. imported from Israel; and in 2006 and 2008 in plants of *Rosa* sp. imported from South Africa and China (Netherlands Food and Consumer Product Safety Authority, 2008). The presence of *M. enterolobii* has been reported in glasshouses in France (Blok *et al.,* 2002) and Switzerland (Kiewnick *et al.,* 2008) which clearly demonstrates that there are pathways for the introduction of this pest into the EPPO region. • This pest has been established in many countries including China, India, Singapore, Taiwan, Thailand (CABI/EPPO, 2022). **b. Possibility of survival during transport, storage and transfer?-Yes** • *M. enterolobii* is a sedentary endoparasite. Its life-cycle is very similar to other root-knot nematodes, and can be summarized briefly as follows. The worms hatch in the soil as second-stage, infective juveniles (J2s) and migrate towards the root of their host plant, which they invade in the zone of elongation. There, they migrate intercellularly, first to the root apex and then to the vascular cylinder, where permanent feeding sites (i.e., giant cells) are established. Now sedentary, J2s further undergo three successive moults to develop into adults. The saccate (pyriform) females remain sedentary, producing large egg masses that are extruded in a gelatinous matrix out of the root, while males (if any)	**Yes and High**

<table>
<tr><td>
migrate out of the plant tissues (Abad et al., 2003). The life-cycle of M. enterolobii takes 4-5 weeks under favourable conditions and females produce around 400-600 eggs.
• The transport duration of sweet potato from exporting countries to Bangladesh is about 20 days. So, the duration is favorable for this insect to survival.
• For the transportation, storage and transfer planting materials and tuber temperature is maintained under 20°C, in which temperature M. enterolobii can survive.
c. Does the pathway appear good for this pest to enter into Bangladesh and establish? - Yes
• The risk of introducing nonindigenous plant pathogens or pests into new areas is increasing rapidly due to globalization and the extensive trade and transport network now established within and among continents (Hulme, 2009).
• Meloidogyne spp. are universally associated with vegetable production across the globe. Meloidogyne enterolobii is a highly pathogenic and aggressive invasive species emerging as an economically important species worldwide.
• As a root-knot nematode species, M. enterolobii can easily be transmitted with soil and plant material. Infested soil and growing media, plants for planting, bulbs and tubers from countries where M. enterolobii occurs are the most probable pathways of introduction into different regions. Soil attached to machinery, tools, footwear or plant products is also another possible pathway.
• The recent interception of this pest in several countries in Europe and the Mediterranean region (Germany, The Netherlands, UK) illustrates that it has the potential to enter different regions.
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 M. enterolobii is very wide. The main host of M. enterolobii are Cucumis sativus (cucumber), Glycine max (soyabean), Ipomoea batatas (sweet potato), Phaseolus vulgaris (common bean), Psidium guajava (guava), Solanum lycopersicum (tomato), Solanum melongena (aubergine), Solanum tuberosum (potato), etc.
• The optimum temperature for reproduction is around 30ºC, but the nematode remains active and feeds at up to 39ºC. Light sandy soils are favored and the nematode is absent in muck or marl soils.
• The climatic requirements and hosts of M. enterolobii are common in Bangladesh.
</td><td></td></tr>
<tr><td>• NOT AS ABOVE OR BELOW</td><td>Moderate</td></tr>
<tr><td>• This pest has not established in new countries in recent years, and
• The pathway does not appears good for this pest to enter Bangladesh and establish, and
• Its host(s) are not common in Bangladesh and climate is not similar to places it is established</td><td>Low</td></tr>
</table>

5.15.7. Determine the Consequence establishment of this pest in Bangladesh

Table-15.2: Which of these descriptions best fit of this pest?

<table>
<tr><td>Description</td><td>Consequence Potential</td></tr>
<tr><td>a. Is this a serious pest of Bangladesh? - Yes.
• Though the host plants and climate requirement of M. enterolobii are similar with Bangladesh, so it will be serious pest for Bangladesh.
b. Economic Impact and Yield Loss
• M. enterolobii is considered as a very damaging pest because of its wide host range, high reproduction rate and the induction of large galls (Castagnone-Sereno, 2012). Although few detailed studies are available, M. enterolobii is referred to as a highly aggressive species (i.e., a very successful parasitic species with high infestation rate on the roots of</td><td>Yes
and
High</td></tr>
</table>

host plants) and induces more severe root galling than other root-knot nematode species. In a microplot experiment, tomato yield losses of up to 65% have been observed (Cetintas *et al.,* 2007). In two greenhouses in Switzerland, yield losses of up to 50% and severe stunting of tomato rootstocks and cucumber were observed (Kiewnick *et al.,* 2008). In heavily infested areas, cultivation may become unviable, as exemplified for guava in Brazil (Carneiro *et al.,* 2007). In okra (*Abelmoschus esculentus*), Silva *et al.* (2019) verified the pathogenicity of this nematode under controlled conditions. **c. Environmental Impact** • Chemical treatment of soil using liquid or granular nematicides is usually highly effective due to the porous nature of the sandy soils that the nematode favours. But the application of chemical pesticides in the soils leads to soil and water pollutions. Thus, the introduction and establishment of this pest would stimulate the use of chemical pesticides in the field that are toxic and harmful to the soil and environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.15.3: 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

5.15.9. Phytosanitary Measures

- Avoid importation of vegetables (Roots, Seedings, Micropropagated plants) from countries, where this pest is available.
- *B. longicaudatus* may be extracted from soil and turf using standard techniques. Because it is a relatively long nematode, centrifugation or immersion sieving methods should enhance recovery rates.
- A phytosanitary certificate may be required for vegetables with roots, seedlings and micropropagated plants

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5.E. DISEASE CAUSING PATHOGEN: VIRUS

5.16	*Sweet Potato Chlorotic Stunt Virus*

5.16.1 Hazard Identification

Scientific Name: *Sweet potato chlorotic stunt virus*

Synonyms: *SPVD-associated closterovirus (SPVD-AC)*
Sweet potato chlorotic dwarf disease
Sweet potato chlorotic stunt crinivirus
Sweet potato sunken vein virus

Common names: SPCSV

Taxonomic tree

Domain: Virus
Group: "Positive sense ssRNA viruses"
Group: "RNA viruses"
Family: Closteroviridae
Genus: Crinivirus
Species: *Sweet potato chlorotic stunt virus*

EPPO Code: SPCSV0.

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022; EPPO, 2021].

5.16.2. Biology

Symptoms are variable in sweet potato depending on variety and also location. There may be a mild yellowing or reddening (Photo 1) of older leaves and stunting, as the name suggests, but often infected plants do not show signs of infection.

However, when SPCSV occurs with other sweet potato viruses the effect on plants can cause Sweet potato virus disease. Leaves become yellow, thin, deformed, and plants rarely set roots, or root production is very low. This interaction has been reported with *Sweet potato feathery mottle virus* (see Fact Sheet no. 258), *Sweet potato virus* G and *Sweet potato cavemovirus*.

Spread of *SPCSV* occurs in three ways. First, by whiteflies, e.g., *Bemisia tabaci.* The virus is picked up as the insects feed on plant sap of diseased plants and, after a short delay, they can infect healthy plants. Secondly, in cuttings used for planting. Thirdly, in storage roots sent to markets: buyers often take the roots and grow sprouts from them for planting. It is unlikely that the virus is seedborne.

Survival of the virus between crops or cropping seasons occurs in vines left in the field after harvest, in storage roots discarded in the field or intentionally kept as a source of planting material. *SPCSV* has been detected in wild Ipomoea hosts, but less frequently than e.g., *Sweet potato feathery mottle virus* or *Sweet potato leaf curl virus*.

5.16.3. Hosts

Sweetpotato; there are no reports that the virus has been found in other plant species or in weeds.

5.16.4. Geographical distribution

Worldwide. Asia, Africa, North, South Central America, Europe. Oceania. It has been recorded from Solomon Islands.

Asia: China (EPPO, 2022), Korea, Taiwan Lebanon (Cheng *et al.* 2020)

Africa: Egypt (IsHak and El-Deeb, 2004), Kenya (EPPO, 2022), South Africa (EPPO, 2022)

Europe: Hungary, Portugal, Spain (EPPO, 2022)

North America: Mexico, USA (Texas – Kao *et al.,* 2000)

EU: present

5.16.5. Hazard Identification Conclusion

Considering the facts that *Sweet potato chlorotic stunt virus* -

- is not known to be present in Bangladesh [CABI/EPPO, 2022; EPPO, 2022].
- is potentially economic important to Bangladesh because it is an important pest of **sweet potato** in Asia and other countries including China, Korea from where vegetables are imported to Bangladesh.
- *SPCSV* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

