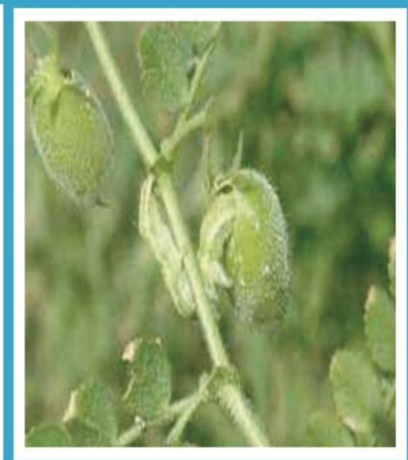
Pest Risk Analysis (PRA) of Pulse in Bangladesh






Strengthening Phytosanitary Capacity in Bangladesh Project
Plant Quarantine Wing
Department of Agricultural Extension
Khamarbari, Farmgate, Dhaka.

June 2017

Pest Risk Analysis (PRA) of Pulses in Bangladesh

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Submitted By

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Foreward

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 Pulse in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and Centre for Resource Development Studies Ltd. (CRDS) on 11 December 2016. The PRA study is a four-month assignment commencing from 11 December 2016 under the SPCB, DAE. The overall objectives of this Pest Risk Analysis are to identify the pests and/or pathways of quarantine concern for a specified area of pulses and evaluate their risk in Bangladesh and to identify risk management options. To carry out the PRA study, the consulting firm conducted field investigations in 70 upazilas under 29 major pulse growing districts of Bangladesh for listing of pests of pulses in Bangladesh. The study covered the interview of 7000 pulse growers; 29 FGDs each of which conducted in one district; information from DD of each districts, UAO and 10 SAAO of each upazila and BARI/BINA Researchers of each region; physical inspection and visits of the pulse fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of pulse including CABI & EPPO.

The study findings revealed that the in Bangladesh, number of insect pest recorded on lentil, chickpea, mungbean, grasspea and cowpea were 8, 14, 18, 5 and 11 respectively of which some attack two or more pulses. Thus there were altogether 23 insect pests recorded from five pulses. Number of diseases recorded on lentil, chickpea, mungbean, grasspea and cowpea were 20, 19, 21, 14 and 15 respectively. A number of diseases were common in two or more pulses and there were altogether 46 diseases so far recorded on five pulses in Bangladesh. From the analysis 8 insect pests, 13 diseases and 6 weeds were identified as quarantine pests for Bangladesh. 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. The findings also suggested the risk management options for the quarantine pests of pulse 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 on 12 June 2017. The concerned professionals of agricultural universities of Bangladesh, DAE (Department of Agricultural Extension), research organizations and other relevant personnel from different organizations were attended the workshop. The online version of this report will be published at www.dae.gov.bd.

I would like to congratulate Consultant Team of CRDS 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, Agricultural Universities, research organizations and groundnut importer and exporters' associations for their assistance and cooperation extended in conducting the PRA study. Thanks are also due to Technical Committee members for their kind review of the report and providing feedbacks improving the quality of the report.

Special thanks to the Secretary and Additional Secretary (Extension) of MOA for their cooperation. I also thanks to the Director General of DAE, Director (Plant Quarantine Wing) and other high officials of IMED and Ministry of Agriculture for their presence at the Draft Report presentation workshop and providing valuable suggestions & Feedbacks. Thanks are due to Mr. Ahsan Ulah, Consultant, SPCB for his advice & guidance.
I hope that the report certainly would contribute to enhance the exports and imports of pulses.

(Dr. Mohammad Ali)
Project Director
Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project
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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 Centre for Resource Development Studies Ltd. (CRDS) for **"Conducting Pest Risk Analysis (PRA) of pulse in Bangladesh"** under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture (MOA), Government of the People's Republic of Bangladesh. The PRA study is a four-month assignment commencing from 11 December 2016 under the SPCB, DAE.

Consultancy services for "Conducting Pest Risk Analysis (PRA) of Pulse in Bangladesh" were provided by the Centre for Resource Development Studies Ltd. (CRDS), Bangladesh. The study team consists of six senior level experts, one coordinator, and field and office level support staffs. The major objective of the study is to listing of major and minor pests of pulse, 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 analysis and survey finding as well as the stages of PRA, risk assessment strategies of the pests likely to be associated with the commodity to be imported from the exporting countries and the risk management options as recommendations.

The report had been reviewed and discussed thoroughly by the SPCB officials along with other experts and representatives through several discussion meetings. This report was presented in the national level workshop for further comments and suggestions. The consultants have finalized the Report of the PRA study of Pulses incorporating the comments and suggestions of the client and feedbacks received from the workshop.

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Acknowledgement

It is my pleasure that Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project under Plant Quarantine Wing (PQW) of Department of Agriculture Extension (DAE) has entrusted Centre for Resource Development Studies (CRDS) Ltd. to carry out the "**Conducting Pest Risk Analysis (PRA) of Pulses in Bangladesh"**. The Report has been prepared based on the past four months (January 2017 to April 2017) activities of the survey study in 29 major Pulses growing districts of Bangladesh as well as on the review of secondary documents. In the process of setting indicators and sampling as well as for revising the questionnaires for the field survey and data collection, monitoring and supervision, data analysis and report writing, we have enjoyed the support of SPCB-PQW. The Team Leader has prepared the report with inputs from Dr. Md. Abdul Latif, Dr. Fazlul Huq, Dr. Abu Taher Mia, Prof. Dr. Md. Abdul Latif, Dr. Shaker Ahmed and Kbd. Md. Rabiul Awal of the PRA study team.

The author is grateful to all persons involved in the PRA study. Our special gratitude to Mr. Md. Golum Maruf, Director General, DAE, Bangladesh, who provided his cooperation and gave us an opportunity to meet his Districts-Level officers in connection with the study. He is also thankful to Mr. Mohammad Mohshin, Director of Plant Quarantine Wing (PQW) of DAE. Special thanks to Dr. Mohammad Ali, Project Director, Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project; Mr. Md. Ahsan Ullah, Consultant (PRA); Mrs. Marina Jebunehar, Senior Monitoring and Evaluation Officer, SPCB for their valuable cooperation and suggestions to the study team in line with the activities performed during study and report preparation.

Active support of the Chairman and the Managing Director of CRDS and Kbd. Md. Rabiul Awal, Survey Coordinator of the study to coordinate the survey team during data collection and monitoring activities is acknowledged with thanks.

