May 2015

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




REPORT

ON

PEST RISK ANALYSIS (PRA) OF POTATO IN BANGLADESH

DEVELOPMENT TECHNICAL CONSULTANTS PVT. LTD (DTCL)
Gulshan-1, Dhaka, Bangladesh

Government of the People's Republic of Bangladesh
Ministry of Agriculture

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MAY 2015

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FORWARD

The Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture conducted the study for the "**Pest Risk Analysis (PRA) of Potato in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and Development Technical Consultants Pvt. Limited (DTCL) on 14 November 2014. The PRA study is a four-month assignment commencing from 21 November 2014 under the SPCB-DAE.

The overall objectives of this Pest Risk Analysis are to identify the pests and/or pathways of quarantine concern for a specified area of 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 70 upazila under 21 major potato growing districts of Bangladesh. The study covered the interview 7000 potato farmers; 21 FGDs each of which conducted in one district; conducted 55 KII and physical inspection and visits of the potato fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of potato.

The study findings evidenced that the eight arthropod pests, twelve pathogenic microorganisms and eleven weeds likely to be associated with the potato in Bangladesh. The study also revealed that pests of quarantine importance included two insect pests, six fungi, 2 bacteria, four nematodes and one viral disease and one weeds of potato that could be introduced into Bangladesh through importation of commercially produced potato seed tubers. 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, 14 quarantine pests were identified as high risk and one pest as medium risk rating. The findings also suggested the risk management options for the quarantine pests of potato in line with the pre and post harvest management and phytosanitary measures.

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

I would like to congratulate Consultant Team of DTCL for conducting the PRA study successfully and also the concerned SPCB professionals in making the total endeavor a success. I express my heartfelt thanks to the officials of DAE, Ministry of Agriculture, BARI, SCA, Agricultural Universities, research organizations and 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 potatoes.

(Sadeque Ibn Shams)
Project Director
Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project
Plant Quarantine Wing (PQW)
Department of Agriculture Extension (DAE)
Ministry of Agriculture, Bangladesh

PREFACE

This Final Report intends to respond to the requirement of the client according to the provision of contract agreement signed between Project Director of Strengthening Phytosanitary Capacity in Bangladesh (SPCB) and the Development Technical Consultants Pvt. Limited (DTCL) for **"Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh"** under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture (MOA), Government of the Peoples Republic of Bangladesh. The PRA study is a four-month assignment commencing from 15 December 2014 under the SPCB-DAE.

Consultancy services for "Conducting Pest Risk Analysis (PRA) of 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 objective of the study is to listing of major and minor pests of 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.

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

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ACKNOWLEDGEMENTS

It is indeed a great honor for us that Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW) of Department of Agriculture Extension (DAE) has entrusted Development Technical Consultant Pvt. Ltd. (DTCL) to carry out the "**Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh"**. The Final Report had been prepared based on the past four-month (December 2014 to March 2015) activities of the survey study in major 21 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 editing, entry, analysis and report writing, we have enjoyed the support of SPCB-PQW. The principal author is Prof. Dr. Md. Razzab Ali, Team Leader with inputs from Prof. Dr. Md. Abdul Karim, Prof. Dr. Md. Ramiz Uddin Miah, Prof. Dr. M. Salahuddin M. Chowdhury and Dr. B. A. A. Mustafi of the PRA study team. The authors are grateful to all persons involved in the PRA study. Our special gratitude to Director General, DAE, Bangladesh, who provided his extended support and gave us an opportunity to meet Director of Plant Quarantine Wing (PQW) of DAE; Mr. Sadeque Ibn Shams, Project Director (PD) of SPCB; Mr. Md. Ahsan Ullah, Consultant (PRA); Mr. Md. Ayub Hossain, Consultant (Procurement); Mrs. Marina Jebunehar, Senior Monitoring and Evaluation Officer of SPCB. We are thankful to all of them for their valuable cooperation and suggestions. Our special grateful thanks also to Mr. Chhabi Haridas, Director, PQW of DAE for his kind cooperation and suggestions to complete the study. The active support of Dr. M. M. Amir Hossain, Managing Director of DTCL and Kbd. Md. Habibur Rahman, Chief Coordinator of the Study and Executive Director of DTLC; Mr. M. Abul Hossain, Director, DTCL and Mr. Md. Mahabub Alam, Manager of DTCL in data collection and monitoring activities also acknowledged with thanks.

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

ACRONYMS

AEZ	:	AGRO-ECOLOGICAL ZONE
BADC	:	BANGLADESH AGRICULTURE DEVELOPMENT CORPORATION
BARI	:	BANGLADESH AGRICULTURAL RESEARCH INSTITUTE
BAU	:	BANGLADESH AGRICULTURAL UNIVERSITY
BBS	:	BANGLADESH BUREAU OF STATISTICS
BSMRAU	:	BANGABANDHU SHEIKH MUJIBUR RAHMAN AGRICULTURAL UNIVERSITY
CABI	:	CENTER FOR AGRICULTURE AND BIO-SCIENCES INTERNATIONAL
DAE	:	DEPARTMENT OF AGRICULTURE 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
MT	:	METRIC TON
NGO	:	NON-GOVERNMENT ORGANIZATION
NO.	:	NUMBER
NPPO	:	NATIONAL PLANT PROTECTION ORGANIZATION
^{o}C	:	DEGREE CELSIUS
PD	:	PROJECT DIRECTOR
PFA	:	PEST FREE AREA
PLRV	:	POTATO LEAF ROLL VIRUS
PPW	:	PLANT PROTECTION WING
PQW	:	PLANT QUARANTINE WING
PRA	:	PEST RISK ANALYSIS
PROF.	:	PROFESSOR
PVT.	:	PRIVATE
PVX	:	POTATO VIRUS X
RH	:	RELATIVE HUMIDITY
SAU	:	SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SCA	:	SEED CERTIFICATION AGENCY
SID	:	STATISTICS AND INFORMATICS DIVISION
SPCB	:	STRENGTHENING PHYTOSANITARY CAPACITY PROJECT IN BANGLADESH
TTC	:	TRIPHENYL TETRAZOLIUM CHLORIDE
UK	:	UNITED KINGDOM
USA	:	UNITED STATES OF AMERICA
USDA	:	UNITED STATES DEPARTMENT OF AGRICULTURE
%	:	PERCENTAGE

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EXECUTIVE SUMMARY

The study "Pest Risk Analysis (PRA) of Potato in Bangladesh" is documented the pests of *Solanum tuberosum* L. (potato) available in Bangladesh and the risks associated with the import pathway of potato seed tubers from exporting countries into Bangladesh. Bangladesh mainly imports fresh seed potatoes (potato tubers) from different exporting countries such as the Netherlands, Belgium, Germany, Denmark, USA and other EU counties. Bangladesh Government imports around 5,000 MT annually.

The study findings evidenced that the eight arthropod pests, twelve disease causing pathogenic microorganisms and eleven weeds likely to be associated with the potato in Bangladesh. The arthropod pests included the major insect pests *Agrotis ipsilon* (potato cutworm), *Myzus persicae* (peach aphid), *Aphis gossypii* (potato aphid) in field condition, whereas *Phthorimaea operculella* (potato tuber worm) were found as minor insect pests at storage condition; the other minor insect pests were *Empoasca fabae* (potato leafhopper), *Agromyza* sp. (potato leaf miner), *Gryllus* spp. (field cricket) and *Gryllotalpa gryllotalpa* (mole cricket) recorded in field condition. But the incidence of *Leptinotarsa decemlineata* (Colorado potato beetle) was not found in the potato field of Bangladesh.

The major diseases caused by pathogenic microorganisms include the *Phytophthora infestans* (late blight of potato), *potato leaf roll virus* (*PLRV*) in field condition, where the infection severity of *Phytophthora infestans* is controlled by the routine application fungicides in the field. The minor diseases of potato include *Alternaria solani* (early blight), *Sclerotinia sclerotiorum* (stem rot), *Rhizoctonia solani* (stem canker and black scurf), *Fusarium oxysporum* (Fusarium wilt), *Fusarium solani* (dry rot), *Verticilium albo-atrum* (Verticilium wilt), *potato yellow mosaic virus* (potato mosaic disease) in field condition, whereas *Streptomyces scabies* (common scab) and *Erwinia carotovora* (soft rot) were recorded in both field and storage condition. The unreliable record also supported for the presence of *Ditylenchus destructor* (potato tuber nematode) in the potato field of Bangladesh. As evident by the soil dilution detection technique, the bacterial wilt of potato caused by *Ralstonia solanacearum* was also found in Panchagar, Nilphamari, Rangpur, Lalmonirhat, Bogra, Joypurhat, Jessore and Rajshahi districts of Bangladesh that could be estimated as quarantine disease in Bangladesh. But the incidence of *Synchytrium endobioticum* (black wart), *Globodera rostochinensis* (golden cyst nematode), *Globodera pallida* (pale cyst nematode) and *Potato virus X* (PVX) diseases were not recorded in the potato field of Bangladesh.

The major weed in the field of potato include the *Chenopodium album* (goosefoot), whereas the minor weeds include the *Cyperus esculentus* (nut sedge), *Cynodon dactylon* (barmuda grass), *Amaranthus acanthochiton* (pigweed), *Solanum nigrum* (black nightshade), *Echinochloa colona* (barnyard grass), *Echinochloa crus-galli* (jungle rice), *Enhydra fluctuans* (harkuch), *Amaranthus spinosus* (spiny pigweed) and *Solanum carolinense* (horse nettle). The *Parthenium hysterophorus* (parthenium weed) was also found in Rajshahi, Jessore, Naogaon districts of Bangladesh that could also be estimated as quarantine weed in Bangladesh.

Information on pests associated with potato in the exporting countries the Netherlands, Belgium, Germany, Denmark, USA and other EU countries reveals that pests of quarantine importance exist. The study also revealed that pests of quarantine importance included two insect pests, thirteen disease causing pathogenic microorganisms including six fungi, two bacteria, four nematodes and one viral disease and one weeds of potato. Without mitigation, these pests could be introduced into Bangladesh through importation of commercially produced potato seed tubers. Pests of quarantine importance include arthropods: *Leptinotarsa decemlineata* (Colorado potato beetle), *Delia platura* (bean seed fly), the following pathogenic fungi: the *Synchytrium endobioticum* (potato wart disease), *Phoma exigua* var. *foveata* (potato gangrene), *Fusarium sulphureum* (potato basal canker), *Phytophthora drechsleri,* (phytophthora rot), *Phytophthora megasperma* (phytophthora blight), *Polyscytalum pustulans* (potato skin spot); the bacteria: *Clavibacter michigansis* subsp*. sepedonicus* (ring rot), *Ralstonia solanacearum* (potato brown rot or bacterial wilt), the nematode: *Globodera rostochiensis* (golden cyst nematode), *Globodera pallida* (pale cyst nematode), *Ditylenchus dipsaci* (tuber nematode); the virus: *Alfalfa Mosaic Virus* (Alfalfa yellow spot) and the weed: *Parthenium hysterophorus* (parthenium weed).

The consequences and potential/likelihood of introduction of each quarantine pest were assessed individually, and a risk rating estimated for each. The consequence of introduction value was estimated assessing five elements that reflect the biology and ecology of the pests: the climate-host interaction, host range, dispersal potential-pathway, economic and environmental impacts. The potential of introduction value was estimated by assessing the quantity of the commodity to be imported annually and the potential for pest introduction and establishment. The two values were summed to estimate an overall Pest Risk Potential, which is an estimation of risk in the absence of mitigation.

Based on the risk assessment and risk rating, 14 quarantine pests were identified as high risk and one pest as medium risk rating. The findings also suggested the risk management options for the quarantine pests of potato in line with the pre and post harvest management and phytosanitary measures.

Among 15 quarantine pests, 14 pests were rated as high risk potential and one fungus such as *Polyscytalum pustulans* was rated as medium risk potential. These mean that all of these 15 quarantine 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 potato industry and specific phytosanitary measures are strongly recommended, while for medium risk potential pest specific phytosanitary measures may be necessary to reduce pest risk.

The following are some mitigative measures that may be considered within a systemic approach to reduce the possible risks associated with the above mentioned quarantine pests:

Pre-harvest management options

- Use of pest resistant varieties especially for controlling nematode
- Pre harvest chemical spray to control pests within production fields
- Use of disinfectants for all equipment before cutting seed tubers
- Crop rotation
- Control of insect vectors
- Pre-harvest inspection

Post-harvest management options

- Sanitation of equipment and material prior to receiving new potato
- Disposal of infected tubers
- Bruise prevention
- Preservation of seed potatoes in cold storage
- Seed grading

Phytosanitary measures

- Requirements of pest free areas for potato production
- Stipulated commercial grade for potatoes to be imported
- Accept only certified seed potato for crop production
- Shipments of potato must be traceable to place of origin in exporting countries
- Pre export inspection and treatment
- Requirement of phytosanitary certification from country of origin
- Port-of-entry sampling, inspection and treatment must be made mandatory.

CHAPTER 1

Risk Analysis Background and Process

1.1. Background

Pest Risk Analysis provides the rationale for phytosanitary measures for a specified PRA area. It evaluates scientific evidence to determine whether an organism is 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, economic and environmental evidences. 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.

Potato is now the third most important food item of Bangladesh by tonnage production and widely cultivated in all the districts during winter. In the last 2-3 decades, production of potato in Bangladesh has increased with the cultivation of high yielding varieties. In 2013, Bangladesh produced about 8.603 million metric tons (MT) of potato against an annual consumption of 6.0 to 6.5 million tons (FAOSTAT, 2015) from which approximately 26 lac metric tons potatoes remain surplus. Therefore, there is a great scope to export potatoes in foreign countries. Already potato exports from Bangladesh started rising since fiscal year 2009-10, in Malaysia, Singapore and the Middle East and also exported to Sri Lanka, Indonesia and several other countries. Around 54,000 tons of potato had been shipped abroad in fiscal year 2013-2014, up from about 28,500 tons in the previous fiscal year 2012-2013 (DAE, 2014). There is also a great opportunity to export table potatoes from Bangladesh to Russia and India. But for the quarantine importance, importing countries need intensive study findings on the insect pests, diseases and other pests associated with potatoes in Bangladesh. Simultaneously, the seed potatoes used for cultivation in Bangladesh mostly imported from the Netherlands as well as from other countries such as Belgium, Germany, Denmark and USA. In the fiscal year 2014-15, Bangladesh imported 5,238.8 MT seed potatoes through Chittagong Seaport, of which 4748.80 MT from the Netherlands, 350.00 MT from Belgium, 140.00 MT from Germany (DAE, 2015). Therefore, a risk of introduction of quarantine pests associated with seed potatoes imported from the country of exports into Bangladesh remains as threat.

The introduction of insect pests, plant diseases, weeds and other pest associated with the commodity is brought about mainly during the accelerated agricultural development in different countries, when plants and plant materials were brought into, or sent out with little or no concern for the insect pests, diseases, weeds and other pests that were transported along with them. There are many instances of accidental introductions of insect pests and destructive diseases from one country to another. In India, the potato tuber moth (*Gnorimoschema operculella*) which entered from Italy in 1900 is an established field and storehouse pest of potato all over the country; wart of potato (*Synchytrium endobioticum*) introduced from Holland in 1952; golden nematode of potato (*Heterodera rostochienssis*) in the last 20 years and onion smut (*Urocystis cepulae*) introduced recently are examples showing how many destructive diseases and pests have entered into this country and have established themselves causing extensive damage.

Several insect pests and diseases are associated with potatoes in field and storage conditions. Ahad (2003) reported that cutworm (*Agrotis ipsilon*), aphid (*Myzus persicae, Aphis gossypii*), potato tuber worm (*Phthorimaea operculella*) and potato leafhopper (*Empoasca fabae*) may inflict heavy damage to the growing crop. Ashrafuzzaman (1991) reported that potatoes suffer from various diseases such as late blight (*Phytophthora infestans*), eally blight (*Alternaria solani*), common scab (*Streptomyces scabies*) and soft rot (*Erwinia carotovora*), stem rot (*Sclerotinia sclerotiorum*), stem canker (*Rhizoctonia solani*), Fusarium wilt (*Fusarium oxysporum*), dry rot (*Fusarium solani*), Verticilium wilt (*Verticilium albo-atrum*), potato mosaic disease and potato leaf curl. Besides, the bacterial wilt caused by *Ralstonia solanacearum* possibly the most destructive bacterial disease of potato and several other plants of economic importance. But the incidence and severity of these bacterial diseases are not well recognized in Bangladesh. In The incidence of golden and pale cyst nematode and potato wart in the field are not known to occur in Bangladesh. Therefore, the incidence, distribution and infestation severity are need to be investigated.

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

1.2. Scope of the Risk Analysis

The scope of this analysis is the potential hazard organisms or diseases associated with fresh tubers of potato imported from different exporting countries such as the Netherlands, Belgium, Germany, Denmark, USA. Risk in this context is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event. For the purposes of this analysis “fresh tubers” means the tubers complete with skin and flesh, without attached stems, leaves or roots.

1.3. Objective of the study

The overall objectives of a Pest Risk Analysis to identify pests and/or pathways of quarantine concern for a specified area of Potato and evaluate their risk, to identify endangered areas, and if appropriate, to identify risk management options.

Specific Objectives of the Study

- List of major and minor pests,
- 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.

1.4. Pathway Risk Analysis Process and Methodology

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

1.4.1. Undertaking of Pest Risk Analysis (PRA)

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

PRA STAGE 1: INITIATION

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

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

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

PRA STAGE 2: PEST RISK ASSESSMENT

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

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

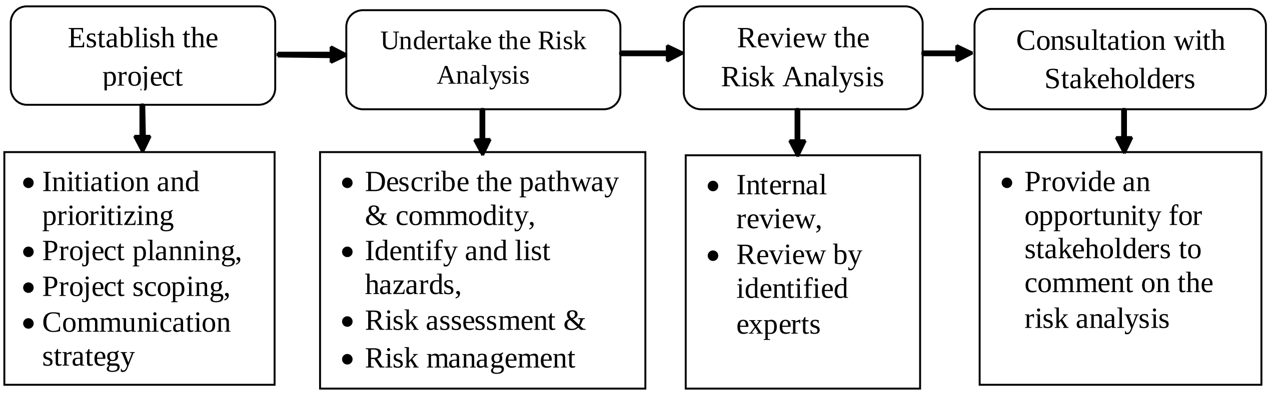
In most cases, these steps will be applied sequentially in a PRA but it is not essential to follow a particular sequence. Pest risk assessment needs to be only as complex as is technically justified by the circumstances. This standard allows a specific PRA to be judged against the principles of necessity, 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 following briefly describes the Biosecurity process and methodology for undertaking pathway risk analyses. The risk analysis process leading to the final risk analysis document is summarized in Figure 1 below:

Figure 1: A summary of the risk analysis development process



1.4.2. Commodity Description

Potato: The **potato** (*Solanum tuberosum* L.) is a starchy, tuberous, perennial crop belonging to the family Solanaceae. Potatoes were introduced outside the Andes region approximately four centuries ago (Basalt-Firth, 1990), and have since become an integral part of much of the world's food supply. It is the world's fourth-largest food crop, following maize, wheat, and rice (FAOSTAT, 2008).

Historical background: Wild potato species occur throughout the Americas from the United States to southern Chile and the crop was originally believed to have been domesticated independently in multiple locations (UWM, 2005), but later genetic testing of the wide variety of cultivars and wild species proved a single origin for potatoes in southern Peru and extreme northwestern Bolivia (from a species in the *Solanum brevicaule* complex), where they were domesticated approximately 7,000–10,000 years ago (Spooner, *et al.*, 2005; OIA, 1989; John, 2005). Following centuries of selective breeding, there are now over a thousand different types of potatoes (OIA, 1989). Over 99% of the presently cultivated potatoes worldwide descended from varieties that originated in the lowlands of south-central Chile, which have displaced formerly popular varieties from the Andean highlands (Miller, 2008; Ames and Spooner, 2008).

Importance: The United Nations FAO reports that the world production of potatoes in 2010 was about 324 million tonnes. Just over two thirds of the global production is eaten directly by humans with the rest being fed to animals or used to produce starch. This means that the annual diet of an average person in the first decade of the 21st century included about 33 kg (73 lb) of potato. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. As of 2012 China led the world in potato production, and nearly a second and seventh of the world's potatoes were produced in India and Bangladesh, respectively (FAOSTAT, 2012; FAOSTAT, 2008).

Characteristics: Potato plants are herbaceous perennials that grow about 60 cm high, depending on variety, with the culms dying back after flowering, fruiting and tuber formation. They bear white, pink, red, blue, or purple flowers with yellow stamens. In general, the tubers of varieties with white flowers have white skins, while those of varieties with colored flowers tend to have pinkish skins (Tony, 2006). Potatoes are mostly cross-pollinated by insects such as bumblebees, which carry pollen from other potato plants, though a substantial amount of self-fertilizing occurs as well.

After flowering, potato plants produce small green fruits that resemble green cherry tomatoes, each containing about 300 seeds. Like all parts of the plant except the tubers, the fruit contain the toxic alkaloid solanine and are therefore unsuitable for consumption. All new potato varieties are grown from seeds, also called "true potato seed-**TPS"** or "botanical seed" to distinguish it from seed tubers. New varieties grown from seed can be propagated vegetatively by planting tubers, pieces of tubers cut to include at least one or two eyes, or cuttings, a practice used in greenhouses for the production of healthy seed tubers. Plants propagated from tubers are clones of the parent, whereas those propagated from seed produce a range of different varieties.

Varieties: While there are close to 4000 different varieties of potato (John, 2002), it has been bred into many standard or well-known varieties, each of which has particular agricultural or culinary attributes. In general, varieties are categorized into a few main groups, such as russets, reds, whites, yellows and purples-based on common characteristics. Around 80 varieties are commercially available in the UK (Anonymous, 2009). The distinction may also arise from variation in the comparative ratio of two potato starch compounds: amylose and amylopectin. Amylose, a long-chain molecule, diffuses from the starch granule when cooked in water, and lends itself to dishes where the potato is mashed. Varieties that contain slightly higher amylopectin content, a highly branched molecule, help the potato retain its shape when boiled (Potato Primer, 2008).

Growth and cultivation: Potatoes are generally grown from seed potatoes - these are tubers specifically collected from disease free area and provide consistent and healthy plants. These locations are selected for their cold hard winters that kill pests and long sunshine hours in the summer for optimum growth. In the UK, most seed potatoes originate in Scotland in areas where westerly winds prevent aphid attack and thus prevent spread of potato virus pathogens (Anonymous, 2014a). Potato growth has been divided into **five phases**. During the first phase, sprouts emerge from the seed potatoes and root growth begins. During the second, photosynthesis begins as the plant develops leaves and branches. In the third phase stolons develop from lower leaf axils on the stem and grow downwards into the ground and on these stolons new tubers develop as swellings of the stolon. This phase is often (but not always) associated with flowering. Tuber formation halts when soil temperatures reach 27°C (81°F); hence potatoes are considered a cool-season crop (Anonymous, 2015a). Tuber bulking occurs during the fourth phase, when the plant begins investing the majority of its resources in its newly formed tubers. At this stage, several factors are critical to yield: optimal soil moisture and temperature, soil nutrient availability and balance, and resistance to pest attacks. The final phase is maturation: the plant canopy dies back, the tuber skins harden, and their sugars convert to starches (Anonymous, 2010).

New tubers may arise at the soil surface. Since exposure to light leads to greening of the skins and the development of solanine, growers are interested in covering such tubers. Commercial growers usually address this problem by piling additional soil around the base of the plant as it grows ("hilling" or "earthing up"). An alternative method used by home gardeners and smaller-scale growers involves covering the growing area with organic mulches such as straw or with plastic sheets (Anonymous, 2010).

In general, the potatoes themselves are grown from the eyes of another potato and not from seed. Home gardeners often plant a piece of potato with two or three eyes in a hill of mounded soil. Commercial growers plant potatoes as a row crop using seed tubers, young plants or microtubers and may mound the entire row. Seed potato crops are 'rogued' in some countries to eliminate diseased plants or those of a different variety from the seed crop.

Harvesting: At harvest time, gardeners usually dig up potatoes with a long-handled spading fork. In larger plots, the plow is the fastest implement for unearthing potatoes. Commercial harvesting is typically done with large potato harvesters, which scoop up the plant and surrounding earth. Immature potatoes may be sold as "new potatoes" and are particularly valued for taste. These are often harvested by the home gardener or farmer by "grabbling", i.e. pulling out the young tubers by hand while leaving the plant in place.

Curing: Potatoes are usually cured after harvest to improve skin-set. Skin-set is the process by which the skin of the potato becomes resistant to skinning damage. Potato tubers may be susceptible to skinning at harvest and suffer skinning damage during harvest and handling operations. Curing allows the skin to fully set and any wounds to heal. Wound-healing prevents infection and water-loss from the tubers during storage. Curing is normally done at relatively warm temperatures 50 to 60°C (122 to 140°F) with high humidity and good gas-exchange if at all possible (Kleinkopf and Olsen, 2003).

Yield: The world dedicated 18.6 million hectares in 2010 for potato cultivation. The average world farm yield for potato was 17.4 tonnes per hectare, in 2010. Potato farms in the United States were the most productive in 2010, with a nationwide average of 44.3 tonnes per hectare (FAOSTAT, 2010). United Kingdom was a close second. New Zealand farmers have demonstrated some of the best commercial yields in the world, ranging between 60 to 80 tonnes per hectare, some reporting yields of 88 tonnes potatoes per hectare (Sarah, 2011; Potat World, 2008).

Storage: Storage facilities need to be carefully designed to keep the potatoes alive and slow the natural process of decomposition, which involves the breakdown of starch. It is crucial that the storage area is dark, well ventilated and for long-term storage maintained at temperatures near 4°C (39°F). For short-term storage before cooking, temperatures of about 7 to 10°C (45 to 50°F) are preferred (Kohli, 2009).

Import of potato: Bangladesh mainly imports fresh seed potatoes (potato tubers) from different exporting countries such as the Netherlands, Belgium, Germany, Denmark, USA and other EU counties. Bangladesh Gorvernment imports around 5,000 MT annually, for example, Bangladesh imported 5238.80 MT seed potato tubers from the Netherlands (4748.80 MT), Belgium (350.00 MT) and Germany (140.00 MT) in the fiscal year 2014-15, whereas 1244.675 MT from the Netherlands, Belgium, Germany, USA and Denmark in the fiscal year 2013-14 and 5211.58 MT from the Netherlands, Belgium, Germany in the fiscal year 2012-13 (DAE, 2015).

Pests: The historically significant *Phytophthora infestans* (late blight) remains an ongoing problem in Europe (Nowicki *et al.,* 2011; Anonymous, 2008) and the United States (Stone, 2014). Other potato diseases include *Rhizoctonia*, *Sclerotinia*, black leg, powdery mildew, powdery scab and leafroll virus.

Insects that commonly transmit potato diseases or damage the plants include the Colorado potato beetle, the potato tuber moth, the green peach aphid (*Myzus persicae*), the potato aphid, beet leafhoppers, thrips, and mites. The potato cyst nematode is a microscopic worm that thrives on the roots, thus causing the potato plants to wilt. Since its eggs can survive in the soil for several years, crop rotation is recommended.

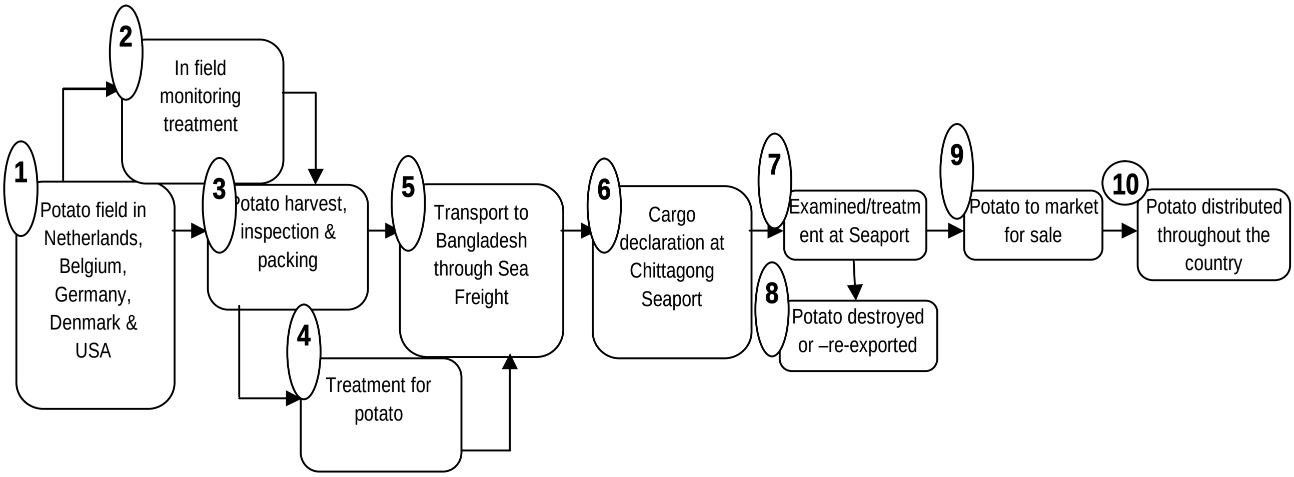
Pesticides: During the crop year 2008, many of the certified organic potatoes produced in the United Kingdom and certified by the Soil Association as organic were sprayed with a copper pesticide to control potato blight (*Phytophthora infestans*) (Derbyshire, 2008) According to the Soil Association, the total copper that can be applied to organic land is 6 kg/ha/year (Anonymous, 2010a).

1.4.3. Pathway Description

For the purpose of this risk analysis, fresh seed potatoes (potato tubers) are presumed to be from anywhere in exporting countries such as the Netherlands, Belgium, Germany, Denmark, USA and other EU counties. Bangladesh Gorvernment imports approximately about 50000 MT annually, for example, Bangladesh imported 5238.80 MT seed potato tubers from the Netherlands (4748.80 MT), Belgium (350.00 MT) and Germany (140.00 MT) in the fiscal year 2014-15, whereas 1244.675 MT from the Netherlands, Belgium, Germany, USA and Denmark in the fiscal year 2013-14 and 5211.58 MT from the Netherlands, Belgium, Germany in the fiscal year 2012-13 (DAE, 2015).

To comply with existing Bangladesh's import requirements for fresh seed potatoes, the commodity would need to be prepared for export by the exporting countries to Bangladesh by ensuring certain pests are not associated with the product. Potato tubers would then be sea freighted from exporting country to Seaport Chittagong, Bangladesh where it will go to a holding facility before being distributed to the seed traders, agricultural agencies (especially BADC) and farmers for cultivation.The linear pathway diagram of import risk of potato pests is furnished below:

Figure 2: Linear Pathway Diagram



1.5. Review of Manageement Options

1.5.1. 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. The use of resistant potato varieties, for example, was successful in the complete control of golden nematode (USDA, 2003).

ii. **Chemical spray program**: Pre-harvest chemical sprays are used to control pests within production fields, for example, the use of nematicides to control the golden nematode. More recently, crop rotation has been supplemented by use of resistant potato cultivars along with nematicides (EPPO, 1997).

iii. **Seed handling**: Before handling seed tubers, thorough washing of all containers, tools, knives and mechanical cutters, planters, and other equipment with a detergent solution, rinsed, and then sanitized with a disinfectant are effective to reduce the contamination of tubers from pathogens. When cutting seed tubers, the cutting tool should be periodically washed and sanitized. It is essential that this be done before cutting seed tubers from a different source. To be effective, disinfectants must be present for a minimum of 10 minutes (preferably 20-30 minutes) on any surface being treated (Rowe *et. al*).

iv. **Crop rotation**: Certain 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 potato plant debris, or in a living form in surviving potato tubers. On occasion, diseased tubers survive the winter and grow the following spring as diseased volunteer plants. These volunteer potatoes are a source of contamination for the current season crops. A three to four year rotation to minimize soil disease problems is recommended (Western Potato Council, 2003). Control of golden nematode is traditionally through crop rotation. More recently, crop rotation has been supplemented by use of resistant potato cultivars and nematicides (EPPO, 1997).

v. **Control of Insects**: Sucking and chewing insects may transmit many diseases. For example the ring rot disease was found to be transmitted by the Colorado potato beetle, leafhoppers and aphids (EPPO, 1997). The control of these insects and the rouging of infected plants as early as possible may prevent spread of diseases in the field (Western Potato Council, 2003).

vi. **Irrigation practices and soil type**: A well drained soil is recommended for planting of potatoes as this make conditions less favorable to disease infection (Johnson). Over irrigation and a poorly drained soil increases the susceptibility to diseases such as powdery scab. The type of irrigation system may also aid in the transmission of some diseases (Western Potato Council, 2003).

vii. **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 potato production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of diseases detected.

1.5.2. Post-harvest Management Options

i. **Sanitization of equipment and material**: All machinery, transport and storage surfaces that the seed will contact should be cleaned and disinfected prior to receiving new potato. Sanitation consists of cleaning and disinfecting all equipment, storage, tools and pallet boxes that contact the seed and ware potatoes. 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 (Western Potato Council, 2003).

ii. **Disposal of infected tuber**: All infected tuber should be discarded away from production site (Rowe *et. al)*.

iii. **Bruise prevention**: Potato tubers bruise easily during harvest in certain conditions. Soil and tuber conditions, as well as harvester operation are likely to influence bruising.

iv. **Seed storage**: Potato should be stored at (3-5oC) with 95% RH. The condition of the potato piles should be checked periodically to ensure temperature and relative humidity are maintained. This is important to minimize disease development. Access to the storage should be restricted to reduce potential for introducing diseases (Western Potato Council, 2003).

v. **Seed grading**: The class and variety of potatoes must be kept separate through harvesting, grading and storage. Grading must be done according to class, variety and disease tolerance. The class of potatoes must clearly identifiable and labeled. 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).