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

Table-5.16.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
a. Has this pest been established in several new countries in recent years?-Yes, • This pest has been established in many Asian and other countries including China, Korea, Taiwan, Lebanon (EPPO, 2022). • *Sweet potato chlorotic stunt virus (SPCSV)* was detected for the first time in North Carolina, United States. *Sweet potato chlorotic stunt virus* when found in association with *Sweet potato feathery mottle virus (SPFMV)* causes *Sweet potato virus disease (SPVD)*,	

a serious disease originally described in Africa in the 1970's. *Sweet potato chlorotic stunt virus* is the whitefly transmitted component of the disease. Sweet potato feathery mottle virus is transmitted by aphids. The only other U.S. report of *SPCSV* was from a single accession in the USDA Sweet Potato Germplasm Repository. No other detections of *SPCSV* have been reported in the United States. In both cases of U.S. *SPCSV* detection, *SPFMV* was also present. Two isolates of *SPCSV* were collected in North Carolina in 2001 and 2003. **b. Possibility of survival during transport, storage and transfer?-Yes** • The spread of the virus may be related to the increase in distribution of the polyphagous B biotype of *B. tabaci* (also known as *B. argentifolii*; Bellows *et al*., 1994). The international trade in poinsettia is thought to have been a major means of dissemination of the B biotype within the EPPO region (EPPO/ CABI, 1997). The virus can be retained at least for 7 days by the vector. • During the period of transportation of sweet potato, the eggs and crawlers of whitefly can easily survive on fruit surfaces of sweet potato. Secondly, sweet potato is packed in wrapping (wooden boxes) and stored in normal conditions. So, the pests could survive during transporting process. Therefore, this pest is rated with **high-risk** potential. **c. Does the pathway appear good for this pest to enter Bangladesh and establish? - Yes,** • Can be moved by infected planting material and grafting but is not seedborne or likely to be transmitted by contact between plants. • Within crops, natural spread of *SPCSV* is ensured by its vector, *B. tabaci.* Internationally, infected young plants of cucurbits intended for planting are a likely pathway to introduce or spread the disease. Also, all stages of the whitefly vector can be carried on plants for planting. There is not, however, known to be a significant movement of sweet potato for planting from areas where the disease occurs. d. **Are the host(s) of this fairly common in Bangladesh and the climate is similar to places it is established?– Yes** • The natural hosts of *SPCSV* are restricted only to sweet potato which is an important vegetable in **Bangladesh**. • These climatic requirements for growth and development of *SPCSV* are more or less similar with the climatic condition of **Bangladesh**.	**YES and HIGH**
• NOT AS ABOVE OR BELOW	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter Bangladesh and establish, and • Its host(s) are not common in Bangladesh and climate is not similar to places it is established	Low

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

Table-5.16.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • *SPCSV* is not present those countries from where we import vegetables. On the other hand it is only restricted under cucurbitaceous family.	**Yes and High**

• So, if we strictly prohibited the importation from those countries where not only the virus but also the vectors are present. **b. Economic Impact and Yield Loss** • SPCSV causes little impact when on its own in sweet potato. However, in Africa, Asia and Central America, yield losses of 50-90% occur when SPCSV occurs with other viruses in susceptible plants. The presence of SPCSV allows the other viruses to reach concentrations in sweet potato that are much greater than when they occur alone. For instance, with Sweet potato feathery mottle virus this may be up to 600 times greater. **c. Environmental Impact** • SPCSV represents a potential threat to many crops. The establishment of it could trigger chemical control programs by using different insecticides for controlling vector of this virus that are toxic and harmful to the environment.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in Bangladesh.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.16.3: Calculation of risk rating

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

Calculated Risk Rating-High

5.16.9. Risk Management Measures

- Avoid importation of vegetables, where this pest and it's vector is available.
- A phytosanitary certificate may be required for vegetables with leaves.

5.16.10. References

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5.F. WEED

5.17	Parthenium weed: *Parthenium hysterophorus*

5.17.1 Hazard Identification

Scientific name: *Parthenium hysterophorus* L.

Synonyms: *Parthenium hysterophorus* var. *lyratum* A.Gray
Argyrochaeta bipinnatifida Cav.
Argyrochaeta parviflora Cav.
Echetrosis pentasperma Phil.
Parthenium glomeratum Rollins,
Parthenium lobatum Buckley,
Parthenium pinnatifidum Stokes,
Villanova bipinnatifida Ortega

Common names: Parthenium weed, bitter weed, bitter-broom, bitterweed, carrot grass, congress grass, false camomile, false ragweed, feverfew, parthenium, parthenium weed, ragweed, ragweed parthenium, Santa Maria, Santa Maria feverfew, white top, whitehead, whitetop

Taxonomic tree

Kingdom: Plantae
Family: Asteraceae
Genus: *Parthnium*
Species: *Parthenium hysterophorus*

EPPO Code: PTNHY. This pest has been included in EPPO A2 list: No. 383

Bangladesh Status: Present in restricted areas of Bangladesh possibly introduced from India.

5.17.2 Biology

P. hysterophorus reproduces only by seeds and is known to be highly prolific, as a single plant produces 15 000 seeds on average and up to 100 000 seeds (GISD Database, Global Invasive Species Database, 2010). Seed viability is high, 85% or higher (Navie *et al.,* 1998). Buried seeds have been found to last longer than seeds on the soil surface, and a significant proportion can still germinate after 8-10 years. Freshly produced seeds demonstrate a degree of dormancy (up to several months) (Navie *et al.,* 1998). In addition, the species is an opportunistic germinator. Seeds can germinate at any time of the year provided moisture is available but they require bare soil to do so (Parsons & Cuthbertson, 1992). The plant flowers 4-8 weeks after germination and flowering continue until drought or frost kills the plant. Under favourable conditions, 2 – 3 life cycles can be completed per year (Fatimah & Ahmad, 2009).

5.17.3 Hosts or habitats

- *P. hysterophorus* grows in a wide range of habitats, including degraded and disturbed lands and streams and rivers. It is a pioneer species that can invade grazing land and degraded pastures, crops, orchards, summer crops, disturbed and cultivated areas, forests, railway tracks and roadsides, recreation areas, as well as river banks and floodplains (Navie *et al*. 1996a).
- According to the Corine Land Cover nomenclature, the following habitats are invaded: arable land, permanent crops (e.g. vineyards, fruit tree and berry plantations, olive), pastures, riverbanks/canalsides (dry river beds), road and rail networks and associated land, other artificial surfaces (wastelands).

- In Australia, the main impact of *P. hysterophorus* has been in the pastoral region of Queensland, where it replaces forage plants, thereby reducing the carrying capacity for grazing animals (Haseler, 1976; Chippendale and Panetta, 1994). Serious encroachment and replacement of pasture grasses has also been reported in India (Jayachandra, 1971) and in Ethiopia (Tamado, 2001; Taye, 2002).
- *P. hysterophorus* is now being reported from India as a serious problem in cotton, groundnuts, potatoes and sorghum, as well as in more traditional crops such as okra (*Abelmoschus esculentus*), brinjal (*Solanum melongena*), chickpea and sesame (Kohli and Rani, 1994), and is also proving to be problematic in a range of orchard crops, including cashew, coconut, guava, mango and papaya (Tripathi *et al.,* 1991; Mahadevappa, 1997).
- Similar infestations of sugarcane and sunflower plantations have recently been noted in Australia (Parsons and Cuthbertson, 1992; Navie *et al.,* 1996). In Ethiopia, parthenium weed was observed to grow in maize, sorghum, cotton, finger millet (*Eleusine coracana*), haricot bean (*Phaseolus vulgaris*), tef (*Eragrostis tef*), vegetables (potato, tomato, onion, carrot) and fruit orchards (citrus, mango, papaya and banana) (Taye, 2002). In Pakistan, the weed has been reported from number of crops, including wheat, rice, sugarcane, sorghum, maize, squash, gourd and water melon (Shabbir 2006; Shabbir *et al.* 2011; Anwar *et al*. 2012).

5.17.4 Geographical distribution

Native distribution: *P. hysterophorus* is native to the area bordering the Gulf of Mexico, and has spread throughout southern USA, the Caribbean and Brazil.

- **North America**: Bermuda, Mexico, USA (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Hawaii, Illinois, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Missouri, Mississippi, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia).
- **Central America and Caribbean**: Belize, Costa Rica, Cuba, Dominican Republic, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Puerto Rico, Saint Barthelemy, Republic of Panama, Trinidad, Trinidad and Tobago.
- **South America**: Argentina, Bolivia, Brazil, Chile, Ecuador, French Guiana, Guyana, Peru, Paraguay, Suriname, Uruguay, Venezuela.

Exoticdistribution

- **EPPO region**: Israel.
- **Africa:** Comores, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Mauritius, Mayotte, Mozambique, Reunion, Seychelles, Somalia, South Africa, Swaziland, Tanzania, Uganda and Zimbabwe.
- **Asia:** Bangladesh, Bhutan, China (south of country), India, Oman and Yemen, Israel, Nepal, Pakistan, Sri Lanka, Japan, Republic of Korea, Taiwan and Vietnam.
- **Oceania:** Australia (Queensland, New South Wales, Northern Territory, Western Australia), French Polynesia, several Pacific islands including Bermuda, New Caledonia, Vanuatu and Christmas island.

5.17.5 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 vegetables, flowers and foliages in Asia including China, India, Nepal, Pakistan, **Japan** [EPPO, 2014; CABI/EPPO, 1999] from where agricultural crops and flowers are imported to Bangladesh.

- can become established in Bangladesh through the transportation of agricultural equipment and imports of the agricultural planting materials including vegetables, flowers and foliages.
- *Parthenium hysterophorus* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.17.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-5.17.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
A. Has this pest been established in several new countries in recent years?-Yes, • The genus *Parthenium* contains 15 species, all native to North and South America. *P. hysterophorus* has a native range in the subtropical regions of North to South America. It is thought that the species originated in the region surrounding the Gulf of Mexico, including southern USA, or in central South America (Dale, 1981; Navie et al., 1996), but is now widespread in North and South America and the Caribbean, and Fournet and Hammerton (1991) indicate that it occurs in 'probably all islands' of the Lesser Antilles. • Since its accidental introduction into Australia and India in the 1950s, probably as a contaminant of grain or pasture seeds, it has achieved major weed status in those countries. It was first recorded in southern Africa in 1880 but was not reported as a common weed in parts of that region until the mid-1980s following extensive flooding on the east coast (McConnachie *et al.,* 2011). Recent reports of the weed from other countries indicate that its geographic range continues to increase. • Because *P. hysterophorus* has shown invasive behaviour where it has been introduced elsewhere in the world and has a highly restricted distribution in the EPPO region, it can be considered an emerging invader in the EPPO region (EPPO, 2012). **b. Posibility of survival during transport, storage and transfer? Yes** • *P. hysterophorus* reproduces only by seeds and is known to be highly prolific, as a single plant produces 15000 seeds on average and up to 100000 seeds (GISD Database, Global Invasive Species Database, 2010). Seed viability is high, 85% or higher (Navie et al., 1998). Buried seeds have been found to last longer than seeds on the soil surface, and a significant proportion can still germinate after 8–10 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	**YES and HIGH**

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

5.17.7 Determine the Consequence establishment of this pest in Bangladesh

Table-5.17.2: 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 pest in pastures 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**

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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 nitrifying bacteria.
- 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).