Dr. Hamiz Uddin Ahmed
Team Leader

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Abbreviations

BARI	**Bangladesh Agricultural Research Institute**
BINA	**Bangladesh Institute of NuclearAgriculture**
CABI	**Centre for Agriculture and Biosciences International**
CRDS	**Center for Resource Development Studies Limited**
DAE	**Department of Agricultural Extension**
DD	**Deputy Director**
DPP	**Development Project Proposal**
IPPC	**International Plant Protection Convention**
ISPM	**International Standard for Phytosanitary Measures**
NGO	**Non-Government Organization**
PC	**Phytosanitary Certificate**
PPW	**Plant Quarantine Wing**
PRA	**Pest Risk Analysis**
PSO	**Principal Scientific Officer**
RARS	**Regional Agricultural Research Station**
SAAO	**Sub-Assistant Agriculture Officer**
SPCB	**Strengthening Phytosanitary Capacity in Bangladesh**
TOR	**Terms of Reference**
UAO	**Upazila Agriculture Officer**

Executive Summary

Bangladesh is a deficit country in pulse production.Different pulses are being imported from six major countries such as Australia, Canada, India, China, Nepal and Turkey. Bangladesh is prodicing asubsantial amount of pulses. In Bangaldesh, the acreage of selected five pulse crops, in 2015-16 cropping year, was about 8.0 lac hectares, while the production was about 9.0 lac metric tons. The crops are grown throughout the country. The production is much lower than the requirement and the deficit is fulfilled by importing the grains from other countries. Currently there is no risk analysis of imported pulses. So, there is a scope of introducing alien pest into Bangladesh which may potentially damage our pulse crops. So, the analysis will contribute to review of existing phytosanitary requirements for import of pulses.The study on Pest Risk Analysis (PRA) of five pulse crops namely lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), mungbean (*Vigna radiata*), grasspea (*Lathyrus sativus*) and cowpea (*Vigna unguiculata*) was undertaken following IPPC Rules and Regulations. In order to perform this task the Government of Bangladesh awarded a project entitled “Strengthening Phytosanitary Capacity in Bangladesh” through the Plant Quarantine Wing of Department of Agricultural Extension under the Ministry of Agriculture. The Plant Quarantine Wing is executing this task with the assistance of Private Organization who has qualified personnel. Center for Resource Development Studies Limited (CRDS), qualifying all requirements has been awarded to conduct the PRA of Pulses in Bangladesh. The PRA process is being conducted with the technical assistance of the Consultant - PRA, Md. Ahsan Ullah, Stregthening Phytosanitary Capacity in Bangladesh Project.

The major objectives of the project included recording of major and minor insect pests, diseases and weeds of pulse crops in Bangladesh and selected six pulses exporting countries and listing of quarantine insect pests, diseases and weeds of pulses. The study also included detail information on pests and pathogens, their entry, establishment and spread, climatic and other characters of both exporting and importing countries, etc. The baseline information on insect pests, diseases and weeds, available in Bangladesh were collected from different secondary sources like published papers, books, journals, internet as well as interview with different stakeholders such as farmers, personnel from DAE, experts and professionals. Primary data were collected through field survey. For these major pulse growing 70 upazilas under 29 districts were selected and visited during January-March, 2017 only because of time constraints. In each upazila 100 farmers (10 blocks and 10 farmers from each block) were selected for data collection. Although the selected 29 districts were used for primary data collection, the entire Bangladesh was considered as the PRA area for pulse crops, which might be endangered by the introduction of invasive alien pests. The PRA was conducted to identify the hazards for the PRA area.

The pathway and commodity has been described elaborately along with the climatic conditions and cultivation practices followed both in the selected exporting countries such as Australia, Canada, China, India, Nepal and Turkey as well as Bangladesh. At the same time the geography and climate of the six selected exporting countries and Bangladesh were also described. The information was used to analyze the performance of the hazard organism(s) in Bangladesh condition if introduced.
For identification of potential hazards under insect pests, diseases and weeds, list of insect pests, diseases and weeds in pulse crops in Bangladesh and six selected countries were made through extensive searches of both national and international sources and internet resources.

Lists of insect pest, diseases and weeds prevailing in Bangladesh have been prepared through field survey, consulting reports and internet searching. In Bangladesh, number of insect pest recorded on lentil, chickpea, mungbean, grasspea and cowpea were 8, 14, 18, 5 and 11 respectively of which some attack two or more pulses. Thus there were altogether 23 insect pests recorded from five pulses. Number of diseases recorded on lentil, chickpea, mungbean, grasspea and cowpea were 20, 19, 21, 14 and 15 respectively. A number of diseases were common in two or more pulses and there were altogether 46 diseases so far recorded on five pulses in Bangladesh. Similarly a total of 19 weeds were identified from pulse crops. Separate lists for insect pests, diseases and weeds of five pulses in six selected pulse exporting countries were also made through searching of different sources like books, journal, reports, internet etc. Pest lists of Bangladesh were critically compared with those of exporting countries and the organisms absent in Bangladesh were identified as quarantine pests for Bangladesh. From the analysis 8 insect pests, 13 diseases and 6 weeds were identified as quarantine pests for Bangladesh.

The identified quarantine insect pests, diseases and weeds were taken in consideration for risk analysis process. Risk assessment considering entry, exposure and establishment potential, and consequences on economy, environment or health, 5 insect pests (*Melanagromyza obtusa, Callosobruchus analis, C. phaseoli, Acanthoscelides obtectus,* and *Sitophilus granaries*), 7 diseases (Ascochyta blight in lentil, Septoria leaf spot in cowpea, Tan spot in mungbean and cowpea, Halo blight in mungbean and cowpea, Pea seed-borne mosaic in lentil and chickpea, Alfalfa mosaic disease in lentil and chickpea, and Cowpea severe mosaic virus in cowpea) and 6 weed species (*Lolium rigidum*, *Galium tricornutum*, *Phalaris minor*, *Thlaspi arvense*, *Boerhavia diffusa*, and *Cardaia draba*) were recognized as potential hazards for Bangladesh and prompted discussion and management options for these species. The report included the pest risk management of these 19 quarantine pests of pulse crops with specific approaches and methods in detail. Thus it is suggested to follow the recommended quarantine practices while importing pulses from the six exporting countries. Management options of hazardous organisms have been dicussed in section 6.

1.0 Scope and Methodology of Pest Risk Analysis

1.1 Background

Pest Risk analysis provides the rationale for phytosanitary for specified PRA area. It evaluates scientific evidence to determine whether an organism is a pest. If so, the analysis evaluates the probability of introduction and spread of the pest and the magnitude of potential economic consequences in a defined area, using biological or other scientific and economic evidence. If the risk is deemed unacceptable, the analysis may continue by suggesting management option that can reduce the risk to an acceptable level. Subsequently, pest risk management option may be used to establish phytosanitary regulation.