1.5.3. Phytosanitary Measures

i. **Requirements of pest free areas**: A pest-free area (PFA) is defined as “an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained” (IPPC, 1996b, 2006). As a sole mitigation measure, the establishment of pest-free areas or pest-free places of production is 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).

   These standards specify the appropriate steps for establishment, maintenance, verification, changes in status, an emergency action plan, reinstatement of status, documentation, and bilateral work plans for high risk pests PFA.

   This method ensures that the specific pests of concern are removed from the pathway. The pest free areas should be approved by the Plant Quarantine Department. This measure is highly effective where it is feasible to implement.

ii. **Production of certified seed potatoes**: 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 potato certification include: sampling and testing of production areas to ensure freedom from nematodes; approval of land and seed to be multiplied; inspection of crops for variety purity and crop health; sampling and testing for presence of viruses; formal classification of seed crops; inspection of tuber samples; and sealing and labeling of certified seed. Potatoes to be imported from other countries should be sourced from an officially recognized seed certification system.

iii. **Traceability to place of origin in importing countries**: A requirement that potatoes be packed in containers with identification labels indicating the place of origin, variety and grade is necessary to ensure traceability to each production site.

iv. **Pre-export Inspection and Treatment:** The NPPO of exporting countries should inspect all consignments in accordance with official procedures in order to confirm those consignments are satisfied with phytosanitary import requirements of importing countries. If a plant quarantine insect *Phthorimaea operculella* Zeller is found during inspection, the consignment may be treated by Methyl bromide (100% CH3Br) fumigation at 40g/m3 in 3 hours (Anon., 2008). Beside, at 21-25oC temperature, this insect can be treated by methyl bromide fumigation at 15-18g/m3 in 5–6 hours (EPPO, 1998, www.eppo.org/Meetings/2006_meetings/treatments.htm).

v. **Issue of Phytosanitary certificate:** The NPPO of exporting countries must issue a phytosanitary certificate for each consignment after completion of the pre-export phytosanitary inspection consistent with International Standards for Phytosanitary Measures No. 7 *Export Certification Systems* (FAO, 2006). The objective of this procedure is to provide formal documentation to Plant Quarantine/Plant Protection Department verifying that the relevant measures have been undertaken offshore.

vi. **Port-of-entry inspection and treatment**: Sampling of potato consignments at port-of-entry in importing country 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.

   Upon arrival in the port of importing country, each consignment should be inspected to detect pests, with export phytosanitary certificate and seed certificate. In the case, *Delia platura*, *Melolontha melolontha*, *Phthorimaea operculella* insects are found in the consignment, PPD will be given the option to treat (if a suitable treatment is available): fumigation by Pure Methyl Bromide at 48g/m3 in 2 hours (Anon., 2008).

1.6. Bangladesh Climate - General

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

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

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

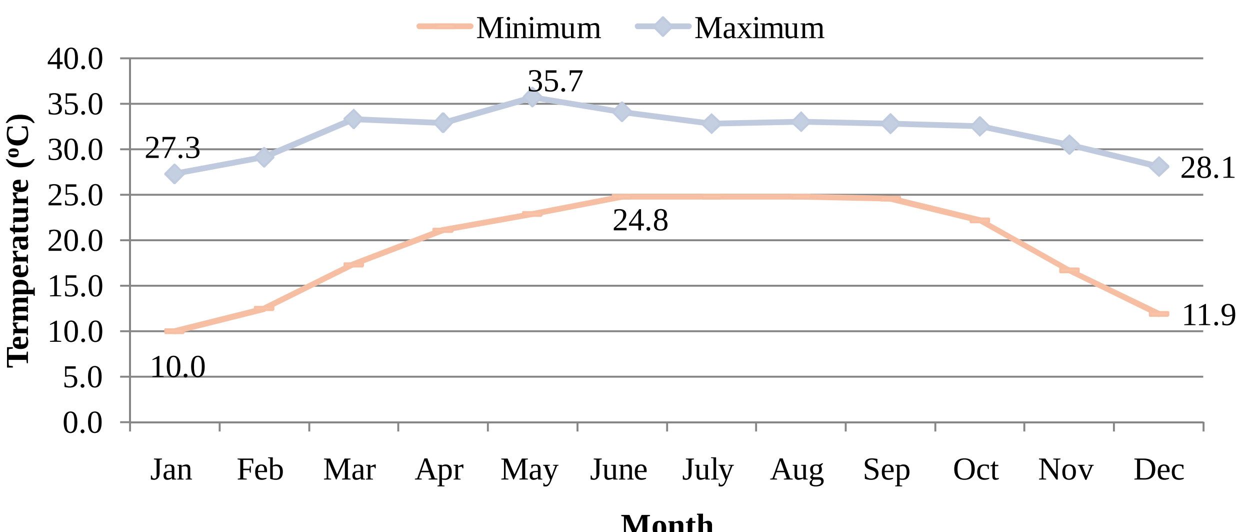


Figure 3. Monthly distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

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

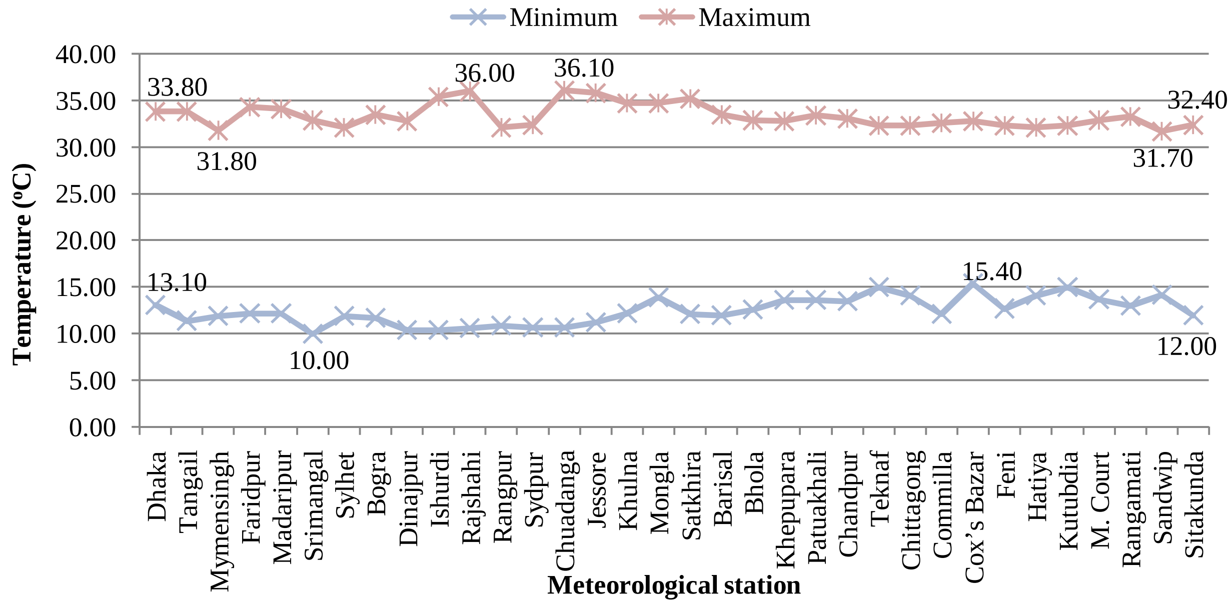


Figure 4. Location-wise distribution pattern of standard normal temperature in Bangladesh, 1981-2012

Source: BBS (2013)

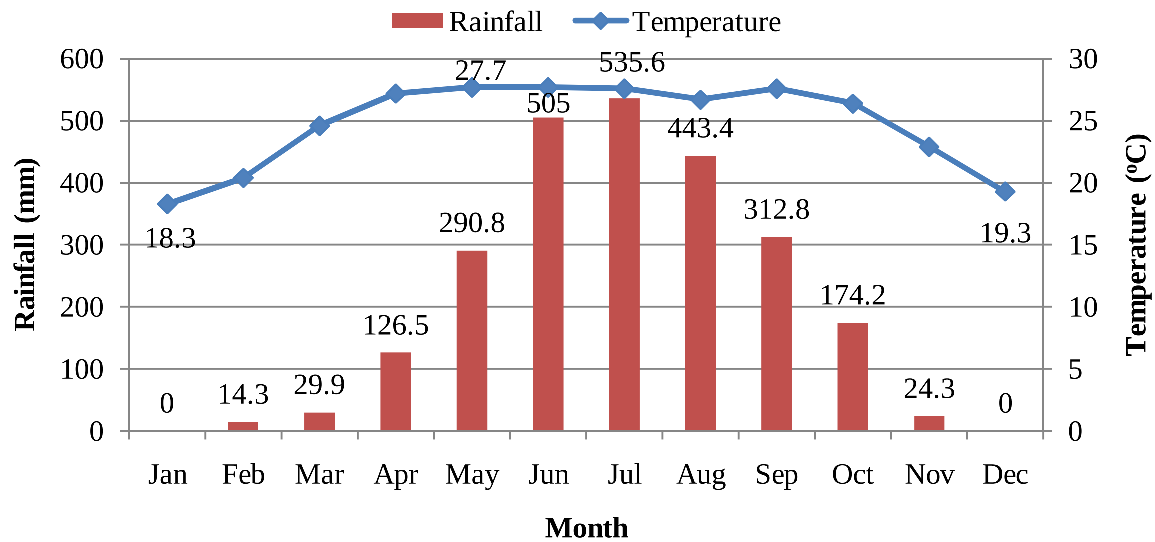


Figure 5. Average monthly Temperature and Rainfall for Bangladesh from 1960-1990

Source: World Bank Group (2015)

1.7. Climate of Exporting Countries-General

1.7.1. The Netherlands-General Climate

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

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

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

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

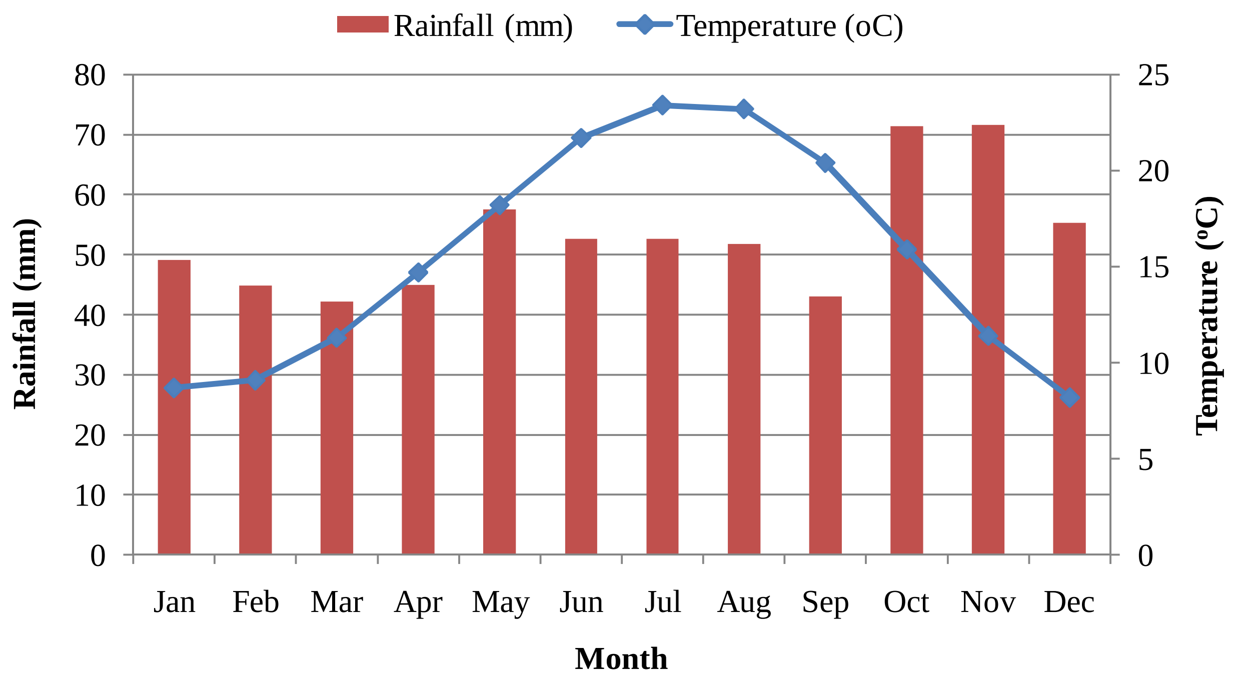


Figure 6. Monthly distribution pattern of standard normal temperature and rainfall in the Netherlands from 2000 to 2008

Source: WeatherOnline (2015a)

1.7.2. Germany-General Climate

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

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

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

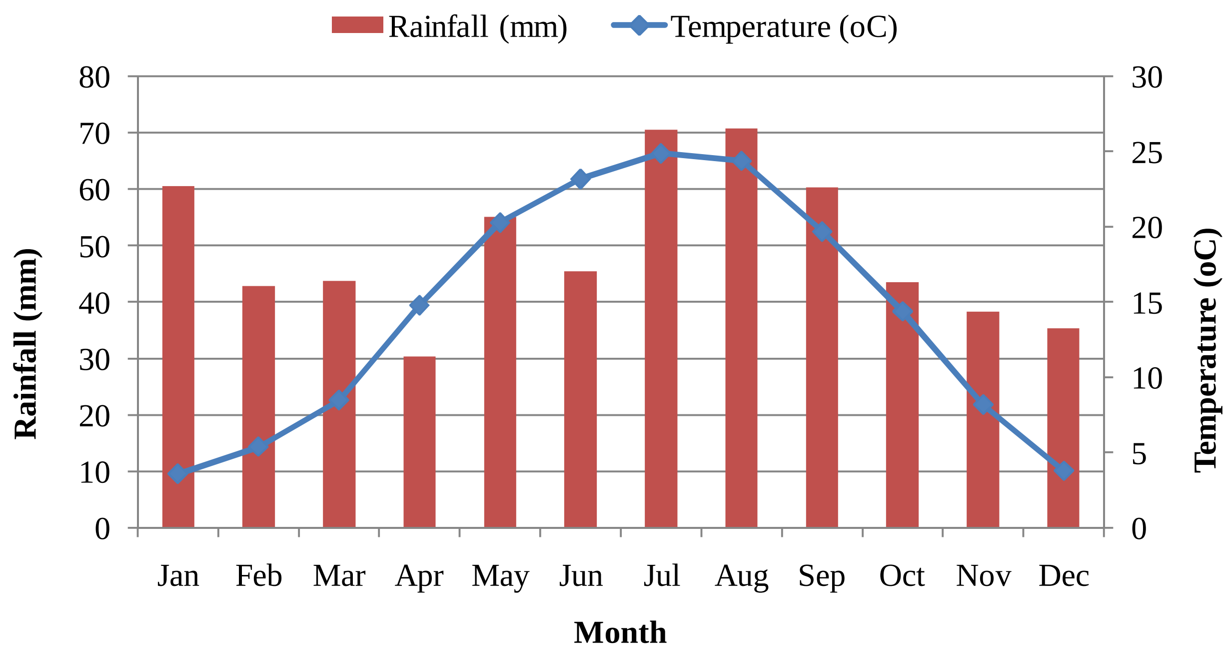


Figure 7. Monthly distribution pattern of standard normal temperature and rainfall in Germany during 2000 to 2008

Source: WeatherOnline (2015b)

1.7.3. Belgium-General Climate

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

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

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

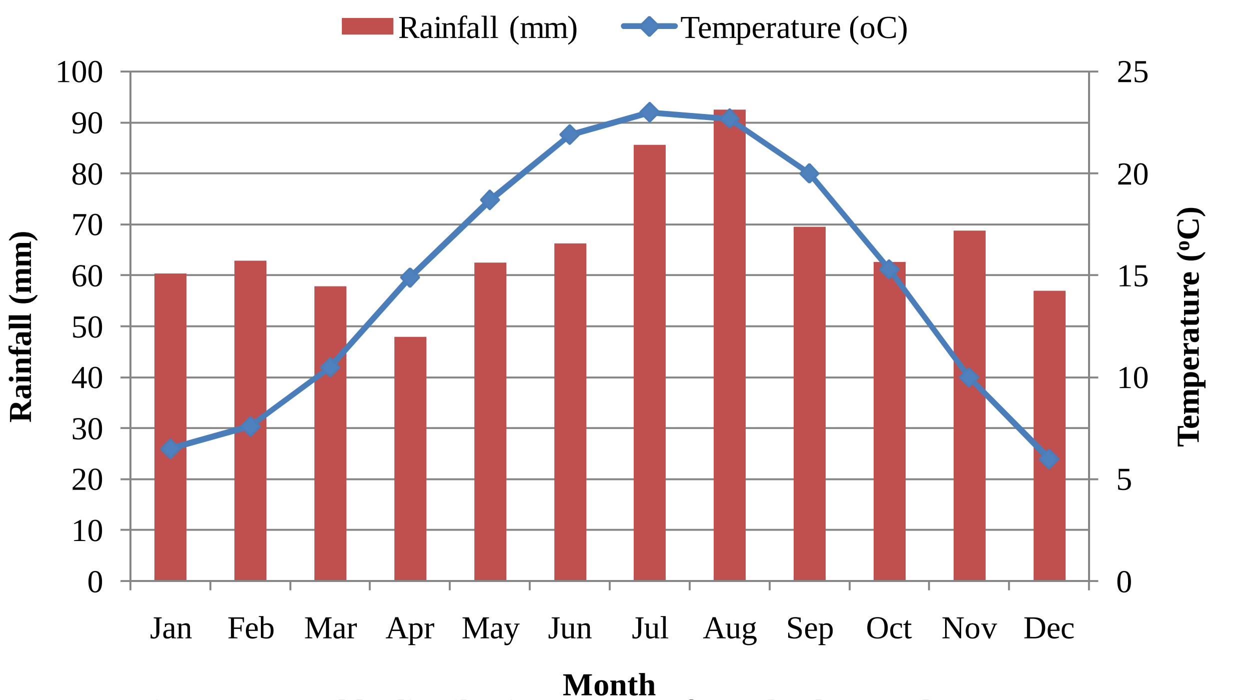


Figure 8. Monthly distribution pattern of standard normal temperature and rainfall in Belgium during 2000 to 2008

Source: WeatherOnline (2015c)

1.7.4. Denmark-General Climate

Denmark is situated in the zone between three European climatic zones (Borea influence in the north, Atlantic influence the west and Continental influence in the east); the climate throughout Denmark is a mixture of these influences. Generally the western parts of the country have Atlantic climate and the eastern parts a more continental influenced climate.

The yearly precipitation is over 900 mm in some parts of Jutland and below 500 mm over The Great Belt between Jutland and Seeland. The rain is more or less even distributed through the year, but as the evaporation is less in the cool months October to March, the winter is the most humid time of the year. Over the year the temperature is naturally highest, over 8.5 degrees C, in the southern parts of the country and below 7.5 in the northern parts of Jutland. July is the warmest month with a mean temperature over 17.5 degrees C in southeast and just below 16 in the northwest of Jutland. January is the coldest period in Denmark, but the mean temperature of c. 0 degrees C is more even throughout the country because of the warming effect from the surrounding sea.

The climate in Denmark is pleasant in the summertime (May - August). Typical daytime temperatures in the midsummer are a little more than 20 degrees C. May is a especially charming month, as the spring is at its height. September can often be very rainy.

The Winter in Denmark can be quite cold. Temperature falls sometimes until 15 - 30°C below zero. Then the country is ruled by snow, ice and icy winds. Even in April it is still possible to have a snowstorm. In the wintertime the sun rises only little above the horizon and for months (roughly October - March) the days are dark and short.

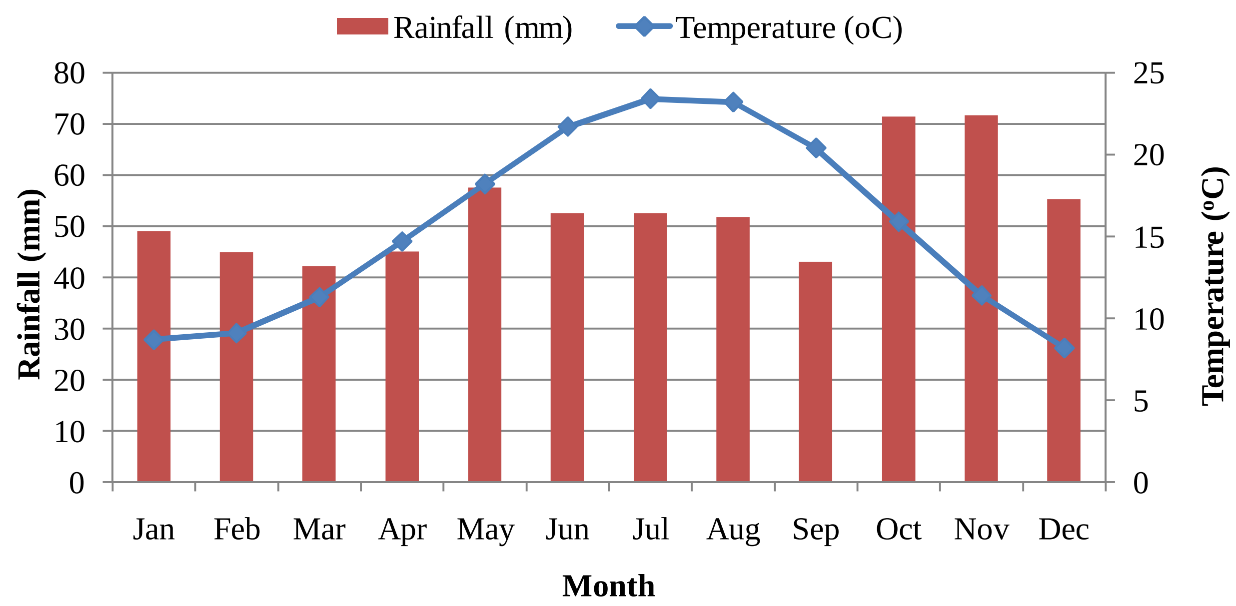


Figure 9. Monthly distribution pattern of standard normal temperature and rainfall in Denmark from 2000 to 2008

Source: WeatherOnline (2015d)

1.7.5. United States of America-General Climate

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

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

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

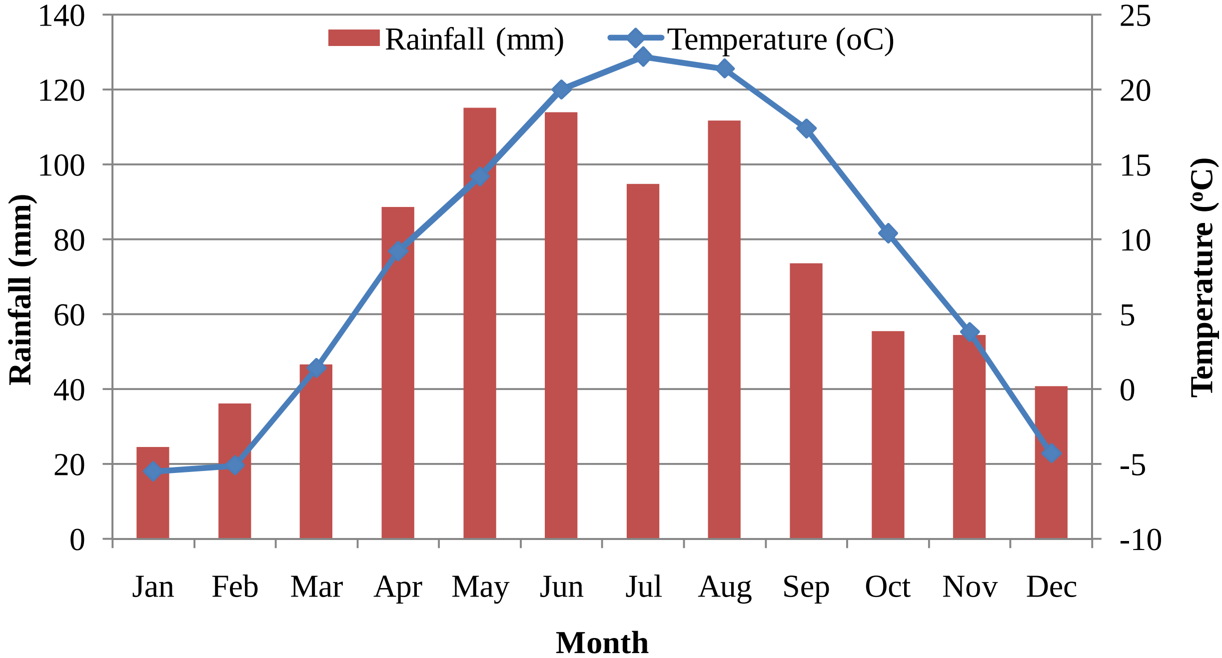


Figure 10. Monthly distribution pattern of standard normal temperature and rainfall in USA from 2000 to 2008

Source: WeatherOnline (2015e)

1.8. Methodology

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

1.8.1. Major Activities of the PRA Process

Field survey

The study survey was conducted with the direct interview of potato farmers in 21 major growing districts of Bangladesh for quantitative data aiming to identify insect pests, diseases, weeds and other pests, their status, damane severity, and management options; quarantine pests with their entry, establishment, risk and their management. The qualitative data were also collectected through focus group discussions (FGD) with potato farmers and through key informant interviews (KII) with extension personnel at field and headquarer level, Plant Quarantine Centres at Sea and land port, officials of Ministry of Agriculture, Bangladesh; Entomologist and Plant Pathologist of Bangladesh Agricultural Research Institute (BARI), Agricultural Universities, officials of Bangladesh Agricultural Development Corporation (BADC), Seed Certification Agency (SCA) and Potato Imorters and Exporters.

Secondary data collection and review

The current PRA related secondary data were collected and gathered from secondary sources such as journals, books, proceedings, CD-ROM search, internet browsing especially through websites of CAB International, EPPO Bulletin and others. The documents were then critically reviewed, synthesized in relation to identify the quarantine pests of potato available in the potato exporting counties such as the Netherlands, Belgium, Germany, Denmark, USA and other EU countries as well as PRA related activities performed there. Ultimately, formulated all of these synthesized information based on the requirement of the current PRA.

Listing of pests of potato

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

1.8.2. Survey location and sample size

The survey study sas conducted in the 21 major potato growing districts of Bangladesh as selected by the client Project Director, Stenghthening Phytosanitary Capacity in Bangladesh (SPCB) under Plant Quarantine Wing (PQW), DAE, Bangladesh. A total 70 upazilas (sub-district) were selected under 21 sampled distrcts, where 10 agricultural blocks were covered under each upazilla and 10 farmers were interviewed in each block through pre-tested questionnaire. Thus, a total of 7,000 farmers were interviewed from all of 21 sampled districts. The focus group discussion (FGD) meeting was also conducted for each of 21 sampled districts with the participation of at least potato farmers aiming to gather qualitative data. Besides, one officer designated as Additional Deputy Director (Plant Protection) for each district had also been interviewed through semi-structured key informant interview (KII) checklist. The district and upazila wise distribution of respondents is given below:

Table-1: Distribution of sample respondents in selected districts of Bangladesh

Sl. No.	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII at district level DAE
1	Dinajpur	1. Sadar	10	100	1	1
		2. Fulbari	10	100		
		3. Birampur	10	100		
		4. Birgonj	10	100		
		5. Birol	10	100		
2	Thakurgaon	6. Sadar	10	100	1	1
		7. Ranisankail	10	100		

Sl. No.	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII at district level DAE
		8. Pirgonj	10	100		
3	Panchogar	9. Debigonj	10	100	1	1
		10. Boda	10	100		
4	Rangpur	11. Sadar	10	100	1	1
		12. Pirgacha	10	100		
		13. Badargonj	10	100		
		14. Nithapukur	10	100		
		15. Taragonj	10	100		
5	Kurigram	17. Sadar	10	100	1	1
		18. Ulipur	10	100		
6	Lalmonirhat	19. Sadar	10	100	1	1
		20. Hatobandha	10	100		
7	Nilphamari	21. Dimla	10	100	1	1
		22. Jaldhaka	10	100		
		23. Kishoregonj	10	100		
8	Gaibandha	24. Polashbari	10	100	1	1
		25. Gobindagonj	10	100		
		26. Sadullapur	10	100		
9	Bogra	27. Sherpur	10	100	1	1
		28. Shibgonj	10	100		
		29. Sonatola	10	100		
		30. Shajanpur	10	100		
10	Joypurhat	31. Sadar	10	100	1	1
		32. Panchbibi	10	100		
		33. Katail	10	100		
		34. Khetlal	10	100		
		35. Akkelpur	10	100		
11	Rajshahi	36. Baghmara	10	100	1	1
		37. Mohanpur	10	100		
		38. Durgapu	10	100		
		39. Paba	10	100		
		40. Puthia	10	100		
12.	Naogaon	41. Sadar	10	100	1	1
		42. Badalgachi	10	100		
		43. Raninagar	10	100		
13.	Munshigonj	44. Sadar	10	100	1	1
		45. Tongibari	10	100		
		46. Sirajdikhan	10	100		
		47. Sreenagar	10	100		
		48. Loahajang	10	100		
14	Narayangonj	49. Sadar	10	100	1	1
		50. Bandar	10	100		
		51. Sonargaon	10	100		
15	Comilla	52. Daudkandi	10	100	1	1
		53. Chandina	10	100		
		54. Barura	10	100		

Sl. No.	District	Upazilla	No. of Block	No. of Farmers	No. of FGD	KII at district level DAE
16	Chandpur	55. Motlab North	10	100	1	1
		56. Motlab South	10	100		
		57. Hajigonj	10	100		
17	Lakshmipur	58. Ramgonj	10	100	1	1
		59. Raipur	10	100		
18	Jhenaidah	60. Courtchandpur	10	100	1	1
		61. Horinakundu	10	100		
19	Jessore	62. Sadar	10	100	1	1
		63. Bagarpara	10	100		
		64. Choughacha	10	100		
20	Sherpur	65. Sadar,	10	100	1	1
		66. Nalitabari	10	100		
		67. Nokhla	10	100		
21	Kishoregonj	68. Sadar	10	100	1	1
		69. Pakundia	10	100		
		70. Kotiossainpur	10	100		
Total = 21		**70**	**700**	**7,000**	**21**	**21**

1.8.3. Development of indicators for field survey

Considering the specific objectives of the study, the major indicators for the field survey were indentified in consultation with the Plant Quarantine Wing (PQW) officials under Department of Agriculture Extension (DAE), Bangladesh. The indicators were potato vatieties cultivated by the farmers; occurrence, status and damage severity of insect pests, diseases, weeds and other associated pests of potato; their potential risk, endangered areas in Bangladesh; identification of quarantine pests of potato; entry and pathways of quarantine pests; effective measures in controlling these pests; options in preventing the entry and spread of quarantine pests, their risk and management options and phytosanitary measures.

1.8.4. Development of data collection tools

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

Field survey questionnaire: For quantitative analysis, the field survey was conducted in 21 major potato growing districts of Bangladesh through face to face interview with 7,000 potato farmers using a set of pre-designed and pre-tested questionnaire (**Appendix-1)** encompassing the relevant study indicators. A field guide emphasizing on the comprehensive list and colorful photographs of insect pests, diseases and weeds of potato was also prepared aiming to enhance the data enumerators and farmers to ease identification of the respective pests whether these were occurred in their field or not.

Focus Group Discussion (FGD): For qualitative analysis, 21 FGD meetings were organized considering one FGD for each sampled districts with the participantion of at least 10 potato farmers for each. The FGD meetings were conducted using pre-designed FGD guidelines (**Appendix-2**).

Key Informant Interview (KII): The key informant interviews were conducted with the extension personnel at field and headquarer level of DAE, officials of Plant Quarantine Centres at Sea and land ports; officials of Ministry of Agriculture; Entomologist and Plant Pathologist of BARI, Agricultural Universities, officials of BADC, SCA and Potato Imorters and Exporters. A total of 40 key personnel were interviewed using a semi-structured KII Checklist (**Appendix-3)** encompassing the qualitative issues of the study.

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

1.8.5. Recruitment and training of field staff

The Junior Entomologist and Junior Plant Pathologist having master's degree in Entomology and Plant Pathology respectively were reqruited as data enumerators. A total 21 data enumerators, of which 1 for each of 21 sampled districts were employed for field level data collection. A total 7 field supervisors for 7 administrative divisions of Bangladesh were also reqruited and employed to supervise the activities of data enumerators. After recruitment, all the data enumerators and supervisors had been trained by three-day training course about data collection procedures for this PRA study.

1.8.6. Method of data collection

Direct personal interview approach was adopted for primary data collection. The field enumerators personally contacted the farmers and filled up the each question of the questionnaire one by one to obtain desired information. In addition, qualitative information was collected through FGD meetings with potato farmers using FGD guidelines under supervision of supervisors. The field level data collection was conducted for a month started from 20 December 2014 to 19 January 2015.

1.8.7. Data analysis

As soon as the filled up questionnaires received from the field, data entry of the questionnaires were completed using SPSS and MS Access computer packages and the data were analyzed for tabulation of the primary data into data tables.

1.8.8. Laboratory Investigation

Field sample collection: The samples for insect pests and diseases from the potato field of carried out to the Dhaka office and preserved with appropriate location wise lebeling in the refreegerator at 4oC in the Plant Pathology laboratory at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The evidences for specific pest especially for bacterial wilt caused by *Ralstonia solanacearum* was proved by in-depth investigations. Both wilted plant and soil samples from potato fields were collected from 21 upazilla under 21 sampled districts.

Detection methods: Two methods were followed to detect the presence of *Ralstonia solanacearum* on the sample, the KIT test and soil dilution plate technique.

KIT Test method: KIT test for rapid diagnosis of bacteria from wilted plant parts (stem) was carried out following guidelines supplied with KIT and in web. Tests are based on antibodies designed to recognize antigens specific to each pathogen. The antigen present in the plant sample was extracted by grinding in the extraction solution. The extracted antigen was then allowed to react with antibodies that capture specific antigens (when present) and resulted a color change that appeared as a line on the strip. The procedure of KIT test is presented below:

The sample (stem of plant) was washed with sterile water. A small piece of stem was cut with a knife. The piece of stem was added in buffer solution and shaked it for 30 seconds. Two drops of solution were then taken and put it on the KIT to react with antibody present on the KIT. The kit was kept for five minutes for observation. After five minutes the kit showed negative result that means color develop only in control.

Soil dilution technique: Collected sample from above mentioned regions were spread on TTC media plate (Kelmen, 1954) to detect the presence of *Ralstonia* on soil. The basal media was prepared with the mixing of Peptone @10 g/lit. Casein @ 1 g/lit, Dextrose @ 0.5 g/lit, Agar @ 17 g/lit together and then autoclaved and cooled at 50oC temperature. Then 5ml solution of TTC (2,3,5,Triphenyl Tetrazolium Chloride) was added in 1 lit basal media. Then it was poured on petridish and thus the TTC media was prepared. Serial dilution plate method (Nesmith, W.