</td><td></td></tr>
<tr><td>• Not as above or below</td><td>Moderate</td></tr>
<tr><td>• This is a not likely to be an important pest of common crops grown in your country.</td><td>Low</td></tr>
</table>

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

Establishment Potential X Consequence Potential = Risk

Table-5.17.3: Calculating risk rating

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

Calculated Risk Rating-High

5.17.9 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.

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5.18	Scarlet Pimpernel: *Anagallis arvensis* L. (1753)

5.18.1 Hazard Identification

Scientific name: *Anagallis arvensis* L. (1753)

Synonyms: *Anagallis caerulea L. (1759)*
Anagallis coerulea Nathh.
Anagallis foemina Miller
Anagallis latifolia L. (1753)
Anagallis mas Vill. (1787)
Anagallis phoenicea Scop. (1772)
Anagallis verticillata All. (1785)

Common names: Scarlet pimpernel, blue pimpernel; care-all; common pimpernel; poor man's weatherglass; red chickweed

Taxonomic tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Primulales
Family: Primulaceae
Genus: Anagallis
Species: *Anagallis arvensis*

EPPO Code: ANGAR (*Anagallis arvensis*)
ANGCO (*Anagallis coerulea*)

Bangladesh status: Not present in Bangladesh [CABI/EPPO, 2022].

5.18.2 Biology

The reproduction of *A. arvensis* is entirely by seed.

Shoot and root length, node and leaf number, and shoot dry weight all vary with both genotype and growth conditions, making it difficult to draw uniform conclusions about the responses of Anagallis arvensis to environmental conditions. Indian genotypes have been found to grow well under 50-100% sunlight, with lower light intensities being better tolerated during early growth.

Variations in genotype and phenotype result in large differences in seed production per plant; from 900 under field conditions in Britain to 250,000 in a glasshouse. Up to 2480 viable seeds have been recorded per square metre of soil after 8 years of cropping and 1 year of pasture in Britain, and in a separate observation seed have been shown to remain viable in field soils for up to 10 years (Holm *et al.,* 1977).

Dormancy in viable seeds relies on complex interrelationships between intrinsic and extrinsic factors, ensuring prolonged dormancy of some seeds whilst others germinate almost throughout the year, although only those germinating under favorable conditions may be expected to survive and reproduce. Germination in different genotypes has been shown to be dependent on various combinations of light and temperature. The species is capable of germination between 2 and 25°C, and optimum germination has been recorded in light at 10-20°C (Holm *et al.,* 1977).

Although flowering in *A. arvensis* is usually initiated by lengthening days, this response is variable and may be modified by temperature so that some plants may flower under a wide range of daylengths.

5.18.3 Hosts or habitats

- **Major Host:** *Arachis hypogaea* (groundnut), *Helianthus* (sunflower), *Ipomoea batatas* (sweet potato), *Oryza sativa* (rice), *Solanum tuberosum* (potato), *Triticum aestivum* (wheat), *Zea mays* (maize)

5.18.4 Geographical distribution

A. arvensis originated in Europe and has been spread, both deliberately as an ornamental and accidentally as a weed, throughout the world. It occurs throughout Europe, except for the Faroe Islands, Iceland, Spitzbergen and northern Russia (Ferguson, 1972). It probably now occurs in all temperate, subtropical and tropical countries, but is principally a weed in cool to warm temperate countries, and in the cooler areas of tropical highlands.

- **Asia:** China (EPPO, 2022), India (EPPO, 2022), Japan (Ishimine *et al.* 1982)), Nepal (Dangol, 1987), Pakistan (Tahira and Khan, 2017), Saudi Arabia (Alhaithloul, 2019), South Korea (Holm *et al.* 1991)), Turkey (EPPO, 2022)
- **Europe:** Belgium, Bulgaria (EPPO, 2022), Denmark, France, Germany, Greece, Hungry, Italy, Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, Ukraine, United Kingdom (EPPO, 2022)
- **North America**: Canada, Mexico, USA (Holm *et al.* 1991).
- **South America**: Argentina, Brazil, Chile, Peru (Seebens *et al.* 2017)
- **Oceania**: Australia, New Zealand (Seebens *et al.* 2017)

5.18.5 Hazard identification conclusion

Considering the facts that *A. arvensis:*

- is not known to be present in all areas of Bangladesh;
- is potentially economic important to Bangladesh because it is an important pest of vegetables in Asia including China, India, Japan, South Korea, Turkey [EPPO, 2022] from where sweet potato are imported to Bangladesh.
- can become established in Bangladesh through the transportation of agricultural equipment and imports of the agricultural planting materials including vegetables, flowers and foliage.
- *A. arvensis* is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.18.6 Determine likelihood of pest establishing in Bangladesh via this pathway

Table-5.18.1: Which of these descriptions best fit of this pest?

Description	Establishment Potential
A. Has this pest been established in several new countries in recent years? - Yes, • In recent years the weed is established in many countries like Zimbabwe (2017), Bulgaria (2018), Japan (1982), Iceland (2017) (CABI, 2022) **b. Possibility of survival during transport, storage and transfer? Yes** • The species is capable of germination between 2 and 25°C, and optimum germination has been recorded in light at 10-20°C (Holm *et al.,* 1977). • Up to 2480 viable seeds have been recorded per square metre of soil after 8 years of cropping and 1 year of pasture in Britain, and in a separate observation seed have been shown to remain viable in field soils for up to 10 years (Holm *et al.,* 1977).	**YES**

• 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,** **Natural Dispersal** • Seed falls from the parent plant and may be moved short distances by wind and water, and with any soil movement. Seed germinates from spring through to autumn. **Accidental Introduction** • Seeds of *A. arvensis* can be spread from field to field by agricultural practices. Seeds are also commonly found in stored and transported grains. The movement of *A. arvensis* has linked to the transport of cereals and oil crops (Semenenko, 2002). **d. Are the host(s) and habitats of this fairly common in Bangladesh and the climate is similar to places it is established?-Yes** • The natural hosts of *A. arvensis* are groundnut, sunflower, sweet potato, rice, potato, wheat and miaze which are also very important vegetables and grains in Bangladesh. • These climatic requirements for growth and development of *A. arvensis* are more or less similar with the climatic condition of Bangladesh. • Therefore, the hosts and habitats as well as climatic requirements for this weed are mostly common in Bangladesh.	**and HIGH**
• **NOT AS ABOVE OR BELOW**	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appear good for this pest to enter your country and establish, and • Its host(s) are not common in your country and your climate is not similar to places it is established	Low

5.18.7 Determine the Consequence establishment of this pest in Bangladesh

Table-5.18.2: Which of these descriptions best fit of this pest?

Description	Consequence Potential
a. Is this a serious pest of Bangladesh? - Yes. • This is a **fairly serious pest** of several important crops and human health rather than flowers for Bangladesh. **b. Economic impact and yield loss** • The low growth and small root system of *A. arvensis* suggest that it is not a very competitive weed in most crops, and this is supported by a number of studies in different countries. It may, however, germinate early in spring before other weeds (and crops) become established, develop into dense masses, and thereby suppress the early growth of slow growing crops. • *A. arvensis* has often been considered to be poisonous to stock, but with little supporting evidence from the field. Indoor feeding tests show potential toxicity in some animals, but since it is selectively left in pastures by grazing animals it is probably unpalatable. There is a recent record of buffalo and cattle deaths in India after field grazing of *A. arvensis* (Sadekar *et al.,* 1996). Cases of human dermatitis have been reported after handling the plant. • The seeds of *A. arvensis* contaminate small-seeded field crops such as lucerne and clovers. • *A. arvensis* is an alternative host for a range of other pests, including beet yellows closterovirus (Stevens *et al.,* 1994), *Alternaria brassicae* (Ansari *et al.,* 1990), *Sclerotinia*	**Yes and High**

sclerotiorum (Singh and Singh, 1986), *Botrytis cinerea* (Madhu-Meeta *et al.,* 1986) and root knot nematodes (Alam, 1981). **c. Environmental Impact** • In introduced areas, *A. arvensis* can acts as a pioneer species. As a result, *A. arvensis* competes with native plants species for space, nutrients, light and water (Beres *et al.,* 2002) and may result in changes to habitats and a decrease in biodiversity.	
• Not as above or below	Moderate
• This is a **not** likely to be an important pest of common crops grown in your country.	Low

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

Establishment Potential X Consequence Potential = Risk

Table-5.18.3: Calculating risk rating

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

Calculated Risk Rating-High

5.18.9 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; and
- 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; and
- 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; and
- Internal surveillance and/or eradication or containment campaign.

f. Sanitary and Phytosanitary Measures (SPS)

- There are several reports of the dispersal of *A. artemisiifolia* to areas or countries through contaminated grains or agricultural practices (EPPO, 2019).
- Improved sanitary measures need to be implemented, including cleaning machinery to prevent seed dispersal between fields. Soil movement between fields should also be avoided.
- At higher spatial scales, the implementation of coordinated screening efforts at multiple stages in the feed machinery transport chains is needed to detect contamination by seeds of *A. artemisiifolia* (EPPO, 2019).
- For plots where the species is detected, all equipment and machinery should be treated as if contaminated and properly sanitized (CropLife, 2019). This includes cleaning footwear and clothing.