For some organisms, it is known beforehand that they are pests, but for others, the question of whether or not they are pests should initially be resolved. The pest risks posed by the introduction of organisms associated with a particular pathway, such as a commodity, should also be considered in a PRA. The commodity itself may not pose a pest risk but may harbour organisms that are pests. Lists of such organisms are compiled during the initiation stage. Specific organisms may then be analyzed individually, or in groups wherein component species share common biological characteristics.

Less commonly, the commodity itself may pose a pest risk. When deliberately introduced and established in intended habitats in new areas, organisms imported as commodities (such as plants for planting, biological control agents and other beneficial organisms, and living modified organisms (LMOs) may pose a risk of accidentally spreading to unintended habitats causing injury to plants or plant products. Such risks may also be analyzed by using the PRA process.

The PRA process is applied to pests of cultivated plants and wild flora, in accordance with the scope of the IPPC. It does not cover the analysis of risk beyond the scope of the IPPC.

Provisions of other international agreements may address risk assessment (e.g. the Convention on Biological Diversity and the Cartagena Protocol on Biosafety to that convention).

Bangladesh has been importing pulse from Australia, Canda, China, India, Nepal and Turkey However, assessment of the potential risk of introduction of any exotic pests and diseases with this commodity to Bangladesh and the probability of their Establishment in Bangladesh condition has not yet been performed. Recently, Plant Quarantine Wing, Department of Agricultural Extension (DAE) felt that an analysis of the biosecurity risks of pulse pests is required. Hence the present activities were taken up. Here pests are referred to insect pests, diseases and weed of pulse and the PRA areas are the selected 29 districts as shown in Table 1.

1.2 Scope of the Risk Analysis

The scope of this risk analysis is to determine the presence of insect pests, diseases, weeds and other organisms of pulses in Bangladesh and to ascertain the potential hazard organisms associated with pulse grains imported from the Australia, Canada, China, India, Nepal and Turkey. Unhusked pulses are imported for food or seed purposes. Risk is defined as the likelihood of the entry of the hazards with the pathway or commodity, probability of establishment and the magnitude of the consequences of the hazards on economic, environment or health point of views. The framework of pest risk analysis associated with importation of pulse grains includes three stages such as initiation, pest risk assessment and pest risk management.The standard focuses on the initiation stage, gatheringinformation, documentation, risk communication, uncertainty, consistency and management of hazards.

1.3 Objectives of the PRA Pulse Crops

Pest Risk Analysis (PRA) of pulse crops is done with the aim of some specific obejectives which are:

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

1.4 PRA Areas

The entire Bangladesh is considered as PRA area in this risk analysis because major pulse crops are grown almost all over the country. Moreover pulse grains are imported through different land ports which are located all regions of Bangladesh. However, survey on insect pests, diseases, weeds and other hazard organisms was done in major pulse growing districts of Bangladesh.

1.5 Methodology of Pest Risk Analysis

PRA process includes three major stages such as Initiation, Pest Risk Assessment and Pest Risk Management. The following methods were sequentially followed to conduct PRA of pulse crops.The process and methodology for undertaking import risk analyses are shown in Figure 1.

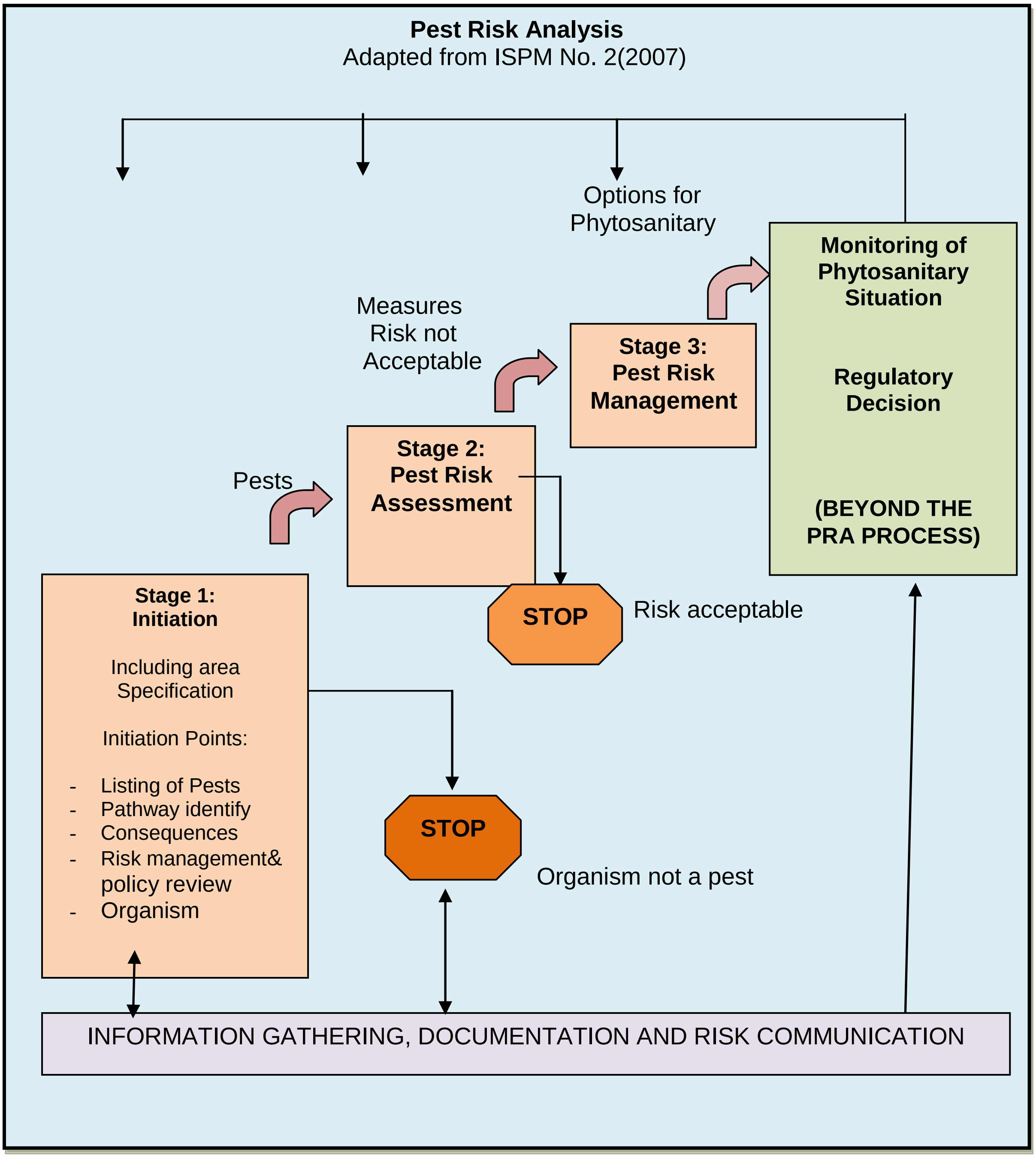


Figure 1.Schematic Diagram of Pest Risk Analysis.