C. and Jenkins, S. F., 1979.) was used to isolate *Ralstonia* from soil, where 1 g soil sample was weighted from collected soils carried with wilted plant samples from potato fields of different locations and took into test tube containing 9 ml distilled sterile water and mixed with it. Then 1 ml solution from this was transferred into another test tube containing 9 ml sterile distilled water and thus made it 1:10 volume. Then 1 ml solution from this was again transferred into another test tube containing 9 ml sterile distilled water and thus made it 1:100 volumes. Then 1 ml solution from this was transferred into another test tube containing 9 ml sterile distilled water and thus made it 1:1000 volumes. Then 0.1 ml from each concentration was taken and spread into 90 mm petridish containing TTC media with glass spreader and sealed it with paraffin tape and put it into incubation chamber for 24 hours at 30oC temperature.

Remarks: The KIT test showed negative result against *Ralstonia* that indicated the absence of bacteria in wilted potato plants collected from sampled areas. Soil dilution technique provided positive results for 8 districts and negative result for rest of the districts. This result showed the presence of *Ralstonia* in soil collected from different potato fields of Bangladesh. With this detection procedure, the identification of the Biovars of the Ralstonia was not performed. It requires further study through intensive survey specifically by the collection of Ralstonia wilted plant, soil and tuber samples from all of the growing locations for the detection of the incidence of *Ralstonia solanacearum* as well as for biovar identification.

CHAPTER 2

Fingdins of Survey Study

2.1. Introduction

The study for "Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh" was done in 21 major growing districts of Bangladesh. The sampled districts were selected by the clientStrengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Bangladesh based on the annual production potato tubers in the districts. Considering the objectives of the study, data were collected through farmers' level field survey for quantitative data as well as focus group discussions and key informant interview were conducted for qualitative data encompassing the issues about occurrence and status of insect pests, diseases, weeds and other associated pests of potato, their damane, infestation severity and management options; potential quarantine pests of potato, their entry, establishment, risk and management. The precise findings of the study have been presented below:

2.2. Potato varieties cultivated by the farmers

The farmers in different growing areas of Bangladesh were usually cultivating different potato varieties and the most familiar varieties commonly they used for cultivation were Granolla (BARI Alu-13), Diamant (BARI Alu-7), Cardinal (BARI Alu-8) developed by Bangladesh Agricultural Research Institute (BARI). Other polular varieties used by the farmers were Malta especially in Chandpur district, Lal pakhri and Shil-bilati especially in Bogra and Rangpur districts, Surjomukhi in Gaibandha districts, Romana, Charki, Patnay, Hagray especially in Naogaon district, Carage especially in Bogra and Jaypurhut districts. Most of the farmers used the BADC (Bangladesh Agricultural Development Corporation) seed potatoes and from their won preserved seeds. Other souces of potato seeds were NGO, Company seed (other than BADC), seeds from neighboring farmers, local seed grower.

2.3. Insect pests of potato

A total number of 7 insect pests of potato were reported by the stakeholders those were found in the field of potato and or storage condition. The incidences and damage potential of reported potato insect pests have been presented below:

Incidence of insect pests: The incidences of major insect pests of potato found were cutworm (*Agrotis ipsilon*) and aphid (*Myzus persicae, Aphis gossypii*) in field condition. The important minor insect pest of potato was potato tuber worm (*Phthorimaea operculella*) found in storage condition, but it was also found in the field condition at harvesting stage of potato tubers. Other minor insect pests were potato leafhopper (*Empoasca fabae*), potato leaf miner (*Agromyza* sp.), field cricket (*Gryllus* spp.) and mole cricket (*Gryllotalpa gryllotalpa*) in field condition (Table 2). The incidene of Colarado potato beetle (*Leptinotarsa decemlineata*) was not found in the field of potato growing areas in Bangladesh.

Damage potential of insect pests: Among these insect pests, cutworm and aphid were more damaging than others. The cutworm caterpillar caused damage potato seedlings cutting stem at ground level; both nymphs and adults of potato aphids caused damage at vegetative stage of potato plants by sucking sap from leaves and tender parts of plants with high infestation severity. Besides sucking plant sap, aphids also tranmited *Potato Leaf Roll Virus (PLRV), Potato mosaic virus* diseases, if not controlled properly. The potato tuber worm damaged at tuberization satage of potatoes with low infestation intensity, but could become severe if potato tubers could not stored properly.

The potato leafhopper and leaf miner caused damage at vegetative stage of plants by sucking sap from leaves and mining leaves, respectively with minor infestation intensity. The soil dwelling insects-field cricket and mole cricket both damaged potato crops by digging soils and cutting roots and stems of potato seedlings in the field with minor infestation intensity.

Table-2: Insect pests of potato, their identity, status and infestation severity

Common name of insect pest	Pest identity	Pest status	Stage and plant parts affected	Infestation severity
Potato cutworm	*Agrotis ipsilon* Order:**Lepidopetera** Family: **Noctuidae**	Major	**Seedling,** whole plant	High
Potato aphid	*Myzus persicae, Aphis gossypii* Order: **Hemiptera** Family: **Aphididae**	Major	Vegetative, **leaf, stem**	High
Potato tuber worm	*Phthorimaea operculella* Order:**Lepidoptera** Family:**Gelechiidae**	Minor	**Tuber**	Low
Potato leafhopper	*Empoasca fabae* Order:**Hemiptera** Family:**Cicadellidae**	Minor	Vegetative, **leaf**	Low
Potato leaf miner	*Agromyza* sp. Order: **Diptera** Family:**Agromyzidae**	Minor	Vegetative, **leaf**	Low
Field cricket	*Gryllus* spp. Order:**Orthoptera** Family:**Gryllidae**	Minor	**Seedling**, stem, root	Low
Mole cricket	*Gryllotalpa gryllotalpa* Order:**Orthoptera** Family:**Gryllotalpidae**	Minor	**Seedling**, stem, root	Low
Colorado potato beetle	*Leptinotarsa decemlineata* Order: **Coleoptera** Family: **Chrysomelidae**	Not recorded in Bangladesh		

2.4. Diseases of potato

A total number of 13 diseases of potato among which 8 caused by fungi, 3 by bacteria and 2 by viruses were reported by the stakeholders those were found in the field of potato and or storage condition. The incidences and damage potential of reported potato diseases have been presented below:

Incidence of diseases: The incidences of major diseases of potato found in the study were late blight of potato (*Phytophthora infestans*), potato leafcurl virus (*Potato Leaf Roll Virus-PLRV)* diseases in the field condition, whereas the late blight was regulated by the routine treatment of fungicide in the potato field. The incidences of minor diseases of potato were early blight of potato (*Alternaria solani*), stem rot (*Sclerotinia sclerotiorum*), potato stem canker or black scurf (*Rhizoctonia solani*), Fusarium wilt (*Fusarium oxysporum*), dry rot (*Fusarium solani*), Verticilium wilt (*Verticilium albo-atrum*) and potato mosaic disease (*Potato yellow mosaic virus*) in the field condition as well as common scab of potato (*Streptomyces scabies*) and soft rot of potato (*Erwinia carotovora*) in both field and storage condition (Table 3). The bacterial wilt disease caused by *Ralstonia solanacearum* also found in Panchagar, Nilphamari, Rangpur, Lalmonirhat, Bogra, Joypurhat, Jessore and Rajshahi districts of Bangladesh. The survey responses about the incidences of Bacterial wilt was also evident by the laboratory investigation through Ralstonia Kit Test and soil dilution methods using TTC (2,3,5,Triphenyl Tetrazolium Chloride) media as recommended by Kelmen (1954) in the Plant Pathology laboratory at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The incidenes of potato golden cyst nematode (*Globodera rostochinensis*), potato pale cyst nematode (*Globodera pallida*), potato black wart (*Synchytrium endobioticum*) and *Potato Virus-X* (*PVX*) were not reported by the stakeholders in the field and storage of potato growing areas of Bangladesh.

Damage potential of diseases: Among these diseases, the late blight and potato leafcurl virus diseases were more damaging than others. The late blight caused damage potato plants at vegetative stage with high infection infection intensity, but the damage severity was controlled by the farmers through routine application of fungicides in the potato field, but the potato leafcurl virus disease caused damage potato plants at vegetative stage with low infection intensity, whereas common scab and soft rot caused damage at tuberization stage with medium and low infection intensity, respectively. The potato stem canker or black scurf, Fusarium/Verticilium wilt, potato mosaic diseases caused damage at vegetative satage with low infection intensity. But all these diseases including late blight of potato were being regularly controlled frequently and timely by the application of chemical pesticides in the field. Therefore, the severity of these diseases stayed behind, otherwise they could become severe. The bacterium *Ralstonia solanacearum* caused damage potato at vegetative stage expressing wilting of standing plants as well as expressing brown rot of tubers with low infection intensity.

Table-3: Diseases of potato, their categorical identity, status and infection severity

Disease	Pathogen identity	Disease status	Stage and plant parts affected	Infection severity	Pest category
Late blight of potato	*Phytophthora infestans* Order: Peronosporales Family: Pythiaceae	Major	Vegetative, leaf, stem	High	Fungi
Phytophthera tuber rot	*Phytophthora infestans* Order: Peronosporales Family: Pythiaceae	Minor	Tuber	Low	Fungi
Early blight of potato	*Alternaria solani* Order: Pleosporales Family:Pleosporaceae	Minor	Seedling, whole plant	Low	Fungi
Stem rot of potato	*Sclerotinia sclerotiorum* Order: Atheliales Family: Atheliaceae	Minor	Vegetative, leaf	Low	Fungi
Stem canker/ black scurf of potato	*Rhizoctonia solani* Order: Ceratobacidiales Family:Ceratobacidiaceae	Minor	Seedling, stem, root	Low	Fungi
Fusarium wilt	*Fusarium oxysporum* Order: Hypocreales Family: Nectriaceae	Minor	Vegetative and tuberization	Low	Fungi
Dry rot of potato	*Fusarium solani* Order: Hypocreales Family: Nectriaceae	Minor	Potato tuber	Low	Fungi
Verticilium wilt	*Verticilium albo-atrum* Order: Hyphomycetales Family: Moniliaceae	Minor	Vegetative and tuberization	Low	Fungi
Black wart of potato	*Synchytrium endobioticum* Order: Chytridiales Family: Synchytriaceae	Not recorded in Bangladesh			Fungi
Common scab potato	*Streptomyces scabies* Order: Actinomycetales Family: Streptomycetaceae	Minor	Tuber	Low to medium	Bacteria
Soft rot of potato	*Erwinia carotovora* Order: Enterobacteriales Family: Enterobacteriaceae	Minor	Tuber	Low	Bacteria
Bacterial wilt and brown rot of potato	*Ralstonia solanacearum* Order: Burkholderiales Family: Burkholderiaceae	Major (limited areas)	Whole plant, tubers	Low	Bacteria
Potato tuber nematode	*Ditylenchus destructor* Order: Tylenchida Family: Anguinidae	Minor	Tuber	Low	Nematode

Disease	Pathogen identity	Disease status	Stage and plant parts affected	Infection severity	Pest category
Golden cyst nematode	*Globodera rostochinensis* Order: Tylenchida Family: Heteroderidae	Not recorded in Bangladesh			Nematode
Pale cyst nematode	*Globodera pallida* Order: Tylenchida Family: Heteroderidae	Not recorded in Bangladesh			Nematode
Potato leafcurl virus	*Potato leafroll virus (PLRV)* Group: Group IV Family: Luteoviridae	Major	Vegetative, leaf	Low	Virus
Potato mosaic disease	*Potato yellow mosaic virus* Group: Group II Family: Geminiviridae	Minor	Vegetative, leaf	Low	Virus
Potato mottle virus/Potato Virus X	*Potato Virus-X* (PVX) Order: Tymovirales Family: Alphaflexiviridae	Not recorded in Bangladesh			Virus

2.5. Weeds of potato

A total number of 12 weeds were reported by the stakeholders those were found in the field of potato. The incidences and damage potential of reported potato weeds have been presented below:

Incidence of weeds: The incidence of major weed of potato found in the study was goosefoot (*Chenopodium album* L.) in the field of potato. The incidences of minor weeds of potato were nutsedge (*Cyperus esculentus*), goosefoot (*Chenopodium album* L.), pigweed (*Amaranthus acanthochiton)* and black nightshade (*Solanum nigrum*), barmuda grass (*Cynodon dactylon*), barnyard grass (*Echinochloa colona*), jungle rice (*Echinochloa crus-galli*), harkuch (*Enhydra fluctuans*), spiny pigweed (*Amaranthus spinosus*), and horse nettle (*Solanum carolinense* L) in the field of potato (Table 4). The parthenium weed (*Parthenium hysterophorus*) ws also found in Rajshahi district among 21 sampled districts of Bangladesh. The stakeholders also reported that the parthenium weed might be entered into Bangladesh through cross boundery from India by the transportation system of border trading.

Damage potential of weeds: Among these diseases, the goosefoot and nutsedge were more damaging than others and caused damage at seedling to vegetative stage with medium to high and low infestation intensity, respectively, where theses weeds were eradicated from the potato field regularly during intercultural operations. The pigweed caused damage potato plants at vegetative stage with medium infestation intensity and all others caused damage with low to medium infestation intensity. As a newly introduced weed, though parthenium caused damage with low infestation intensity, but it could cause severe damage and spread to other areas, if not controlled properly.

Table -4: Weeds of potato, their identity, status and infestation severity

Weed	Weed identity	Pest status	Stage of plant affected	Infestation severity
Bermuda grass (*Durba**)	*Cynodon dactylon* Order: Poales Family:Poaceae	Minor	Seedling to tuberization	Low
Nutsedge (*Mutha**)	*Cyperus esculentus* Order: Poales Family: Cyperaceae	Minor	Seedling to vegetative	Low
Goosefoot (*Bathuwa**)	*Chenopodium album* L. Order: Caryophyllales Family: Chenopodioideae	Major	Seedling to vegetative	Medium to high

Barnyard grass (*Shama ghas**)	*Echinochloa colona* Order: Poales Family: Poaceae	Minor	Seedling to vegetative	Low
Jungle rice	*Echinochloa crus-galli* Order: Poales Family: Poaceae	Minor	Seedling to vegetative	Low
Harkuch (*Helancha**)	*Enhydra fluctuans* Order: Asterales Family: Asteraceae	Minor	Seedling to vegetative	Low
Pigweed (*Shaknate**)	*Amaranthus acanthochiton* Order: Caryophyllales Family:Amaranthaceae	Minor	Seedling to vegetative	Low
Spiny pigweed (*Kantanate**)	*Amaranthus spinosus* Order: Caryophyllales Family:Amaranthaceae	Minor	Seedling to vegetative	Low
Black nightshade (*Bonbegun**)	*Solanum nigrum* Order: Solanales Family: Solanaceae	Minor	Seedling to tuberization	Low
Horsenettle (*Kantabegun**)	*Solanum carolinense* L. Order: Solanales Family: Solanaceae	Minor	Seedling to vegetative	Low
Parthenium weed	*Parthenium hysterophorus* Order: Asterales Family: Asteraceae	Minor (limited areas)	Growing season	Low

*Bengali name

2.6. Endangered areas of serious pests of potato

The bacterial wilt and brown rot of potato caused by *Ralstonia solanacearum* was reported in Panchagar, Nilphamari, Rangpur, Lalmonirhat, Bogra, Joypurhat, Jessore and Rajshahi districts of Bangladesh.

The parthenium weed (*Parthenium hysterophorus*) also found in Rajshahi district among the sampled 21 districts of Bangladesh. The stakeholders also reported that the parthenium weed might be entered into Bangladesh through cross boundery from India by the transportation system of border trading. Therefore, the restriction shoul be taken to prevent the dessimination of these quarantine disease and weed to other areas as well as to take management against these noxous pests.

2.7. Management options for potato pests

Management options for insect pests: According to the responses by the stakeholders, the most effective and commonly practiced management options against the insect pests of potato were spraying insecticides on the standing potato field, broadcasting of granular insecticides in the furrow during planting of seed tubers, potato tuber treatment through insecticides before planting, cultural practices such as irrigation and hand picking especially for cutworm and weeding by destroying the harbor of insect pests, rouging or removal of insect infested plants especially for virus diseases transmitted by aphids, crop rotation with non-solanaceous crop and application of IPM.

Management options for diseases: The most effective and commonly practiced management options against the insect pests of potato were spraying of fungicide on the standing potato field, potato tuber treatment through fungicide before planting, cultivation of disease free seed tubers, development of resistant varieties through tissue culture method, rouging or removal of diseased plants from the potato field, removal of weeds to prevent disease harbor, crop rotation with non-solanaceous crop.

Management options for weeds: According to the responses by the stakeholders, the most effective and commonly practiced management options against the insect pests of potato were weeding in the standing potato field, spraying herbicide in the potato field, mulching with water hyacinth and paddy straw, proper irrigation, earthen up on ridge.

2.8. Possible ways of entry of quarantine pests into Banlgadesh

As reported by the Plant Quarantine Station of Seaport-Chittagong, Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Bangladesh imported seed potatoes mainly from Netherlands, Belgium, Germany, Denmark, USA, but no pests of potato had yet been intercepted in any of the consignment of potatoes imported. Besides, there is a possibility to enter potato pests through the potato seed consignment, if imported potatoes without considering the standard phytosanitary system of Internation Standard Phytosanitary Measures (ISPM).

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

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

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

2.10. Options to prevent the spread of quarantine pests of potato within Bangladesh

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

- Proper idenfication of the quarantine pests
- Awareness build up among the farmers and other stakeholders about quarantine pests including their management,
- Restriction should be applied for the dessimination of infested potatoes from pest infested areas to pest free areas,
- Production of pest free potatoes by the application of proper management for pests,
- Intensive and frequent inspection of potato field by the experts,
- Follow the quarantine rules and regulation,
- Proper training of the quarantine personnel particularly on quarantine pests of respective crops along with their management options and phytosanitary measures.

Measures need to be taken by the exporters to export potatoes

- Pest free potatoes should be produced,
- Pre and post-harvest phytosanitary technique should be followed,
- Pest infested/infected potatoes should be discarded from the lots,
- Proper grading for the quality potatoes for seeds and ware should be ensured,
- Proper packing should be followed,
- Graded and packed potato tubers should be preserved in cold storage,
- Phytosanitary certificate must be ensured before emporting the potatoes.

CHAPTER 3

PRA STAGE 1: INITIATION

3.1. Initiating Pest Risk Analysis (PRA) by the identification of a pathway

Based on the Memo No.: Phyto-34-2/2014/698 decision on 18 November 2014 by the Project Director of Strengthening Phytosanitary Capacity in Bangladesh under Plant Quarantine Wing (PQW) of Department of Agriculture Extension, Ministry of Agriculture, Bangladesh, the seed potato (*Solanum tuberosum*) tubers which have highly introduction potential of associated pests must be analyzed for pest risk assessment to prevent introduction of the dangerous pests into Bangladesh. Thereafter, this Pest Risk Analysis (PRA) of Potato in Bangladesh had been initiated by the identification of a new pathway. The pathway is import of seed potatoes from the Netherlands, Belgium, Germany, Denmark and USA to Bangladesh. It is decided for this PRA to assess the pests likely to be associated with the pathway and represents potential hazard to the country of Bangladesh.

3.2. Commodity imported

The seed potato (*Solanum tuberosum*) tubers belonging to the Family Solanaceae.

3.3. Identification of PRA Area

The PRA areas are the 21 major potato growing districts of Bangladesh (From 20°34˝ North Latitude to 26°38˝ North Latitude. From 88°01˝ East Longitude to 92°41˝ East Longitude) such as Dinajpur, Thakurgaon, Panchagar, Rangpur, Kurigram, Lalmonirhat, Nilphamari, Gaibandha, Bogra, Joypurhat, Rajshahi, Naogaon, Munshiganj, Narayanganj, Comilla, Chandpur, Lakshmipur, Jhenaidah, Jessore, Sherpur and Kishoregonj.

3.4. Information for PRA

Information sources utilized for this PRA are all published material available in international scientific journals, books, reports, websites of CABI, EPPO, personal communications, geographic data and unpublished results that have been made available to the risk assessors. Where these information sources have been used, this is indicated in the text by references enclosed in brackets. The primary data collected through field survey and Focus Group Discussion (FGD) of major potato growing districts (21) and Key Informant Interviews (KII) had also been utilized for this PRA.

3.5. Previous PRA, Current Status and Pest Interceptions

In the past, there was no previous pest risk assessment on Ware and Seed Potatoes from any of the exporting countries including the Netherlands, Belgium, Germany, Denmark, USA, other EU countries. As reported by the Plant Quarantine Station, Seaport Chittagong, Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Bangladesh, during inspection in port of entry of seed potatoes from these exporting counties, not a pest had been detected yet today on the commodity imported into Bangladesh (DAE, 2015).

3.6. Initiation Conclusion

The initiation point for this PRA is the identification of a new potential pathway, the export of fresh potatoes from any exporting countries including the Netherlands, Belgium, Germany, Denmark and USA to Bangladesh, and the potential pest hazards, likely to be associated with the pathway.

CHAPTER 4

PRA STAGE 2: PEST RISK ASSESSMENT

The pest risk assessment was done with the aim to revise Bangladesh's phytosanitary measure regarding the potatoes imported from any potato exporting countries including Netherlands, Netherlands, Belgium, Germany, Denmark and USA into Bangladesh.

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

The pests associated with potatoes have been categorized and listed below based on their scientific name, taxonomic position, common name, infective phase, plant parts affected, geographical distribution and their quarantine status.

Table-5 lists the pests associated with *Solanum tuberosum* that also occur in the Netherlands, Netherlands, Belgium, Germany, Denmark, USA, other EU countries, India and Bangladesh etc and the absence or presence of these pests in Bangladesh. Based on Table 5, any pest that meets all above criteria will be selected for further assessment (Table-8).

Table-5: Pests Associated with Seed Potatoes *(Solanum tuberosum)* in Bangldesh, the Netherlands, Germany, Denmark, USA and other EU countries

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
ARTHROPODS								
Order: Coleoptera Family:Scarabaeidae								
Melolontha melolontha Linnaneus	White grub	Netherlands, Germany, Denmark, Scotland, USA	Grub, adult	Flowers, leaves, **tubers**	Yes	No	Yes	CABI, 2006 EPPO, 2006 Ahad, 2003
Family: Chrysomelidae								
Leptinotarsa decemlineata	Colorado potato beetle	France, Germany, Netherlands, Italy, Canada, USA	Grub, **adult**	Flowers, Leaves	No	Yes	Yes	Hsiao, 1985; Jolivet, 1991; CABI/EPPO, 1991
Order: Diptera Family: Anthomyiidae								
Delia plantura Meigen	Bean seed fly	France, Germany, Italy, UK, Scotland, USA, India,	Maggot	Whole plant	No	Yes	Yes	CABI, 2006; EPPO, 2006
Order: Hemiptera Family: Aphididae								
Myzus persisae Shulzer	Peach-potato aphid	Europe, Netherlands, Scotland	Nymph, adult	Leaves, stems, flowers	Yes	No	Yes	CABI, 2006; EPPO, 2006; Ahad, 2003
Aphis gossypiii Thomas 1878	Potato aphid	North America, Europe, Asia	Nymph, adult	Leaves, stems, flowers	Yes	No	Yes	CKM, 2015; Ahad, 2003
Order: Lepidoptera Family: Gelechiidae								
Phthorimaea operculella (Zeller 1873)	Potato tuber worm	Europe, Netherlands, Scotland, China	Caterpillar	Leaves, stem, root, **tubers**	Yes	No	Yes	CABI, 2006; EPPO, 2006; '13; Ahad, 2003

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
Family: Noctuidae								
Agrotis ipsilon Ochsenheimer in 1816	Potato cutworm	India, Germany, Greece, Netherlands, UK,	Caterpillar	Leaf, **stem,** root, tubers	Yes	No	Yes	Alam & Ahmad, 1969; Islam *et al.*, 1991; CIE, 1969
FUNGI								
Order: Pleosporales Family:Pleosporaceae								
Alternaria solani	Early blight of potato	Netherlands, Germany, USA,	Condia, mycelia	Leaf, stem	Yes	No	Yes	EPPO, 2006; Sorauer, 1896
Order: Atheliales **Family:** Atheliaceae								
Sclerotinia sclerotiorum	Stem rot of potato	Netherlands, Germany, Denmark, USA	Condia, mycelia	Leaf, stem, whole plant	Yes	No	Yes	EPPO, 2006; Asharafuzzaman, 1991
Order: Helotiales Family: Sclerotiniaceae								
Botrytis cinerea Pers.	Grey mould disease	Europe, Netherlands, Germany, Belgium, Denmark, Scotland	Conidia, mycelia	Leaves, stem, tubers	Yes	No	Yes	CAB Abstracts, 1973-1998; Asharafuzzaman, 1991
Order: Plasmodiophorales Family: Plasmodiopharaceae								
Spongospora subterranea J.A.Toml.	Powdery scab	Netherlands, Canada, Scotland	Conidia, mycelia	Tubers	Yes	No	Yes	CABI, 2006; Asharafuzzaman, 1991
Order: Phyllachorales Family: Phyllachoraceae								
Colletotrichum coccodes Wallr.	Black dot of potato	Netherlands, Scotland, Canada	Conidia, mycelia, acervuli	Leaves, stem, root, tubers	Yes	No	Yes	Asharafuzzaman, 1991

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
Order: Chytridiales **Family: Synchytriaceae**								
Synchytrium endobioticum (Schilb.) Percival	Black wart of potato	Netherlands, Scotland, Canada	Sporangiospore, sporangia, mycelia	Leaves, stem, tubers	No	Yes	Yes	CABI, 2006; EPPO, 1998; EPPO, 2006
Order: Diaporthales **Family: Valsaceae**								
Phoma exigua var. *foveata* Foister	Potato Gangrene	Netherlands, France, Germany, Ireland, Scotland	Condia, pycnidia, mycelia	Stem, leaves, **tubers**	No	Yes	Yes	CABI, 2006; EPPO, 2006; http://nt.arsgrin. gov/fungalda tabases/
Order: Hypocreales **Family: Nectriaceae**								
Fusarium oxysporum	Fusarium wilt, tuber dry rot	Netherlands, Scotland	Conidia, spodochia, mycelia, chlamydospore	Whole plant	Yes	No	Yes	CABI, 2006; Asharafuzzaman, 1991
Fusarium solani	Dry rot of potato	Bangladesh	Conidia, spodochia, mycelia, chlamydospore	Whole plant	Yes	No	Yes	Asharafuzzaman, 1991
Fusarium sulphureum (Fr.) Sacc	Potato basal canker	France, Germany, UK, USA	Conidia, spodochia, mycelia, chlamydospore	Whole plant	No	Yes	Yes	CABI, 2006
Order: Peronosporales **Family: Pythiaceae**								
Phytophtora infestans (Mont.) de Bary	Late blight of potato	Netherlands, Scotland	Sporangiospore, sporangia, mycelia	Leaf, stem, tubers	Yes	No	Yes	CABI, 2006; Asharafuzzaman, 1991
Phytophthora drechsleri K.	Phytophthora blight	France, Greece, Scotland, UK, Canada, USA	Sporangiospore, sporangia, mycelia	Whole plant	No	Yes	Yes	CMI, 1979 http://nt.arsgrin. gov/fungalda tabases

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
Phytophthora megasperma Drechsler	Potato root rot	United States, France, Ireland, Italy, UK, Scotland.	Sporangiospore, sporangia, mycelia	Whole plant	No	Yes	Yes	CABI, 2006 http://nt.arsgrin. Gov
Order: Polyporales **Family: Meripilaceae**								
Polyscytalum pustulans (Owen & Makef) M.B. Ellis	Skin spot disease of potato	Europe, Britain, Germany, Russia, Canada, USA	Sporangiospore, sporangia, mycelia	Stem, root, **tubers**	No	Yes	Yes	CABI, 2006; EPPO, 2006;
Order: Ceratobacidiales **Family: Ceratobacidiaceae**								
Rhizoctonia solani (Frank) Donk	Black scurf, stem canker	Netherlands, Scotland	Sclerotia, mycelia	Root, stem, leaves, flowers, **tubers,**	Yes	No	Yes	CABI, 2006; Mai *et al.,* 1993; Asharafuzzaman, 1991
Order: Hyphomycetales **Family: Moniliaceae**								
Verticillium albo-atrum Reinke & Berthold	Verticilium wilt of potato	France, Germany, Greece, Netherlands, Scotland, UK	Conidia, mycelia, Chlamydospore	Root, stem, leaves, flowers, **tubers,**	Yes	No	Yes	CABI, 2006; EPPO, 2006; CIP, 1996; Asharafuzzaman, 1991
BACTERIA								
Order: Actinomycetales **Family: Streptomycetaceae**								
Streptomyces scabies Thaxter 189	Common scab of potato	France, Germany, Netherlands, Scotland	Bacterial cell	Tuber	Yes	No	Yes	CABI, 2006; Asharafuzzaman, 1991
Microbacteriaceae								
Clavibacter michiganensis	Ring rot of potato	France, Germany, Netherlands, Ireland, Russia, USA	Bacterial cell	Tubers	No	Yes	Yes	EPPO, 1997; Smith, 2010; Devis *et al.,* 1984

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
Order: Enterobacteriales **Family: Enterobacteriaceae**								
Pectobacterium carotovorum (*Erwinia carotovora*)	Soft rot	France, Germany, Netherlands, Scotland	Bacterial cell	Root, stem, leaves, **tubers**	Yes	No	Yes	CABI, 2006; EPPO, 2006; Asharafuzzaman, 1991
Order: Burkholderiales **Family: Burkholderiaceae**								
Ralstonia solanacearum (Smith, 1896) Yabuuchi *et al.*, 1996	Brown rot, Bacterial wilt of potato	Netherlands, Germany, France, Scotland	Bacterial cell	Leaves, stem, root, seed, **tubers**	Yes (limited areas)	Yes	Yes	CABI, 2006; EPPO, 2006; EPPO/CABI, 1992; EPPO, 1978
NEMATODE								
Order: Tylenchida **Family: Heteroderidae**								
Globodera rostochinensis (Wollenweder)	Golden cyst nematode	France, Germany, Netherlands, Scotland, India, USA	Juvenile-2	Root, stem, **tubers**	No	Yes	Yes	CABI, 2006; EPPO, 1978
Globodera pallida (Stone, 1973) Behrens 1975	Pale cyst nematode	EPPO region, Scotland, India, Netherlands, Scotland	Juvenile-2	Root, stem, **tubers**	No	Yes	Yes	CABI/EPPO, 1999; EPPO, 2006
Anguinidae								
Ditylenchus destructor Thorne, 1945	Potato tuber nematode	EPPO region, Mediterranean region, Scotland, Canada, USA	Juvenile-2	Root, leaves, vegetative organs, **tubers**	Yes (Unreliable record)	No	Yes	CABI/EPPO, 2001; EPPO, 2006
Ditylenchus dipsaci (Kuehn, 1857) Filipjev, 1936	Potato tuber nematode	EPPO region, Mediterranean region, Scotland, Canada, USA	Juvenile-2	Root, leaves, vegetative organs, **tubers**	No	Yes	Yes	CABI/EPPO, 1999; EPPO, 2006

Pest	Common Name	Geographic Distribution	Infestation /Infective phase	Plant Part Affected	Presence in Banlgadesh	Quarantine Pest (Yes/No)	Follow Pathway (Yes/No)	References
VIRUSES								
Group: Group IV **Family: Luteoviridae**								
Potato Leafroll Virus (PLRV)	Potato leaf curl virus	Netherlands, Scotland	Virus particle	Whole plant	Yes	No	Yes	CABI, 2006; Asharafuzzaman, 1991; Ahad, 2003
Group: Group IV **Family: Bromoviridae**								
Alfalfa Mosaic Virus (AMV)	Alfalfa yellow spot	Europe, Australia, New Zealand, USA, Canada	Virus particle	Whole plant	No	Yes	Yes	Edwardson and Christie, 1997
Group: Group IV Order: Tymovirales **Family:**Alphaflexiviridae								
Potato Virus-X (PVX) Smith 1931	Potato mottle virus	Netherlands, UK, Germany, France, Greece, other EU countries,	Virus particle	Whole plant	No	Yes	Yes	EPPO, 2015
WEED								
Order: Asterales **Family: Asteraceae**								
Parthenium hysterophorus L.	Parthenium weed	USA, Mexico, India, Belgium, Poland	Seed	Annual herb aggressively disturb sites	Yes (limited areas)	Yes	Yes	Dale, 1981; Navie *et al*., 1996; EPPO, 2014; Holm *et al.*, 1991

4.2. Quarantine Pests Likely to be Associated with Seed Potatoes Imported from the Netherlands, Belgium, Germany, Denmark and USA

Based on the Table 5, Quarantine pests that are reasonably likely to follow the pathway on commercial shipments of seed potatoes *(Solanum tuberosum)* from other countries including the Netherlands, Belgium, Germany, Denmark, USA and other EU countries included 15 species and were further analyzed in this risk assessment and are summarized in **Table 6.** All of these pests are needed to applied phytosanitary measures to each pest based on risk ratings.

Table-6: Quarantine pests likely to be associated with *Solanum tuberosum* imported from Netherlands, Belgium, Germany, Denmark and USA selected for further analysis

Pest species	Common name	Order	Family	Category
Leptinotarsa decemlineata	Colorado potato beetle	Coleoptera	Chrysomelidae	Insect
Delia platura Meigen	Bean seed fly	Diptera	Anthomyiidae	Insect
Synchytrium endobioticum (Schilb.) Percival	Black wart disease	Chytridiales	Synchytriaceae	Fungi
Phoma exigua var. *foveata* Foister	Potato gangrene	Diaporthales	Valsaceae	Fungi
Fusarium sulphureum (Fr.) Sacc	Potato basal canker	Hypocreales	Nectriaceae	Fungi
Phytophthora drechsleri Tucker	Potato root rot	Peronosporales	Pythiaceae	Fungi
Phytophthora megasperma Drechsler	Phytophthora blight	Peronosporales	Pythiaceae	Fungi
Polyscytalum pustulans (M.N. Owen & Makef)	Skin spot of potato	Polyporales	Meripilaceae	Fungi
Clavibacter michiganensis subsp. *michiganensis*	Potato ring rot	Actinomycetales	Microbacteriaceae	Bacteria
Ralstonia solanacearum (Smith) Yabuuchi *et al.*, 1996	Brown rot/Bacterial wilt	Burkholderiales	Burkholderiaceae	Bacteria
Globodera rostochinensis (Wollenweder)	Golden cyst nematode	Tylenchida	Heteroderidae	Nematode
Globodera pallida (Stone, 1973) Behrens 1975	Pale cyst nematode	Tylenchida	Heteroderidae	Nematode
Ditylenchus dipsaci (Kuehn, 1857) Filipjev, 1936	Potato tuber nematode	Tylenchida	Anguinidae	Nematode
Alfalfa Mosaic Virus (AMV)	Alfalfa yellow spot	-	Bromoviridae	Virus
Potato Virus-X (PVX)				Virus
Parthenium hysterophorus L.	Parthenium weed	Asterales	Asteraceae	Weed

4.3. Risk Assessment

The risk assessment was done in accordance with International Plant Protection Convention (IPPC) and the International Standards for Phytosanitary Measures (ISPMs) including ISPM 2 and ISPM 11. The import risk assessment consists of two main components, the consequence of the introduction and the introduction potential of pests to the importing country. The consequences of introduction evaluate the economical and environmental impact of the pest while the introduction potential measures the entry, establishment and dispersal to the importing country. Each risk is then assigned a qualitative value and a risk rating value (Table 7). The risk values are combined to give an overall estimate of the risk.