5.18.10 References

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5.19. 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), the PRA scheme developed by CAB International (2007) and EPPO (European and Mediterranean Plant Protection Organization) (1997).

From the quantitatively risk analysts of quarantine pests likely to be associated and follow the pathway of sweet potato imports from Japan, Thailand, India, China, Vietnam, the Philippines, Indonesia, and other exporting countries to Bangladesh, out of 18 potential hazard organisms, 15 hazard organisms were identified with high-risk potential and 3 was moderate potential risk.

The overall pest risk potential ratings of 18 quarantine pests of sweet potato for Bangladesh are included in the following Table-5.19:

Table-5.19: The Overall Pest Risk Potential Rating

Sl. No.	Potential Hazard Organism	Scientific name	Family	Order	Pest Risk Potential
Insect pests					
1	Tomato/Potato psyllid	*Bactericera cockerelli*	Triozidae	Hemiptera	**High**
2	Spiked Mealybug	*Nipaeccoccus nipae*	Pseudococcidae	Hemiptera	**Moderate**
3	Sweet Potato Leaf miner	*Bedellia somnulentella*	Lyonetiidae	Lepidoptera	**Moderate**
4	Cotton Leaf worm	*Spodoptera littoralis*	Noctuidae	Lepidoptera	**High**
Mite					
5	Tomato Russet Mite	*Aculops lycopersici*	Eriophyidae	Acariformes	**High**
6	Red spider mite	*Tetranychus evansi*	Tetranychidae	Acariformes	**High**
Fungus					
7	White Rust of Sweet Potato	*Albugo ipomoeae-panduratae*	Albuginaceae	Peronosporales	**High**
8	Ceratocystis Blight	*Ceratocystis fimbriata*	Ceratocystidaceae	Microascales	**High**
9	Leaf & Stem Scab	*Elsinoe batatas*	Elsionaceae	Myriangiales	**High**
10	Fusarium Wilt of Sweet Potato	*Fusarium oxysporum f.sp. batatas*	Nectriaceae	Hypocreales	**Moderate**
11	Scurf of Sweet Potato	*Monilochaetes infuscans*	Chaetosphaeriaceae	Chaetosphaeriales	**High**
Bacteria					
12	Crown Gall	*Rhizobium radiobacter*	Rhizobiaceae	Rhizobiales	**High**
13	Gall	*Rhizobium rhizogenes*	Rhizobiaceae	Rhizobiales	**High**
Nematode					
14	Sting nematode	*Belonolaimus longicaudatus*	Belonolaimidae	Metazoa	**High**
15	Pacara Earpod tree root-knot nematode	*Meloidogyne enterolobii*	Meloidogynidae		**High**
Virus					
16	Sweet Potato Chlorotic Stunt Virus	*Sweet Potato Chlorotic Stunt Virus*	Closteroviridae		**High**

Weed					
17	Parthenium weed	*Parthenium hysterophorus*	Asteraceae	Asterales	**High**
18	Scarlet Pimpernel	*Angallis arvensis*	Primulales	Primulales	**High**

Uncertainty

The quarantine pest species those remain uncertainty as potential hazards due to lack of their detail information. Such uncertain species was Cirtus Locust (*Chondracris rosea),* Winter cherry bug (*Acanthocoris sordidus),* Barnacle Scale (*Ceroplastes cirripediformis),* Sweet potato butterfly (*Acraea acerate),* Pink-spotted Hawk moth (*Agrius Cingulatus).* Southern Armyworm (*Spodoptera eridania),* Impatiens hawkmoth (*Theretra oldenlandiae),* Spotted Tortoise Beetle (*Asidimorpha miliaris),* Chafer Beetle (*Apogonia cribricollis),* Cocoa Weevil (*Araecerus fasciculatus),* Sweet Potato Leaf weevil (*Blosyrus impomoeae),* Flea Beetle (*Chaetocnema confinis),* West Indian Sweet Potato Weevil (*Euscepes postfasciatus),* Green Weevil (*Hypomeces squamosus)* and Carmine Spider Mite (*Tetranychus cinnabarinus*). The taxonomic identity of this uncertain species is given in the Table-5.20.

Table-5.20: Quarantine pest species for Bangladesh likely to be associated with host plants and/or plant parts during importation from exporting countries, but remained as uncertain hazards due to lack of detail information

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
Arthropods					
Insect Pests					
1	Cirtus Locust	*Chondracris rosea*	China, Japan, Malaysia, Thailand	Tuber, Vine	CABI/EPPO, 2021
2	Winter cherry bug	*Acanthocoris sordidus*	Japan, Taiwan	Tuber, Vine	CABI (2021)
3	Barnacle Scale	*Ceroplastes cirripediformis*	India	Vine	Sunil Joshi *et al.* (2021)
4	Sweet potato butterfly	*Acraea acerate*	Ethiopia, Kenya, Nigeria	leaves	Girma (1993)
5	Pink-spotted Hawk moth	*Agrius Cingulatus*	USA	Flower, Leaf	CABI Data Mining (Undated)
6	Southern Armyworm	*Spodoptera eridania*	Natherlands, United States, Brazil,	Leaf, seedlings, Tuber	EPPO (2021)
7	Impatiens hawkmoth	*Theretra oldenlandiae*	China, India, Indonesia, Japan, Malaysia, Nepal	Leaf, inflorescence	CABI (Undated)
8	Spotted Tortoise Beetle	*Asidimorpha miliaris*	India, Indonesia, Malaysia, Singapore, Thailand	Leaf, Vine	AVA (2001)
9	Chafer Beetle	*Apogonia cribricollis*	Indonesia, Malasia, Singapure	Leaf, Vine	EPPO (2021)
10	Cocoa Weevil	*Araecerus fasciculatus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Tuber, vine	Waterhouse (1993)
11	Sweet Potato Leaf weevil	*Blosyrus impomoeae*	India	Leaf, Vine	EPPO (2021)
12	Flea Beetle	*Chaetocnema confinis*	India, Japan, Thailand	Tuber, Leaf	CABI and EPPO

Sl. No.	Common name	Scientific name	Distribution to flower exporting countries	Plant parts likely to carry the pest	References
					(2009); Jolivet (1979)
13	West Indian Sweet Potato Weevil	*Euscepes postfasciatus*	Japan	Tuber, Leaf	Kohama and Sugiyama (2000)
14	Green Weevil	*Hypomeces squamosus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Tuber, Leaf	CABI (Undated a)
Mite Pest					
15	Carmine Spider Mite	*Tetranychus cinnabarinus*	China, India, Indonesia, Japan, Malaysia, Singapore, Thailand	Leaf, vine, tuber	EPPO (2021)

CHAPTER VI

RISK MANAGEMENT

6.1. Risk Management Options and Phytosanitary Procedures

Pest risk management evaluates and selects options for taking 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 sweet potato from Japan, Thailand, India, China, Indonesia, Vietnam, or any other countries of sweet potato export (i.e. produced under standard cultivation, harvesting and packing activities). Plant Quarantine Wing of Bangladesh will consider the risk management measures proposed below is commensurate with the identified risks.

6.1.1. Pre-harvest Management Options

(i) **Use of Pest Resistant Varieties:** The use of resistant varieties is a common and effective component in reducing pest risk.

(ii) **Chemical Spray Program:** Pre-harvest chemical sprays need to be used to control pests within production fields, for example, the use of nematicides to control the nematode.

(iii) **Crop Rotation:** Certain sweet potato 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 plant debris, or in a living form in surviving fallen parts of plants. On occasion, diseased tubers are the source of contamination for the current season crops. Therefore, a crop rotation to minimize soil disease problems is recommended.

(iv) **Control of Insect and Mite Pests:** Sucking and chewing insect and mite pests may transmit many diseases. For example, the *Tomato black ring virus* disease was found to be transmitted by the aphids (EPPO, 1997). The control of these insects and the rouging of infected parts of plants as early as possible may prevent spread of diseases in the field.

(v) **Irrigation Practices and Soil Type:** A well-drained soil is recommended for planting of sweet potato as this make conditions less favorable to disease infection (Johnson, 1969). Over irrigation and a poorly drained soil increases the susceptibility to diseases particularly nematode disease. 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 sweet potato production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of diseases detected.

6.1.2. Post-harvest Management Options

(i) **Sanitization of Equipment and Material:** All machinery, transport and storage surfaces that the sweet potato plant parts and tubers will contact should be cleaned and disinfected prior to receiving new plants and tubers. Since most disinfectants are inactivated by soil and plant debris, it is essential that this material be removed by thoroughly cleaning the equipment and storage with a pressure washer or steam cleaner before the disinfectant is applied.

(ii) **Disposal of Infected Tubers:** All disease infected tubers should be discarded away from production site.

(iii) **Grading:** The class and variety of sweet potato tubers must be kept separate through harvesting, grading and storage. Grading must be done according to class, variety and disease tolerance. The class of sweet potato tubers must clearly identifiable and labeled.

6.1.3. Phytosanitary Measures

(i) **Pest Free Areas:** As a sole mitigation measure, the establishment of pest-free areas or pest-free places of production may be completely effective in satisfying an importing country's appropriate level of phytosanitary protection (IPPC, 1996b, 1999). Establishment and maintenance of pest-free areas or production sites should be in compliance with international standards (*e.g.*, IPPC, 1996b, 1999, 2006).

(ii) **Stipulated Commercial Grade for Tubers:** 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 sweet potato tubers that reflects the acceptable tolerance level of the country.

(iii) **Accept only Certified Sweet Potato Tubers for 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 tubers to be multiplied; inspection of crops for variety purity and crop health; inspection of tuber samples; and sealing and labeling of certified seed. Sweet potato tubers 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 sweet potato tubers and planting materials be packed in containers with identification labels indicating the place of origin, variety and grade is necessary to ensure traceability to each production site.