1.5.1 Methodology of Data Collection

In order to collect the information and present status of different insect pests, diseases and weeds in pulse field and also infestation with insect pests in the storage and storage diseases, an extensive survey was conducted at 700 blocks under 70 upazilas of 29 major pulse growing districts of Bangladesh (Table 1, Figure 2). Information was colleted by interviewing with Sub-Assistant Agriculture Officer (SAAO), Upazila Agriculture Officer (UAO) and the Deputy Director (DD), Department of Agricultural Extension (DAE), and scientists of BARI and BINA research stations using structured questionnaire to know the present status of insect pests, diseases and weeds of pulse crops in respected districts. Moreover information on the area of pusle cultivation and production in the selected districts were collected from the DAE office. With the assistance of DAE, ten farmers from each of 10 blocks in each upazila were selected for interview on the incidence and severity of insect pests, diseases and weeds in their pulse crops in the field and storage and control measures followed by them. Primary data on incidence and severity of different insect pests, diseases and weeds were collected available in the field from the standing pulse crops of the selected farmer's field from each upazila and recorded. A list of selected districts and upazilas are provided in Table 1. List of DAE/BARI/BINA personnel met during Information collection are shown Appendix XVIII.

For conducting Pest Risk Analysis (PRA) all the Formats and Questionnaires used are included in the AppendicesXIII-XVII

Table 1.List of Districts and Upazilas selected for PRA Studies of Pulse crops

Sl. No.	District	Upazila
01.	Gopalgonj	1. Sadar
		2. Kashiani
		3. Tungipara
02.	Madaripur	4. Shibchar
		5. Rajoir
		6. Kalkini
		7. Sadar
03.	Shariatpur	8. Noria
		9. Bhedergonj
		10. Jangira
		11. Goshairhat
04.	Magura	12. Mohammadpur
		13. Sadar
05.	Narail	14. Sadar
		15. Lohagora
06.	Faridpur	16. Bhanga
		17. Sadar
07.	Rajbari	18. Pansha
		19. Goalanda
08.	Pirojpur	20. Sadar
		21. Mothbaria
09.	Barishal	22. Sadar
		23. Ujirpur
10.	Bagerhat	24. Morolgonj
		25. Sadar
		26. Shoronkhola
11.	Satkhira	27. Kolaroa
		28. Sadar
		29. Shamnagar
12.	Khulna	30. Dumuria
		31. Fultala
13.	Jessore	32. Jikargacha

Sl. No.	District	Upazila
		33. Sarsa
		34. Bagarpara
14.	Jhenidah	35. Kaligonj
		36. Moheshpur
		37. Sadar
15.	Khagrachari	38. Sadar
		39. Dighinala
		40. Panchari
16.	Feni	41. Sonagazi
		42. Chagalnaya
17.	Dhaka	43. Dhamrai
		44. Keranigonj
18.	Sirajgonj	45. Ullapara
		46. Raigonj
19.	Chittagong	47. Satkania
20.	Chapainwabgonj	48. Sadar
		49. Shibgonj
		50. Bholahat
21.	Rajshahi	51. Paba
		52. Charghat
		53. Bagha
22.	Barguna	54. Amtali
		55. Sadar
23.	Sherpur	56. Sadar
		57. Nokhla
24.	Mymensingh	58. Goffargaon
		59. Trishal
		60. Ishwarganj
25.	Kishoregonj	61. Sadar
		62. Pakundia
26.	Lakshmipur	63. Raipur
		64. Sadar
27.	Thakurgaon	65. Baliadanga
		66. Ranishoinkol
28.	Tangail	67. Bhuapur
		68. Sadar
29.	Patuakhali	69. Doshmina
		70. Bauphal

1.5.1.1 Appointment and Training of Field Researchers

Agricultural graduates were appointed as field researchers. Theoretical and practical training on identification and data collecton of insect pests, diseases and weeds of pulse crops was given by specialist scientists of BARI. Questionnaires and field data collection Format were supplied to the enumerator for collectionof appropriate information from the Farmers, SAAO, UAO, DD and Researchers.

1.5.1.2 Field Survey and Primary Data Collection

Seven teams consisting two members in each wereformed for field survey and collection of information based on questionnaire and format from the farmers and concerned officials of 29 districts (Figure 2). Each team was supplied with colored photographs of damage symptom for insect pests, diseases and weeds for identification.Moreover, primary information of insect pests, diseases and weeds of pulses in filed and storage was collected from Nepal by visiting during the study period.