Table-7: Risk rating and corresponding risk value for risk assessment of quarantine pests

Risk rating	Rating value
High	3
Medium	2
Low	1

4.3.1. Assess Consequences of Introduction of Pests (Table 5 & 6)

The undesirable outcomes being considered are the negative impacts resulting from the introduction of quarantine pests. After identifying those quarantine pests that could reasonably be expected to follow the pathway, the assessment of risk continues by considering the consequences of introduction.

For each of these quarantine pests, the potential consequences of introduction are rated using five **Risk Elements**. These elements reflect the biology, host ranges and climatic/geographic distributions of the pests. For each Risk Element, pests are assigned a rating of **low** (1 point), **medium** (2 points) or **high** (3 points). A Cumulative Risk Rating is then calculated by summing all Risk Element values.

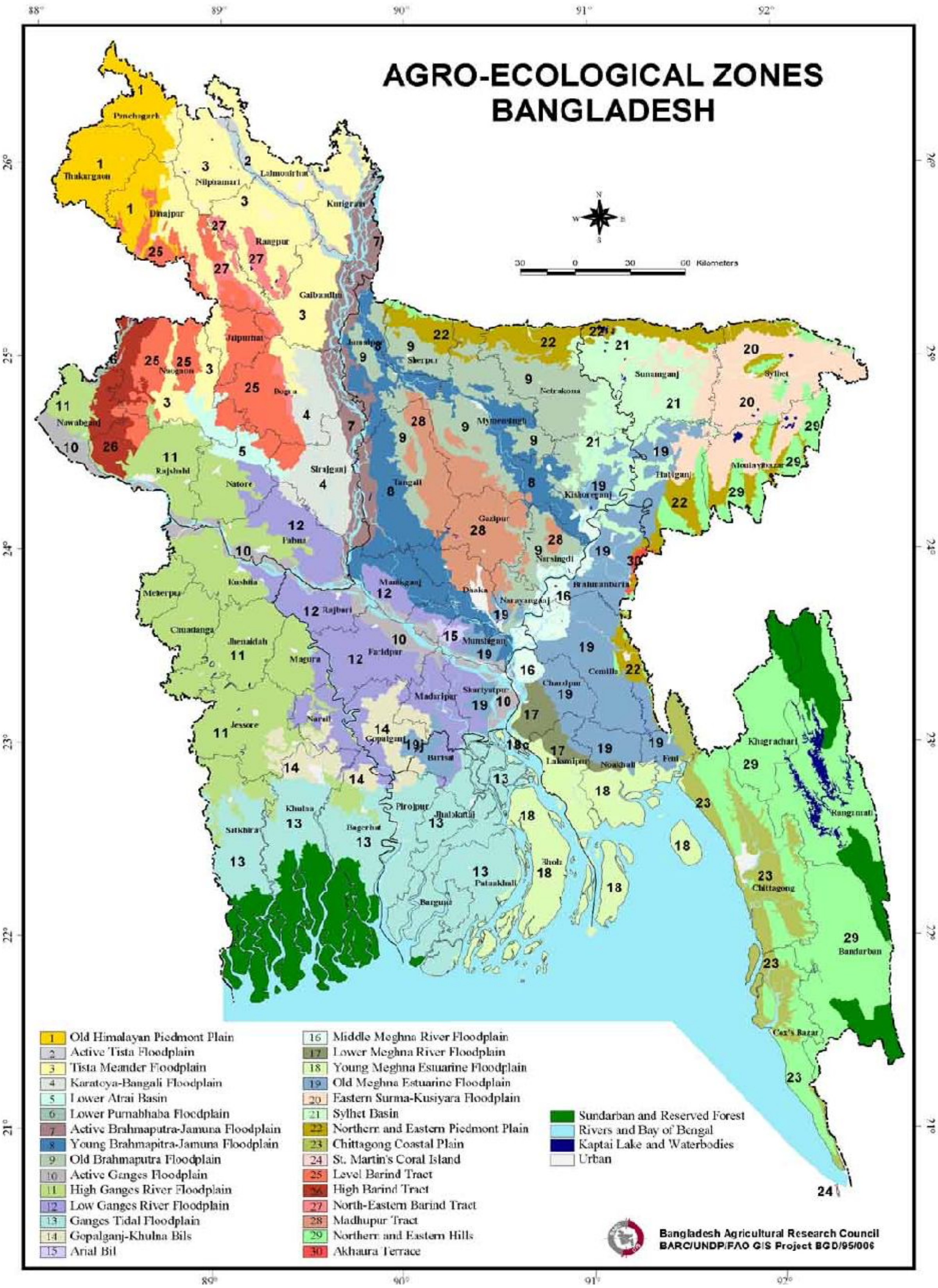
Risk Element 1: Climate-Host Interaction

When introduced to new areas, pests can be expected to behave as they do in their native areas if host plants and climates are similar. Ecological zonation and the interactions of the pests and their biotic and abiotic environments are considered in the element. Estimates are based on availability of both host material and suitable climate conditions. To rate this Risk Element, the 30 defined agriculture ecological zones[1] are used. Due to the availability of both suitable host plants and suitable climate, the pest has potential to establish a breeding colony:

Rating scores are as follows:

Low **:** In a single ecological zone……………….......…….. **1 point.**
Medium **:** In two or three ecological zones……..........……….**2 points**.
High **:** In four or more ecological zones…...........……..... **3 points**

Figure-11: Agro-ecological zone (AEZ) map of Bangladesh



Source: http://www.barcapps.gov.bd/barc_english/index.php/2013-05-16-10-30-07/spatial-database

Risk Element 2: Host Range

The risk posed by a plant pest depends on both its ability to establish a viable, reproductive population and its potential for causing plant damage. For arthropods, risk is assumed to be correlated positively with host range. For pathogens, risk is more complex and is assumed to depend on host range, aggressiveness, virulence and pathogenicity; for simplicity, risk is rated as a function of host range.

Rating scores are as follows:

Low **:** Pest attacks a single species or multiple species within a single genus…...**1 point**
Medium **:** Pest attacks multiple species within a single plant family……………………**2 points**
High **:** Pest attacks multiple species among multiple plant families……...................**3 points**

Risk Element 3: Dispersal Potential and Pathway

A pest may disperse after introduction to a new area. The following items are considered:

- Reproductive patterns of the pest
- Inherent powers of movement

Rating scores are as follows:

Low **:** Pest has neither high reproductive potential nor rapid dispersal capability.....**1 point**

Medium **:** Pest has either high reproductive potential or the species is capable of rapid dispersal…………………………………………………………………….........**2 points**

High **:** Pest has high biotic potential, *e.g.*, many generations per year, many offspring per reproduction ("r-selected" species), and evidence exists that the pest is capable of rapid dispersal, *e.g.*, over 10 km/year under its own power; via natural forces, wind, water, vectors, *etc*., or human assistance……………………………………**3 points**

Risk Element 4: Economic Impact

Introduced pests are capable of causing a variety of direct and indirect economic impacts. These are divided into three primary categories (other types of impacts may occur):

- Lower yield of the host crop, *e.g.*, by causing plant mortality, or by acting as a disease vector.
- Lower value of the commodity, *e.g.*, by increasing costs of production, lowering market price, or a combination.
- Loss of foreign or domestic markets due to presence of new quarantine pest.

Rating scores are as follows:

Low **:** Pest causes any one or none of the above impacts….......................**1 point**
Medium **:** Pest causes any two of the above impacts………………..................**2 points**
High **:** Pest causes all three of the above impacts………………..................**3 points**

Risk Element 5: Environmental Impact

The assessment of the potential of each pest to cause environmental damage proceeds by considering the following factors:

- Introduction of the pest is expected to cause significant, direct environmental impacts, *e.g.*, ecological disruptions, reduced biodiversity.

- Pest is expected to have direct impacts on plant species as endangered or threatened in Bangladesh1.
- Pest is expected to have indirect impacts on plant species as endangered or threatened by disrupting sensitive, critical habitat.
- Introduction of the pest would stimulate chemical or biological control programs.

Rating scores are as follows:

Low : None of the above would occur…................**1 point**
Medium : One of the above would occur…..................**2 points**
High : Two or more of the above would occur…....**3 points**

4.3.1.1. Assessment of Risk Rating of Consequences of Introduction of Quarantine Pests

1. Consequences of Introduction of *Leptinotarsa decemlineata* Say 1824 (Colorado potato beetle)	**Risk Rating**
Climate-Host Interaction **EPPO region:** Following its introduction from the USA to Bordeaux, France, in 1922, the beetle spread rapidly throughout the region despite intensive control operations to contain it. *Leptinotarsa decemlineata* is present in Austria (first reported in 1941), Belarus, Belgium (1935), Bulgaria (1958), Czech Republic, Estonia, France, Germany (1936), Greece (1963), Hungary (1947), Italy, Latvia, Libya, Lithuania, Luxembourg (1936), Moldova, Netherlands (1937), Poland (1946), Portugal (1943), Romania, Russia (European, Siberia, Far East), Slovakia, Spain (1935), Switzerland (1937), Turkey, Ukraine, Yugoslavia. It has been reported from but is not established in Denmark, Finland, Norway (1948), Sweden and the UK (1901) (including the islands of Guernsey and Jersey (1939), Thomas & Wood (1980)). **Africa:** Libya. **Asia:** Armenia, Azerbaijan, Georgia, Iran, Kazakhstan, Kyrgyzstan, Russia (Siberia, Far East), Tajikistan, Turkey, Turkmenistan, Uzbekistan. **North America:** Canada (British Columbia to eastern provinces); Mexico, USA (widespread; probably originated in western USA it was first collected from wild Solanaceae at what is now the border between Nebraska and Iowa in 1811; it had reached the Atlantic coast by 1874). **Central America and Caribbean:** Costa Rica (found in the past but not established), Cuba, Guatemala. **EU:** Present. (CABI/EPPO, 1991). The pest is sensitive to very low and very high temperature conditions. The Colorado potato beetle are very adaptable species, in different temperature conditions and even can survive in temperatures up to -5ºC but for the full development threshold temperature is 11.5ºC. The food intake is maximum at 25°C. Females lay their eggs from 15 to 30°C temperatures and continue over a period of several weeks, until midsummer, with each female laying up to 2000 eggs (EPPO/CABI, 1992). This climate is near and the same climates of Bangladesh. Based on this distribution and climatic requirement, Colorado potato beetle could become established in different agro-ecological zones of Bangladesh with **High (3) Risk**.	**High (3)**
Host Range The host plants of *L. decemlineata* are all within the family Solananceae and wild Solanaceae can act as a reservoir for infestation (EPPO/CABI, 1992). It attacks potatoes and various other cultivated and wild solanaceous plants. Resistance exists, to varying degrees, among *Solanum* spp.; for example, *S. berthaultii*, *S. chacoense, S. pinnatisectum* and *S. tarijense* are highly resistant (Carter, 1987).	**Medium (2)**

[1]Irfanullah, H.M. 2011. Conserving threatened plants of Bangladesh: miles to go before we start? Bangladesh Association of Plant Taxonomists, *Bangladesh J. Plant Taxon.* **18**(1): 81-91.

Certain potato cultivars are also resistant (Shapiro *et al.*, 1983). Potatoes, tomatoes and aubergines are at risk wherever cultivated throughout the EPPO region. Wild solanaceous species occur widely and can act as a reservoir for infestation. Based on this host range, Colorado Potato Beetle could become established in Bangladesh with **Medium (2) Risk**.	
Dispersal Potential and Pathway The beetles overwinter in the soil as adults, with the majority aggregating in woody areas adjacent to fields where they have spent the previous summer. The emergence of post-diapause beetles is more or less synchronized with potatoes. If fields are not rotated, they are colonized by overwintered adults that walk to the field from their overwintering sites or emerge from the soil within the field. If fields are rotated, the beetles are able to fly up to several kilometers to find a new host habitat. Once they have colonized the field, the overwintered beetles first feed and then oviposit within 5-6 days depending on temperature. A single female is capable of producing @ 2000 eggs. Overwintered adults live for one-two months after colonizing host plants in the spring. [http://resistance.potatobeetle.org]. The number of generations is varying between about four in the hottest areas of its habitat (cycle completed in 30 days) to one full and one partial generation near the colder extremes (Svikle, 1976). *L. decemlineata* is generally considered to be a sluggish flier, however, beetles can be transported for longer distances on strong winds (Johnson, 1969). According to Hurst (1975), under suitable conditions, winds may carry beetles 75 to 100 km. Beetles arriving Sweden and U.K. have been airborne or drifting the last part of the distance on sea and washed up on the shores (Johnson, 1969; Gransbo, 1980; Wiktelius, 1985). The most important way of dispersal is a passive of transport of beetles by shipments of potatoes. Dispersal associated with transport on ships has been frequent in U.K. (Bartlett, 1980). Based on this information, the main means of natural spread of the beetle over large areas is by wind-borne migration, particularly of the spring generation. Adults can also be carried over long distances in sea water. Adults and larvae can be easily transported on potato plants and tubers, and in all forms of packaging and transport. Fresh vegetables grown on land harbouring overwintered beetles are common means of transport in international trade (Bartlett, 1980). Based on these dispersal potential and pathways, Colorado potato beetle could become established in Bangladesh with **High (3) Risk**.	**High (3)**
Economic Impact *L. decemlineata* is one of the most widespread and destructive pests of potato. Both adults and larvae feed on this host, and often cause complete defoliation of the potato plants attacked, with considerable yield losses (50% of the crop in some EPPO countries). In favourable weather and biological circumstances, populations are liable to expand dramatically; even with 90% egg mortality and varying degrees of larval mortality, after 5 years without control, a population of 1.1 x 1012 could build up from a single pair of parents. *L. decemlineata* is also suspected of spreading several potato diseases, including *Ralstonia solanacearum* and *Clavibacter michiganensis* subsp. *sepedonicus* (CABI/EPPO, 1992). Damage has also been reported on other crops; for example, tomato yield was reduced by 67% in a field test in Maryland, USA, when numbers of larvae increased from five to ten per plant (Schalk & Stoner, 1976). *L. decemlineata* is also considered to be a serious pest of aubergine in Europe and North America. Fresh vegetables grown on land harbouring overwintered beetles are common	**High (3)**

means of transport in international trade (Bartlett, 1980). Therefore, the exports of potatoes are also restricted into Bangladesh due to probability of presence and spreads of this pest from the exporting countries, where it is common in the field. Based on these Economic Impacts, the Colorado potato beetle could become established in Bangladesh with **High (3) Risk** potential.	
Environmental Impact The use of insecticides remains the most common means of controlling this pest and, in many EPPO countries, such control is obligatory by law (CABI/EPPO, 1992). In laboratory tests in Ontario (Bond & Svec, 1977), methyl bromide fumigation of newly harvested potatoes successfully controlled *L. decemlineata* without injuring tubers. In Russia, methyl bromide fumigation of wagons containing both seed and ware potatoes is carried out (CABI/EPPO, 1992). The introduction of this insect pest would stimulate the use of insecticides in the field and use of methyl bromide fumigation of newly harvested potatoes for controlling this pest is suspected to cause significant and direct ecological disruptions. Based on these Environmental Impacts, Colorado Potato Beetle could become established in Bangladesh with **High (3) Risk** potential**.**	**High (3)**
2. Consequences of Introduction of *Delia platura* (Meigen) (Bean Seed Fly)	**Risk Rating**
Climate/ Host Interaction *Delia platura* is found in Australia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Norway, Portugal, United Kingdom, United States. **Asia:** China, Georgia, India, Iran, Isarel, Japan, Korea, Lebanon, Kazakhstan, Nepal, Pakistan, Saudi Arabia, Sri Lanka, Syria, Turkey, Uzbekistan, Yemen (http://zipcodezoo.com/Animals/D/Delia_platura.asp; CABI, 2006). In Bangladesh, *Solanum turberosum* is the major crop plant cultivating all over the country during winter. The complete cycle from egg to adult ranges from 15 to 77 days depending on temperature, oviposition by adults occurs within a temperature range of 10-27°C. (http://wiki.bugwood.org/Delia_platura) Based on this distribution, we estimate that *D. platura* could only become established in most of the agro-ecological zones in Bangladesh. One or more of its potential hosts occurs in these zones.	**High (3)**
Host range *Delia platura* maggot is extremely polyphagous (more than 40 host plants) and has been recorded to attack multiples species within different families including: **Fabaceae** (bean), **Cucurbitaceae** (melon, cucumber), **Chenopodiaceae** (spinach), **Liliaceae** (asparagus**), Solanaceae** (tomato, tobacco), **Poaceae** (maize), etc. It sometimes extends damage caused by other pests; this is the case in radish, turnip, onion, potato (http://www.inra.fr/hyppz/RAVAGEUR/6delpla.htm)	**High (3)**
Dispersal Potential and Pathway Hill (1987) outlined the biology as follows: eggs are laid on disturbed soil, especially in the vicinity of rotting organic matter; each female lays approximately 100 eggs. In the UK there are three to four overlapping generations per year, but this can rise to five in warmer areas. Larvae of *D. platura* may borne internally in roots; they are invisible and liable to disperse by going with roots in trade/transport for long distance movement (Hill, 1987).	**Medium (2)**
Economic Impact *Delia platura* is a serious pest of seeds and seedlings. Larrain (1994) reported	**High (3)**

damage to onion seedlings and shallots (*Allium ascalonicum*) in Chile that reached 17.9 and 35.8%, respectively. Chaudhary *et al.* (1989) found up to six larvae per seed and up to 90% infestation of spring-sown maize in India. There is also some evidence that *D. platura* may transmit some bacterial diseases of plants, namely *Bacillus phytophthorus*, *Erwinia carotovora* and *Erwinia stewartii* [*Pantoea stewartii* subsp. *stewartii*] (Griffiths, 1993).	
Environmental Impact *Delia platura* represents a potential threat to many crops. The establishment of it could trigger chemical control programs by using different insecticides that are toxic and harmful to the environment. The standard treatment for control of this pest is to treat preventatively with preplant, in-furrow insecticides (http://wiki.bugwood.org/Delia_platura).	**Medium (2)**
3. Consequences of Introduction of *Synchytrium endobioticum* (Schilb.) Percival (Wart Disease of Potato)	**Risk Rating**
Climate-Host interaction *Synchytrium endobioticum* originated in the Andean zone of South America. It was introduced from there into the UK and from there to continental Europe in the 1880s, and into North America (Newfoundland) in the 1900s. It spread widely throughout the UK and the European continent in the early decades. Especially, its present in China. (CABI, 2006). Temperatures of 12-14oC favor infection (Compendium of potato diseases). This climate is near and the same climates of Bangladesh during winter. Based on this distribution, we estimate that *S. endobioticum* could become established into different agro-ecological zones in Bangladesh.	**High (3)**
Host range The *Synchytrium endobioticum* only cultivated host is potato, but wild species of Solanum are also infected in Mexico. Tomato and a number of other solanaceous plants, including *Schizanthus* sp., *Capsicastrum nanum, Physalis franchetii, Datura* sp*. and Solanum dulcamara* are hosts by artificial inoculation.	**Medium (2)**
Dispersal potential and Pathway *Synchytrium endobioticum* is a soil borne fungal parasite which does not produce hyphae, but sporangia containing anywhere from 200-300 motile zoospores. In the spring, at temperatures above 8°C and given sufficient moisture, the overwintering sporangium found in decaying warts in the soil germinate and release uninucleate zoospores. The zoospores possess a single flagellum (tail) which enables them to move in soil water to reach the host. The infected cell swells as the enclosed fungus forms a short-lived but quickly reproducing structure, the summer sporangium, from which numerous zoospores are released to infect neighbouring cells. This cycle of infection and release may be repeated for as long as conditions are suitable, resulting in the host tissue becoming thoroughly infected (Canadian Food Inspection) Agency (http://www.inspection.gc.ca/english/sci/surv/data/synende.shtml) Soil water can carry zoospores downstream, although the lifespan of a released zoospore is 1-2 hours. Earthworms can move resting spores short distances. Wind is an active dispersal agent in regions of strong dry summer winds. Local dispersal has been shown in resting spores in soil attached to vehicles and contaminated manure. Long-range dispersal by tuber-movement, especially in international trade, attached soil and plants presents problems of control (CABI, 2006). Once *S. endobioticum* has been introduced into a field, the whole crop may be rendered unmarketable and moreover the fungus is so persistent that potatoes	**High (3)**

cannot be grown again safely for many years, nor can the land be used for any plants intended for export.(CABI and EPPO for the EU under Contract 90/399003 – EPPO quarantine pest). The fungus can survive in soil as resting sporangia for as long as 38 years, even through adverse condition.	
Economic Impact *Synchytrium endobioticum* is on the A2 quarantine pest list of EPPO (OEPP/EPPO, 1982), and is also of quarantine significance for all the regional plant protection organizations which have established quarantine lists. *Synchytrium endobioticum* generally has a much more limited distribution outside of Europe. Indirect losses arising from restrictions on the export of plants from infested areas present a problem to European countries (CABI, 2006)	**High (3)**
Environmental Impact Wart disease is so important that, for some 65 years, quarantine and domestic legislations have been in force throughout the world to prevent its spread. Numerous EPPO publications were devoted to it in the 1950s and 1960s. Very little specific chemical control information on Syn*chytrium endobioticum* and worldwide control of spread is being attempted through quarantine legislation (Compendium of Potato Diseases). According to the recent studies, extraction reagents used were chloroform and calcium chloride in the method described by EPPO, calcium chloride and zinc sulphate in the Plant Protection Service method (PPS method). (C. M. van Leeuwen, J. G. N. Wander).	**High (3)**
4. Consequences of Introduction of *Phoma exigua* var. *foveata* (Foister) (Potato Gangrene)	**Risk Rating**
Climate-Host Interaction *Phoma exigua* var. *foveata* is of Andean origin (Otazu *et al*., 1979) and was probably introduced into Scotland (UK) in the 1930s with breeding material (Boerema & van Kesteren, 1981). It has since spread to other potato cultivation areas in Europe and Oceania. **EPPO region**: Present in Estonia, Greece, Latvia, Lithuania, Poland (Wnekowski, 1993). Widespread in Denmark, Ireland, Norway, Sweden and UK (including Guernsey and Jersey); locally established in Belgium, Bulgaria, Cyprus, Czech Republic, Egypt, Finland (Seppanen, 1983), France, Germany, Netherlands, Romania, Slovenia and Switzerland. **Asia**: Cyprus (*P. exigua* var. *exigua*), Yemen. **Africa**: Egypt (Hide, 1986), Morocco (unconfirmed), Sierra Leone, South Africa, Tunisia (found in the past but not established). **North America**: Reports from Canada and USA refer only to *P. exigua* var. *exigua*. **South America**: Andean region, Peru. **Oceania**: Australia (South Australia, Tasmania), New Zealand. **EU**: Present. Based on this distribution, we estimate that *Phoma exigua* var. *foveata* could become established in many of the agro-ecological zones in Bangladesh, where *Solanum tuberosum* is the major crop in winter.	**High (3)**
Host range The principal host is potatoes. In its native Andean region, it occurs on intercropped *Chenopodium quinoa* and wild potatoes. The fungus has been isolated from some other cultivated hosts and from certain weeds growing in affected potato crops. Throughout the EPPO region, potatoes (*Solanum tuberosum*) are the host of concern. (CABI, EPPO, 2006).	**Low (1)**
Dispersal Potential and Pathway Exposure of tubers to contamination in the field may lead to a degree of true latent	**Medium (2)**

infection where the periderm is penetrated, but no further development occurs and the tubers appear healthy. *Phoma exigua* var. *foveata* is readily spread by infected tubers remaining in the soil. (CABI, 2006). Wounding is the single most important factor favoring development of gangrene. The type of wound can also influence severity; more severe gangrene develops from crush wounds than from shallow cuts. Spread of the gangrene fungus to unaffected tubers can occur not only naturally in soil, but also by mechanical transmission of spores on digging and grading equipment. Cold wet soils and cold conditions during handling also favor the development of gangrene.	
Economic Impact *Phoma exigua* var. *foveata* is an A2 quarantine organism and details about is biology, distribution and economic importance can be found in EPPO Data Sheet no. 78 (Bulletin OEPP/EPPO Bulletin 12). Planting infected tubers does not generally result in significant yield reduction, although losses of up to 20% have occurred where more than 60% of seed tubers were infected (Smith *et al.*, 1988). Unless the lesions are very large or the soil conditions unsuitable, planting of seed tubers infected with *Phoma exigua* var. *foveata* does not usually reduce yield significantly. However, crops from severely infected seed (over 60% infection) were reported to yield up to 20% less and have an increased proportion of tubers in smaller size grades. In trials with artificially infected seed, yield depressions of up to 60% were reported. Fungicidal sprays in the field may be successful in reducing later incidence of gangrene in store (Cooke & Logan, 1984).	**High (3)**
Environmental Impact Very little specific environment impact information is available on *Phoma exigua* var. *foveata*. However, the introduction of *Phoma exigua* var. *foveata* into Bangladesh would likely stimulate eradication or control programs similar to those that have been implemented for the species. The species may be successfully controlled by chemical means (dips, fumigation and dusts) (Copeland & Logan, 1975; Carnegie *et al.*, 1988), and disease incidence can be greatly reduced by judicious control of store temperatures. Various fungicides are available which give good control of gangrene, including benomyl, thiabendazole and 2-aminobutane (as a fumigant; OEPP/EPPO, 1984).	**Medium (2)**
5. Consequences of Introduction of *Fusarium sulphureum* (Fr.) Sacc (Basal Canker)	**Risk Rating**
Climate-Host Interaction *Fusarium sulphureum* **is** probably found worldwide. It has been reported on potato tubers from Australia, Canada, Cyprus, East and West Germany, Iran, New Zealand, UK and USA. (CABI, 2006). Dry rot (*Fusarium sulphureum* and *Fusarium solani* var *coeruleum*) are historically the most important diseases of stored potatoes. Dry rot is caused by soil-borne *Fusarium sulphureum* which infect through wounds at lifting and grading. Warm, humid storage encourages diseases development. Bangladesh's climate characterized by an alternating monsoon and dry season. Temperature fluctuations in growing season at winter (December-January) is 320C (Cox's Bazar district) to 80C (Srimangal district). Its distribution	**High (3)**

corresponds to most of the agro-ecological zones in Bangladesh including: High Land of North (Tista River Floodplain) and North-West regions (Ganges River Floodplain), Brahmaputra-Jamuna Floodplain regions, Meghna River and Estaurine Floodplain regions of Bangladesh.	
Host range *Fusarium sulphureum* has been recorded to attack multiple species in multiple families including: **Liliaceae** *(Allium cepa);* **Poaceae** ***(****Avena sativa, Triticum aestivum, Hordeum vulgara);* **Brassicaceae** *(Brassica juncea var. juncea, Brassica napus var. napus, Brassica nigra);* **Cucurbitaceae** *(Cucumis melo, Cucurbita (pumpkin);* **Caryophyllaceae** *(Gypsophila panicu);* **Cananabaceae** *(Humulus lupulus);* **Fabaceae** *(Medicago sativa, Pisum sativum);* **Pinaceae** *(Pinus strobus);* **Solanaceae** *(Solanum tuberosum),* **Chenopodiaceae** *(Spinacia oleracea).* (CABI, 2006)	**High (3)**
Dispersal Potential and Pathway *Fusarium sulphureum* is an important fungus belonging to a group of pathogenic Ascomycetes which cause root and vascular disease in cereal and vegetable crops. Like other Fusarium species, *Fusarium sulphureum* produces three kinds of spores: microspores, macrospores and chlamydospores. Macro- and microspores spread rapidly as large numbers of airborne spores, which act as continual inoculum. Chlamydospores persist in the soil for many years and can be present in the soil clinging to tubers at harvest. (G. A. Secor, 1992). Seed pieces decay when the pathogens infect cut or injured surfaces or when seed potatoes are infected before cutting. Tubers begin to rot either while they are being held after cutting or after they are planted. (*L.E.Hanson et al*). Infection originates in surface wounds during harvest and handing. Like other Fusarium species, *Fusarium sulphureum* disperses readily by soil, water and planting material (CABI, 2006). Additionally, the species can be dispersed by infested plant materials, such as *Allium cepa, Cucumis melo, Medicago sativa.* (CABI, 2006).	**High (3)**
Economic Impact Dry rot is probably the most important cause of postharvest potato losses in the northeastern United States and nationwide (*L.E.Hanson et al).* The storage rot of potatoes caused by *F. sambucium* can be a serious problem; in both Europe and eastern Canada it is known as the common rot of stored potatoes. *Fusarium sulphureum* is economically important as a storage rot of potatoes where it may complete or be associated with *Fusarium sambucium* (*Theo Booth, C. 1971*). For a long time, dry rot was considered the most important cause of storage losses but in recent years, its importance has declined.	**Medium (2)**
Environmental Impact Dry rot is caused by several fungal species in the genus *Fusarium,* thus the name Fusarium dry rot. The most important dry rot pathogen in the Northeast is *Fusarium sambucinum,* although *Fusarium solani* is also present. Losses appear to be increasing because *Fusarium sambucinum* has become resistant to the benzimidazole fungicides that are commonly used to control dry rot of potato. Thiabendazole (TBZ) has been applied postharvest since the early 1970s to control dry rot in storage. TBZ and thiophanate methyl, another benzimidazole fungicide, have been used to prevent decay of seed pieces caused by *Fusarium* species. Resistance to TBZ and other benzimidazole fungicides was discovered in Europe in 1973 and in the United States in 1992.(M. N. Beremand)	**Medium (2)**

6. Consequences of Introduction of *Phytophthora drechsleri* Tucker (Phytophthora Blight)	Risk Rating
Climate-Host Interaction *Phytophthora drechsleri* was reported as a causal agent of poinsettia foliage blight in 1985 (*Yoshimura, M., M. Aragaki, Plant Dis. 69:511-531*) and of chrysanthemum root rot in 1950 (Frezzi, M. J. Rev. Invest. Agric. Buenos Aires 4:47-133). In Pennsylvania, poinsettia and chrysanthemum root rot caused by *Phytophthora drechsleri* was detected from July through October in consecutive years between 1997 and 2000. *Phytophthora drechsleri* is a water- and soil-borne fungus, favors warm temperatures (28-31ºC), is highly sensitive to mefenoxam (*Kim, S. H., unpublished*), and has a broad host range of over 100 species. This species is distributed throughout much of subtropical and tropical regions and it is also reported as present in many countries including: Africa (Egypt, Madagascar, Zimbabwe), Asia (Iran, Japan, Lebanon, Malaysia), Australasia (Australia, New Zealand, Papua New Guinea), Europe (France, Greece, UK), North America (Canada, Mexico, USA), South America (Argentina, Brazil, Colombia) (CMI, 1979). High humidity and a temperature of 28-32°C are conducive for rapid build-up of the disease in the field. Optimum temperature for growth, sporangia formation and zoospore germination of *P. drechsleri f. sp. cajani* has been found to be around 25 to 30°C (Pal and Grewal, 1984; Singh and Chauhan, 1988). According to Kannaiyan *et al.* (1980), an optimum temperature range from 27 to 33°C (minimum 9°C and maximum 36°C) supported the growth of *P. drechsleri*. Based on all the above mentioned information, we estimate that *Phytophthora drechsleri* could become established in all the agro-ecological zones in Bangladesh.	**High (3)**
Host range Originally isolated from rotting potatoes, *Phytophthora drechsleri* has a host range that includes as many as 40 plant families. Host range of this species includes: **Brassicaceae** (*Brassica oleracea* var. *capitata* (cabbage), **Fabaceae** *(Cajanus cajan* (pigeon pea), *Medicago sativa* (lucerne), *Robinia pseudoacacia* (black locust); **Asteraceae** (*Carthamus tinctorius* (safflower), *Helianthus annuus* (sunflower); **Pinaceae** (*Cedrus deodara* (Himalayan cedar), *Pinus radiata* (pine); **Vitaceae** (*Cissus rhombifolia* (grape ivy), **Cucurbitaceae** (*Citrullus lanatus* (watermelon), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita* (pumpkin), *Lagenaria siceraria* (bottle gourd); **Euphorbiaceae** (*Euphorbia pulcherrima* (poinsettia, *Manihot esculenta* (cassava); **Rosaceae** (*Malus domestica* (apple), *Rubus idaeus* (raspberry), *Prunus armeniaca* (apricot); **Anacardiaceae** (*Pistacia vera* (pistachio); **Solanaceae** (*Solanum tuberosum* (potato), *Capsicum annuum* (chili pepper), *Lycopersicon esculentum* (tomato), *Solanum melongena* (eggplant)...	**High (3)**
Dispersal Potential and Pathway The Phytophthora blight pathogen (*Phytophthora drechsleri*) is capable of surviving in soil (even in the absence of a living host) and also in infected crop debris for at least one year (Bisht and Nene, 1990). Bisht and Nene (1990) also found zoospores to be the primary source of inoculum, and noted that rain and wind primarily contributes to the dispersal of the inoculum over short distances. Singh and Chauhan (1985) noticed a more rapid development of blight at night in the field, and the light was inhibitory to zoospore germination. One of the sources of disease appearance in the field is plant debris mixed with seed material where pigeonpea has not been cultivated for several years. Rainsplash and wind also contribute to short distance dispersal of zoospores (Bisht and Nene, 1990).	**High (3)**