(v) **Pre-export Inspection and Treatment:** The NPPOs of exporting countries will inspect all consignments in accordance with official procedures in order to confirm those consignments are satisfied with import requirements on phytosanitary of Bangladesh. If quarantine pests with high-risk potential are found during inspection, the phytosanitary procedures should be maintained:

(a) Consignments of sweet potato tubers and other planting materials from countries where these pests occur should be inspected for symptoms of infestation and those suspected should be cut open in order to look for larvae. EPPO recommends (OEPP/EPPO, 1990) that such tubers should come from an area where high risk potential pests do not occur and where routine intensive control measures are applied.

(b) Tubers and planting materials may also be treated in transit by cold treatment (e.g. 13 or 14 days at 0.0 or 0.6°C, respectively) (FAO, 1983).

(vi) **Requirement of Phytosanitary Certification from Country of Origin:** The Phyto-pathological service of the country of origin should ensure the sweet potato tubers and planting materials from which the consignment is derived was not grown in the vicinity of unhealthy sweet potato and was inspected by a duly authorized official/phytopathological service and the tubers and other planting materials 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 sweet potato tubers and/or other planting materials should be inspected to detect pests, with export phytosanitary certificate and seed certificate. Sampling of tubers and/or planting materials 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.

(viii) The consignment could re-export or destroy, if quarantine pests or regulated articles with high-risk potential are found during an inspection.

6.2. Risk Management Conclusions

All the pests that 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.

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি সম্প্রসারণ অধিদপ্তর
কন্দাল ফসল উন্নয়ন প্রকল্প
খামারবাড়ী, ফার্মগেট, ঢাকা।

Questionnaire for Farmers on **Conducting Pest Risk Analysis (PRA) of Sweet Potato (*Ipomoea batatas*) in Bangladesh**

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সেট-১: মিষ্টিআলু চাষীদের জন্যে জরিপ প্রশ্নাবলী

কোডঃ				

মোবাইল ফোন											

A.0 মিষ্টিআলু চাষীর ব্যক্তিগত তথ্যাদিঃ

A.1 উত্তরদাতার নাম: ---

A.2 গ্রাম -- **A.3** কৃষি ব্লক: ---

A.4 উপজেলা: -- **A.5** জেলা: ---

A.6 শিক্ষাগত যোগ্যতা: ------------------------------------- **A.7** বয়স: --------------------------------------- ।

A.8 পেশাগত:[কোড: ১=বড় চাষী, ২=মধ্যম চাষী, ৩=ক্ষুদ্র চাষী, ৪=প্রান্তিক কৃষক, ৫=ভূমিহীন কৃষক] [বি.দ্র: ১=ভূমিহীন কৃষক হলো যার কোন কৃষি জমি নাই, ২=প্রান্তিক কৃষক হলো যার ১-৪৯ শতাংশ কৃষি জমি আছে; ৩= ক্ষুদ কৃষক হলো যার ৫০-২৪৯ শতাংশ কৃষি জমি আছে, ৪=মাঝারি কৃষক হলো যার ২.৫-৭.৪৯ একর কৃষি জমি আছে, এবং ৫=বড় কৃষক হলো যার ৭.৫০ একরের বেশি কৃষি জমি আছে।] ☐

A.9 লিঙ্গ: (কোড: ১=পুরুষ, ২=মহিলা) ☐

B.0 মিষ্টিআলুর আবাদ ও পি.আর.এ সংক্রান্ত তথ্যাবলিঃ

B.1 উত্তরদাতার ব্যবহৃত জমির ধরণ/ প্রকৃতিঃ

আলুচাষে ব্যবহৃত জমির ধরণ	জমির পরিমাণ (শতাংশ)
১. মোট চাষযোগ্য জমির পরিমাণ	
২. চলতি মৌসুমে মিষ্টিআলু চাষ করেছেন এমন জমির পরিমান বলুন?	
৩. মিষ্টিআলু চাষে নিয়োজিত জমির আনুমানিক শতকরা পরিমান (%) বলুন	
৪. কত বৎসর যাবৎ মিষ্টিআলু চাষ করছেন?	

B.2 আপনি এবছর কোন জাতের মিষ্টিআলু করেছেন, দয়া করে বলবেন কি?

চাষকৃত/ব্যবহৃত মিষ্টিআলুর জাত	বিভিন্ন জাতের মিষ্টিআলুর চাষকৃত জমির পরিমাণ (শতাংশ)	উৎপাদন (বস্তা/একর*)
১.		
২.		
৩.		
৪.		
৫.		

*১ বস্তা = ৮৫ কেজি

B.4 মিষ্টিআলুর চাষের জন্যে সাধারণত: কোন কোন উৎস থেকে বীজ/চারা/লতা ক্রয় করেন?

উৎসসমূহ	উত্তরের ধরণ (কোড: হ্যাঁ=১, না=২)	উৎস অনুযায়ী চারার গুনগত মান কেমন? [কোড: ১=ভালো, ২=মাধ্যম, ৩=ভালো নয়]
১. নিজের		
২. প্রতিবেশী কৃষক কাছ থেকে		
৩. স্থানীয় বাজার থেকে		
৪. বিএডিসি থেকে		
৫. অন্য কোন কোম্পানীর		
৬. স্থানীয় বীজ উৎপাদনকারী		
৭. সরাসরি আমদানীকারকের নিকট থেকে		
৮. বিভিন্ন গবেষনা প্রতিষ্ঠান		
৮. এনজিও		
৯. মিষ্টিআলু ব্যবসায়ী		
১০. অন্যান্য (যদি থাকে)-----------		

B.5 মাঠপর্যায়ে বা গুদামে মিষ্টিআলুর ক্ষতিকর পোকামাকড়ের উপস্থিতি এবং উপদ্রবের ধরণ/ অবস্থা কেমন? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

ইং	পোকার নাম	আক্রমণ হয়? [১=হ্যাঁ, ২=না]	আক্রমনের অবস্থা? (১=মূখ্য পোকা, ২=গৌণ পোকা)	আক্রমনের পর্যায় (১=চারা, ২=বাড়ন্ত গাছ, ৩=ফলজ গাছ, ৪= গুদামে)	কোন অংশ আক্রান্ত হয় [১=পাতা, ২=কান্ড, ৩=মিষ্টি আলু]	আক্রমনের তীব্রতা? (কোড: ১=বেশী, ২=মধ্যম, ৩=কম)
১	মিষ্টিআলুর উইভিল (Sweet Potato weevil)					
২	টরট্স বিটল (Tortoise beetle)					
৩	কাল শুয়োপোকা (Black hairy caterpillar)					
৪	হর্ণ ওয়ার্ম (Horn worm)					
৫	সুইট পটেটো বাগ (Sweet potato bug)					
৬	সুইট পটেটো ভাইন বোরার (Sweet potato vine borer)					
৭	কটুই পোকা (Black Cutworm)					
৮	লিফ মাইনার (Sweet Potato leaf miner)					
৯	তামাকের সাদামাছি					

	(Tobacco Whitefly)					
১০	মিষ্টিআলুর পাতা ফড়িং/জ্যাসিড (Sweet potato leafhopper /Jassid)					
১১	মিষ্টিআলুর পাতার শুয়োপোকা (Sweet potato leaf caterpillar)					
১২	মিষ্টিআলুর থ্রিপস (Sweet Potato Thrips)					
১৩.	পাটের বিছাপোকা (Jute hairy caterpillar)					
১৪.	মিলিবাগ (Mealy bug)					
১৫.	টারনিপ মথ (Turnip Moth)					
১৬.	ফ্লি বিটল (Flea Beetle)					
১৭.	অন্যান্য---------(যদি থাকে)					

B.6. ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে এমন কোন বাহক পোকা-মাকড় দেখেছেন কি যা মিষ্টিআলু গাছে ভাইরাস বা অন্য রোগ ছড়ায়? (কোড: হ্যাঁ=১, না=২)। ☐

খ. যদি উত্তর হ্যাঁ হয়, তাহলে বাহক বা ভেক্টর পোকা-মাকড়সমূহের নাম উল্লেখ করুন:

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------------- ।

B.7. ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে বর্তমানে এমন নতুন কোন পোকা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না? (কোড: হ্যাঁ=১, না=২)। ☐

খ. যদি উত্তর হ্যাঁ হয়, তাহলে পোকা মাকড়গুলো কি কি? নাম উল্লেখ করুন:

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------------- ।

B.8. মিষ্টিআলু ক্ষেতে বা গুদামে আগের তুলনায় বর্তমানে অধিকর ক্ষতি করে এমন কতগুলো অনিষ্টকারী পোকার নাম বলুন?

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------------- ।

B.9. আপনার জানামতে মিষ্টিআলুর এমন কোন ক্ষতিকর পোকা আছে কি, যেগুলো পার্শ্ববর্তী কোন দেশ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পূর্বে ছিল না? (কোড: হ্যাঁ=১, না=২)। ☐

ক. যদি উত্তর হ্যাঁ হয়, তাহলে সে সব পোকার নাম বলুন?