1.5.1.3 Secondary Data Collection

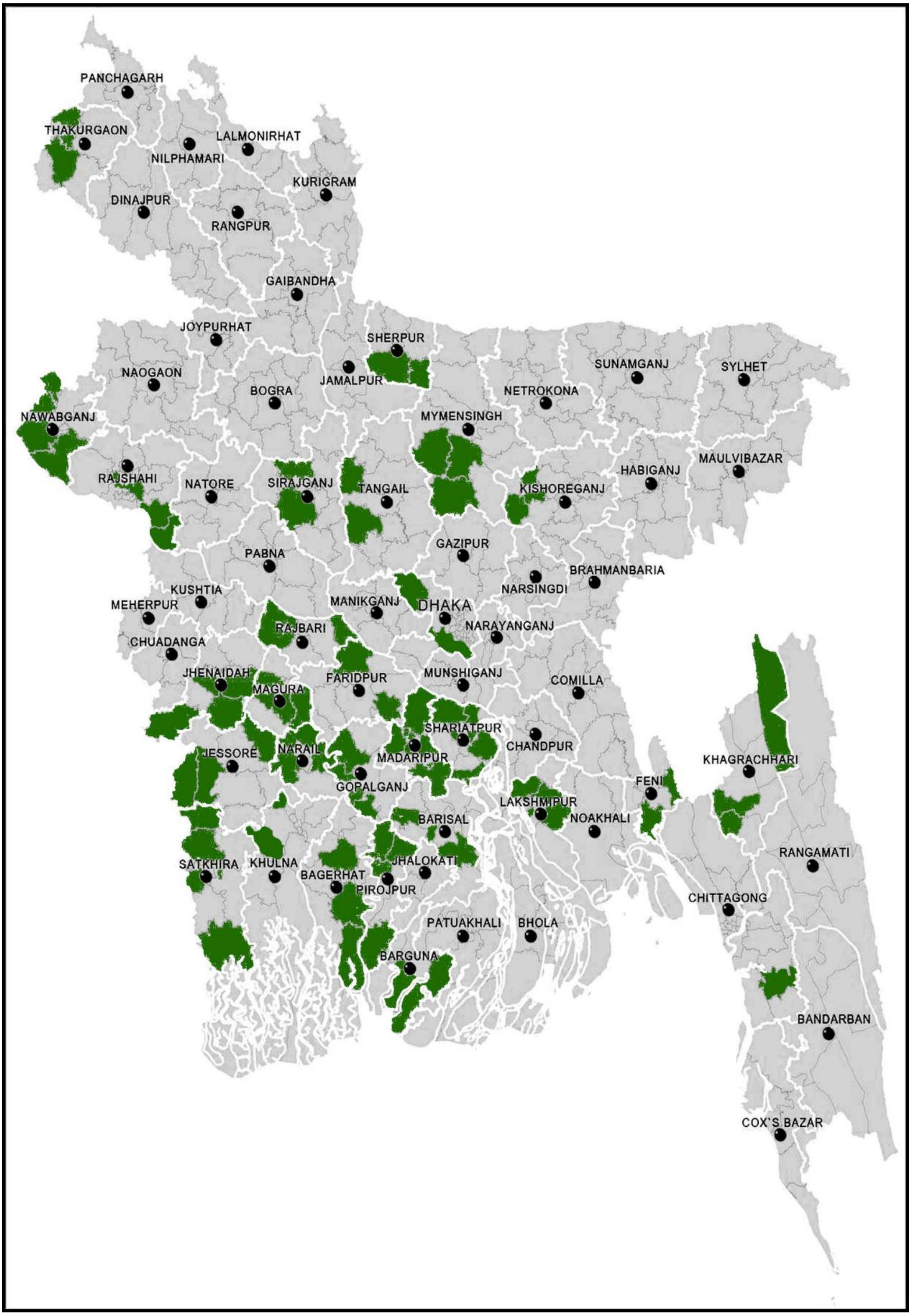
The secondary data on insect pests, diseases and weeds of pulses were collected from scientists of BARI and BINA, university teachers, DAE personnels, books, journals, published reports, CD of CABI and internet searching. Moreover information was collected from concerned Nepalese scientists by visiting Nepal.These data were checked with primary data and the final list of insect pests, diseases, weedsand other pestsof pulses in field and storage were prepared.

1.5.1.4 Internet Searching

Information on insect pests, diseases, weeds and other pests of pulse crops in fieldand storage were collected worldwide through internet searching especially of Australia, Canada, China, India, Nepal and Turkey from where pulse grains are imported to Bangladesh. Major pulse growing areas of exporting countries to Bangladesh were identified and climate data of those areas were also collected so far available. Insect pests, diseases and weed control measures taken in the field, pre-shipment phytosanitary measures and other handling procedures followed in the exporting countries were also gathered. Collected information was analyzed to identify the quarantine pests, diseases and weeds.

1.5.1.5 Interpretation of Results

The collected information on insect pests, diseases and weeds of pulse from different locations were analyzed and interpreted with the aim to find out variations in order toknow the incidence and status of each pest against the location. The most vulnerable stage of plant growth for insect pests and disease attack was also determined based on both primary and secondary data. Finally, a check list was prepared based on locally available insect pests, diseases and weeds of pulses in Bangladesh in comparison with six exporting countries.



Figrue 2.Study Area of Pulses Showing in Bangladesh Map

1.5.2 Methodology of Risk Analysis

The process and methodology for undertaking import risk analyses need to collect the information on insect pests, diseases and weeds of the particular commodity in the importing country, the primary data collection and secondary data collection from relevant persons, published reports, journal article or books as well as from internet resources. Prepare a separate pest list of importing country as well as of each exporting countries hereinafter will be called as country of origin. Compare the lists critically to identify the potential destructive exotic pests.The detail process of Pest Risk Analysis is shown in Figure 3.

1.5.3 Commodity and Pathway Description

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

1. The country of origin, including geographic and climatic condition, relevant crop growing practices, pest management systems;
2. Pre-export processing and transport systems;
3. Export and transit conditions, including packaging, mode and method of shipping;
4. Nature and method of transport and storage on arrival in Bangladesh;
5. Characteristics of Bangladesh climate, and relevant agricultural practices.

This information provides context for the assessment of the potential hazard organisms.

1.5.4 Hazard Identification

For any risk assessment the first step is to identify the hazard as the risk is related to hazard. Hazards are the unwanted insect pests, diseases (pathogen) or weeds which could be introduced into Bangladesh by risk goods, in this case selected pulses, and are potentially capable of causing harm to pulse production in Bangladesh, must be identified. This process begins with the collation of a list of organisms that might be associated with the commodity in the country of origin. Such list is compared with the existing pests present in Bangladesh to prepare a list of exotic pests harmful for Bangladesh if introduced.

This list is to be further refined and species removed or added to the list depending on the strength of the association and the information available about its biology and life cycle. Each pest or pathogen is assessed mainly on its biological characteristics and its likely interaction with the Bangladesh environment and climate. Hitch-hiker organisms sometimes associated with a commodity, but which do not feed on it or specifically depend on that commodity in some other way are also included in the analysis. This is because there may be economic, environmental and human health consequences of these organisms entering and/or establishing. Diagrammatic representation of hazard identification is shown in Figure 4.