Economic Impact The disease assumed importance in the early 1980s with the introduction and dissemination of short-duration types of pigeonpea. The disease incidence in West Bengal, India, was as high as 26.3% (*Kannaiyan et al., 1984*) causing enormous crop losses. A severe epidemic occurred in experimental plots at ICRISAT (International Crops Research Institute for the Semi- Arid Tropics), India in the 1975-1976 crop season (*Reddy et al., 1990*). The loss of >84.5% of the plant population was recorded in short duration cultivars by Singh (1996). It was also noticed that infected susceptible plants of variety Pusa 33 rarely survived at IARI (Indian Agricultural Research Institute) in 1995. In South India, total yield loss was observed in some short-duration pigeonpea crops (*Reddy and Sheila, 1994*). The species has a host range that includes as many as 40 plant families, so introduction of the species has the potential to infest plants that are listed as threatened or endangered. (e.g. *Cucumis, Solanum*).	**High (3)**
Environmental Impact Introduction of *Phytophthora drechsleri* into Bangladesh is likely to initiate chemical application. For example, the systemic fungicide metalaxyl was first developed in the early 1970s (Sandler *et al.*, 1989). It was used against a variety of Phytophthora species causing diseases in different crops including pigeonpea (Kotwal *et al.*, 1981; Chaube *et al.*, 1984; Agrawal, 1987; Chauhan and Singh, 1991a; Singh *et al.*, 1999a). Pal and Grewal (1983) reported fentin acetate+maneb to be the best effective when applied before inoculation. Seed treatment with new formulations of metalaxyl, i.e. mancozeb+metalaxyl, was as effective as an old formulation of metalaxyl in suppressing disease development (Singh *et al.*, 1999a). This fungicide provided maximum protection up to 15 days after sowing (DAS).	**Medium (2)**
7. Consequences of Introduction of *Phytophthora megasperma* Drechsler (Root Rot)	**Risk Rating**
Climate-Host Interaction *Phytophthora megasperma* is found in Australia, New Zealand, United States, France, Greece, Ireland, Italy, Spain, United Kingdom, Scotland. Asia: *P. megasperma* widespread in Japan, Philippines. (http://zipcodezoo.com/Chromista/P/Phytophthora_medicaginis.asp, CABI, 2006). The optimum soil temperatures for infection of *Phytophthora megasperma* range from 24-27oC. Most isolates of the fungus are active in this temperature range but a high temperature isolate (HTI) has also been identified. It has an optimum temperature range of 27-33oC and a maximum of 39oC. (http://nudistance.unl.edu/homer/disease/agron/alfalfa/AlfPhyt.html) Based on this distribution, we estimate that *P. megasperma* could become established in most of the agro-ecological zones in Bangladesh. One or more of its potential hosts occurs in these zones.	**High (3)**
Host Range *Phytophthora megasperma* has been recorded to attack multiple species in multiples families including: **Liliaceae** (asparagus), **Brassicaceae** (cabbage, cauliflower), **Apiaceae** (carrot), **Solanaceae** (tomato, potato, eggplant), **Rosaceae** (apple, apricot, cherry, plum, peach, strawberry and rose), **Rutaceae** (lemon, grape fruit), **Asteraceae** (sunflower), **Poaceae** (rice, sugar cane), **Sterculiaceae** (cacao), **Cucurbitaceae** (cucumber), **Caryophyllaceae** (carnation), **Lauraceae** (avocado) (CABI, 2006).	**High (3)**

Dispersal Potential and Pathway There is no evidence that *Phytophthora megasperma* is seed borne (Richardson, 1979). It can be introduced in diseased nursery stock, so nursery hygiene is essential. Zoospores can be passively spread long distances in irrigation water, or in drainage ditches (Ribeiro and Linderman, 1991).	**Medium (2)**
Economic Impact Generally, *Phytophthora megasperma* is one of the less aggressive species of Phytophthora, and causes debilitation rather than substantial plant death (CABI, 2006).	**Medium (2)**
Environment Impact Soil water management techniques, particularly those that minimize prolonged periods of flooding (Wilcox and Mircetich, 1985b), are regarded as one of the most effective ways of managing all diseases caused by *P. megasperma*. The Oomycete-active fungicides have the capacity to slow disease development, but they will not eradicate *P. megasperma* from the soil.	**Medium (2)**
8. Consequences of Introduction *of Polyscytalum pustulans* (M.N. Owen & Wakef.) M. B. Ellis (Skin Spot of Potato)	**Risk Rating**
Climate-Host Interaction The fungus *Polyscytalum pustulans* is distributed worldwide including Africa, South Africa, Asia, Soviet Far-East (USSR), Oceania, Australia (Tasmania), New Zealand, Europe, Britain and Northern Ireland, Germany, Irish Republic, Norway, Romania, USSR (Russia), North America, Canada, USA (CAB abstract, 2015). http://www.cabdirect.org/abstracts/20056500202.html The disease is largely restricted to cool temperate regions and the production of conidia requires high humidity (>85% RH) and they develop within 5 days at 16°C (CABI, 2006). Based on this distribution, we estimate that *Polyscytalum pustulans* could become established in few agro-ecological zones of Bangladesh. One or more of its potential hosts occurs in these zones.	**Medium (2)**
Host range *Polys ytalum pustulans* can infect the roots of Solanaceae, including species of Solanum, Nicotiana, Datura and tomatoes, producing brown lesions (Hide, 1981). Its major host is *Solanum tuberosum* (Potato) and the minor host is Solanum (Nightshade) (CABI, 2006).	**Low (1)**
Dispersal Potential and Pathway The primary source of infection within a crop is largely the seed potatoes (Boyd and Lennard, 1961). Contaminated seed tubers are the main source of inoculum in most seed and ware crops. *P. pustulans* spreads and sporulates first at the base of stems, stolons and roots nearest the mother tuber and then spreads outwards (Hirst and Salt, 1959). The spread and development of skin spot is also enhanced by wet, cool soils during the harvest period. *P. pustulans* can also survive for more than 6 months in dry soil in potato stores and can be dispersed into the air (Carnegie *et al.*, 1978). Infection of healthy tubers can occur from airborne inoculum (Carnegie and Cameron, 1987). *P. pustulans* can be detected in field soil up to 4 years after a potato crop and can cause the infection of healthy tubers (Carnegie and Cameron, 1990). Sporulation from sclerotia in stem tissue buried in soil declines with time until none occurs after 7 years although mycelium is still viable at this time (Hide and Ibrahim, 1994).	**High (3)**
Economic Impact The affecting seed quality, skin spot, as a skin blemish disease, can reduce the	**High (3)**

value of the crop when the outlet is as washed pre-packed tubers for the supermarket. Skin blemishes can considerably reduce the return on the crop. Potato processors who store tubers at low temperature and use sprout suppressants can incur increased peeling losses when skin spot develops (French, 1976). Such stocks can be totally unusable and have to be replaced incurring the additional costs of buying replacement stock. As the severity of skin spot increases on tubers, emergence is delayed or prevented and the number of main stems and the number of small tubers is reduced (Hide *et al.,* 1973). The total yield of infected seed stocks was usually significantly lower than that of healthy stocks.	
Environmental Impact The establishment of *Polyscytalum pustulans* in Bangladesh could trigger the initiation of chemical application. Because this disease affects total yield and the size of the tubers (Hide *et al.*, 1973), it is necessary to control the disease. Fungicides can be applied to seed tubers to control disease development on the growing crop and, hence, on daughter tubers.	**Medium (2)**
9. Consequences of Introduction of *Clavibacter michiganensis* subsp. *michiganensis* (Potato ring rot)	**Risk Rating**
Climate-Host Interaction *C. michiganensis* subsp. *michiganensis* was first described in North America and presumably originated there. **EPPO region:** Austria, Belarus, Belgium, Bulgaria, Czech Republic, Egypt, Finland (unconfirmed), France, Germany, Greece, Hungary, Ireland, Israel, Italy (including Sardinia and Sicily), Lebanon, Lithuania, Morocco, Netherlands, Norway (eradicated), Poland, Portugal (eradicated), Romania, Russia (European, Siberia), Slovenia, Spain, Switzerland, Tunisia, Turkey, UK (found in the past but not established), Ukraine, Yugoslavia. **Asia:** Armenia, Azerbaijan, China (found in the past but not established), India (Madhya Pradesh), Iran, Israel, Japan, Lebanon, Turkey. Africa: Egypt, Kenya, Madagascar, Morocco, South Africa, Tunisia, Togo, Uganda, Zambia, Zimbabwe. **North America:** Widespread in Canada (British Columbia to Nova Scotia) and USA (California, Florida, Georgia, Hawaii, Iowa, Illinois, Indiana, Michigan, North Dakota, Ohio, Wyoming), Mexico. Central **America and Caribbean:** Costa Rica, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Martinique (unconfirmed), Panama. South America: Argentina, Brazil (São Paulo), Chile, Colombia, Ecuador, Peru, Uruguay. **Oceania:** Australia (New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia), New Zealand, Tonga. **EU:** Present (EPPO, 1997). *Clavibacter michiganensis* subsp. *sepedonicus* has a relatively low temperature optimum for growth (21°C) and is mainly confined to cooler areas of the world. In the southern part of the EPPO region, climatic conditions would probably not favour ring rot except, perhaps, in mountainous areas (EPPO, 1997). The traditional potato production areas in Bangladesh are in the winter season of the country, which can experience minimum temperatures as low as 14.1oC.	**Medium (2)**
Host range The natural infection causing disease has been found on potatoes only. Sugar beet has been described as a natural symptomless host and the bacterium has also been found in sugar beet seeds. In inoculation tests many members of the Solanaceae, including tomatoes and aubergines, were found to be susceptible (CABI, 2006).	**Medium (2)**
Dispersal Potential and Pathway *C. michiganensis* subsp. *sepedonicus* is a short, non-motile, gram-positive rod. Its means of spread are through the planting of infected seed potatoes and	**High (3)**

contamination of containers, equipment and premises. When seed potatoes are cut before planting the cutting knife is an important dispersal unit: after cutting an infected tuber, 20-30 healthy tubers may be infected. Planters and graders which have been contaminated by bacteria from a few badly diseased potatoes are also a potent infection source. Spread in the field from plant to plant is usually very low, but there is experimental evidence that some insects, including Colorado beetle, by way chewing can spread the bacterium (EPPO, 1997). The bacterium is not known to survive in soil in the absence of potato debris, but can survive from season to season in volunteer potato plants (Rowe *et al*.). The risk of dispersal is therefore linked to sanitation and handling of the potatoes and equipment at ports of entry as well as distribution sites across the country. This risk may be further increase with the island wide distribution of the commodity throughout the relatively small island as well as the farming culture within Jamaica, where there are few distributors of planting materials and sharing of equipment by farmers. This disease is particularly serious because it has the potential to spread quickly throughout a farm and may lead to severe losses if left unchecked (Rowe *et al.*)	
Economic Impact Economic losses are due to wilt and tuber rotting in the field and in store. Damage is caused by destruction of vascular tissues and subsequent wilting and dying of plants and secondary rotting of tubers. Indirectly, expenses of disinfecting machinery, stores, and prohibition of potato cultivation may increase economic loss. Crop losses have been mainly reported from North America with up to 50% and from Russia with 15-30% of plants infected and up to 47% crop loss (EPPO, 1997). Once established the cost of control is considered to be high as the disease require vigilance from all sectors of the industry, from growers through to consumers.	**High (3)**
Environmental Impact The bacterium *C. michigansis* subsp. *sepedonicus* is not expected to stimulate the initiation of chemical or biological control programmes, since currently none exist (EPPO, 1997). The host range of ring rot is largely limited to potato, though sugar beet is a symptomless host. Laboratory testing has extended the bacterium range of host infestation to the family Solanaceae to include tomatoes and aubergines. Based on its limited natural host range and no existing chemical and biological control methods.	**Low (1)**
10. Consequences of Introduction of *Ralstonia solanacearum* (Smith, 1896) Yabuuchi *et al.*, 1996 (Brown rot and Bacterial wilt of potato)	**Risk Rating**
Climate-Host Interaction *R. solanacearum* is widespread in tropical, subtropical and warm temperate areas throughout the world. For the EPPO region, it is mainly race 3 which is of importance, since this so-called low-temperature strain is adapted to cooler climates in the highlands of the tropics and in the Mediterranean area. Its occurrence has now also been reported from temperate zones, and in particular race 3 has been reported from a number of European countries in the 1990s. The distribution is given below separately for *R. solanacearum* as a whole (except race 3), for confirmed or possible records of race 3, and for records of race 2 (EPPO, 1978). ***R. solanacearum* (except race 3)** **EPPO region**: Denmark (found but not established in ornamental *Musa*), Netherlands (race 1 found incidentally in ornamental turmeric (*Curcuma*) in the glasshouse, imported from Thailand), Germany (intercepted only), Russia (reported on various crops, e.g. soybean, other than the hosts of race 3; status doubtful). **Asia**: Armenia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China (widespread), Georgia, Hong Kong, India (widespread), Indonesia (widespread),	**High (3)**

Iran, Japan, Korea Democratic People's Republic, Korea Republic, Malaysia (widespread), Myanmar, Nepal, Pakistan, Philippines, Russia (Far East), Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam. **Africa**: Angola, Burkina Faso, Burundi, Congo, Ethiopia, Gabon, Gambia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Nigeria, Réunion, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Swaziland, Tanzania, Tunisia, Uganda, Zaire, Zambia, Zimbabwe. **North America**: Canada (found but not established on tomato and pelargonium in Ontario only), Mexico, USA (Arkansas, Florida, Georgia, Hawaii, North Carolina). **Central America and Caribbean**: Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Nicaragua, Panama, Paraguay, Puerto Rico, St. Lucia, St. Vincent and Grenadines, Trinidad and Tobago. **South America**: Argentina, Belize, Brazil (widespread), Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela. **Oceania**: American Samoa, Australia (widespread), Cook Islands, Fiji, French Polynesia, Guam, Micronesia, New Caledonia, New Zealand, Papua New Guinea, Samoa, Tonga, Vanuatu.

Race 3 of *R. solanacearum*
(Records of unspecified races on potato in the EPPO region are treated as probable records of race 3). The bacterium is under eradication wherever it has occurred in the EU or in other EPPO countries.

EPPO region: Algeria (probable), Austria (probable, isolated incidents in 1995), Belarus (unconfirmed), Belgium (single outbreak in 1992; not found since 1994), Bulgaria (probable, found in the 1940/50s but not established), Cyprus (found in the 1950s but not established), Egypt, Finland (intercepted only), France (isolated incidents in 1995), Greece (including Crete), Israel (found at one site in the 1970s but eradicated), Italy (found in the 1950s; isolated incidents in 1995), Latvia (old unconfirmed records; now absent), Lebanon (probable), Libya (probable), Moldova (probable), Morocco (old unconfirmed records, never found on potato; now absent), Netherlands (isolated incidents in the early 1990s, several outbreaks in 1995), Poland (old unconfirmed reports from the 1940s; now absent), Portugal (isolated incidents on mainland in 1995; old unconfirmed report in Madeira, now absent), Romania (reported from symptoms only in the 1950s; now absent), Spain (probable, found in 1981 but not established, in Canary Islands only; never found on mainland, the report in the first edition (EPPO/CABI, 1992) of an earlier, now eradicated, presence was erroneous), Sweden (probable, found on *S. dulcamara* in the 1970s and eradicated), Tunisia (old unconfirmed records; not found in recent surveys), Turkey, UK (single outbreak in potato in England in 1993; not since reported in potato, but still found in *S. dulcamara*), Ukraine (old unconfirmed records; now absent) and Yugoslavia (probable). **Asia**: China (recorded on potato in Fujian, Guangdong, Guangxi, Hebei, Jiangsu and Zhejiang), Cyprus (see above), India, Indonesia (Java), Iran, Israel (see above), Japan, Nepal, Philippines (probable), Turkey. **Africa**: Algeria (probable), Burundi, Egypt, Kenya, Libya (probable), Morocco (see above), South Africa, Tunisia (see above), Zambia. **North America**: Mexico. **Central America and Caribbean**: Costa Rica. **South America**: Argentina, Brazil, Chile, Peru, Uruguay. **Oceania**: Australia.

Race 2 of *R. solanacearum*
(Causing Moko disease of bananas)
EPPO region: Libya. **Asia**: India (West Bengal), Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Viet Nam. **Africa**: Ethiopia, Libya, Malawi, Nigeria, Senegal, Sierra Leone, Somalia. **North America**: Mexico, USA (Florida). **Central America and Caribbean**: Belize, Costa Rica, Cuba, Dominican Republic (unconfirmed), El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Nicaragua,

Panama, Trinidad and Tobago. **South America**: Argentina, Brazil, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Venezuela. The disease is most severe at 24-35°C; it is seldom found in temperate climates where the mean temperature for any winter month falls below 10°C. There are distinct temperature requirements for optimum disease development and reproduction for the different races (biovars) (Swanepol, 1990). Race 1 affecting tobacco, tomatoes, potatoes, aubergines, diploid bananas and many other (solanaceous) crops and weeds, with high growth temperature optimum (35-37°C). Race 2 affecting triploid bananas (causing Moko disease) and *Heliconia* spp., with high temperature optimum (35-37°C). Race 3 affecting mainly potatoes and tomatoes without a high virulence on other solanaceous crops, with lower temperature optimum (27°C) (Buddenhagen *et al.,* 1962). High soil moisture and periods of wet weather or rainy seasons are associated with high disease severity. Soil moisture is also one of the major factors affecting reproduction and survival of the pathogen; the most favourable soil moisture is -0.5 to -1 bar while -5 to -15 bar is unfavourable (Nesmith & Jenkins, 1985). Slightly unfavourable weather conditions such as low temperatures influence symptom expression. In Kenya, certified and obviously healthy (but latently infected) potato seed tubers produced at altitudes of 1520-2120 m showed infection when planted at lower altitudes (Nyangeri *et al.*, 1984). This was due to a latent infection of the tubers grown in an environment less favourable to the pathogen. Based on the geographical distribution and interaction with climatic conditions, we can estimate that the *R. solanacearum* can be established in all agro-ecological zones of Bangladesh.	
Host range The host range, which includes over 200 plant species, is one of the widest of all the phytopathogenic bacteria. The most susceptible plant family, in terms of numbers of species affected is the ***Solanaceae***, but more than fifty other plant families also contain susceptible species. *R. solanacearum* does not behave as a single bacterium with a uniform biology and host range, but as a complex of variants, variously described as groups, races, biovars, biotypes, sub-races and strains. The different classifications of *R. solanacearum* have caused a considerable amount of confusion in the literature. Buddenhagen *et al.* (1962) distinguished three races on the basis of pathogenicity: Race 1: Affecting tobacco, tomatoes, potatoes, aubergines (**Solanaceae)**, diploid bananas (**Musaceae**) and many other (solanaceous) crops and weeds, with high growth temperature optimum (35-37°C). Race 2: Affecting triploid bananas (causing Moko disease) and *Heliconia* spp. (**Heliconiaceae)**, with high temperature optimum (35-37°C). Race 3: Affecting mainly potatoes and tomatoes without a high virulence on other solanaceous crops, with lower temperature optimum (27°C). Other hosts are the weeds *S. dulcamara*, *S. nigrum*, *S. cinereum* (in Australia); the composite weed *Melampodium perfoliatum* (**Asteraceae**) in Costa Rica; *Pelargonium hortorum* (**Geraniaceae**). Two additional races affecting *Zingiber officinale* (**Zingiberaceae***)* and mulberries (*Morus* spp.- **Moraceae**), respectively, were also distinguished (Buddenhagen, 1986), but their status is still unclear. By artificial inoculation the weeds *Eupatorium cannabinum, Cerastium glomeratum*, *Portulaca oleracea, Ranunculus scleratus* and *Tussilago farfara*, several of which commonly inhabit edges of waterways, have been shown to be potential hosts (Elphinstone 1996). There are also reports of natural occurrence of race 3 biovar 2 in *Pelargonium hortorum* (Janse, 1996; Janse *et al.,* 2004).	**High (3)**

Dispersal Potential and Pathway The natural spread of most of the *R. solanacearum* races is very limited and slow. However, race 2, which causes Moko disease of banana, is known to be transmitted by insects and has a high potential for natural spread. Race 3 may be spread more easily with surface water when infected *S. dulcamara* grows with its roots floating in water. The bacterium may subsequently be spread to other hosts when contaminated surface water is used for irrigation (Olsson, 1976). In tropical areas, many weeds have been shown to be alternate hosts. The slow rate of development of the bacterium on the weeds allows them to withstand infection, and so provide a bridge for the pathogen between crops. The main path for international spread is by (latently) infected seed potatoes and other vegetative propagating materials. Natural infection of true seed has only been firmly established for groundnut. There are a few reports of occurrence of race 1 in tomato, capsicum and aubergine seed (Persley, 1986b; Kelman *et al.*, 1994; Singh, 1995). Infections of potato tubers may be latent, due to unfavourable weather conditions, partly resistant cultivars or low virulence of certain pathogen strains; tubers with latent infection are the most probable means of introduction into a new area.	**High (3)**
Economic Impact *R. solanacearum* constitutes a serious obstacle to the culture of many solanaceous plants in both tropical and temperate regions. The greatest economic damage has been reported on potatoes, tobacco and tomatoes in the south-eastern USA, Indonesia, Brazil, Colombia and South Africa. In the Philippines, in 1966-1968, there were average losses of 15% in tomatoes, 10% in aubergines and *Capsicum*, and 2-5% in tobacco (Zehr, 1969). In the Amazon basin in Peru, about half the banana plantations are affected and the rapid spread of the pathogen threatens to destroy plantations throughout the Peruvian jungle (French & Sequeira, 1968). In India, there are sometimes total losses in tomato crops. In the eradicated outbreak in Israel, losses occurred in potato, being heavier for the spring crop than the autumn crop, because of the high temperatures under which the former matures (Volcani & Palti, 1960). Extensive losses on potato were reported in Greece in 1951-1953 (Zachos, 1957). Disease severity mostly increases if *R. solanacearum* is found in association with root nematodes. In tobacco, nematode infestation changes the physiology of the plants, causing susceptibility to bacterial wilt (Chen, 1984). Experiments in India showed that the combined pathogenic effects of *R. solanacearum* and *Meloidogyne javanica* were greater than the independent effects of either (Sitaramaiah & Sinha, 1984). I n potatoes, *R. solanacearum* causes wilting of plants, with extensive rotting of tubers. Rotted tubers have to be rejected for quality reasons. Latent infected tubers detected by laboratory testing have to be rejected as seed potatoes because of their potential to transfer disease to future generations of potatoes. *R. solanacearum* is in particular a limiting factor in tropical agriculture, where losses up to 75% of the potato crop have occurred in several countries (Cook & Sequeira, 1994; Oerke *et al.,* 1994). Extensive losses have also been reported from Mediterranean countries. No records of the economic impact of the disease outbreaks in countries such as Belgium, England and the Netherlands could be found. Apart from the considerable cost of infected ware and seed potato lots being rejected, the cost of eradication programmes and disease surveys in connection with the disease outbreaks must have been very large. In addition, most likely the export of seed and ware potatoes has been considerably reduced.	**High (3)**

Environmental Impact The control of bacterial wilt has proved to be very difficult, especially for race 1 with its broad host range. Chemical control is nearly impossible to apply. Soil fumigants showed either slight or no effects (Murakoshi & Takahashi, 1984). Antibiotics such as streptomycin, ampicillin, tetracycline and penicillin also showed hardly any effect (Farag *et al.*, 1982); in fact, streptomycin application increased the incidence of bacterial wilt in Egypt (Farag *et al.*, 1986).	**High (3)**
11. Consequences of Introduction of *Globodera rostochiensis* (Wollenweber) (Golden Potato Cyst Nematode or Golden Nematode)	**Risk Rating**
Climate-Host Interaction *Globodera rostochiensis* distributes large in the world, including the temperate regions to tropical countries (CABI, 2006). The worldwide distributions (EPPO, 1978) of *Globodera rostochiensis* are **EPPO region:** Albania, Algeria, Austria, Belarus, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Egypt, Estonia, Faroe Islands, Finland, France, Germany, Greece (including Crete), Hungary (one locality only), Iceland, Ireland, Latvia, Lebanon, Libya, Lithuania, Luxembourg, Malta, Morocco, Netherlands, Norway, Poland, Portugal (including Madeira; unconfirmed in Azores), Spain (including Canary Islands), Russia (Central Russia, Eastern Siberia, Far East, Northern Russia, Southern Russia, Western Siberia), Slovakia, Sweden, Switzerland, Tunisia, UK (England, Channel Islands), Ukraine, Yugoslavia (unconfirmed). Found in Israel on only two occasions in 1954 and 1965 in a small area in the Sharon region, and was successfully eradicated. **Asia**: Cyprus, India (Kerala, Tamil Nadu), Japan (Hokkaido), Lebanon, Pakistan, Philippines, Sri Lanka, Tajikistan, Russia (Eastern Siberia, Far East, Western Siberia). **Africa**: Algeria, Egypt, Libya, Morocco (intercepted only), Sierra Leone, South Africa, Tunisia. **North America**: Canada (Newfoundland, British Columbia Vancouver Island only), Mexico, USA (New York; eradicated in Delaware). **Central America and Caribbean**: Costa Rica, Panama. **South America**: Throughout the high Andean region: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela. More southerly in range than *G. pallida*. **Oceania**: Australia (two outbreaks, one in Western Australia in 1986, the other in Victoria in 1991; both are subject to official eradication programmes), New Zealand, Norfolk Island. **EU**: Present. The optimum temperature for the hatch of *Globodera rostochiensis* is about 15°C (Evans, 1968). Therefore, it can be established in all ecological zones of Bangladesh. One or more of its potential hosts occurs in these zones.	**High (3)**
Host Range *Globodera rostochiensis* has been recorded on a wide range of Solanaceae including: *Lycopersicon esculentum* (tomato), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Datura stramonium* (jimsonweed), *Lycopersicon pimpinellifolium* (currant tomato), *Oxalis tuberosa* (oca), *Solanum* (nightshade), *Solanum aviculare* (kangaroo apple), *Solanum gilo* (gilo), *Solanum indicum*, *Solanum marginatum* (white-edged nightshade), *Solanum mauritianum* (tree tobacco), *Solanum nigrum* (black nightshade), *Solanum quitoense* (Narangillo), *Solanum sarrachoides* (green nightshade) (UK) (CABI, 2006).	**Medium (2)**
Dispersal Potential and Pathway The potato cyst nematodes are dispersed with soil debris and plant material contaminated by the cysts and by infected or contaminated potato tubers. (http://nematode.unl.edu/pest6.htm). In general, the potato cyst nematodes will survive in any environment where potatoes can be grown. A period of 38-48 days (depending on soil temperature) is	**High (3)**

required for a complete life cycle of the potato cyst nematodes (Chitwood and Buhrer, 1945). Potato cyst nematode eggs can remain dormant and viable within the cyst for 30 years (Winslow and Willis, 1972). After mating, each female produces approximately 500 eggs (Stone, 1973b).	
Economic Impact Crop losses induced by the golden nematode range 20-70% (Greco, 1988). It has been estimated that approximately 2 t/ha of potatoes are lost for every 20 eggs/g soil (Brown, 1969). Up to 80% of the crop can be lost when nematode populations are raised to very high levels by repeated cultivation of potatoes. In Chile, yield losses of 20, 50 and 90% were obtained with population densities of 9, 28 and 128 eggs/g soil (Moreno *et al.*, 1984; Greco and Moreno, 1992). Rhizoctonia and other fungal diseases associated with nematode feeding may also contribute to the yield loss. In Canada, *Globodera rostochiensis* was found in Newfoundland in 1962 and 800,000$Can /year has been spent on control and research of golden cyst nematode (Miller, 1986). Besides that, affected plants suffer tubers are smaller (CABI, 2006). This means it effects on quality of potato tubers as well as seed potatoes. Control on golden cyst nematode, *Globodera rostochiensis* is major by soil fumigants but fumigant nematicides are toxic and expensive (Mazin, 1991). Moreover, golden cyst nematode (*Globodera rostochiensis*) is quarantine pest for EPPO, APPPC, NAPPO (OEPP/EPPO, 1978; 1981). Therefore, the presence of the potato cyst nematodes in potato growing areas prevents the export of potatoes to international markets due to the restrictions imposed by many countries against this pest. Based on these Economic Impacts, the Potato cyst nematodes could become established in Bangladesh with **High (3) Risk** potential.	**High (3)**
Environmental Impact Introduction of *Globodera rostochiensis* into Bangladesh is likely to initiate chemical, because it is a serious pest of economically important crops. The fumigation to control this nematode may also harm to the beneficial organisms available to the soils. This species has the potential to attack plants (Solanum) that are main crop in Bangladesh. As a large chemical will be used for it's controlling. Therefore, it can impacts on ecological system.	**High (3)**
12. Consequences of Introduction of *Globodera pallida* (Stone, 1973) Behrens, 1975 (White Potato Cyst Nematode)	**Risk Rating**
Climate-Host Interaction The centre of origin of *Globodera pallida* is in the Andes Mountains in South America, then they were introduced to Europe with Potatoes and spreaded with seed potatoes to other areas. The present distribution covers temperate zones down to sea level and in the tropics at higher altitudes (many countries in EPPO region, Asia including India, Africa, America and Oceania including Scotland). In these areas, distribution is linked with that of the potato crop (www.eppo.org/quarantine/nematodes/globodera-_pallida/HETDSP_ds.pdf, (CABI, 2006)). Potato crop distributes in most of the agro-ecological areas of Bangladesh such as High Land of North (Tista River Floodplain) and North-West regions (Ganges River	**High (3)**

Floodplain), Brahmaputra-Jamuna Floodplain regions, Meghna River and Estuarine Floodplain regions of Bangladesh. Base on all information available, we estimate this nematode could become established in all agr-ecological regions in Bangladesh.	
Host range The hosts of *Globodera pallida* are restricted to the **Solanaceae**. Major hosts are *Lycopersicon esculentum* (tomato), *Solanum melongena (*aubergine) and *Solanum tuberosum* (potato). In addition to many other hosts in the family **Solanaceae** listed as following: *Datura tatula, Lycopersicon glandulosum, L. hirsutum, L. mexicanum, L. esculentum peruvianum, L. pyriforme, Physalis philadelphica, Physochlaina orientalis, Salpiglossis sp., S. acaule, S. aethiopicum, S. ajanhuiri, S. alandiae, S. alatum, S. anomalocalyx, S. antipoviczii, S. armatum, S. ascasabii, S. asperum, S. berthaultii, S. blodgettii, S. boergeri, S. brevimucronatum, S. bulbocastanum, S. calcense, S. calcense, S. cardenasii, S. caldasii, S. canasense, S. capsicibaccatum, S. capsicoides, S. carolinense, S. chacoense, S. chaucha, S. chloropetalum, S. citrillifolium, S. coeruleiflorum, S. commersonii, S. curtilobum, S. curtipes, S. demissum, S. demissum x S. tuberosum, S. dulcamara, S. durum, S. elaeagnifolium, S. famatinae, S. garciae, S. gibberulosum, S. giganteum, S. gigantophyllum, S. gilo, S. glaucophyllum, S. goniocalyx, S. gracile, S. heterophyllum, S. heterodoxum, S. hirtum, S. hispidum, S. indicum, S. intrusum, S. jamesii, S. jujuyense, S. juzepczukii, S. kesselbrenneri, S. kurtzianum, S. lanciforme, S. lapazense, S. lechnoviczii, S. leptostygma, S. longipedicellatum, S. luteum, S. macolae, S. macrocarpon, S. maglia, S. mamilliferum, S. marginatum, S. melongena, S. miniatum, S. multidissectum, S. nigrum, S. nitidibaccatum, S. ochroleucum, S. ottonis, S. pampasense, S. parodii, S. penelli, S. phureja, S. pinnatisectum, S. platypterum, S. polyacanthos, S. polyacanthos S. polyadenium, S. prinophyllum, S. quitoense, S. radicans, S. rostratum, S. rybinii S. salamanii, S. saltense, S. sambucinum, S. sanctae-rosae, S. sarrachoides, S. schenkii S. schickii, S. semidemissum, S. simplicifolium, S. sinaicum, S. sinaicum, S. sisymbrifolium, S. sodomaeum, S. soukupii, S. sparsipilum, S. stenotomum, S. stoloniferum, S. subandigenum, S. sucrense, S. tarijense, S. tenuifilamentum, S. toralopanum, S. triflorum, S. tuberosum ssp. andigena, S. tuberosum ssp. tuberosum, S. tuberosum 'Aquila', S. tuberosum 'Xenia N', S. utile, S. vallis-mexicae, S. vernei, S. verrucosum, S. villosum, S. violaceimarmoratum, S. wittmackii, S. wittonense, S. xanti, S. yabari* and *S. zuccagnianum* (Ellenby, 1945, 1954; Mai, 1951, 1952; Winslow, 1955z; Stelter, 1957, 1959, 1987; Roberts and Stone, 1981; http://plpnemweb.cudavis.edu/nemaplex/Taxadata/G053S2.htm).	**High (3)**
Dispersal Potential and Pathway The cyst of *Globodera pallida* contain as many as 500 eggs, the eggs can remain viable for many years in the absence of Solanaceous (25-30-40 years) before gradually deteriorating. this nematode adapts to develop at cool temperatures range of 100C to180C. Most juveniles go into a form of dormancy known as diapause, in this state, they can remain viable for many years. The lifecycle takes 38-48 days to complete (depending on soil temperature) (Chitwood and Buhrer, 1945; Franco,1979; Stelter, 1971; Stone, 1973b; Jones and Jones, 1974; Golinowski *et al.*,1997; www.Scotland.gov.uk/consultations/agriculture/pcn-_technical_paper_seerad.pdf). *Globodera pallida* have no natural means of dispersal, and can only move the short distances traveled by juveniles attacked towards root in soil. However, Potato Cyst Nematode (*G. pallida*) are usually spread by cysts for long distance by contaminated soil, attached to tuber, plants for transplanting or to farm machinery and other pathway as transport vehicles, non-host plant material, containers and packing and	**High (3)**

so on. (CABI, 2006); www.eppo.org/quarantine/nematodes/globodera-_pallida/HETDSP_ds.pdf	
Economic Impact *Globodera pallida* are major pests of the potato crop in cool-temperate areas. Damage is related to the number of viable eggs per unit of soil, and is reflected the weight of tubers produced. It has been estimated that approximately 2 tons/ha of potatoes are lost for every 20 eggs/g soil. Up to 80% of the crop can be lost when nematode populations are raise to very high levels by repeated cultivation of potatoes (Brown, 1969). In the UK, potato yields lost 6.25 tons/ha per 20 eggs/g soil (Wood *et al.*, 1995), etc. Besides that, affected plants suffer tubers are smaller (CABI, 2006). This means it effects on quality of potato tubers as well as seed potatoes. Control on *Globodera pallida* is major by soil fumigants but fumigant nematicides are toxic and expensive (Mazin, 1991). Moreover, *Globodera pallida* is quarantine pest for EPPO, APPPC, NAPPO (OEPP/EPPO, 1978; 1981).	**High (3)**
Environmental Impact Apart from using nematicide, methyl bromide was the most effective fumigant available to control *Globodera pallida*. But methyl bromide is an ozone-deleting substance (Thomas, 1996). The fumigation to control this nematode may also harm to the beneficial organisms available to the soils. This species has the potential to attack plants (Solanum) that are main crop in Bangladesh. As a large chemical will be used for its controlling. Therefore, it can impacts on ecological system.	**High (3)**
13. Consequences of Introduction of *Ditylenchus dipsaci* (Kuehn, 1857) Filipjev (Stem and Bulb Nematode)	**Risk Rating**
Climate-Host Interaction *Ditylenchus dipsaci* occurs locally in most temperate areas of the world (Europe and the Mediterranean region, North and South America, northern and southern Africa, Asia and Oceania) but it does not seem able to establish itself in tropical regions except at higher altitudes that have a temperate climate. (www.eppo.org/QUARANTINE/nematodes/Ditylenchus_dipsaci/DITYDI_ds.pdf) So far, informations about distribution of this nematode have not reported in Bangladesh. However, there are some temperate places in Bangladesh such as, Northern regions nearer to Himalayans where grow most host plants of nematode. Base on this distribution, we estimate that *Ditylenchus dipsaci* could become established in northern agro-ecological areas in Bangladesh.	**High (3)**
Host range *Ditylenchus dipsaci* is known to attack over 450 different plant species in multiple families including the principal hosts as **Fabaceae** (*Phaseolus* spp, *Trifolium pratense, Trifolium repens*, *Medicago sativa*, *Pisum sativum*, *Vicia faba*,...), **Liliaceae** (*Allium* spp, *Allium cepa*, *Allium porrum*, *Allium sativum*, *Gladiolus hybrids*, *Narcissus pseudonarcissus, Tulipa* spp), **Poaceae** (*Zea mays*, *Secale cereale*, *Avena sativa*, *Avena sterilis*, *Triticum* spp.), **Asteraceae** (*Helianthus annuus*), **Solanaceae** (*Solanum tuberosum*, *Nicotiana tabacum*), **Brassicaceae** (*Beta vulgaris* var. saccharifera), **Cannabaceae** (*Cannabis sativa*),….. And other host plants such as, minor hosts are *Allium cepa* var. aggregatum	**High (3)**