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------------- ।

B.10. আপনি সাধারণত কিভাবে মিষ্টিআলুর ক্ষতিকর পোকামাকড়ের আক্রমণ দমন করেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ

(কোডঃ ১= গাছে কীটনাশক স্প্রে করে, ২=কান্ড লাগানোর সময় দানাদার কীটনাশক ছিটিয়ে, ৩=পানি সেচ দেওয়ার পূর্বে কীটনাশক ছিটিয়ে, ৪= পানি সেচ দেওয়ার সময় কীটনাশক ব্যবহার করা, ৫= কান্ড লাগানোর পূর্বে কীটনাশক ব্যবহার করে কান্ড শোধন করা; ৬ সেচ, ৭= ক্ষতিকর পোকাসমূহ হাত দিয়ে সংগ্রহ করে মেরে ফেলা, ৮= পার্চিং, ৯= সমন্বিত বালাই পদ্ধতি (আই.পি.এম.),১০= সুষম সার ব্যবহার করে, ১১= অন্যান্য -------------------- -(দয়া করে উল্লেখ করুন)]

B.11. মাঠপর্যায়ে বা গুদামে মিষ্টিআলুর রোগসমূহের উপস্থিতি এবং আক্রমনের ধরণ/অবস্থা কেমন? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

ইং	রোগ সমূহের নাম	রোগের আক্রমণ হয়? [১=হ্যাঁ, ২=না]	আক্রমনের অবস্থা? (কোড: ১=মূখ্য, ২=গৌণ রোগ)	আক্রমনের পর্যায় (১=চারা, ২=বাড়ন্ত গাছ, ৩=ফলজ গাছ, ৪=গুদামে)	কোন অংশ আক্রান্ত হয় [১=পাতা, ২=কান্ড, ৩=মিষ্টিআলু)	আক্রমনের তীব্রতা? (কোড: ১=বেশী, ২=মধ্যম, ৩=কম)
১	পাতার দাগ (Cercospora leaf spot of sweet potato)					
২	ব্লাক রট/চারকোল রট (Black rot/ charcoal rot)					
৩	নরম পঁচন (Soft rot)					
৪	হোয়ায়িট রাষ্ট (White rust)					
৫	মিষ্টিআলুর গাছ নেতিয়ে পড়া (Fusarium Wilt of sweet potato)					
৬	ব্যকটেরিয়া জনিত কারণে মিষ্টি আলুর মূল পঁচা রোগ (Bacterial Root Rot of Sweet Potato)					
৭	মিষ্টি আলুর ফেদারি মটল ভাইরাস (Feathery mottle)					
৮	মিষ্টি আলুর ক্লোরোটিক ফ্লিক বিটল (Sweet potato chlorotic fleck virus (SPCFV))					
৯	মিষ্টি আলুর লিফ কার্ল ভাইরাস					
১০	রুট নট (Root knot of sweet potato)					
১১.	রেনিফর্ম নেমাটোড (Reniform nematode of sweet potato)					
১২.	রুট লেসন (Root lesion)					
১৩.	টিউবার রট (Tuber rot)					
১৪.	পাতা ও কান্ডে দাদ (Leaf & Stem Scab)					
১৫	অন্যান্য--------------					

B.12. **ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে ভেক্টর বাহিত কোন ভাইরাস বা অন্য কোন রোগ আছে কি??** (কোডঃ হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে বাহক বা ভেক্টর বাহিত রোগসমূহের নাম উল্লেখ করুন:

১। ----------------------------------, ২। ---------------------------------, ৩। -------------------------------- ।

B.12. **ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে বর্তমানে এমন কোন নতুন রোগের আক্রমন দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না?** (কোডঃ হ্যাঁ=১, না=২)।

খ. যদি উত্তর হ্যাঁ হয়, তাহলে রোগসমূহ কি কি? নাম উল্লেখ করুন:

১। ----------------------------------, ২। ---------------------------------, ৩। -------------------------------- ।

B.13. **আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে আগের তুলনায় বর্তমানে বেশী ক্ষতি করে এমন কতগুলো রোগের নাম বলুন?**

১। ----------------------------------, ২। ---------------------------------, ৩। -------------------------- ।

B.14. **ক. আপনার জানামতে মিষ্টিআলুর ক্ষেতে বা গুদামে এমন রোগ আছে কি, যেগুলো পার্শ্ববর্তী কোন দেশ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পূর্বে ছিল না? (কোডঃ হ্যাঁ=১, না=২)।**

খ. যদি উত্তর হ্যাঁ হয়, তাহলে এ সকল রোগের নাম বলুন?

১। ----------------------------------, ২। ---------------------------------, ৩। -------------------------------- ।

B.15. **মিষ্টিআলু ক্ষেতে বা গুদামে আপনি কিভাবে রোগ-বালাই দমন করে থাকেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ**

[কোডঃ ১= মাটিতে কান্ড বপনের পূর্বে ছত্রাকনাশক দিয়ে কান্ড শোধন করে, ২=গাছে বালানাশক স্প্রে করে, ৩= বাহক দমনের জন্য কীটনাশক স্প্রে করা, ৪= জমিতে জৈব-সার প্রয়োগ করে, ৫= জমিতে সেচ প্রদান করে, ৬= জমি থেকে রোগাক্রান্ত গাছসমূহ তুলে ধ্বংস করা, ৭= জমিতে থেকে আগাছা পরিস্কার করে পোকার আবাসস্থল নষ্ট করা, ৮= সমন্বিত বালাই পদ্ধতি (আই.পি.এম.), ৯= সুষম সার ব্যবহারের মাধ্যমে, ১০= অন্যান্য ---------------------------(দয়া করে উল্লেখ করুন)]

B.16. **মাঠপর্যায়ে মিষ্টিআলু ক্ষেতে আগাছার আক্রমন, বাগানের পর্যায়, আক্রমনের অবস্থা এবং ক্ষতির তীব্রতা কেমন? (খালী ঘরে সংখ্যা লিখুন)**

ইং	ইাম	আগাছার আক্রমণ হয়? [১=হ্যাঁ, ২=না]	আক্রমনের অবস্থা? (কোডঃ ১=মূখ্য আগাছা, ২=গৌণ আগাছা)	গাছের কোন পর্যায় আক্রমন করে? [১=চারা, ২=বাড়ন্ত, ৩=ফলজ]	আক্রমনের তীব্রতা? (কোডঃ ১=বেশী, ২=মধ্যম, ৩=কম)
১	দূর্বা ঘাস				
২	মুথা				
৩	বথুয়া				
৪	চাপড়া				
৫.	বনসরিষা				
৬.	পার্থেনিয়াম				
৭.	শ্যামা				
৮.	শাক নটে				
৯.	কাঁটা নটে				
১০.	বন বেগুন				
১১.	কাঁটা বেগুন				
১২.	মালঞ্চ				
১৩.	হেলেঞ্চা				
১৪.	ক্ষেতপাপড়ি				
১৫.	অন্যান্য				

B.17. **ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বর্তমানে নতুন এমন কোন আগাছা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না?**

(কোডঃ হ্যাঁ=১, না=২)। ☐

খ. যদি উত্তর হ্যাঁ হয়, তাহলে আগাছাসমূহ কি কি? নাম উল্লেখ করুন:

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------।

B.18. **আপনার এলাকায় মিষ্টিআলু ক্ষেতে আগের তুলনায় বর্তমানে বেশী ক্ষতি করে এমন কতগুলো আগাছার নাম বলুন?**

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------।

B.19. **ক. আপনার জানামতে মিষ্টিআলু এমন আগাছা আছে কি, যেগুলো পার্শ্ববর্তী কোন দেশ থেকে আমাদের দেশে প্রবেশ করেছে, যা আমাদের দেশে পূর্বে ছিল না?** ([কোডঃ হ্যাঁ=১, না=২)। ☐

খ. যদি উত্তর হ্যাঁ হয়, তাহলে এ সকল আগাছাগুলোর নাম বলুন?

১। ----------------------------------, ২। --------------------------------, ৩। -------------------------------।

B.20. **মিষ্টিআলু ক্ষেতে সাধারণতঃ কিভাবে আগাছা দমন করে থাকেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ**

[কোডঃ ১= মিষ্টিআলু ক্ষেত থেকে আগাছা উঠিয়ে, ২= ক্ষেতে দানাদার আগাছানাশক ছিটিয়ে, ৩= জমি তৈরীর সময় আগাছা উঠিয়ে, ৪= মালচিং করে, ৫= গাছের গোড়ায়/আইলে মাটি উঠিয়ে, ৬= সেচ দিয়ে, ৭= অন্যান্য (উল্লেখ করুন)]

তথ্য সংগ্রহকারীর নামঃ স্বাক্ষর ও তারিখঃ

ফিল্ড সুপারভাইজারের নামঃ স্বাক্ষর ও তারিখঃ

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি সম্প্রসারণ অধিদপ্তর
কন্দাল ফসল উন্নয়ন প্রকল্প
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Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Sweet Potato (*Ipomoea batatas*) in Bangladesh

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কোডঃ				

A.0 **এফজিডি এর স্থানঃ** -- ।

A.2 গ্রাম --| **A.3** কৃষি ব্লক: --|

A.4 উপজেলা: ---| **A.5** জেলা: ---|

B.1 **আপনাদের চাষকৃত মিষ্টিআলুর মধ্যে সবচেয়ে জনপ্রিয় জাত গুলো কি কি?**
১. ----------------------, ২.----------------------, ৩. -------------------,

B.2 **আপনারা মিষ্টিআলুর যে বীজ ব্যবহার করেন, তার উৎসসমূহ কি কি?**
১. ----------------------, ২.----------------------, ৩. -------------------,

B.3 **আপনার এলাকায় সাধারণত মিষ্টিআলু ক্ষেতে কোন ধরনের ক্ষতিকর পোকামাকড়ের আক্রমন দেখা যায়? (নাম উল্লেখ করুন)**
ক. মুখ্য ক্ষতিকর পোকামাকড়:
১. ----------------------------------, ২.--------------------------------, ৩. -----------------------------,

খ. গৌণ ক্ষতিকর পোকামাকড়:
১. ----------------------------------, ২.--------------------------------, ৩. --------------------------------,

B.4 **আপনাদের এলাকায় সাধারণত মিষ্টিআলু ক্ষেতে বা গুদামে কোন কোন রোগ বালাই গুলো দেখা যায়? (রোগের নাম উল্লেখ করুন)**