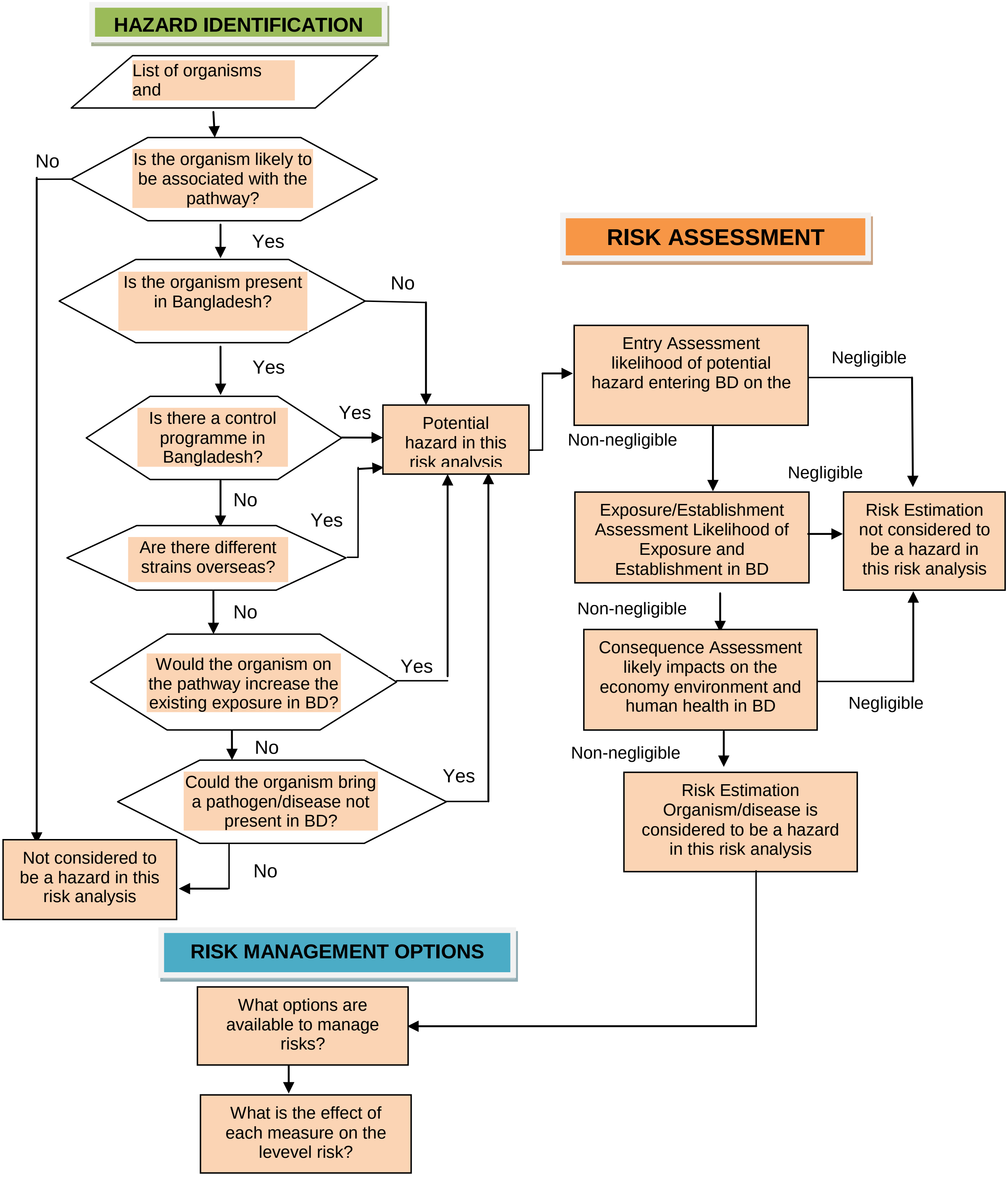


Figure 3. Diagram of the risk analysis process. The three main aspects of analysis include: hazard identification, risk assessment, and risk management.

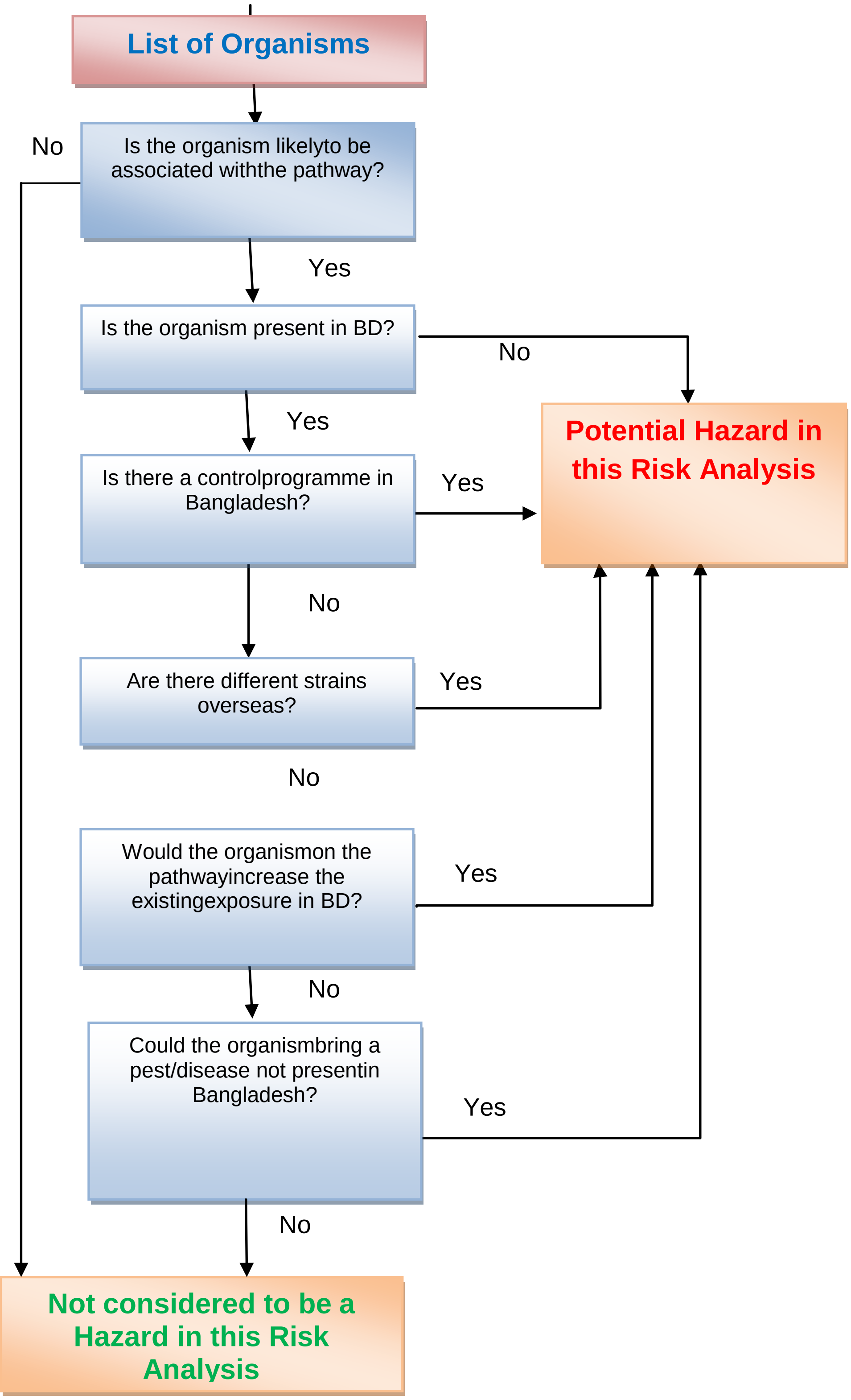


Figure 4. Diagrammatic Representation of Hazard Identification

1.5.5 Methodology ofRisk Assessment

Risk assessment is the evaluation of the likelihood of entry, exposure and establishment of a potential hazard, and the environmental, economic, human and animal health consequences of the entry within Bangladesh. The aim of risk assessment is to identify hazards which present an unacceptable level of risk, for which risk management measures are required. Descriptors are used in assessing the likelihood of entry, exposure and establishment, and the economic, environmental, social and human health consequences. The approach taken in this Risk Analysis is to assume the commodity is imported without any risk management. In this risk analysis hazards have been grouped where appropriate to avoid unnecessary duplication of effort in the assessment stage of the project. Diagrammatic representation of risk assessment and risk management is shown in Figure 5.