(shallot), *Apium graveolens* (celery), *Brassica napus* var. napus (rape), *Carduus acanthoides* (Welted thistle), *Crocus sativus* (saffron), *Cucurbitaceae* (cucurbits), *Dianthus caryophyllus* (carnation), Hydrangea (hydrangeas), *Ipomoea batatas* (sweet potato), *Lens culinaris* ssp. culinaris (lentil), *Onobrychis viciifolia* (sainfoin), *Petroselinum crispum* (parsley), *Phaseolus coccineus* (runner bean). Wild hosts are *Astranti* sp. (winter wild oat), Bergenia (elephant-leaved saxifrage), *Brassica rapa* subsp. Rapa (turnip), *Chenopodium murale* (nettleleaf goosefoot), *Cirsium arvense* (creeping thistle), *Convolvulus arvensis* (bindweed), *Hieracium pilosella* (mouse-ear hawkweed), *Lamium album* (white deadnettle), *Lamium amplexicaule* (henbit deadnettle), *Lamium purpureum* (purple deadnettel), *Myriophyllum verticillatum* (whorled watermilfoil), *Nerine sarniensis* (guernsey lily), *Ranunculus arvensis* (Corn buttercup), Raphanus raphanistrum (wild radish), *Stellaria media* (common chickweed), *Taraxacum officinale* complex (dandelion).	
Dispersal Potential and Pathway The lifecycle of stem and bulb nematode is short (takes approximately 20 days in onion plant at 150C). Females lay 200-500 eggs each. They can survive in dry conditions and desiccation for many years. As well as they also survive for years without a host plant Therefore, *Ditylenchus dipsaci* can spread widely by irrigation water, farm tools and machinery and other sources. (CABI, 2006; www.eppo.org/quarantine/nematodes/Ditylenchus_dipsaci/DITYDI_ds.pdf). Specially, *Ditylenchus dipsaci* has been shown to be seed-borne on 15 plant species (Neergaard, 1977). This means the nematode is wide spread by seeds of crops.	**High (3)**
Economic Impact *Ditylenchus dipsaci* is one of the most devastating plant parasitic nematodes, especially in temperate regions. Without control, it can cause complete failure of host crops. In heavy infestation crop losses of 60-80% are not unusual; e.g., in Italy up to 60% of onion seedlings died before reaching the transplanting stage and for garlic crop losses of about 50% were recorded from Italy and more than 90% from France and Poland. In Morocco, *D. dipsaci* was found in 79% of seed stocks of *Vicia faba* examined (nematode.unl.edu/ditdips.htm). *Ditylenchus dipsaci* effects on seed quality because infected seeds are darker, distorted, smaller in size and may speckle-like spots on the surface (Sikora and Greco, 1990). And it has been reported to be seed borne, so the commercial seeds infestation of this nematode can be effected. A survey in the UK showed that it occurred widely in economically important crops including 36-45% of seed stocks of broad been, red beet and carrots, 14-17% of shallots, over 3 % of onions and leeks (Green and Sime, 1979). High incidences of seed infection have been reported such as, 67% in broad bean seeds (Stainer and Lanprecht, 1983). Some nations listed *Ditylenchus dipsaci* as plant quarantine pest consist of EPPO, CPPC,IAPSC,NAPPO(www.eppo.org/quarantine/nematodes/Ditylenchus_dipsaci/DITYDI_ds.pdf) and Bangladesh	**High (3)**
Environmental Impact Very little environmental impact information is available on *Ditylenchus dipsaci*, but treatment of crop seeds with nematicides, methyl bromide fumigation could be effected to environmental (Schiffers *et al.*, 1984; Caubel *et al.*, 1985; Whitehead and Tite, 1987; Adamova and Rotrekl, 1991; Hooper, 1991).	**Medium (2)**

14. Consequences of Introduction of *Alfalfa mosaic virus* (AMV) (Alfalfa Yellow Spot)	Risk Rating
Climate-Host Interaction *Alfalfa mosaic virus* has a world-wide distribution as Europe, Africa, North America, South America, Oceania and Asia (China-Nei menggu, Shaanxi, Taiean and Zhejiang). Based on this distribution, we estimate that AMV could become established in all agro-ecological zones in Bangladesh. There are many potential hosts of it's occurs in these zones.	**High (3)**
Host range AMV has a very wide host range infecting at least 697 species in 167 genera of 71 families (Edwardson and Christie, 1997). Major hosts are: *Apium graveolens* (celery), *Apium graveolens* var. *rapaceum* (Celeriac), *Capsicum annuum* (bell pepper), *Cicer arietinum* (chickpea), *Cucurbitaceae* (cucurbits), *Glycine max* (soyabean), *Lablab purpureus* (hyacinth bean), *Lactuca sativa* (lettuce), *Lycopersicon esculentum* (tomato), *Medicago sativa* (lucerne), *Nicotiana tabacum* (tobacco), *Phaseolus* (beans), *Solanum tuberosum* (potato), *Trifolium incarnatum* (Crimson clover), *Trifolium pratense* (purple clover), *Trifolium repens* (white clover), *Viburnum opulus* (Guelder rose), *Vigna radiate* (mung bean), *Vigna unguiculata* (cowpea). Minor hosts are: *Cajanus cajan* (pigeon pea), *Capsicum* (peppers), *Cercis siliquastrum* (Judas tree), *Coriandrum sativum* (coriander), *Cyphomandra betacea* (tree tomato), *Euonymus japonicus* (japanese spindle), *Eutrema wasabi* (Wasabi), *Hibiscus cannabinus* (kenaf), *Lavandula latifolia* (broadleaved lavender), *Pelargonium* (pelargoniums), *Phaseolus vulgaris* (common bean), *Pisum sativum* (pea), *Solanum melongena* (aubergine), *Trifolium subterraneum* (subterranean clover), *Vicia faba* (broad bean), *Vigna angularis* (adzuki bean), *Vinca minor* (common periwinkle), *Vitis vinifera* (grapevine). Wild hosts are: *Lotus corniculatus* (bird's-foot trefoil), *Medicago* (medic), *Solanum nigrum* (black nightshade), *Vicia cracca* (Tufted vetch).	**High (3)**
Dispersal potential and the Pathway AMV is transmitted in the styled-borne or non-persistent manner (Swenson, 1952) by many species of aphids including *Acyrthosiphon possum* and *Myzus persicae* (Edwardson and Christie, 1997). It overwinters in perennial legumes and infected seed and potato tubers provide other sources of virus. AMV has been reported to spread through lucerne crops quite rapidly with its incidence increasing about 1.8 times each year for 5 years (CABI, 2006) AMV is reported to be seedborne in several host species, including Solanum brevidens and *Solanum tuberosum* (Valkonen *et al.*, 1992), *Medicago* spp. (Jones and Pathipanawat, 1989; Jones and Nicholas, 1992; McKirdy and Jones, 1995), *Vicia faba* (Fortass and Bos, 1991), lucerne (Walkey *et al.*, 1990), soyabean (Laguna *et al.*, 1988) and *Trifolium alexandrinum* (Mishra *et al.*, 1980).	**High (3)**
Economic Impact AMV infection of parent lucerne plants can result in a 30-50% reduction in seed germination (Hemmati and McLean, 1977). On the Soybean, AMV infections have been detected at high levels in Nebraska (40% and 26% of fields in 2001 and 2002, respectively) and Wisconsin (28% and 13% of fields in 1999 and 2000, respectively).	**Medium (2)**

AMV is of local economic importance in celery, peppers, tomatoes, lucerne, peas, potatoes and *Trifolium* spp. It has a different economic impact on different crop types and the situation in which they are grown. On forage crops it will decrease herbage and root production (Bailiss and Ollennu, 1986; Jones, 1992). In temperate climates it can reduce the ability of perennial legumes to overwinter (Gibbs, 1962). Infection reduces the flowering and seed yield of *Trifolium subterraneum* (Jones, 1992) and the crop yield of *Vigna angularis* can be reduced by up to 70% (Iizuka, 1990).	
Environmental impact AMV infection of medic seed harvested decreased by up to 76% in insecticide sprayed plots (Jones and Ferris, 2000). AMV is reported to be seedborne in several host species, including *Solanum brevidens* and *Solanum tuberosum* (Valkonen *et al.*, 1992), *Medicago* spp. (Jones and Pathipanawat, 1989; Jones and Nicholas, 1992; McKirdy and Jones, 1995), *Vicia faba* (Fortass and Bos, 1991), lucerne (Walkey *et al.*, 1990), soyabean (Laguna *et al.*, 1988) and *Trifolium alexandrinum* (Mishra *et al.*, 1980).	**Medium (2)**
15. Consequences of Introduction of *Parthenium hysterophorus* L. (Parthenium weed)	**Risk Rating**
Climate-Host Interaction 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. 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 including Pakistan. Parthenium weed is an aggressive colonizer of disturbed ground, able to germinate, grow and flower over a wide range of temperatures and photoperiods. It occurs in the humid and sub-humid tropics, showing a marked preference for black, alkaline, cracking, clay soils of high fertility, but is able to grow on wide variety of soil types from sea level up to 1800 m (Evans, 1987a). In Ethiopia, it grows from low to high-mid-altitude areas at 900-2500 m asl (Taye, 2002). High clay content in soils prolonged the rosette stage, enhanced relative growth rates in height and diameter, and hampered root growth, but promoted biomass allocation to shoots (Annapurna and Singh, 2003). Mahadevappa (1997) noted that parthenium weed has several built-in properties and efficient behavioural mechanisms that enable it to overcome many ecological adversities and thus continue to survive under stress. The weed finds access to any type of land but it is especially prolific in disturbed habitats, for example, roadsides and railway tracks, stock yards, around buildings and on waste land, from where it spreads and invades agricultural systems. Seed germination of this weed occurred at the mean minimum (10°C) and maximum (25°C) temperatures of the collection site, as well as over a wide range of fluctuating temperatures (12/2°C - 35/25°C) in light (Tamado et al., 2002). Seed germination can occur over a wide range of soil pH (2.5-10), with an optimum of 5.5-7.0 (Parsons and Cuthbertson, 1992). Germination may be increased after cold stratification, and with exposure to light (Karlsson et al., 2008).	**High (3)**

Based on the geographical distribution pattern and climatic conditions, we can estimate that this weed could become established in most of the agro-ecological zones of Bangladesh	
Hosts/Species Affected 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).	**High (3)**
Dispersal Potential and Pathway Parthenium weed seed can be moved and spread via water, farm machinery, industrial machinery, feral animals, humans, vehicles, stock fodder, movement of stock, grain and seed (PAG, 2000). It can also be spread by the wind because its seeds are small (1-2 mm diameter) and light (50 µg) and able to travel long distances (Navie *et al.*, 1996; Taye, 2002). The transportation of soil, sand and gravel from *Parthenium*-infested areas to non-infested areas for construction purposes may be the reason for the high infestation along the roadsides and around buildings (Taye, 2002). Continental and inter-continental dispersal may occur when seeds contaminate commercial seed stocks or farm machinery. It can be spread via flowing water or can be blown by wind, making prevention of spread difficult. Once introduced it can be spread by vehicles and farm machinery, and the transport of goods, sand, soil and compost from infested areas to uninfested areas. Long distance and local dispersion of parthenium weeds mainly caused by agricultural activities, animal production, flooding or other natural disaster, foraging and seed trading (PAG, 2000).	**High (3)**
Economic Impact It is only in the past 20-30 years that parthenium weed has come to the fore as a weed of major economic importance, based mainly on its rapid spread in Australia and India (McFadyen, 1992; Navie *et al.*, 1996; Evans, 1997a and Mahadevappa, 1997). Since its impact is multi-faceted, affecting crop production, animal husbandry, human health and biodiversity, its overall economic impact is difficult to quantify. 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,	**High (3)**

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 (54%) after *Digitaria abyssinica* (63%) (Tamado and Milberg, 2000) and sorghum grain yield was reduced from 40 to 97% depending on the year and location (Tamado, 2001). 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. The growth and nodulation of legumes were inhabited by parthenium weed because of the effect of allelochemicals on nitrogen fixing and nitrifying bacteria (Kanchan and Jayachandra, 1981; Dayama, 1986). Another, indirect effect of parthenium weed on crop production is its role as an alternate host for crop pests. A wide range of crop insects and diseases has been reported from parthenium weed both in the neotropics and in its exotic range (McClay et al., 1995; Evans, 1997a; Singh, 1997). For example, it appears to be an important secondary host of a beetle pest (*Pseudoheteronyx* sp.) of sunflower in Australia, of plant parasitic nematodes in the USA (Navie et al., 1996), as well as of a major polyphagous lepidopteran pest (*Diacrisia obliqua* [*Spilartica obliqua*]) in India (Evans, 1997a). Similarly, it has been reported as a reservoir of *Xanthomonas campestris* pv. *phaseoli* [*X. axonopodis* pv. *phaseoli*], *Pseudomonas solancearum* [*Burkholderia solanacearum*], Tomato yellow leaf curl virus, Potato X virus and Potato Y virus in both Cuba and India (Evans, 1997a). Parthenium weed also significantly impacts on livestock production by affecting grazing land, animal health, milk and meat quality and the marketing of pasture seeds and feed grain. It can reduce the percentage cover of palatable species of grasslands in India by up to 90% (Jayachandra, 1971). The most comprehensive economic analysis has been made in Australia, where *Parthenium* weed monocultures in grazing land in Queensland were estimated to cover more than 17,000 km², reducing cattle stocking rates by as much as 80% (McFadyen, 1992), with a net annual loss of revenue calculated at up to AU$17 million (Chippendale and Panetta, 1994). Further losses result if farms also supply harvesting machinery, fodder or grain, since there is now legislation to prevent their movement from infested properties because of contamination by weed seed. An additional, non-quantifiable side effect of parthenium weed is on animal health, as the sesquiterpene lactone, parthenin, has been shown to cause severe dermatitis, anorexia and intestinal damage, which can lead to death of buffalo, cattle and sheep (Towers and Subba Rao, 1992), and 10-50% of the weed in the diet can kill these animals within 30 days (Naarasimhan et al., 1977a, b, 1980; More et al., 1982). Taints of meat have been detected from sheep given a diet of 30% parthenium weed (Tudor et al., 1982) and tainting of milk, meat and honey have also been reported (Towers and Subba Rao, 1992; Taye, 2002).	
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. The importance value index (IVI) of parthenium weed remained at a maximum in both cropped and non-cropped areas across the seasons (Tiwari and Bisen, 1984). 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	**High (3)**

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. 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).	

4.3.1.2. Cumulative Risk Rating for Consequences of Introduction

The assessment of the Consequences of Introduction of Quarantine Pests has been summarized for each pest by summing the five Risk Elements to produce a Cumulative Risk Rating. This Cumulative Risk Rating is considered to be a biological indicator of the potential of the pest to establish, spread, and cause economic and environmental impacts. The cumulative Risk Rating should be interpreted as follows:

- **Low** **:** 5 - 8 points
- **Medium** **:** 9 - 12 points
- **High** **:** 13 - 15 points

A cumulative Risk Rating is then calculated by summing all risk element values. The values determined for the Consequences of Introduction for each pest are summarized in Table 8.

Table-8: Summary of Consequences of Introduction

Pest	Risk Element 1	Risk Element 2	Risk Element 3	Risk Element 4	Risk Element 5	Cumulative Risk Rating
Leptinotarsa decemlineata Say 1824 Order: **Coleoptera** Family:**Chrysomelidae**	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (14)
Delia platura (Meigen) Order: **Diptera** Family: **Anthomyiidae**	High (3)	High (3)	Medium (2)	High (3)	Medium (2)	High (13)
Synchytrium endobioticum (Schilb.) Percival Order: **Chytridiales** Family: **Synchytriaceae**	High (3)	Medium (2)	High (3)	High (3)	High (3)	High (14)
Phoma exigua var. *foveata* (Foister) Order: **Diaporthales** Family: **Valsaceae**	High (3)	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (11)
Fusarium sulphureum (Fr.) Sacc Order: **Hypocreales** Family: **Nectriaceae**	High (3)	High (3)	High (3)	Medium (2)	Medium (2)	High (13)
Phytophthora drechsleri Tucker Order: **Peronosporales**	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (14)

Pest	Risk Element 1	Risk Element 2	Risk Element 3	Risk Element 4	Risk Element 5	Cumulative Risk Rating
Family: **Pythiaceae**						
Phytophthora megasperma Drechsler Order: **Peronosporales** Family: **Pythiaceae**	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Polyscytalum pustulans (M.N. Owen & Wakef.) Order: **Polyporales** Family: **Meripilaceae**	Medium (2)	Low (1)	High (3)	High (3)	Medium (2)	Medium (11)
Clavibacter michiganensis subsp. *michiganensis* Order: **Actinomycetales** Family: **Microbacteriaceae**	Medium (2)	Medium (2)	High (3)	High (3)	Low (1)	Medium (11)
Ralstonia solanacearum (Smith, 1896) Order: **Burkholderiales** Family: **Burkholderiaceae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Globodera rostochiensis (Wollenweber) Order: **Tylenchida** Family: **Heteroderidae**	High (3)	Medium (2)	High (3)	High (3)	High (3)	High (14)
Globodera pallida (Stone) Behrens Order: **Tylenchida** Family: **Heteroderidae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Ditylenchus dipsaci (Kuehn) Filipjev Order: **Tylenchida** Family: **Anguinidae**	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (14)
Alfalfa mosaic virus (AMV) Family: **Bombiviridae**	High (3)	High (3)	High (3)	Medium (2)	Medium (2)	High (13)
Parthenium hysterophorus Order: **Asterales** Family: **Asteraceae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)

4.3.2. Assess Introduction Potential of Quarantine Pests

The potential of introduction is a function of the quantity of the commodity to be imported as well as the opportunity provided for the quarantine pests to survive pre and post harvest handling. The pest's opportunity is defined by six criteria that consider the potential for the pest survival along the pathway. These include the pest's opportunity to survive pre- and postharvest treatment and shipment, the possibility of avoiding detection at port of entry and the potential to find suitable host.

Sub-element 1- Quantity of commodity imported annually

The rating for the quantity imported annually is based on the amount of commodity expected to be imported. For qualitative import risk assessments, the amount of the commodity imported is estimated in units of standard 40-foot long shipping containers. The rating assigned is as follows:

Table 9: Showing the risk rating and value assigned to quantity of shipping containers imported annually

Quantity (Containers/year)	Rating	Rating value
<10	Low	1
10-100	Medium	2
>100	High	3

Approximately 98% of the potato produced in Bangladesh is propagated from imported seed potatoes. In 2012-13, Bangladesh imported potatoes 5211.6 tons of seed potatoes from Netherlands, Belgium and Germany (DAE, 2015) which amounts to 208 forty-foot shipping containers annually, considering 25 tons capacity for each container. The probability of all pest entering as a direct result of the quantity of the commodity being imported is therefore **high (3).** As there no potatoes were imported from India, but there is a great possibility to invade Parthernium weed from India through different kinds of agricultural products and other equipment importation across the land port into Bangladesh. Therefore, we can estimate that this weed could be entered into Bangladesh. Thus, the risk is rated **high (3)** in this sub-element.

Sub-element 2: Survive post harvest treatment

For two arthropod species, as for other species of *Delia*, seed dressing is an important control method, usually with bromophos (Hill, 1987). Trotus and Ghizdavu (1996) found that carbofuran, prometryn, imidacloprid and bifenthrin gave good control. The use of insecticides remains the most common means of controlling the *Leptinotarsa decemlineata* and, in many EPPO countries, such control is obligatory by law. Throughout the EPPO region where *L. decemlineata* is present, the beetle is considered not to be as important a pest of potato as previously. This is because effective plant protection products are available and the routine control of *L. decemlineata* has become incorporated into the established pattern of potato cultivation (EPPO/CABI, 1978). So, both *Delia platura* and *L. decemlineata* are rated **Low (1)** for this risk element.

For the fungi, *Synchytrium endobioticum* (Schilb.) Percival, chemical treatment of seed have had limited success (Peaden *et al.*, 1985), mainly because of internal infection. Recent work indicates that the pathogen may be eliminated from seed by temperature treatment (Huang *et al.*, 1994). But, temperature treatment with potato will be break potatoes. Therefore, they are rated to be **High (3)** for this risk element.

There are many measures to control the fungus such as *Phoma exigua* var. *foveata* (Foister), *Fusarium sulphureum* (Fr.) Sacc, *Phytophthora drechsleri* Tucker and *Phytophthora megasperma* Drechsler. Chemical control is one of the effective measures to prevent these species. For example, gangrene caused by *Phoma exigua* var. *foveata*. may be successfully controlled by chemical means (dips, fumigation and dusts) (Copeland & Logan, 1975; Carnegie *et al*., 1988), and disease incidence can be greatly reduced by judicious control of store temperatures. Effect of application timing of phosphonate on the control of *Phytophthora drechsleri*. When phosphonate was applied into the nutrient solution 4 days before inoculation with *Phytophthora drechsleri*, control efficacy was highest showing over 76% and 94% at 50ppm and 100ppm, respectively. They are rated to be **Medium (2)** for surviving post harvest treatment.

For skin spot disease (*Polyscytalum pustulans)***,** it could be controlled by chemical but its tolerance on tubers is 0.5% and its allowable surface area cover is 12.5% (SASA, 2007). As this is rated **Medium (2)** for this risk element.

Cutting, grading and handling of seed tubers are all measures employed in the post harvest management of potatoes, but are also ideal means of spreading ring rot (*Clavibacter michiganensis* subsp. *michiganensis*) within and between potato stocks. Tools and machinery used in these practices can also serve as reservoir for the ring rot bacterium. The bacterium can survive for at least a month on machinery and much longer if the machinery dries rapidly and is kept under dry conditions after contamination. Sharing equipment and machinery that is used to harvest, grade or process seed and ware potatoes therefore poses a very high risk of cross-infection between different growers. Ring rot can also survive and remain infectious for several years on potato bags, boxes, store walls and other surfaces that have been contaminated by rotting ooze even if exposed to temperatures well below zero (Rowe et. al). Though grading, lot inspection (purely physiological) and mandatory disinfection of tools and equipment use for harvest or in storage of potatoes are employed in Netherland and Canada, these methods have not proven to eliminate the risk of infested potatoes being exported. Additionally, potatoes stored for extended periods of time at cool temperatures as is the practice in Canada and Netherland only enhance the survival capabilities of the bacterium (Rowe et. al). The post harvest survival potential of the bacterium is therefore **high (3)**.

The control of bacterial wilt caused by *Ralstonia solanacearum* has proved to be very difficult, especially for race 1 with its broad host range. Chemical control is nearly impossible to apply. Soil fumigants showed either slight or no effects (Murakoshi & Takahashi, 1984). Antibiotics such as streptomycin, ampicillin, tetracycline and penicillin also showed hardly any effect (Farag *et al.*, 1982); in fact, streptomycin application increased the incidence of bacterial wilt in Egypt (Farag *et al.*, 1986). Biological control has been investigated, but is still in its infancy. Avirulent mutants of the bacterium have also been used in some studies (See Ciampi-Panno *et al.*, 1989; Gallardo & Panno, 1989; Hartman & Elphinstone, 1994). Several resistant cultivars of potato, as well as other crops, are available, but the race and strain diversity of the pathogen make it difficult to utilize these in different countries. Potato cultivars developed in Colombia with a *Solanum phureja* and *S. demissum* background showed resistance to *R. solanacearum* in seven countries (French, 1985; Hartman & Elphistone, 1994). This is rated **High (3)** for this risk element.

The potato golden cyst nematodes (*Globodera rostochiensis***)** are among the most difficult pests to control (Chitwood, 1951). Once established, they are difficult to eradicate because the potato cyst nematodes have one of the highest survival values for any organism, and can survive for over 30 years as eggs protected by the durable cyst wall (Chitwood, 1951; Winslow and Willis, 1972). Moreover, the build-up of nematode populations is slow, and their presence is not easily detected; once the nematode populations increase to high levels, drastic crop losses occur. This is rated **High (3)** for this risk element.

Both species of nematode are damaging pests to the potato industry and are difficult to control because cysts and juveniles of *Globodera pallida* and juveniles of *Ditylenchus dipsacci* can survive without their hosts and they are also internal nematode. Therefore, cleaning the soil from potato tubers does not control completely these species (CABI, 2006). So far, we have not had any treatment for post harvest potato tubers by chemical and other methods. Based on above mentioned information, they are rated **High (3)** for this risk element.

As there is no direct means of controlling the virus *Alfalfa mosaic virus* (AMV)), the method of control must either be aimed at the thrips vectors or involve the application of sanitation measures. Survive post harvest treatment of these viruses are rated to be **High (3).**

A range of herbicides including atrazine, dicamba, 2.4-D, picloram and glyphosate, all applied at high volume, have been employed successfully in Queensland, Australia (Haseler, 1976). However, chemical control over the enormous areas infested by parthenium weed in Queensland is economically unviable and non-sustainable (Parsons and Cuthbertson, 1992), as well as environmentally undesirable (Navie *et al.*, 1996). In India, the economics of spraying are even more untenable. Nevertheless, in Australia, spot spraying with atrazine plus a non-ionic surfactant is recommended as a pre-emergence treatment. Post-emergence control has been achieved with 2,4-D, often in combination with picloram (Navie et al., 1996), whilst low rates of glyphosate have proven to be effective in coffee plantations in Kenya (Njoroge, 1989). Based on above mentioned information, they are rated **High (3)** for this risk element.

Sub-element 3- Survival potential during shipment

Most seed potatoes are transported from Netherlands to Bangladesh by seaway. Therefore, the period of time taken for shipment through seaway from Netherlands to Chittagong Seaport of Bangladesh is about 25-30 days. Secondly, it is packed in wrapping (wooden boxes) and stored in normal conditions. So the pests could survive during transporting process. Therefore, all pests are rated **High (3)** for this risk sub-element. But from India, the Parthenium weed cab easily be entered into Bangladesh during trading of agricultural produces and machineries through cross boundary transportation. Therefore, this pest weed is rated **High (3)** for this risk sub-element.

Sub-element 4- Not are detected at the port of entry suitable for survival

The adult beetles of *Leptinotarsa decemlineata* can survive transportation with potato shipment situation in Britain (Bartlett, 1980). Therefore, in samples taken from large consignments of potatoes, adult *L. decemlineata* may remain undetected. This pest is rated **Low (1)** for this risk sub-element. Larvae of *Delia platura* may borne internally in roots; they are invisible and liable to disperse by going with roots in trade/transport for long distance movement (Hill 1987). This pest is rated **Medium (2)** for this risk sub-element.

Synchytrium endobioticum is one of the most important on potatoes, we can discover it through symptoms on the surface of tubers. However, the infected cell swells as the enclosed fungus forms a short-lived but quickly reproducing structure, the summer sporangium, from which numerous zoospores are released to infect neighbouring cells. It is rated to be **Medium (2).**

Tubers may carry a latent infection of *Phoma exigua* var. *foveata* in the periderm which cannot be detected by visual symptoms alone. If tubers are bruised and then incubated at a low temperature (5_0C), any latent infection should develop to give symptoms. It is rate to be **Medium (2).**

For *Fusarium sulphureum***,** extensive rotting causes the tissue to shrink and collapse, usually leaving a dark sunken area on the outside of the tuber and internal cavities. Yellow, white, or pink mold may be present. So, infected tubers caused by this fungus species could be easy to discover though symptoms on the surface of tubers. It is rated to be **Low (1).**

The Phytophthora blight pathogen is soilborne (Bisht and Nene, 1990) and it survives as chlamydospores (Sarkar, 1988) or in the form of oospores (Singh and Chauhan, 1992) in diseased crop debris. It is waterborne, but not seedborne (Reddy et al., 1998). Very little specific symptom information of *Phytophthora drechsleri* on tubers. Therefore, it is very difficult to detect at the port of entry, we estimate that it is rated **High (3)** for this risk element. According to Barr (1980), *Phytophthora megasperma* produced large oogonia (45-55µm) only when crossed with an isolate of the opposite mating type, but this size is still small and difficult to detect (http://www.jstor.org/pss/3793181). This pest is rated **High (3)** for this risk sub-element.

For *Polyscytalum pustulans* that causes a skin blemish disease of potato tubers. The symptoms are small, discrete, black or purplish pimples occurring singly or in groups on the tuber surface (French, 1976). Secondly, the size of these funguses is very small. In fact, it would be more difficult to discover. This pest is rated **High (3)** for this sub-element.

The conditions used in storage are similar to those used in shipping to prevent changes in the tuber’s physiological condition due to spoilage or sprouting. Appropriate temperature and relative humidity, adequate ventilation and treatment with sprouting inhibitor are employed during storage of potatoes. These conditions do not however inhibit the survival of the bacterium (*Clavibacter michiganensis* subsp. *michiganensis*); in fact, the ring rot bacterium is capable of surviving at temperatures well below freezing (Rowe *et al.*). The same article also reports that the bacterium survival is longest in cool dry temperatures. As previously mentioned, the positive test obtained on samples of potatoes imported from Netherland is evident that the bacterium can survive shipping conditions. This probability of risk rating is therefore **high (3)** for this sub-element.

The transport or storage will not reduce survival of *Ralstonia solanacearum* in infested fresh potato export consignments. However, possible development of the brown rot disease in potato tubers with latent infections of *R. solanacearum* at the time of testing in the country of origin may increase the probability of detecting diseased consignments in the import control. This probability of risk rating is therefore **high (3)**.

Potato golden cyst nematodes (*Globodera rostochiensis*), in common with other cyst nematodes, do not cause specific symptoms of infestation (CABI, 2006). In fact, potato tubers infested with potato cyst nematodes often go unrecognized. To be confident that these symptoms are caused by potato golden cyst nematodes and to give an indication of population density, soil samples must be taken or the females or cysts must be observed directly on the host roots. They are rated **High (3)** for this risk element.

As Potato tubers, bulbs, roots, stem, soil adhering potato tubers and transport means liable to carry *Globodera pallida* and *Ditylenchus dipsacci* so we can detect them at Port-of-Entry. However, the tiny cysts of *Globodera pallida* (0.5mm in diameter) and small juveniles of these nematode can easily escape unnoticed in the tuber eyes, or in soil that may adhere to tubers at harvest (Jon Pickup and *et al.*, 2002). They are rated **Medium (2)** for this risk element.

Alfalfa mosaic virus (AMV)) are latent diseases and only suitable hosts and vectors are infected viruses. They are rated to be **High (3).**

Parthenium hysterophorus is presumed to have entered India along with food grains imported from the USA (Vartak, 1968) and it has since spread to most of the sub-continent (Nath, 1988). It is thought to have entered Pakistan, Nepal and Bangladesh via road connections, where thousands of vehicles cross between India and these countries every day at several places. From the experience in India, Australia and Africa, it is clear that there is considerable risk of accidental introduction via crop or pasture seed and other possibilities. Hence, this pest is rated **high (3)** for this risk sub-element.

Sub-element 5- Imported or moved subsequently to an area with an environment suitable for survival

Major hosts of *Leptinotarsa decemlineata* (potato, tomato…) are grown in all agro-ecological zones in Bangladesh the ability to contact with an environment suitable for survival for this pest is **High (3)**. *Delia platura* is more popular in temperate areas (European country) (CABI, 2006), however, Vietnam is a tropical country. This pest is rated **Low (1)** for this risk sub-element. *Melolontha melolontha* appears mainly in template areas (European country) (CABI, 2006). This pest is rated **Medium (2)** for this risk sub-element.

The wart disease occur at all soil pH values, the optimum temperature range for infection is 12-14$_{o}$C. *Synchytrium endobioticum* can be survived in soil as resting sporangia for as long as 38 years, even through adverse condition. *S. endobioticum* is grown at optimum temperature range 12-14oC (CABI, 2006). This temperature is more or less similar with many of the agro-ecological zones of Bangladesh during winter. Therefore, these pest are rated **High (3)** for this risk element.

Phoma exigua var. *foveata*, *Fusarium sulphureum, Phytophthora drechsleri* and *Phytophthora megasperma* is probably found worldwide and could become established in many potato planting areas in the world, especially, warm, humid storage encourages diseases development (CABI, 2006). Therefore, most of the agro-ecological zones are the places have sub-tropical climate conditions suitable for survival of this fungus species. They are rated **High (3)** for this risk element.

Potato tubers from Netherlands and other EU countries are likely to be grown in every potato growing areas of in Bangladesh. Based on their known cool temperate regions destructions, it is estimated that climates would be suitable for *Polyscytalum pustulans* to establish permanent populations in North and North-West zones of Bangladesh. This pest is rated **Medium (2)** for this risk element.

Clavibacter michiganensis subsp. *sepedonicus* has a relatively low temperature optimum for growth (21°C) and is mainly confined to cooler areas of the world (EPPO, 1997). The traditional potato production areas in Bangladesh are in the winter season of the country, which can experience minimum temperatures as low as 14.1oC. Therefore, this bacterium is estimated to present a **Low (1)** risk of being moved to a habitat suitable for survival.