ক. মুখ্য রোগ:
১. ----------------------------, ২.--------------------------------, ৩. ------------------------------,

খ. গৌণ রোগ:
১. ----------------------------, ২.--------------------------------, ৩. ------------------------------,

B.5 **আপনার এলাকায় সাধারণত মিষ্টিআলু ক্ষেতে কোন কোন আগাছাসমূহের আক্রমন দেখা যায়? (নাম উল্লেখ করুন))**
ক. মুখ্য আগাছা:
১. ----------------------------, ২.--------------------------------, ৩. ------------------------------,

খ. গৌণ আগাছা:

১. ------------------------------, ২.----------------------------------, ৩. ------------------------------,

B.6 **ক. আপনার এলাকায় মিষ্টিআলু ক্ষেতে বা গুদামে এমন কোন বাহক পোকা-মাকড় দেখেছেন কি যা গাছে ভাইরাস বা অন্য রোগ ছড়ায়? যদি উত্তর হ্যাঁ হয়, তাহলে বাহক বা ভেক্টর পোকা-মাকড়সমূহের নাম উল্লেখ করুন:**

১) -----------------------------------, ২) --------------------------------, ৩) ------------------------------।

B.7 **আপনার এলাকায় মিষ্টিআলু ক্ষেতে বর্তমানে এমন নতুন কোন পোকা-মাকড়, রোগ-বালাই ও আগাছা দেখা যাচ্ছে কি, যা পূর্ববর্তী সময়ে ছিল না? যদি থেকে থাকে, তাহলে সেগুলো কি কি? নাম উল্লেখ করুন:**

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ বালাই:

গ. আগাছা:

B.8 **আপনার এলাকায় মিষ্টিআলু ক্ষেতে আগের তুলনায় বর্তমানে অনেক বেশী ক্ষতি করে এমন কতগুলো অনিষ্টকারী পোকা-মাকড়, রোগ-বালাই ও আগাছার নাম বলুন?**

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ বালাই:

গ. আগাছা:

B.9 **আপনাদের এলাকার মিষ্টিআলু ক্ষেতে ক্ষতিকর পোকা-মাকড়, রোগ ও আগাছা দমনে কি কি কার্যকর ব্যবস্থা গ্রহন করা হয়?**

ক. ক্ষতিকর পোকামাকড় দমনে কার্যকর ব্যবস্থা:

খ. রোগ বালাই দমনে কার্যকর ব্যবস্থা:

গ. আগাছা দমনে কার্যকর ব্যবস্থা:

B.10 **আপনাদের জানামতে মিষ্টিআলু ক্ষেতে এমন কোন ক্ষতিকর পোকা-মাকড়, রোগ-বালাই ও আগাছা আছে কি, যেগুলো পার্শ্ববর্তী দেশ থেকে আমাদের দেশে প্রবেশ করেছে মনে হয়, অথচ সেগুলো পূর্বে আমাদের দেশে ছিল না? যদি থেকে থাকে, তাহলে তাদের নাম বলুন?**

ক. ক্ষতিকর পোকামাকড়:

খ. রোগ বালাই:

গ. আগাছা:

ফোকাস গ্রুপ ডিসকাশন (এফ.জি.ডি.)-এ অংশগ্রহনকারীদের তালিকা

নং	নাম	গ্রাম	পেশা	মোবাইল	স্বাক্ষর
১					
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১০					

এফজিডি পরিচালনাকারীর নামঃ-- ।

স্বাক্ষর ও তারিখ: -- ।

মোবাইল নম্বর:-- ।

Government of the People's Republic of Bangladesh
Department of Agricultural Extension
Tuber Crops Development Project
Khamarbari, Farmgate,
Dhaka.

Checklist for Key Informant Interview (KII) on Conducting Pest Risk Analysis (PRA) of Sweet Potato (*Ipomoea batatas*) in Bangladesh

Prepared by:

DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD. (DTCL)
Niketan, Gulshan-1, Dhaka-1212
E-mail: info@dtcltd.com, Website: www.dtcltd.com

Set-3: KII Checklists on PRA of Sweet Potato

Name of Key Informant…….. ………………………………. Designation …………………………..….
Organization:…………………………...…………… Working area: …………………………
Mobile:……….…………..……………..…………

Checklist for Review/Key informant discussions on Pests of Sweet Potato

1.0 INFORMATION ABOUT INSECT PESTS OF SWEET POTATO

1.1 What are the major pests (insect, disease and weed) that cause potential damage to sweet potato in Bangladesh (HQ)/your area?

1.2 What are the key insect pests of sweet potato that cause potential damage in every year in Bangladesh/your area?

1.3 What are the minor insect pests that may harm to sweet potato, if not to be controlled?

1.4 What are the insect pests of sweet potato, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh?

1.5 From which countries, the sweet potato seed tubers are being usually imported into Bangladesh?

1.6 Is there any information about the insect pests of sweet potato available in the exporting country of sweet potato to Bangladesh? If yes, what are those insect pests? Please mention the name of insect pests?

1.7 What are the quarantine insect pests of sweet potato that might already be entered into Bangladesh through importation of sweet potato from other countries or through cross boundary from neighboring countries that were not seen earlier?

1.8 Is there any record, the consignment of sweet potato exported to foreign country that was intercepted and returned to Bangladesh, due to occurrence of any insect pests in the consignment? If yes, which country and what are the insect pests? Please mention the name.

1.9 What are the possible ways of entry of newly introduced insect pests of sweet potato that were not seen earlier in the field or storage in your area/Bangladesh?

1.10 What are the options to prevent the entry and spread of potential insect pests of sweet potato within Bangladesh?

1.11 What are the effective options to control the quarantine insect pests that are found in the sweet potato field or storage in your area/Bangladesh?

1.12 What are the effective ways to prevent the entry of quarantine insect pests of sweet potato into Bangladesh from the countries of sweet potato export?

1.13 Give your suggestions for the better management of the insect pests of sweet potato in Bangladesh.

FIELD GUIDE

ON

INSECT PESTS, DISEASES AND WEEDS OF SWEET POTATO

for "Pest Risk Analysis (PRA) of Sweet Potato in Bangladesh"

বাংলাদেশে মিষ্টি আলুর পি.আর.এ. কার্যক্রমের লক্ষ্যে

মিষ্টি আলুর ক্ষতিকর পোকা-মাকড়, রোগ ও আগাছার মাঠ নির্দেশিকা

Sponsored by

Tuber Crops Development Project (TCDP)

Department of Agricultural Extension (DAE)

Khamarbari, Dhaka, Bangladesh

Government of the People's Republic of Bangladesh
Department of Agricultural Extension
Tuber Crops Development Project
Khamarbari, Farmgate,
Dhaka.

Pest Risk Analysis (PRA) of Sweet Potato (***Ipomoea batatas***) in Bangladesh

Carried out by

Development Technical Consultants Pvt. Limited (DTCL)

Niketon, Gulshan-1, Dhaka, Bangladesh

Prepared by

Dr. Md. Razzab Ali

Professor

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মিষ্টি আলুর ক্ষতিকর কীটপতঙ্গ (Insect Pests of Sweet Potato)

১। Sweet potato weevil: *Cyclas formicarius* (Fabricius), *Blosyrus asellus* (Olivier), *Manophyas* sp. (Curculionidae: Coleoptera)