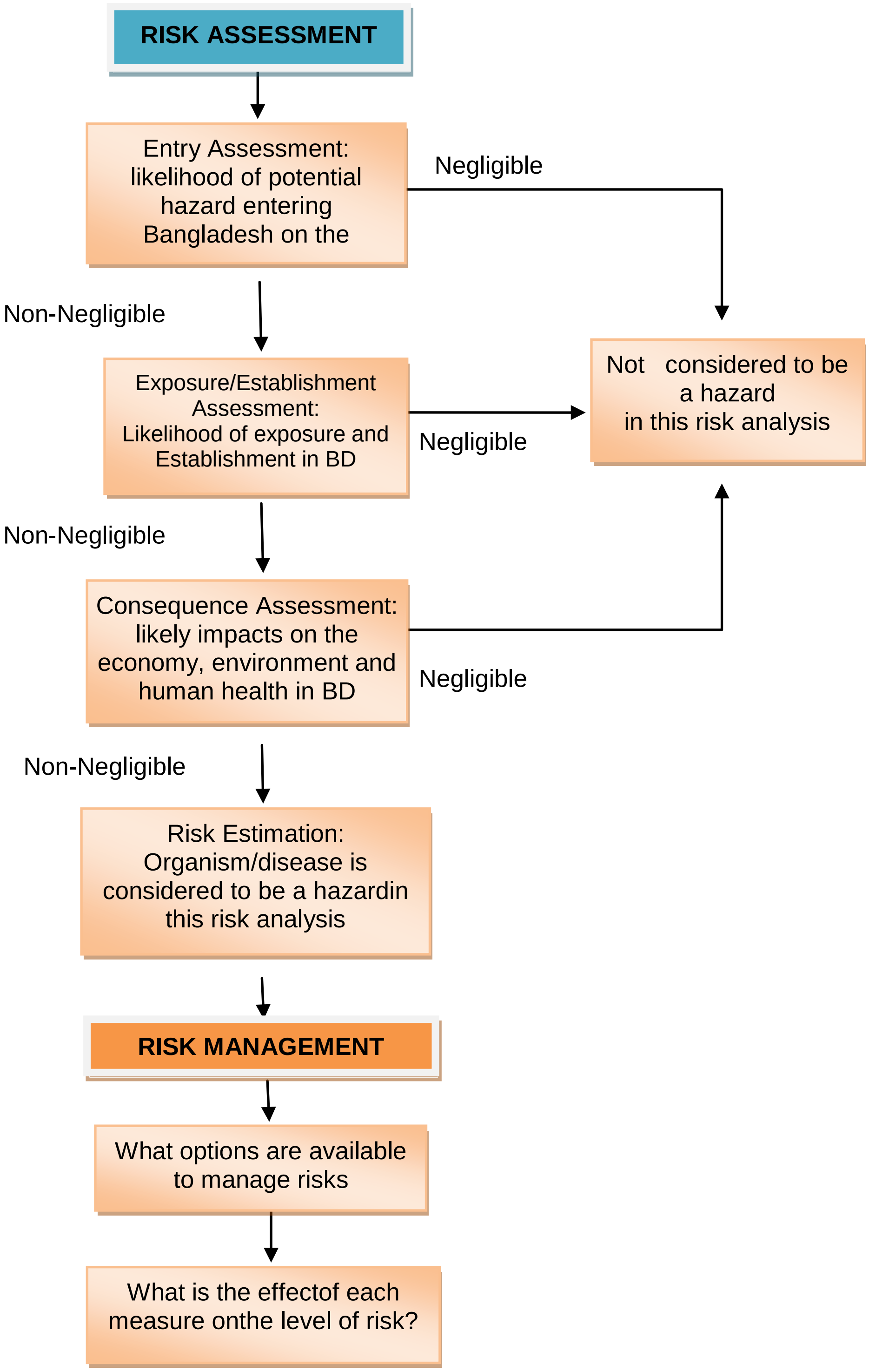


Figure 5. Diagrammatic Representation of the Process Followed for Risk Assessment and Management.

1.5.6 Assessment of Uncertainties

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

1.5.7 Analysis of Measures to Mitigate Biosecurity Risks

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

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

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

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

1.5.8 Risk Evaluation

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

1.5.9 Option Evaluation

Measures that are expected to be effective against the hazard species are considered. A package of risk management measures is likely to be required to address the risk from all identified hazards. While there are currently six established pathways (Australia, Canada, China India, Nepal and Turkey) forpulse grains coming into Bangladesh, border interception for these pathways cannot be extrapolated to predict any possible level of slippage or efficacy of treatments. However, border interceptions can be used as evidence of hazard organism association with the commodity. Each new pathway must be regarded as unique, given differing pre- and post-harvest practices and treatment measures. Different pest species are associated with each pathway and measures therefore must be tailored to the individual organisms.

1.5.10 Review and Consultation

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

2.0 INITIATION

2.1 Introduction

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

2.2 Identification of Pathways

The pathways for conducting present PRA include five pulses namely, chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), mungbean (*Vigna radiata* (L.) R. Wilczek, Grass pea (*Lathyrus* sativus) and cowpea (*Vigna unguiculata*(L.) Walp) imported from Australia, Canada, China, India, Nepal and Turkey.

2.2.1 Commodity Description

2.2.1.1 Introduction

Pulses are grown in virtually every corner of the globe. They have a strong history of nourishing people around the world for centuries. Along with the early cereal grains, pulses were among the first crops cultivated as far back as 11,000 years ago. In the past three decades, global pulse production has grown rapidly. In the past ten years alone, the world has produced between 50 and 60 million tonnes of pulses each year. Nearly 173 countries grow pulses. As of 2015, the world's biggest producers of pulses were India, Canada, Myanmar, China, Nigeria, Brazil, Australia, USA, Russia, and Tanzania, while the world's most important pulse exporters also include Argentina, France, Ethiopia, and Turkey (http://pulses.org/what-are-pulses/where-do-pulses-grow).