Ralstonia solanacearum is widespread in tropical, subtropical and warm temperate areas throughout the world. For the EPPO region, it is mainly race 3 which is of importance, since this so-called low-temperature strain is adapted to cooler climates in the highlands of the tropics and in the Mediterranean area (EPPO, 1978). High soil moisture and periods of wet weather or rainy seasons are associated with high disease severity (Nesmith & Jenkins, 1985). Slightly unfavourable weather conditions such as low temperatures influence symptom expression. Based on the interaction with climatic conditions, this bacterium is estimated to present a **High (3)** risk of being moved to a habitat suitable for survival.

The potato golden cyst nematode (*Globodera rostochiensis*) is recorded in the temperate regions of tropical countries, so it could be suitable climatic conditions in North and North-Western agro-ecological zones in Bangladesh for pest survival. This pest is rated **High (3)** for this risk element.

Bangladesh annual imported more than 100 containers per year of potato tubers and they are sold in every regions of Bangladesh. In other words, the climate condition in growing potato crop areas is adapted to these nematode (*Globodera pallida*, and *Ditylenchus dipsacci*). Therefore, these nematodes are estimated to present a **High (3)** risk of being moved to a habitat suitable for survival.

Alfalfa mosaic virus (AMV) is the important virus on potatoes in the world. This virus has a wide hosts range and transmitted via seed. Seed transmission is often regarded as being important in establishing primary infections from which there is secondary transmission by aphid vectors or nematodes (*Longidorus* sp.). In Bangladesh, under sub-tropical condition suitable for survival. This virus could become established in all the agro-ecological zones in Bangladesh. Therefore, they are rated to be **High (3)** for risk element.

Parthenium weed is an aggressive colonizer of disturbed ground, able to germinate, grow and flower over a wide range of temperatures and photoperiods. It occurs in the humid and sub-humid tropics, showing a marked preference for black, alkaline, cracking, clay soils of high fertility, but is able to grow on wide variety of soil types from sea level up to 1800 m (Evans, 1987a). Mahadevappa (1997) noted that parthenium weed has several built-in properties and efficient behavioural mechanisms that enable it to overcome many ecological adversities and thus continue to survive under stress. Areas receiving less than 500 mm of rainfall are probably unsuitable, although the weed has strong adaptive methods to tolerate both moisture stress (Kohli and Rani, 1994) and saline conditions (Hegde and Patil, 1982). The weed finds access to any type of land but it is especially prolific in disturbed habitats, for example, roadsides and railway tracks, stock yards, around buildings and on waste land, from where it spreads and invades agricultural systems. Therefore, most of the agro-ecological zones are the places have sub-tropical climate conditions suitable for survival of this weed species. They are rated **High (3)** for this risk element.

Sub-element 6- Come into contact with host material suitable for reproduction

Once the adults of *Leptinotarsa decemlineata* have colonized the field, the overwintered beetles first feed and then oviposit within 5-6 days depending on temperature. A single female is capable of producing ca. 600 eggs. Overwintered adults live for one-two months after colonizing host plants in the spring. [http://resistance.potatobeetle.org]. The suitable hosts (potatoes, tomato, eggplants) are available in almost all agro-ecological zones in Bangladesh. This pest is rated **High (3)** for this risk sub-element.

Delia platura maggot is extremely polyphagous (more than 40 host plants). In Bangladesh, this species could become established in many suitable host plants for their reproduction. Therefore, *Delia platura* is estimated to present a **High (3)** risk of being moved to a host suitable for survival.

Solanum tuberosum is the major host plant of *Synchytrium endobioticum, P. exigua* var. *foveata, Fusarium sulphureum, Phytophthora drechsleri,* and *Phytophthora megasperma*, especially storage potatoes. On the other hand, *Solanum tuberosum* distributed widely in most of the agro-ecological zones of Bangladesh where there are many other host plants (tomato, eggplant, tobacco, etc) suitable for reproduction of these species of fungi. On the other hand, there are many host plants suitable for reproduction such as *Cucumis melo, Cucurbita (pumpkin), Allium cepa,* etc. Risk of these species of fungi coming into contact with host material suitable for reproduction therefore are estimated to be **High (3),** except for *Polyscytalum pustulans* which have a limited capacity for natural dispersal, therefore, they are considered to have a **Medium (2)** risk of coming into contact with host material via this pathway.

Imported potato seeds are sold throughout Bangladesh. Latently infected potatoes by *Clavibacter michigansis* subsp*. michigansis* and *Ralstonia solanacearum* may present a risk if they come into contact with potential host (primarily potato). The seed tubers may be stored and handled together and in effect increase spread of the pathogen in a lot of potatoes. Seed potatoes used for planting in Bangladesh are also the major parts from imports. Therefore, the risk rating for both of these bacteria is **high (3).**

The most important host of the golden nematode (*Globodera rostochiensis*) is potato. According to the EPPO quarantine pest datasheet (EPPO/CABI, 1978), seed potato is the main means by which the cyst is introduced into new areas. With Bangladesh's reliance on imported seed potato and its wide distribution into the potato growing areas of the country, it is expected that the nematode cyst once introduced will find suitable host. The risk rating is therefore **high (3).**

Potato is a suitable host of *Globodera pallida*, and *Ditylenchus dipsacci*. Besides that, many other host plants among families Sonalaceae, Fabaceae, Brassicaceae, Asteraceae etc. (such as tomato, aubergine, onion, garlic, and so on) are also grown popularly in Vietnam. Therefore, they are considered to have a **High (3)** risk of coming into contact with host material via this pathway.

Alfalfa mosaic virus (*AMV*) have a wide host range suitable for reproduction. Natural plant hosts of AMV include many crops and weed species (Harrison, 1957; 1958b; Smith and Short, 1959; Calvert and Harrison, 1963; Schmelzer, 1963; Hollings, 1965) such as hop, cotton, tomato, Lucerne. The hosts always exist in Bangladesh. They are rated to be **High (3)** for this risk element.

In Australia, parthenium weed germinates mainly in spring and early summer. It produces flowers and seeds throughout its life and dies in late autumn (Navie et al., 1996). It is a prolific seed producer (15,000-25,000 achenes per plant) (Haseler, 1976; Navie et al., 1996; Mahadevappa, 1997), and can grow at any time of the year as long as there is moisture (Tamado, 2001; Taye, 2002) and continues to flower and fruit until senescence. The longevity of surface-lying seeds seems to be short with little or no dormancy, but there is evidence that buried achenes can remain viable for at least 4-6 years (Navie *et al.*, 1996), and Navie *et al.*, (1998) estimated the half-life of buried seed to be about 6 years. Whereas Tamado et al. (2002) reported that the viability of the seeds was greater than 50% after 26 months of burial in the soil, indicating the potential build-up of a substantial and persistent soil seed bank. Therefore, this weed pest is rated to be **High (3)** for this risk sub-element.

Summary of Cumulative Risk Rating for Potential of Introduction

The assessment of the Potential of Introduction of Quarantine Pests has been summarized for each pest by summing the six Sub-elements to produce a Cumulative Risk Rating for Potential of Introduction. The cumulative Risk Rating should be interpreted as follows:

- **Low** **:** 6 - 9 points
- **Medium** **:** 10 - 14 points
- **High** **:** 15 - 18 points

A cumulative Risk Rating for Potential of Introduction is then calculated by summing all risk Sub-element values. The values determined for the Potential of Introduction for each pest are summarized in Table 10.

Table-10: Risk Rating for Potential of Introduction of Quarantine Pests

Pest	Sub-Element 1	Sub-Element 2	Sub-Element 3	Sub-Element 4	Sub-Element 5	Sub-Element 6	Cumulative Risk Rating
Leptinotarsa decemlineata Say 1824 Order: **Coleoptera** Family:**Chrysomelidae**	High (3)	Low (1)	High (3)	Low (1)	High (3)	High (3)	High (14)
Delia platura (Meigen) Order: **Diptera** Family: **Anthomyiidae**	High (3)	Low (1)	High (3)	Medium (2)	Medium (2)	High (3)	High (14)
Synchytrium endobioticum (Schilb.) Percival Order: **Chytridiales** Family: **Synchytriaceae**	High (3)	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (16)
Phoma exigua var. *foveata* (Foister) Order: **Diaporthales** Family: **Valsaceae**	High (3)	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	High (16)
Fusarium sulphureum (Fr.) Sacc Order: **Hypocreales** Family: **Nectriaceae**	High (3)	Medium (2)	High (3)	Low (1)	High (3)	High (3)	High (15)
Phytophthora drechsleri Tucker Order: **Peronosporales** Family: **Pythiaceae**	High (3)	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (17)
Phytophthora megasperma Drechsler Order: **Peronosporales** Family: **Pythiaceae**	High (3)	Medium (2)	High (3)	High (3)	High (3)	High (3)	High (17)
Polyscytalum pustulans (M.N. Owen & Wakef.) Order: **Polyporales** Family: **Meripilaceae**	High (3)	Medium (2)	High (3)	High (3)	Medium (2)	Medium (2)	High (15)
Clavibacter michiganensis subsp. *michiganensis* Order: **Actinomycetales** Family: **Microbacteriaceae**	High (3)	High (3)	High (3)	High (3)	Low (1)	High (3)	High (16)

Pest	Sub-Element 1	Sub-Element 2	Sub-Element 3	Sub-Element 4	Sub-Element 5	Sub-Element 6	Cumulative Risk Rating
Ralstonia solanacearum (Smith, 1896) Order: **Burkholderiales** Family: **Burkholderiaceae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (18)
Globodera rostochiensis (Wollenweber) Order: **Tylenchida** Family: **Heteroderidae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (18)
Globodera pallida (Stone) Behrens Order: **Tylenchida** Family: **Heteroderidae**	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (17)
Ditylenchus dipsaci (Kuehn) Order: **Tylenchida** Family: **Anguinidae**	High (3)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (17)
Alfalfa mosaic virus (AMV) Family: **Bombiviridae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (18)
Parthenium hysterophorus L. Order: **Asterales** Family: **Asteraceae**	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (18)

4.4. Conclusion: Pest Risk Potential and Pests Requiring Phytosanitary Measures

The Pest Risk Assessment (PRA) is based on the International Standard for Phytosanitary Measures No 11 (2004) and the PRA scheme developed by European and Mediterranean Organization (1997).
To estimate the pest risk potential for each pest, the cumulative risk rating for the Consequences of Introduction and Potential of Introduction is summed. The risk potential ratings are assigned as follows:

Low **:** 11-18 points
Medium **:** 19-26 points
High **:** 27-33 points

Table11: The Overall Pest Risk Potential Rating

Pest	Consequences of Introduction	Potential of Introduction	Pest Risk Potential
Leptinotarsa decemlineata Say 1824 Order: **Coleoptera** Family:**Chrysomelidae**	High (14)	High (14)	High (28)
Delia platura (Meigen) Order: **Diptera** Family: **Anthomyiidae**	High (13)	High (14)	High (27)
Synchytrium endobioticum (Schilb.) Percival Order: **Chytridiales** Family: **Synchytriaceae**	High (14)	High (16)	High (30)
Phoma exigua var. *foveata* (Foister) Order: **Diaporthales** Family: **Valsaceae**	Medium (11)	High (16)	High (27)
Fusarium sulphureum (Fr.) Sacc Order: **Hypocreales** Family: **Nectriaceae**	High (13)	High (15)	High (28)
Phytophthora drechsleri Tucker Order: **Peronosporales** Family: **Pythiaceae**	High (14)	High (17)	High (31)
Phytophthora megasperma Drechsler Order: **Peronosporales** Family: **Pythiaceae**	Medium (12)	High (17)	High (29)
Polyscytalum pustulans (M.N. Owen & Wakef.) Order: **Polyporales** Family: **Meripilaceae**	Medium (11)	High (15)	Medium (26)
Clavibacter michiganensis subsp. *michiganensis* Order: **Actinomycetales** Family: **Microbacteriaceae**	Medium (11)	Medium (16)	High (27)
Ralstonia solanacearum (Smith, 1896) Order: **Burkholderiales** Family: **Burkholderiaceae**	High (15)	High (18)	High (33)
Globodera rostochiensis (Wollenweber) Order: **Tylenchida** Family: **Heteroderidae**	High (14)	High (18)	High (32)
Globodera pallida (Stone) Behrens Order: **Tylenchida** Family: **Heteroderidae**	High (15)	High (17)	High (32)
Ditylenchus dipsaci (Kuehn) Filipjev Order: **Tylenchida**	High (14)	High (17)	High (31)

Pest	Consequences of Introduction	Potential of Introduction	Pest Risk Potential
Family: **Anguinidae**			
Alfalfa mosaic virus (AMV) Family: **Bombiviridae**	High (13)	High (18)	High (31)
Parthenium hysterophorus L. Order: **Asterales** Family: **Asteraceae**	High (15)	High (18)	High (33)

Potential ratings:

- **- Low** : Pest will typically not require specific mitigations measures;
- **- Medium** : Specific phytosanitary measure may be necessary.
- **- High** : Specific phytosanitary measures are strongly recommended. Port-of-entry inspection is not considered sufficient to provide phytosanitary security.

Identification and selection of appropriate sanitary and phytosanitary measures to mitigate risk for pests with particular Pest Risk Potential ratings is undertaken as part of the risk management phase.

From the quantitatively risk analysts of quarantine pests likely to be associated and follow the seed Potatoes pathway to Bangladesh from the Netherlands, Belgium, Germany, Denmark, other EU countries and USA, the following pests (15) were identified as having high (14) and medium (1) unmitigated risk potential:

There are 14 pests with **High** risk rate:

Arthropods

Leptinotarsa decemlineata Say 1824

Delia platura (Meigen)

Fungi

Synchytrium endobioticum (Schilb.) Percival
Phoma exigua var. *foveata* (Foister)
Fusarium sulphureum (Fr.) Sacc
Phytophthora drechsleri Tucker
Phytophthora megasperma Drechsler

Bacteria

Clavibacter michiganensis subsp. *michiganensis*
Ralstonia solanacearum (Smith, 1896)

Nematode

Globodera rostochinensis (Wollenweder)
Globodera pallida (Stone, 1973) Behrens 1975
Ditylenchus dipsaci (Kuchn, 1857) Filijev, 1936

Virus

Alfalfa Mosaic Virus (AMV)

Weed

Parthenium hysterophorus L.

There is 1 pest with **Medium** risk rate:

Fungi

Polyscytalum pustulans (M.N. Owen & Makef) M.B. Ellis

4.5. Uncertainty

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

There is a major uncertainty concern regarding the prevalence of above mentioned high and medium risk rated insect pests, diseases and weed of potatoes in the Netherlands, Belgium, Germany, Denmark and USA potato export.

The assessment should have included information on export volumes and frequency to other countries, the average size of export lots, the number of lots found infested with pests of potato in the importing countries, and preferably, any information on incidence level in potato pests infested potato consignments or lots would be valuable.

Thus, the assessment of uncertainties and assumptions for each organism often covers similar areas of information or lack of information, with key factors or variables being relevant across different organism groups. The following sections (4.5.1-4.5.5) outline these considerations. The uncertainties and assumptions are covered in these sections rather than individually in each pest risk assessment.

4.5.1. Uncertainties and assumptions around hazard biology

- The Colorado potato beetle (*Leptinotarsa decemlineata*) is a well known hitch-hiker species, and has been associated with *Solanum tuberosum* in the United States of America. But the seed potato tubers were imported from USA only one time in the fiscal year 2013-14. Currently there are no data demonstrating this association between this hitch-hiker pest and the pathway imported from USA. Interception data rather than biological information would be required to clarify this issue.
- The biology of insects that have been reared in the laboratory for several generations is often different to wild counterparts established in greenhouses or in field conditions (Mangan & Hallman 1998). Aspects such as life cycle, preovipositional period, fecundity and flight ability (Chambers 1977), as well as cold or heat tolerance can be influenced by the highly controlled laboratory environment. Laboratory reared insects may differ in their responses to environmental stress and exhibit tolerances that are exaggerated or reduced when compared with wild relatives. For example longevity and fecundity of adult *Aphis gossypii* in a greenhouse was longer and higher than those in a growth chamber with similar conditions (Kim & Kim 2004).
- If a pest species occurs in Bangladesh often its full host range, or behaviour in the colonised environment remains patchy. It is difficult to predict how a species will behave in a new environment, particularly if it has not become established as a pest elsewhere outside its natural range. Therefore there will be considerable uncertainty around the likelihood of an organism colonising new hosts or the consequences of its establishment and spread on the natural environment. Where indigenous plants are discussed as potential hosts this is extrapolated from the host range (at genus and family level) overseas and is not intended as a definitive list.
- There was no evidence of occurrence and record for potato cyst nematode, black wart, Potato Virus X in the potato field of Bangladesh. Therefore, interception data rather than information on occurrence of these pests would be required to clarify this issue.

4.5.2. Uncertainty and assumptions around ecological races of the pests

- There are distinct temperature requirements for optimum disease development and reproduction for the different races (biovars) of brown rot causing bacterium, *Ralstonia solanacearum* (Swanepol, 1990). The race 1 of this species affecting tobacco, tomatoes, potatoes, aubergines, diploid bananas and many other (solanaceous) crops and weeds, with high growth temperature optimum (35-37°C). Race 2 affecting triploid bananas (causing Moko disease) and *Heliconia* spp., with high temperature optimum (35-37°C).

Race 3 affecting mainly potatoes and tomatoes without a high virulence on other solanaceous crops, with lower temperature optimum (27°C) (Buddenhagen *et al.,* 1962). Therefore, the molecular data on biovar detection rather than occurrence of biological information would be required to clarify this issue.

4.5.3 Assumption around transit time of potato on the Sea Pathway

- An assumption is made around the transit time the potato tuber takes to get from the field in the Netherlands, or Belgium, or Germany or Denmark or USA to Bangladesh ready for wholesale if it is transported by Sea shipment. It is assumed that harvesting and packing of potato tubers will take up to two days that transport of the commodity to the seaport could take up to one day, and then transit to Bangladesh could take up to 25 days and into distribution areas could also take up to two days. In total it is assumed that transport of seed potatoes from the Netherlands, or Belgium, or Germany or Denmark or USA by sea will take at least 30 days to reach Bangladesh.

4.5.4. Further work that would reduce uncertainties

Section of PRA	Uncertainties	Further work that would reduce uncertainties
Taxonomy	None	
Pathway	Presence of a pathway from imported produce to suitable protected environments, such as botanical gardens.	• Monitor all suitable protected environments which are near points of entry of infested produce. • Check reports of finds by other EU countries
Distribution	None	-
Hosts	None	-
Establishment	Establishment potential under glasshouse in the PRA area.	Continue to monitor the literature for reports of establishment in protected environments.
Spread	Rate of potential spread in areas at risk within the PRA area	Continue to monitor the literature for reports on ability to spread.
Impact	Potential to cause damage in protected environments	Continue to monitor the literature for reports on damage caused in protected environments
Management	None	-

CHPTER 5

PRA STAGE 3: PEST RISK MANAGEMENT

5.1. Risk Management Options

For each organism classified as having a high pest risk potential, risk management /mitigation options are proposed, which identifies the options available for managing the risk. In addition to the options presented, feedback is sought from stakeholders on these options through consultations. The risk analysis is then finalized following consultations and will present options, refined if appropriate, for the phytosanitary measures to be considered. Measures are recommended to the Chief Plant Quarantine Officer for decision once the measures are deemed to be appropriate.

5.1.1. 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. The use of resistant potato varieties, for example, was successful in the complete control of golden nematode (USDA, 2003).

ii. **Chemical spray program**: Pre-harvest chemical sprays may be used to control pests within production fields, for example, the use of nematicides to control the golden nematode.

iii. **Seed handling**: Before handling seed tubers, all containers, tools, knives and mechanical cutters, planters, and other equipment should be thoroughly washed with a detergent solution, rinsed, and then sanitized with a disinfectant. When cutting seed tubers, the cutting tool should be periodically washed and sanitized. It is essential that this should be done before cutting seed tubers from a different source. To be effective, disinfectants must be present for a minimum of 10 minutes (preferably 20–30 minutes) on any surface being treated (Rowe *et al.*).

iv. **Crop rotation**: Certain 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 potato plant debris, or in a living form in surviving potato tubers. On occasion, diseased tubers survive the winter and grow the following spring as diseased volunteer plants. These volunteer potatoes are a source of contamination for the current season crops. A three to four year rotation to minimize soil disease problems is recommended (Western Potato Council, 2003).

v. **Control of Insects**: Sucking and chewing insects may transmit many diseases. For example the ring rot disease was found to be transmitted by the Colorado potato beetle, leafhoppers and aphids (EPPO, 1997). The control of these insects and the rouging of infected plants as early as possible may prevent spread of diseases in the field (Western Potato Council, 2003).

vi. **Irrigation practices and soil type**: A well drained soil is recommended for planting of potatoes as this make conditions less favourable to disease infection (Johnson, 1969). Over irrigation and a poorly drained soil increases the susceptibility to diseases such as powdery scab. The type of irrigation system may also aid in the transmission of some diseases (Western Potato Council, 2003).

vii. **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 potato production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of diseases detected.

5.1.2. Post-harvest Management Options

i. **Sanitization of equipment and material**: All machinery, transport and storage surfaces that the seed will contact should be cleaned and disinfected prior to receiving new potato. Sanitation consists of cleaning and disinfecting all equipment, storage, tools and pallet boxes that contact the seed and ware potatoes. 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 (Western Potato Council, 2003).
ii. **Disposal of infected tuber**: All infected tuber should be discarded away from production site (Rowe *et. al*).
iii. **Bruise prevention**: Potato tubers bruise easily during harvest in certain conditions. Soil and tuber conditions, as well as harvester operation are likely to influence bruising. Therefore, bruise of potato tubers should be prevented during harvest.
iv. **Seed storage**: Potato should be stored at 3-5oC with 95% RH. The condition of the potato piles should be checked periodically to ensure temperature and relative humidity are maintained. This is important to minimize disease development. Access to the storage should be restricted to reduce potential for introducing diseases (Western Potato Council, 2003).
v. **Seed grading**: The class and variety of potatoes must be kept separate through harvesting, grading and storage. Grading must be done according to class, variety and disease tolerance. The class of potatoes must clearly identifiable and labeled.

5.1.3. 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).

   Potatoes grown in an area that has not been determined to be free of high risk pests would be required to be grown in approved production sites registered with the National Plant Protection Organization (NPPO) of the Netherlands, Belgium, Germany, Denmark and USA. Initial approval of the production sites would be completed jointly by the NPPO of exporting countries and Plant Quarantine Wing (PQW) under the Department of Agriculture Extension (DAE) of Bangladesh. Thus, Bangladesh must require from importing countries that potatoes be produced in a pest free area. This will ensure that the specific pests of concern are removed from the pathway. This measure is highly effective where it is feasible to implement.
ii. **Stipulated commercial grade for potatoes**: This ensures a certain level of quality and cleanliness which results from commercial handling. This is a significant measure for pests that affect quality or associated with contaminants (eg. soil). Bangladesh should therefore make request for a certain grade of potato that reflects the acceptable tolerance level of the country.
iii. **Accept only certified seed potato for crop production**: This measure is highly effective in mitigating pest risk, because it ensures the absence of specific pests, particularly pathogens, or a defined low prevalence of pests at planting. The main components of seed potato certification include: sampling and testing of production areas to ensure free from nematodes; approval of land and seed to be multiplied; inspection of crops for variety purity and crop health; sampling and testing for presence of viruses; formal classification of seed crops; inspection of tuber samples; and sealing and labeling of certified seed. Potatoes to be imported from the Netherlands, Germany, Denmark, Belgium, USA and other EU countries should be sourced from an officially recognized seed certification system.

iv. **Shipments traceable to place of origin in exporting countries**: A requirement that potatoes 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 which are insect pests with high risk potential (*Leptinotarsa decemlineata* Say or *Delia platura* or all) are found during inspection, the consignment may be treated by pure (100%) methyl bromide (CH_3Br) at 48g/m$_3$/2 hours. Beside, at 21-25$_o$C temperature, these insects can be treated by methyl bromide fumigation at 15-18g/m$_3$ in 5 – 6 hours (EPPO, 1998, www.eppo.org/Meetings/2006_meetings/treatments.htm).

   In case of other quarantine pests which cause diseases with high risk potential (*Synchytrium endobioticum, Phoma exigua* var. *foveata, Fusarium sulphureum, Phytophthora drechsleri, Phytophthora megasperma, Clavibacter michiganensis* subsp. *michiganensis, Ralstonia solanacearum, Globodera rostochinensis, Globodera pallid, Ditylenchus dipsaci, Alfalfa Mosaic Virus (AMV)*) are found during inspection, the consignment should not be exported to Bangladesh.

vi. **Requirement of phytosanitary certification from country of origin:** The phytopathological service of the country of origin should ensure the potato from which the consignment is derived was not grown in the vicinity of unhealthy potato crops and was inspected by a duly authorized official/phytopathological service and the seed potatoes have been produced in areas within the country free from all pests and diseases.

vii. **Port-of-entry inspection and treatment**: Upon arrival in the Bangladesh, each consignment of potato should be inspected to detect pests, with export phytosanitary certificate and seed certificate. Sampling of potato consignments at port-of-entry in Bangladesh should combine visual inspection and laboratory testing. Visual inspection is useful to verify that certain phytosanitary certification requirements have been met and consignment is generally free of contaminants. The efficacy of this measure depends on the statistical level of sampling and the ability to detect the pests or article of concern (eg. soil). Laboratory testing requires that a portion of each sample taken for inspection be subjected to laboratory analysis for the detection of pathogens.

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

viii. Phytosanitary measure for pests with medium risk rate

Low Pest Prevalence Area: Area of low pest prevalence is an area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures (IPPC, 1999).

Any protocol for establishing and maintaining an area of low pest prevalence also should include a pest-reporting procedure and emergency action plan to address target pest detections in the pest-free or low-prevalence zones (IPPC, 1999, 2005a). For pest species (*Polyscytalum pustulans*) rated at the medium risk apply measures to minimize risk (ISPM, 2005) as follows:

- Field

- Variety grown - some are more resistant than others
- Sow at a time to harvest before pests are economic - pest avoidance
- Pest control mehtods - reduce pest level

- Harvest

- Harvest when pests are not present, or when at low level - pest monitoring required

- Select only healthy plants
- Isolate harvested material to avoid re-infection

- Grading

- Acceps only unsymptom/unblemished product
- Remove any infected material
- Clean commodity before packing - brushing, waxing etc

- Packing

- Identify individual producers on the packs - grower registration
- Isolate packing area to avoid re-infestation
- Isolate commodity after packing to avoid re-infestation - cool rooms

- Treatment

- Treatments to be conducted in accordance with importers requirements
- Specified treatment of the consignment - such treatments are applied post-harvest and could include chemical, thermal, irradiation or other physical methods
- Dispactch or storage to avoid re-infestation
- Certificate of treatment on inspection for free this pest.

- Entry inspection

- Inspection to level trquired to detec pest to required confidence limits
- Audit of documentation
- Feedback in case of non-compliance

Combined with inspection, effective integrated pest management (IPM) programs would be a possible mitigation option.

5.2 Risk Management Conclusions

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

CHAPTER 6

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MYcÖRvZš¿x evsjv‡`k miKvi

Kwl.m¤cÖmviY Awa`ßi

evsjv‡`k dvB‡Uvm¨vwbUvix mÿgZv kw³kvjxKiY cÖKí

Dw™¢` msiÿY DBs, Lvgvievox, dvg©‡MU, XvKv|

‡dvbt 9103774|

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh under Strengthening Phytosanitary Capacity in Bangladesh

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‡mU-1: Avjy Pvl‡`i R‡b¨ Rwic ckœvejx

‡KvW:					‡gvevBj ‡dvb											

A.0 Avjy Pvlxi e¨w³MZ Z_¨vw`t

A.1 DËi`vZvi bvg: --

A.2 Mvg -- **A.3** Kwl.eK: --

A.4 Dc‡Rjv: -- **A.5** ‡Rjv: --

A.6 wk¶vMZ thvM¨Zv: ------------------------------------- **A.7** eqm: --------------------------------------- |

A.8 ‡ckvMZ:[‡KvW: 1=eo Pvlx, 2=ga¨g Pvlx, 3=ÿz`ª Pvlx] **A.9** wj½: (‡KvW: 1=cyiæl, 2=gwnjv) ☐

B.0 আলুর আবাদ ও পি.আর.এ সংক্রান্ত তথ্যাবলিt

B.1 DËi`vZvi e¨eüZ Rwgi aiY/ cKvZ:

Avjy Pv‡l e¨eüZ Rwgi aiY	Rwgi cwigvY (kZvsk)
1. G eQi Avjy Pvl K‡i‡Qb Ggb Rwgi cwigvb ejyb?	
2. Ab¨ dm‡ji Zzjbvq GeQi Avjy Pv‡l wb‡qvwRZ Rwgi AvbycvwZK kZKiv cwigvb (%) ejyb	
3. KZ ermi hver Avjy Pvl K‡ib?	

B.2 Avcwb GeQi †Kvb R¨v‡Zi AvjyPvl K‡i‡Qb, `qv K‡i ej‡eb wK?

PvlKZ/e¨eüZ Avjy RvZ	wewfbœ R¨v‡Zi Avjy PvlKZ Rwgi cwigvY (kZvsk)	Drcv`b (e¯'v/GKi*)
1.		
2.		
3.		
4.		
5.		
6.		
7.		

*1 e¯'v = 85 ‡KwR

B.3 *Rwg Ges ¸`v‡g Avjy¯^xRi Rv‡Zi cwZ ¶wZKi ‡cvKvgvKo, ‡ivM-evjvB* এবং আগাছার সংবেদনশীল প্রতিক্রিয়া †Kgb?

bs	Avjy¯^xRi Rv‡Zi bvg	hvi cwZ ms‡e`bkxj (‡KvW: 1=¶wZKi ‡cvKvgvKo, 2=‡ivM-evjvB, 3=AvMvQv, 4=‡cvKvgvKo I ‡ivM, 5=AvMvQv I †ivM, 6=‡KvbUvB bv)| kb¨ v‡b ‡KvW b¤^i wjLyb|	
1.	ewi Avjy-1 (nxiv)		
2.	ewi Avjy-4 (AvBjmv)		
3.	ewi Avjy-7 (Wvqvg›U)		
4.	ewi Avjy-8 (KwWbvj)		
5.	ewi Avjy-11 (PgK)		
6.	ewi Avjy-12 (axiv)		
7.	ewi Avjy-13 (Mv‡bvjv)		
8.	ewi Avjy-15 (we‡bjv)		
9.	ewi Avjy-16 (Awi›`v)		
10.	ewi Avjy-17 (ivRv)		
11.	ewi Avjy-18 (evivKv)		
12.	ewi Avjy-19 (wešœ)		
13.	ewi Avjy-20 (Rvijv)		
14.	¸o¸wo		
15.	jvj-cvLwi		
16.	wkj wejvZx		
17.	‡gwiÛv		
18.	ewi wUwcGm -1		
19.	ewi wUwcGm -2		
20.	bZzb Avg`vbxKZ.exR Avj¸		
21.	Ab¨vb¨ (hw` _v‡K)-------------		

B.4 *Avjy¯^ P‡li R‡b¨ mvavi YZ: ‡Kvb ‡Kvb Drm ‡_‡K exRAvjy*সমূহ ক্রয় করেন?