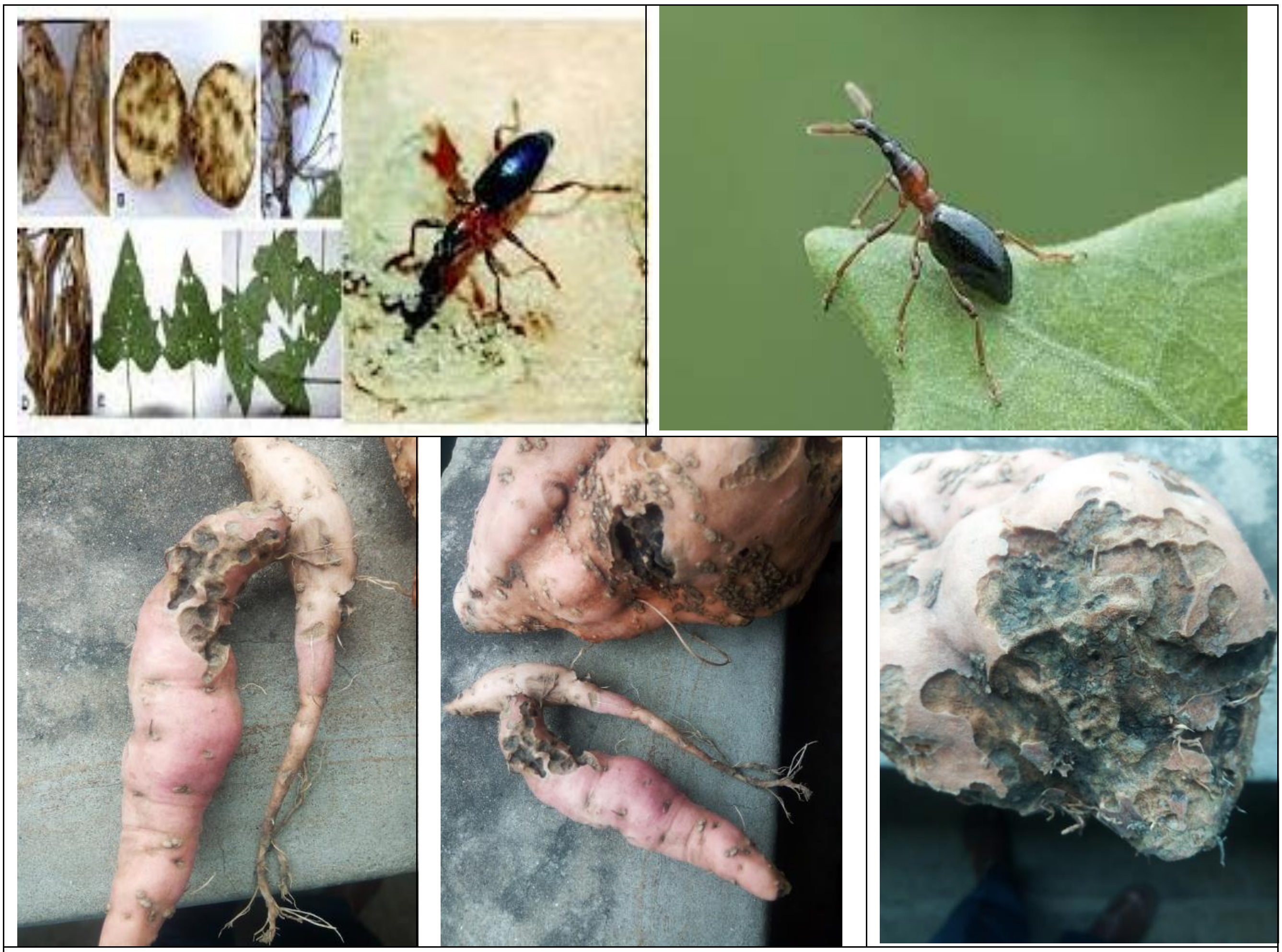

Fig 1. Sweet potato weevil

2. Tortoise beetle infestation in sweet potato: *Aspidomorpha dorsata* Fabricius; *Metriona circumdata* Herbst. (Chrysomelidae: Coleoptera)

Fig 2. Tortoise beetle infestation in sweet potato

3. Black hairy caterpillar: *Estigmene chinensis* Hope (Arctiidae: Lepidoptera)

Fig 3. Black hairy caterpillar infestation in sweet potato

4. Sweet Potato Hornworm: *Herse convolvuli* Linnaeus (Sphingidae: Lepidoptera)

Fig 4. Sweet potato hornworm adult (left) and larva (middle & right)

5. Sweet potato bug: *Oliarus lodgarti* Distant (Cixiidae: Hemiptera)

Fig 5. Sweet potato bug

6. Sweet potato vine borer: *Omphisa anastomosalis* Guenee (Pyralidae: Lepidoptera)


Fig 6. Sweet potato vine borer

7. Black Cutworm, *Agrotis ipsilon* (Noctuidae: Lepidoptera)


Fig 7. Cutworm larva (left) and cutworm affected sweet potato plant (right)

8. Sweet Potato leaf miner: *Bedellia somnulentella* (Lyonetiidae: Lepidoptera)


Fig 8. Sweet Potato leaf miner infested leaflets

9. Tobacco Whitefly: *Bemisia Tabaci* (Aleyrodidae: Hemiptera)

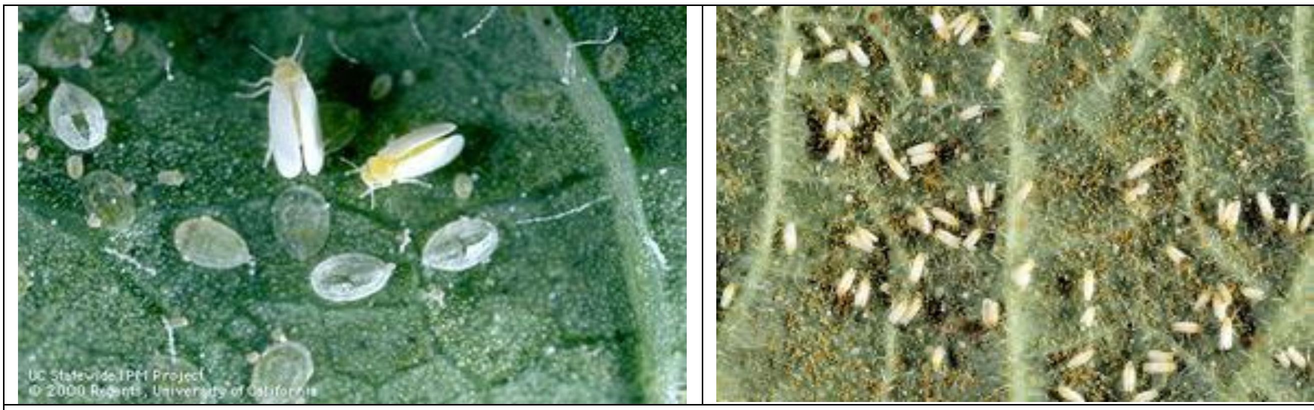

Fig 9. White fly infestation in sweet potato

10. Sweet potato leafhopper: *Exitianus indicus* Distant (Cicadellidae:Homoptera)

Fig 10. Sweet potato leafhopper

11. Sweet potato leaf caterpillar: *Euchromia polymena* (Syntomidae:Lepidoptera)

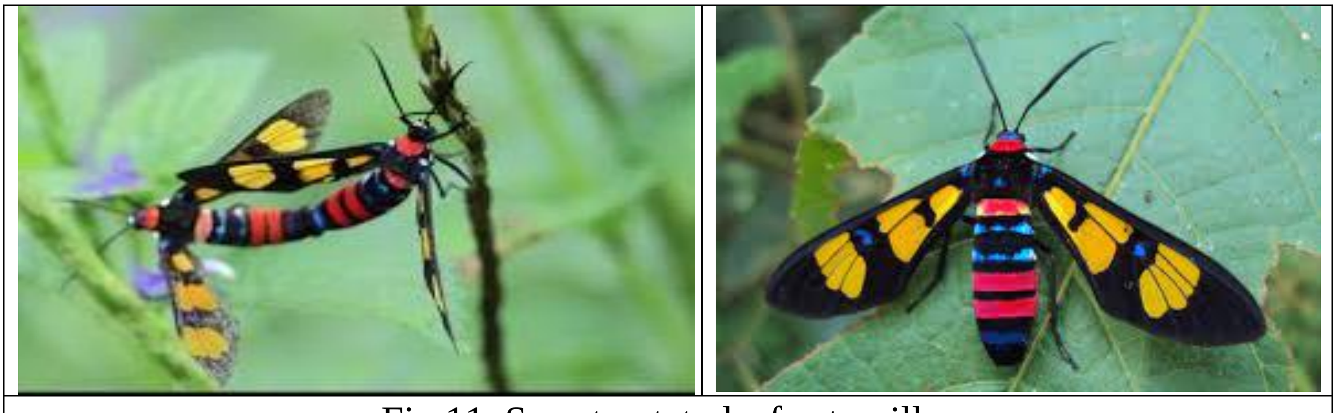

Fig 11. Sweet potato leaf caterpillar

12. Sweet potato leaf caterpillar: *Euchromia polymena* (Syntomidae:Lepidoptera)

Fig 12. Sweet potato leaf caterpillar

13. Sweet Potato Thrips: *Dendrothripoides innoxius* (Thripidae: Thysanoptera)

Fig 13. Sweet Potato Thrips

14. Jute hairy caterpillar: *Spilarctia obliqua* (Arctiidae: Lepidoptera)

Fig 14. Jute hairy caterpillar

15. Mealy bug: *Phenacoccus solenopsis* (Pseudococcidae: Hemiptera)

Fig 15. Mealy bug

16. Turnip Moth: *Agrotis Segetum* (Noctuidae: Lepidoptra)

Fig 16. Turnip Moth

17. Turnip Moth: *Agrotis Segetum* (Noctuidae: Lepidoptra)

Fig 17. Turnip Moth

মিষ্টি আলুর কন্দ ও গাছের রোগ সমূহ (Diseases of Sweet potato)

1. Cercospora leaf spot of sweet potato

Fig 1. Cercospora leaf spot of sweet potato

2. Black rot/ charcoal rot of sweet potato

Fig 2. Black rot/ charcoal rot of sweet potato

3. Soft rot of sweet potato

Fig 3. Soft rot of sweet potato

4. White rust of sweet potato

Fig 4. White rust of sweet potato

5. Fusarium Wilt of Sweet Potato

Fig 5. Fusarium Wilt of Sweet Potato

6. Bacterial Root Rot of Sweet Potato

Fig 6. Bacterial Root Rot of Sweet Potato

7. Sweet potato feathery mottle virus (SPFMV)

Fig 7. Sweet potato feathery mottle virus (SPFMV)

8. Sweet potato chlorotic fleck virus (SPCFV)

Fig 8. Sweet potato chlorotic fleck virus (SPCFV)

9. Sweet potato leaf curl virus (SPLCV)

Fig 9. Sweet potato leaf curl virus (SPLCV)

10. Root knot of sweet potato

Fig 10. Sweet potato infected by root knot nematode

11. Reniform nematode of sweet potato

Fig 11. Sweet potato infected by Reniform nematode

মিষ্টিআলুর আগাছ সমূহ (Weeds of sweet potato)

১. Durba (Barmuda) grass, 2. Mutha grass, 3. Bathua grasss

		
1. Barmuda grass/(Durba)	**2. Mutha grass**	**3. Bathua grass**

4. Chapra grass, **5. Chota shema (Barnyard grass)**

4. Chapra grass

5. Chota shema (Barnyard grass)

6. Boro shema grass (Jungle rice)

6. Boro shema (Jungle rice)

7. Kanta Nate (Spiny pig weed) **8. Shak Nate (Pig weed)**

7. Kanta Nate (Spiny pig weed)

8. Shak Nate (Pig weed)

9. Malancha (Alligator weed) **10. Helencha (Hurkuch)**

9. Malancha (Alligator weed)	10. Helencha

11. Khetpapri **12. Bon begun (Black night shade)**

11. Khetpapri	12. Bon begun (Black night shade)

13. Kanta begun (Wild solanum)

13. Kanta begun (Wild solanum)

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