Drmmgn	DË‡ii aiY (‡KvW: n¨vu=1, bv=2)|	
1. wb‡Ri Avjy		
2. cwZ‡ekx KIK KvQ †_‡K		
3. weGwWwm exR		
4. Ab¨ ‡Kvb ‡Kv¤úvbxi exR		
5. ¯'vbxq exR Drcv`bKvix		
6. mivmwi Avg`vbxKvi‡Ki wbKU ‡_‡K		
7. wewfb M‡elbv cwZôvb		
8. GbwRI		
9. AvjyexR e¨emvqx		
10. Ab¨vb¨ (hw` _v‡K)-----------		

B.5 gvVchv‡q Avjy ¶wZKi ‡cvKvgvK‡oi Dcw¯wZ Ges Dc`‡ei aiY/ Ae¯v ‡Kgb? (`qv K‡i Lvjx N‡i msL¨v wjLyb)

bs	‡cvKvi bvg	পোকার আক্রমনের অবস্থা: (‡KvW: gvÎv (‡ekx ÿwZKi) †cvKv=1, ‡MŠY ‡cvKv (A_©‰bwZK ÿwZKi bq)=2, এই পোকার আক্রমন হয় না=৩)।	
1	Rve †cvKv (Aphid)		
2	KvUB ‡cvKv (Cutworm)		
3	Avjy myZjx ‡cvKv (Potato tuber worm)		
4	cvZv dwos (leafhopper)		
5	wPÂ evM (Chinch bug)		
6	cvZv myo½Kvix ‡cvKv (Leaf miner)		
7	ফিল্ড ক্রিকেট (Field cricket)		
8	DiPzv (Mole cricket)		
9	Ab¨vb¨ (hw` _v‡K)		

B.6 Avcbvi GjvKvq ¸`v‡g AwbóKvix ‡cvKv I B`yiRvZxq cvbxi Dc`‡ei Ae¯wK? (`qv K‡i Lvjx N‡i msL¨v wjLyb)

bs	evjvB‡qi bvg	পোকা/ইদুঁর জাতীয় প্রানীর আক্রম‡bi Ae¯v: [‡KvW: gvÎv (‡ekx ÿwZKi) evjvB=1, ‡MŠY evjvB (A_©‰bwZK ÿwZKi bq)=2, এই বালাইয়ের আক্রমন হয় না=৩]।	
1	Avjy myZjx ‡cvKv		
2	B`yi		
3	kRviæ		
4	cvwL		
5	Ab¨vb¨ (hw` _v‡K)		

B.7 gv‡V Avjy Mv‡Qi ‡Kvb chvq I অংশ ক্ষতিকর পোকা দ্বারা আক্রান্ত হ**q** এবং আক্রমনের তীব্রতা কেমন? **(Lvjx N‡i msL¨v wjLyb)**

bs	‡cvKvi bvg	¶wZKi KxUcZ‡½i cwZ Avjy SzuKc~Y© avcmgn [†KvW: 1=Pvix, 2=evoš MvQ, 3=Avjy K›` e„×i chvq]।	Mv‡Qi Ask hv ÿwZKi পোকা দ্বারা আক্রান্ত হয় (‡KvW: 1=AvjyMv‡Qi cvZv, 2=KvÛ, 3=Avjy K›`, 4=wkKo)।	আক্রমনের তীব্রতা (‡KvW: 1=Lye ‡ekx, 2=‡ekx, 3=ga¨g, 4=Kg, 5=Lye Kg আক্রমন হয়)
1	Rve †cvKv (Aphid)			
2	KvUB ‡cvKv (Cutworm)			
3	Avjy myZjx ‡cvKv (Potato tuber worm)			
4	cvZv dwos (leafhopper)			
5	wPÂ evM (Chinch bug)			
6	cvZv myo½Kvix ‡cvKv (Leaf miner)			
7	ফিল্ড ক্রিকেট (Field cricket)			
8	DiPzv (Mole cricket)			
9	Ab¨vb¨ (hw` _v‡K)			

B.8 Avcbvi GjvKvq Avjy‡Z Kjv‡i‡Wv c‡U‡Uv weUj-এর উপস্থিতি/আক্রমন হয় কি? (‡KvW: n¨uv=1, bv=2)।

B.9 hw` DËi n¨uvnq, Zvn‡j

K. D³ ‡cvKv Mv‡Qi ‡Kvb ধাপে আক্রমন করে? উল্লেখ করুন:

(‡KvW: 1=Pvix, 2=evoš MvQ, 3=Avjy K›` e„×i chvq)।

L. D³ পোকা গাছের কোন কোন অংশে আক্রমন করে? উল্লেখ করুন:

(‡KvW: 1=AvjyMv‡Qi cvZv, 2=KvÛ, 3=Avjy K›`)।

M. D³ ‡cvKv Øviv Avjy MvQi ÿwZi ZxeZv ‡Kgb? D‡jL Kiæb:
(‡Kvড: ১=খুব বেশী, ২=বেশী, ৩=মধ্যম, ৪=কম, ৫=খুব কম আক্রমন হয়)।

B.10 *K. Avcbvi GjvKvq Avjy ÿ‡Z ev ¸`v‡g eZgv‡b bZzb ‡Kvb ‡cvKv ‡`Lv hv‡"Q wK, hv ceeZx mg‡q wQj bv?*
(‡KvW: n¨uv=1, bv=2)।

L. hw` DËi n¨uv nq, Zvn‡j ‡cvKv gvKo¸‡jv wK wK? bvg D‡jL Kiæb:

1। --।

2। --।

3। --।

B.11 *Avcbvi GjvKvq Avjy ÿ‡Z ev ¸`v‡g Av‡Mi Zzjbvq eZgv‡b AwaKi ÿwZ K‡i Ggb KZ¸‡jv AwbóKvix ‡cvKvi bvg ejyb?*

1। --।

2। --।

3। --।

B.12 *Avcbvi Rvbvg‡Z Avjy Ggb ‡Kvb ÿwZKi ‡cvKv Av‡Q wK, ‡h¸‡jv cvkeZx ‡`k ‡_‡K Avgv‡`i ‡`‡k c‡ek K‡i‡Q, hv Avgv‡`i ‡`‡k c‡e wQj bv? (‡KvW: n¨uv=1, bv=2)।*

K. hw` DËi nüv nq, Zvn‡j ‡m me ‡cvKvi bvg ejyb?

1। --।

2। --।

3। --।

B.13 আপনি সাধারণত কিভাবে আলুর ক্ষতিকর পোকামাকড়ের আক্রমণ দমন করেন? নিচের খালিঘরে কোড নাম্বার লিখুনঃ

(‡KvWt 1= Avjy MvQ KxUbvkK ‡¯c K‡i, 2= Avjy exR K›`mgn ecb Kivi mgq bvjv‡Z `vbv`vi KxUbvkK c‡qvM, 3= ‡mP ‡`qvi Av‡M `vbv`vi KxUbvkK wQwU‡q, 4= ‡m‡Pi mv‡_ KxUbvkK c‡qvM K‡i, 5= gwU‡Z ec‡bi c‡e KxUbvkK w`‡q exR K›`mgn ‡kvab K‡i, 6= ‡mP c`vb, 7= ¶wZKi ‡cvKvmgn we‡kl K‡i KvUB ‡cvKv nvZ w`‡q msMn K‡i ‡g‡i ‡djv, 8= cwL emvi Rb¨ Rwg‡Z LyuwU cy‡Z ‡`qv, 9= mgwšZ evjvB c×wZ (আই.পি.এম.), ১০= সুষম সার ব্যবহারের মাধ্যমে পোকার আক্রমন কমিয়ে, ১১= অন্যান্য (দয়া করে উল্লেখ করুন)]

B.14 মাঠপর্যায়ে আলুর রোগসমূহের উপস্থিতি এবং আক্রমনের ধরণ/অবস্থা কেমন? (দয়া করে খালী ঘরে সংখ্যা লিখুন)

bs	*‡ivM mg‡ni bvg*	রোগের আক্রমনের অবস্থা *[‡KvW: gL¨ (‡ekx ÿwZKi) ‡ivM=1, ‡MŠY ‡ivM (A_©‰bwZK ÿwZKi bq)=2,* এই রোগের আক্রমন হয় না=৩]	
1	*Avjy bvex aŸmv ‡ivM*		
2	*Avjy AvMvg aŸmv ‡ivM*		
3	*Avjy KvÛ cPv ‡ivM*		
4	*Avjy ‡÷g K¨v¼vi/ ¯‹vd ‡ivM*		
5	*Avjy `v` ‡ivM*		
6	*Avjy cvZv ‡gvov‡bv ‡ivM*		
7	*Avjy ‡gvRvBK ‡ivM*		
8	*Avjy wfZ‡ii Kv‡jv `vM*		
9	*Avjy Aš—i dvucv ‡ivM*		

10	Avjy ïK‡bv cPv ‡ivM		
11	e¨vK‡Uwiqv RwbZ X‡j cov ‡ivM		
12	QÎvK RwbZ X‡j cov ‡ivM		
13	Ab¨vb¨ (hw` _v‡K----------------)		

B.15 Avcbvi GjvKvq ¸`v‡g Avjy ‡ivMmg~‡ni Dcw**স্থিতি ও আক্রমনের ধরণ **‡Kgb? (`qv K‡i Lvjx N‡i msL¨v wjLyb)

bs	‡ivMmg~‡ni bvg	রোগের আক্রমনের অবস্থা [‡KvW: gvÎv (‡ekx ÿwZKi) ‡ivM=1, ‡MŠY ‡ivM (A_©‰bwZK ÿwZKi bq)=2, এই রোগের আক্রমন হয় না=৩]	
1	Avjy `v` ‡ivM		
2	Avjy wfZ‡ii Kv‡jv `vM		
3	Avjyi Aši dvUv ‡ivM		
4	Avjy ïK‡bv cPv ‡ivM		
6	Avjy ‡Mvjvcx cPv ‡ivM		
7	Avjy dvBUc‡_iv cPv ‡ivM		
8	Avjy big cPv †ivM		
9	Ab¨vb¨ (hw` _v‡K ----------)		

B.16 মাঠপর্যায়ে আলুর গাছের কোন পর্যায়/ অংশ রোগ দ্বারা আক্রান্ত হয় এবং ক্ষতির তীব্রতা কেমন? (খালী ঘরে সংখ্যা **wjLyb)**

bs	‡ivMmg~‡ni bvg	Avjy Mv‡Qi Sz‡Kc~Y© avcmg~n (‡KvW: 1=Pviv, 2=evoš MvQ, 3=Avjy K›` e„w× chvq, 4=¸`v‡g)	Mv‡Qi ‡h Ask †ivM Øviv আক্রান্ত হয় (‡KvW: 1=cvZv, 2=KvÛ, 3=Avjy K›`, 4=wkKo)	আক্রমনের তীব্রতা (‡KvW: 1=Lye ‡ekx, 2=‡ekx, 3=ga¨g, 4=Kg, 5=Lye Kg আক্রমন হয়)
1	Avjy bvex aŸmv ‡ivM			
2	Avjy AvMvg aŸmv ‡ivM			
3	Avjy KvÛ cPv ‡ivM			
4	Avjy ‡÷g K¨v¼vi/ ¯‹vd ‡ivM			
5	Avjy `v` ‡ivM			
6	cvZv ‡KvKov‡bv ‡ivM			
7	Avjy ‡gvRvBK ‡ivM			
8	Avjy Aši Kv‡jv `vM			
9	Avjy Aši dvUv ‡ivM			
10	Avjy ïK‡bv cPv ‡ivM			
11	e¨vK‡Uwiqv RwbZ X‡j cov			
12	QÎvK RwbZ X‡j cov			
13	Ab¨vb¨ (hw` _v‡K------------)			

B.17 Avcbvi GjvKvq Avjy‡ÿ‡Z ev ¸`v‡g e¨vK‡Uwiqv RwbZ X‡j cov ‡ivM/ Avjy ev`vgx cPv ‡ivM-Gi Dcw¯'wZ/ আক্রমন আছে কি? **(‡KvW: n¨uv=1, bv=2)|**

B.18 hw` DËi n¨uv nq, Zvn‡j

K. D³ রোগ গাছের কোন ধাপে/ পর্যায়ে আক্রমন করে? উল্লেখ করুন:

(‡KvW: 1=Pviv, 2=evoš MvQ, 3=Avjy K›` e„w× chvq)|

K. D³ ‡ivM Øviv Avjy Mv‡Qi ÿwZi ZxeZv ‡Kgb? D‡jL Kiæb
(†KvW: 1=Lye বেশী, ২=বেশী, ৩=মধ্যম, ৪=কম, ৫=খুব কম আক্রমন হয়)।

B.19 Avcbvi GjvKvq Avjy‡ÿ‡Z Avjy ‡mvbvjx Kvg.‡ivM (‡Mv‡ì b wm÷ ‡bgv‡UvW) RwbZ X‡j cov ‡ivM-Gi উপস্থিতি/ আক্রমন আছে কি? (‡KvW: n¨uv=1, bv=2)|

B.20 ***hw` DËi n¨unq, Zvn‡j***

***K. D³ ‡ivM Mv‡Qi ‡Kvb av‡c* আক্রমন করে? উল্লেখ করুন:**

*(‡KvW: 1=Pviv, 2=evoš MvQ, 3=Avjy K›` eu× chvq)***|**

L. D³ ‡ivM Øviv Avjy MvQ‡Qi ÿwZi ZxeZv ‡Kgb? D‡jL Kiæb:

(কোড: ১=খুব বেশী, ২=বেশী, ৩=মধ্যম, ৪=কম, ৫=খুব কম আক্রমন হয়)

B.21 ***Avcbvi GjvKvq Avjy‡ÿ‡Z*** *Avjy am¬i Kwg. ‡ivM (c¨vj wm÷ ‡bgv‡UvW) RwbZ X‡j cov ‡ivM-Gi* **উপস্থিতি/আক্রমন আছে কি?** *(‡KvW: n¨u=1, bv=2)***|**

B.22 ***hw` DËi n¨unq, Zvn‡j***

K. D³ **রোগ গাছের কোন ধাপে আক্রমন করে? উল্লেখ করুন:**

*(‡KvW: 1=Pviv, 2=evoš MvQ, 3=Avjy K›` eu× chvq)***|**

L. D³ †ivM Øviv Avjy MvQ‡Qi ÿwZi ZxeZv ‡Kgb? D‡jL Kiæb:

(কোড: ১=খুব বেশী, ২=বেশী, ৩=মধ্যম, ৪=কম, ৫=খুব কম আক্রমন হয়)।

B.23 ***Avcbvi GjvKvq Avjy‡ÿ‡Z ev ¸`v‡g Kv‡jv IqvU*** *‡ivM (e¨vK IqvU)-Gi* ***Dcw¯wZ Av‡Q wK?***

*(‡KvW: n¨u=1, bv=2)***|**

B.24 ***hw` DËi n¨unq, Zvn‡j D³ ‡ivM Øviv Avjy MvQ‡Qi ÿwZi ZxeZv ‡Kgb? D‡jL Kiæb:***

(কোড: ১=খুব বেশী, ২=বেশী, ৩=মধ্যম, ৪=কম, ৫=খুব কম আক্রমন হয়)।

B.25 **ক. আপনার এলাকায় আলু ক্ষেতে বা গুদামে বর্তমানে এমন কোন নতুন রোগের আক্রমন দেখা যাচ্ছে কি, যা পূর্ববর্তী** ***mg‡q wQj bv?*** *(‡KvW: n¨u=1, bv=2)***|**

L. hw` DËi n¨unq, Zvn‡j ‡ivMmgn wK wK? bvg D‡jL Kiæb:

1| ---|

2| ---|

3| ---|

B.26 ***Avcbvi GjvKvq Avjy‡ÿ‡Z ev ¸`v‡g Av‡Mi Zzjbvq eZgv‡b ‡ekx ÿwZ K‡i Ggb KZ¸‡jv ‡iv‡Mi bvg ejyb?***

1| ---|

2| ---|

3| ---|

B.27 ***K. Avcbvi Rvbvg‡Z Avjy Ggb ‡ivM Av‡Q wK, ‡h¸‡jv cvkeZx ‡`k ‡_‡K Avgv‡`i ‡`‡k c‡ek K‡i‡Q, hv Avgv‡`i ‡`‡k c‡e wQj bv? (‡KvW: n¨u=1, bv=2)|***

L. hw` DËi nüunq, Zvn‡j G mKj †iv‡Mi bvg ejyb?

1| ---|

2| ---|

3| ---|

B.28 ***Avjy‡¶‡Z Avcwb wKfv‡e ‡ivM-evjvB `gb K‡i _v‡Kb? wb‡Pi LwjN‡i ‡KvW bv¤vi wjLyb:***

*[‡KvWt 1= gwU‡Z ec‡bi c‡e QÎvKbvkK w`‡q exR K›`mgn ‡kvab K‡i, 2= Avjy K›`mgn ecb Kivi mgq bvjv‡Z `vbv`vi KxUbvkK wQwU‡q, 3=Avjy MvQ‡Q QÎvKbvkK ‡¯c K‡i, 4= ‡mP ‡`qvi Av‡M `vbv`vi KxUbvkK wQwU‡q, 5= evnK `g‡bi Rb¨ KxUbvkK ‡¯ú Kiv, 6= Rwg‡Z ‰Re-mvi c‡qvM K‡i, 7= Rwg‡Z ‡mP c`vb K‡i, 8= Rwg ‡*থেকে রোগাক্রান্ত আলু গাছসমূহ তুলে ধ্বংস করা, ৯= জমিতে থেকে আগাছা পরিস্কার ক*i ‡cvKvi Avevm¯j* নষ্ট করা, ১০= সমন্বিত বালাই পদ্ধতি (আই.পি.এম.), ১১= সুষম সার ব্যবহারের মাধ্যমে রোগের আক্রমন থেকে ফসল *iÿv Kiv, 12= Ab¨vb¨ (`qv K‡i D‡jL Kiæb)]*

B.29 gvVchv‡q Avjy MvQ‡i ‡Kvb chvq/Ask আগাছা দ্বারা বেশী আক্রান্ত হয় এবং ক্ষতির তীব্রতা কেমন? (খালী ঘ‡i msL¨v wjLyb)

bs	bvg	আক্রমনের অবস্থা [‡KvW: gL¨ (‡ekx ÿwZKi) AvMvQv=1, ‡MŠY AvMvQv (A_©bwZK ÿwZKi bq)=2, GB আগাছার আক্রমন হয় না=৩]	**AvMvQvi cwZ Avjy SuzwKc~Y© avcmgn** [‡KvW: 1=Pvi v, 2=evoš MvQ, 3=Avjy K›` e„w× chvq]	আগাছা দ্বারা আলুতে আক্রমনের **ZxeZv** [‡KvW: 1=Lye ‡ekx, 2=‡ekx, 3=ga¨g, 4=Kg, 5=Lye কম আক্রমন হয়]
1	`ev Nvm			
2	gyv			
3	e_qv			
4	PvcOv			
5	k¨vgv			
6	gvjÂ			
7	‡n‡jÂv			
8	‡¶Z-cvcov			
9	kvK b‡U			
10	KvUv b‡U			
11	eb ‡e¸b			
12	KvUv ‡e¸b			
13	Ab¨vb¨			

B.30 K. Avcbvi GjvKvq Avjy‡ÿ‡Z eZgv‡b bZzb Ggb ‡Kvb AvMvQv ‡`Lv hv‡"Q wK, hv ceeZx mg‡q wQj bv? (‡KvW: n¨vu=1, bv=2)| ☐

L. hw` DËi n¨vuq, Zvn‡j AvMvQvmgn wK wK? bvg D‡jL Kiæb:

1| --|

2| --|

3| --|

B.31 Avcbvi GjvKvq Avjy‡ÿ‡Z Av‡Mi Zzjbvq eZgv‡b ‡ekx ÿwZ K‡i Ggb KZ¸‡jv AvMvQvi bvg ejyb?

1| --|

2| --|

3| --|

B.32 K. Avcbvi Rvbvg‡Z Avjy Ggb AvMvQv Av‡Q wK, ‡h¸‡jv cvkeZx ‡`k ‡\_‡K Avgv‡`i ‡`‡k c‡ek K‡i‡Q, hv Avgv‡`i ‡`‡k c~‡e wQj bv? ([‡KvW: n¨vu=1, bv=2)| ☐

L. hw` DËi nüvnq, Zvn‡j G mKj AvMvQv¸‡jvi bvg ejyb?

1| --|

2| --|

3| --|

B.33 Avjy‡¶‡Z mvavi YZ: wKfv‡e AvMvQv `gb K‡i _v‡Kb? wb‡Pi LwjN‡i ‡KvW b¤i wjLyb:

[‡KvWt 1= Avjy‡¶Z ‡_‡K AvMvQv DwV‡q, 2= Avjy‡¶‡Z `vbv`vi AvMvQvbvkK wQwU‡q, 3= Rwg ˆZixi mgq AvMvQv DwV‡q, 4= gvjwPs K‡i, 5= Avjy AvB‡j gwU DwV‡q, 7= ‡mP w`‡q, 11= Ab¨vb¨ (D‡jL Kiæb)]

Z_¨ msMÖnKvixi bvgt ¯v¶i I ZvwiLt

wdì mycvifvBRv‡ii bvgt ¯v¶i I ZvwiLt

MYcRvZšx evsjv‡`k miKvi

Kwl.m¤cÖmviY Awa`ßi

evsjv‡`k dvB‡Uv‡m‡bUvix kw³kvjxKiY cKí

Dw™¢` msiÿY DBs, Lvgvievox, dvg©‡MU, XvKv|

‡dvbt 9103774|

Questionnaire for Farmers on Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh under Strengthening Phytosanitary Capacity in Bangladesh

Prepared by:

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‡mU-2: Gd.wR.wW. MvBWjvBbmgn

‡KvW:				

A.0 **GdwRwW Gi ¯'vbt --|**

A.2 Mvg -- **A.3** Kwl.eK: --

A.4 Dc‡Rjv: --- **A.5** ‡Rjv: ---

B.1 ***Avcbv‡`i e¨eüZ Avjy exR¸‡jvi g‡a¨ me‡P‡q Rbwcq RvZ¸‡jv wK wK?***

B.2 ***Avcbviv ‡h exR Avjy e¨envi K‡ib, Gi Drmmgn wK wK?***

B.3 ***Avcbvi GjvKvq mvaviYZ Avjy‡Z ‡Kvb ai‡bi ¶wZKi ‡পাকামাকড়ের আক্রমন ‡`Lv hvq? (bvg D‡jL Ki‡b)***

K. gL¨ ¶wZKi ‡cvKvgvKo:

L. ‡MŠY ¶wZKi ‡cvKvgvKo:

B.4 ***Avcbv‡`i GjvKvq mvaviYZ Avjy‡Z ‡Kvb ‡Kvb ‡ivM evjvB ¸‡jv ‡`Lv hvq? (‡iv‡Mi bvg D‡jL Ki‡b)***

K. gL¨ ‡ivM:

L. ‡MŠY ‡ivM:

B.5 ***Avcbvi GjvKvq mvaviYZ Avjy‡ÿ‡Z ‡Kvb ‡কান আগাছাসমূহের আক্রমন ‡`Lv hvq? (bvg D‡jL Ki‡b))***

K. gL¨ AvMvQv:

L. ‡MŠY AvMvQv:

B.6 ***Avcbv‡`i GjvKvq K‡j‡i‡Wv c‡U‡Uv weUj-G*র আক্রমনের অবস্থা *‡Kgb? Avcbv‡`i GjvKvq Gi Dcw¯'wZ ev Abycw¯'wZ ‡KvbwU m¤ú‡K Avcwb wbwðZ? hw` Dcw¯'Z ‡_‡K _v‡K Zvn‡j Zv wKfv‡e wbwðZ n‡jb?***

B.7 ***Avcbv‡`i GjvKvq Avjy ev `vgx cPu‡ivM/e¨vK‡Uwiqv RwbZ X‡j cov-*এর আক্রমনে*i Ae¯'v ‡Kgb? Avcbv‡`i GjvKvq Gi Dcw¯'wZ ev Abycw¯'wZ ‡KvbwU m¤ú‡K Avcwb wbwðZ? hw` Dcw¯'Z ‡_‡K _v‡K Zvn‡j K‡e Ges wKfv‡e Zv wbwðZ n‡jb?***

B.8 ***Avcbv‡`i GjvKvq Avjy ‡mvbvjx wm÷ ‡bgv‡UvW ‡ivM-*এর আক্রমনের অবস্থা *‡Kgb? Avcbv‡`i GjvKvq Gi Dcw¯'wZ ev Abycw¯'wZ ‡KvbwU m¤ú‡K Avcwb wbwðZ? hw` Dcw¯'Z ‡_‡K _v‡K Zvn‡j K‡e Ges wKfv‡e Zv wbwðZ n‡jb?***

B.9 ***Avcbv‡`i GjvKvq Avjy am~i wm÷ ‡bgv‡UvW ‡ivM-*এর আক্রমনের অবস্থা *‡Kgb? Avcbv‡`i GjvKvq Gi Dcw¯'wZ ev Abycw¯'wZ ‡KvbwU m¤ú‡K Avcwb wbwðZ? hw` Dcw¯'Z ‡_‡K _v‡K Zvn‡j K‡e Ges wKfv‡e Zv wbwðZ n‡jb?***

B.10 ***Avcbv‡`i GjvKvq Avjy Kv‡jv IqvU ‡ivM-*এর আক্রমনের অবস্থা *‡Kgb? Avcbv‡`i GjvKvq Gi Dcw¯'wZ ev Abycw¯'wZ ‡KvbwU m¤ú‡K Avcwb wbwðZ? hw` Dcw¯'Z ‡_‡K _v‡K Zvn‡j K‡e Ges wKfv‡e Zv wbwðZ n‡jb?***

B.11 ***ÿwZKi ‡cvKv-gvKo, ‡ivM-evjvB I AvMvQv Øviv Avjyiw‡Qi ‡Kvb ‡Kvb e„× chvq/avcmgn ‡*বশী আক্রান্ত হয়?**

K. ÿwZKi ‡cvKvgvKo:

L. ‡ivM evjvB:

M. AvMvQv:

B.12 ***ÿwZKi ‡cvKv-gvKo I ‡ivM Øviv Avjyiw‡Qi ‡Kvb ‡Kvb Ask ‡*বশী আক্রান্ত হয়?**

K. ÿwZKi ‡cvKvgvKo:

L. ‡ivM evjvB:

B.13 ***ÿwZKi ‡cvKv-gvKo, ‡ivM-evjvB I AvMvQvi Avjy ÿwZi ZxeZv ‡Kgb nq?***

K. ÿwZKi ‡cvKvgvKo:

L. ‡ivM evjvB:

M. AvMvQv:

B.14 ***Avcbvi GjvKvq Avjy ‡ÿ‡Z ev ¸`v‡g eZgv‡b Ggb bZzb ‡Kvb ‡cvKv-gvKo, ‡ivM-evjvB I AvMvQv ‡`Lv hv‡"Q wK, hv ceeZx mg‡q wQj bv? hw` ‡_‡K _v‡K, Zvn‡j ‡m¸‡jv wK wK? bvg D‡jL Ki‚b:***

K. ÿwZKi ‡cvKvgvKo:

L. ‡ivM evjvB:

M. AvMvQv:

B.15 ***Avcbvi GjvKvq Avjyi ÿ‡Z ev ¸`v‡g Av‡Mi Zzjbvq eZgv‡b A‡bK †ekx ÿwZ K‡i Ggb KZ¸‡jv AwbóKvix ‡cvKv-gvKo, ‡ivM-evjvB I AvMvQvi bvg ejyb?***

K. ÿwZKi ‡cvKvgvKo:

L. ‡ivM evjvB:

M. AvMvQv:

B.16 ***Avcbv‡`i GjvKvi Avjyi ÿ‡Z ÿwZKi ‡cvKv-gvKo, ‡ivM I AvMvQv `g‡b wK wK KvhKi e¨e¯'v Mnb Kiv nq?***

K. ÿwZKi ‡cvKvgvKo `g‡b KvhKi e¨e¯'v:

L. ‡ivM evjvB `g‡b KvhKi e¨e¯'v:

M. AvMvQv `g‡b KvhKi e¨e¯'v:

B.17 ***Avcbv‡`i GjvKvi ¸`v‡g Avjyi ÿwZKi †cvKv-gvKo I ‡ivM-evjvB `g‡b wK wK KvhKi e¨e¯'v Mnb Kiv nq?***

K. ÿwZKi †cvKvgvKo `g‡b KvhKi e¨e¯'v:

L. †ivM evjvB `g‡b KvhKi e¨e¯'v:

B.18 ***Avcbv‡`i Rvbvg‡Z Ggb Avjy Ggb ‡Kvb ÿwZKi ‡cvKv-gvKo, ‡ivM-evjvB I AvMvQv Av‡Q wK, ‡h¸‡jv cvkeZx ‡`k ‡_‡K Avgv‡`i ‡`‡k c‡ek K‡i‡Q g‡b nq, A_P ‡m¸‡jv c‡e Avgv‡`i ‡`‡k wQj bv? hw` ‡_‡K _v‡K, Zvn‡j Zv‡`i bvg ejyb?***

K. ÿwZKi †cvKvgvKo:

L. ‡ivM evjvB:

M. AvMvQv:

‡dvKvm Mæc wWmKvkb (Gd.wR.wW.)-G AskMnbKvix‡`i ZvwjKv

bs	bvg	Mvg	‡ckv	‡gvevBj	¯^vÿi
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

GdwRwW cwiPvjbvKvixi bvgt-- |

¯vÿi I ZwiLt ---|

‡gvevBj b¤i t---|

Government of the People's Republic of Bangladesh
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Checklist for Key Informant Interview (KII) on Conducting Pest Risk Analysis (PRA) of Potato in Bangladesh under Strengthening Phytosanitary Capacity in Bangladesh

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Set-3: KII Checklists on PRA of Potato

Name of Key Informant…….. ………………………………. Designation ………………………..….

Organization:………………………..…………… Working area: …………………………

Mobile:……….…………..…………………..…………

Checklist for Review/ Key informant discussions on Pests of Potato

DAE Head office (PQW & PPW), Director Field Service (FSD); BARI Scientist, BADC, SCA, DG-Seed, Agricultural University, Potato Exporters' Association, District offices of DAE (ADDITIONAL DEPUTY DIRECTOR (PP)/PPS)

1.0 INFORMATION ABOUT INSECT PESTS OF POTATO

1.1 What are the major insect pests that cause potential damage to potato in Bangladesh (HQ)/your area? [PQW & PPW-DAE), SCA, **ADDITIONAL DEPUTY DIRECTOR (PP)/PPS**, BADC, BARI, Agricultural University, Potato Exporters Association]

1.2 What are the key insect pests of potato that cause potential damage in every year in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

1.3 What are the minor insect pests that may harm to potato, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

1.4 What are the insect pests of potato, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, DG-Seed, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Potato Exporters Association]

1.5 What is the status of Colorado potato beetle in Bangladesh/your area? [DAE-HQ (PQW & PPW, FSD), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University] Is it present or absent in Bangladesh/your area?

1.6 If present, how it was identified for confirmation? [DAE-HQ (PQW & PPW, FSD), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

1.7 From which countries, the potato seed tubers are being usually imported into Bangladesh? [DAE-HQ (PQW & PPW), Secretary (MoA), SCA, DG-Seed, BADC, Potato Exporters Association]

1.8 Is there any information about the insect pests of potato available in the exporting country of potato to Bangladesh? If yes, what are those insect pests? Please mention the name of insect pests? [DAE-HQ (PQW & PPW), SCA, BADC, DG-Seed, Potato Exporters Association]

1.9 What are the quarantine insect pests of potato that might already be entered into Bangladesh through importation of potato seeds from other countries or through cross boundary from neighboring countries that were not seen earlier? [PQW/PPW-DAE), SCA, **Additional DD (PP)/PPS**, BARI, BADC, Agril. University, Potato Exporters Association]

1.10 Is there any record, the consignment of 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. [DAE-HQ (PQW & PPW), Secretary (MoA), SCA, DG-Seed, Potato Exporters Association]

1.11 What are the possible ways of entry of newly introduced insect pests of potato that were not seen earlier in the field or storage in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University, Potato Exporters Association]

1.12 What are the options to prevent the entry and spread of potential insect pests of potato within Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, DG-Seed, BARI, Agril. University, Potato Exporters Association]

1.13 What are the effective options to control the quarantine insect pests that are found in the potato field or storage in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

1.14 What are the effective ways to prevent the entry of quarantine insect pests of potato into Bangladesh from the countries of potato export? [DAE-HQ (PQW & PPW), SCA, BADC, Agril. University]

1.15 What steps are being taken by the PQW of DAE to prevent the entry of quarantine insect pests of potato through imported potato tubers? [DAE-HQ (PQW & PPW), SCA]

1.16 Give your suggestions for the better management of the insect pests of potato in Bangladesh. [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.0 INFORMATION ABOUT DISEASES OF POTATO

2.1 What are the major diseases that cause potential damage to potato in Bangladesh (HQ)/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Potato Exporters Association]

2.2 What are the key diseases of potato that cause potential damage in every year in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.3 What are the minor diseases that may harm to potato, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.4 Among the diseases of potato available in Bangladesh/your area, which insect pests cause severe damage to potato crops every year in Bangladesh? [**Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.5 What are the diseases of potato, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, DG-Seed, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Potato Exporters Association]

2.6 What is the status of brown rot and bacterial wilt of potato caused by the bacterium, *Ralstonia solanacearum* in the field of potato in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University, Potato Exporters Association]

a. Is it present or not?

b. If present, is there any evidence of occurrence of this disease?

c. If observed, when and where?

2.7 What is the status of golden cyst nematode that cause wilt of potato in the field of potato in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University, Potato Exporters Association]

a. Is it present or not?

b. If present, is there any evidence of occurrence of this disease?

c. If observed, when and where?

2.8 What is the status of pale cyst nematode that cause wilt of potato in the field of potato in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University, Potato Exporters Association]

a. Is it present or not?

b. If present, is there any evidence of occurrence of this disease?

c. If observed, when and where?

2.9 What is the status of black wart of potato in your area/Bangladesh? [DAE(PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, BADC, Agril. University, Potato Exporters Association]

a. Is it present or not?

b. If present, is there any evidence of occurrence of this disease?

c. If observed, when and where?

2.10 What is the status of Potato virus-X in the field of potato in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

a. Is it present or not?

b. Is there any evidence of occurrence of this disease? [ELISA Test]

2.11 Is there any information about the diseases of potato available in the exporting country of potato to Bangladesh? If yes, what are those diseases? Please mention the name of diseases? [DAE-HQ (PQW & PPW), SCA, DG-Seed, Potato Exporters Association]

2.12 What are the quarantine diseases of potato that might already be entered into Bangladesh through importation of potato seeds from other countries or through cross boundary from neighboring countries that were not seen earlier? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University, Potato Exporters Association]

2.13 Is there any record, the consignment of potato exported to foreign country that was returned to Bangladesh, due to occurrence of any diseases in the consignment? If yes, which country and what are the diseases? Please mention the name. [DAE-HQ (PQW & PPW), SCA, DG-Seed, Potato Exporters Association]

2.14 What are the possible ways of entry of newly introduced diseases of potato that were not seen earlier in the field or storage in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, BADC, Agril. University, Potato Exporters Association]

2.15 What are the options to prevent the entry and spread of potential diseases of potato within Bangladesh? [DAE(PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

2.16 What are the effective options to control the quarantine diseases that are found in the potato field or storage in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.17 What are the effective ways to prevent the entry of quarantine diseases of potato into Bangladesh from the countries of potato export? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

2.18 What steps are being taken by the PQW of DAE to prevent the entry of quarantine diseases of potato through imported potato tubers? [DAE-HQ (PQW & PPW), SCA, BADC]

2.19 Give your suggestions for the better management of the diseases of potato in Bangladesh. [DAE(PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, BADC, Agril. University, Potato Exporters Association]

3.0 INFORMATION ABOUT WEEDS OF POTATO

3.1 What are the major weeds that cause potential damage to potato in Bangladesh/your area? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agril. University, Potato Exporters Association]

3.2 What are the minor weeds that may harm to potato, if not to be controlled? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agril. University]

3.3 Among the weeds of potato available in Bangladesh/your area, which weeds cause severe damage to potato crops every year in Bangladesh? [**Additional DD (PP)/PPS**, BADC, BARI, Agril. University]

3.4 What are the weeds of potato, which incidences are being seen in recent years, but not seen earlier in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

3.5 Is there any information about the weeds of potato available in the exporting country of potato to Bangladesh? If yes, what are those weeds? Please mention the name of weeds? [DAE-HQ (PQW & PPW), Secretary (MoA), SCA, DG-Seed]

3.6 What are the quarantine weeds of potato that might already be entered into Bangladesh through importation of potato seeds from other countries or through cross boundary from neighboring countries that were not seen earlier? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.7 Is there any record, the consignment of potato exported to foreign country that was intercepted and returned to Bangladesh, due to occurrence of any weeds/weed seeds in the consignment? If yes, which country and what are the weeds? Please mention the name. [DAE-HQ (PQW & PPW), Secretary (MoA), SCA, DG-Seed]

3.8 What are the possible ways of entry of quarantine weeds of potato that were not seen earlier in the field or storage in your area/Bangladesh? [DAE (PQW&PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agricultural University]

3.9 What are the options to prevent the entry and spread of potential weeds of potato within Bangladesh? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BARI, Agril. University]

3.10 What are the effective options to control the quarantine weeds that are found in the potato field or, storage in your area/Bangladesh? [DAE-HQ (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

3.11 What are the effective ways to prevent the entry of quarantine weeds of potato into Bangladesh from the countries of potato export? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]

3.12 What steps are being taken by the PQW of DAE to prevent the entry of quarantine weeds of potato through imported potato tubers? [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC]

3.13 Give your suggestions for the better management of the weeds of potato in Bangladesh. [DAE (PQW & PPW), SCA, **Additional DD (PP)/PPS**, BADC, BARI, Agricultural University]