Five species of pulse crops for conducting PRA include lentil, chickpea, mungbean, Grass pea and cowpea. Lentil is the most widely grown crop in the world as well as in Bangladesh. The contributions of Pulse crops are two ways. These are the sources of cheap protein and thus helping poor people for maintaining their health and also fixing atmospheric nitrogen and added to the soil for its use and for use by subsequent crops. Presently, the world leading lentil producing country is Canada. India is in the second position which is followed by Australia. Bangladesh is in the ninth position after Nepal.Chickpea is grown in tropical, sub-tropical and temperate regions. Kabuli type is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics (19, 20). Chickpea is valued for its nutritive seeds with high protein content, 25.3-28.9 %, after dehulling (15).

2.2.1.2 History

Short history on the origin of selected five pulse crops are briefly enumerated below:

Lentils probably originated in the Near East and rapidly spread to Egypt, central and southern Europe, the Mediterranean basin, Ethiopia, Afghanistan, India and Pakistan, China and later to the New World including Latin America (10, 11, 17). It is probably the oldest of grain legumes to be domesticated (5). It is now cultivated in most subtropical and also in the Northern hemisphere such as Canada and Pacific Northwest regions. During 2014, the top lentil producing countries were Canada, India, Australia, Turkey and Nepal (4). The plant was given the scientific name *Lens culinaris* in 1787 by Medikus, a German botanist and physician (10, 14, 23).

Chickpea is the English name of the plant. In different countries it is known as Bengal gram (Indian), Garbanzo (Latin America), Hommes, Hamaz (Arab world), Nohud, Lablabi (Turkey)

(21). Chickpea is grown in tropical, sub-tropical and temperate regions. Kabuli type is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics (19,20). van der Maesen (1972) believed that the species originated in the southern Caucasus and northern Persia. However, Ladizinsky (1975) reported the center of origin to be southeastern Turkey. van der Maesen (1987) recognized the southeastern part of Turkey adjoining Syria as the possible center of origin of chickpea based on the presence of the closely related annual species, *C. reticulatum* Ladizinsky and *C. echinospermum* P.H. Davis. Wild *C. reticulatum* is interfertile with the cultivated pulse and morphologically closely resembles cultivated *C. arietinum.* It is regarded as the wild progenitor of chickpea (16). "Botanical and archeological evidence show that chickpeas were first domesticated in the Middle East and were widely cultivated in India, Mediterranean area, the Middle East, and Ethiopia since antiquity. Brought to the New World, it is now important in Mexico, Argentina, Chile, Peru and the U.S. Also important in Australia.Wild species are most abundant in Turkey, Iran, Afghanistan, and Central Asia" (11).

Mungbean was domesticated in Persia (Iran), where its progenitor (*Vigna radiata* subspecies *sublobata*) occurs wild (12, 26). Archaeology has turned up carbonized mung beans in many sites in India (13). Areas with early finds include the eastern zone of the Harappan civilization in Punjab and Haryana, where finds date back about 4500 years, and South India in the modern state of Karnataka where finds date back more than 4000 years. Some scholars therefore infer two separate domestications in the northwest and south of India. In South India there is evidence for evolution of larger-seeded mung beans 3500 to 3000 years ago (12).Mungbean is of ancient cultivation in India and the plant is not found in a wild state. It is probably derived from *Phaseolus radiatus* L., which occurs wild throughout India and Burma, and which is occasionally cultivated (18).By about 3500 years ago mung beans were widely cultivated throughout India. Cultivated mung beans later spread from India to China and Southeast Asia. Archaeobotanical research at the site of Khao Sam Kaeo in southern Thailand indicates that mung beans had arrived in Thailand by at least 2200 years ago (9). Finds on Pemba Island indicate that during the era of Swahili trade, in the 9th or 10th century, mung beans also came to be cultivated in Africa (29. Green gram is said to have been widely cultivated in India and adjacent regions for several thousand years, and to have spread at an early time into other Asian countries and to northern Africa. Its present wide distribution throughout the tropics and subtropics of Africa, the west of India, north of America and Australia is comparatively recent. Currently, green gram is the most important seed legume in Thailand and the Philippines; it ranks second in Sri Lanka and third in each of India, Burma, Bangladesh and Indonesia. It is a minor crop in Australia, China, Iran, Kenya, Korea, Malaysia, the Middle East, Peru, Taiwan and the USA. About 90% of the world production of mungbean is in South Asia, especially in Bangladesh, Burma, India, Indonesia, Pakistan, Philippines, Sri Lanka and Thailand (24).

The origins of **Grass pea** are unclear. Archaeological evidence suggests that domestication of grass pea probably occurred in the Balkan region around 6,000 BC, and further remains have been found in India dating to 2,000-1,500 BC. Grass pea is now widely cultivated and naturalized in many areas of southern, central and eastern Europe, around the Mediterranean Basin and in Iraq and Afghanistan. Grass pea is an economically important crop in Bangladesh, India, Pakistan, Nepal, and Ethiopia (8).

Cowpea has been a staple crop and important protein source for many cultures since the Roman Empire. It was the most commonly cultivated bean used for human consumption in the Old World (2). Roman writers such as Pliny referred to it as phaseolus. Thomas Jefferson is credited with first using the name cowpea. Today the crop is still widely popular, and good harvests are critical to ensure adequate levels of protein in the diets of populations in India and East Asia (2).

2.2.1.3 Pulses in Bangladesh

Farmers in Bangladesh have been growing pulses over generations. In the traditional growing areas, farmers adopted age-old practices with no inputs and with little care. Traditionally, local varieties with low yield potential were cultivated in Bangladesh. To enhance the yield, BARI, BINA and BSMRAU developed 39 pulse varieties with high yield potential during recent years. These varieties are resistant to major diseases and can yield at least 35-60% higher than local varieties. Their cultivation is mainly concentrated in the Gangetic calcareous floodplain with soil pH 6.5-7.5. In recent years, there has been substantial progress in pulses research and development in Bangladesh (1).As food pulse crops supply cheaper protein and also enrich the soil with symbiotically fixed nitrogen through the rhizobium, the common nodule bacteria attached with the root system. Pulses occupy about 4 percent of the total cropped area and contribute about 2 percent to the total grain production of Bangladesh (7).Many different species of pulses are grown in the country. The major pulses are Grasspea (*Lathyrus sativus* L.), Lentil (*Lens culinaris* Medik.), Chickpea (*Cicer arietinum* L.), Black gram (*Vigna mungo* (L.) Hepper) and Mungbean (*Vigna radiata* (L.) Wilez.), and the minor ones are Cowpea (*Vigna unguiculata* (L.) Walp., Pigeon pea (*Cajanus cajan* (L.) Millsp.), Field pea (*Pisum sativum* L.), Faba bean (Vicia faba L.) and Horse gram (*Macrotyloma uniflorum*) (6). According to the area covered, the first five places are occupied by grasspea (248,365 ha), lentil (209,049 ha), chickpea (85,641 ha), black gram (68,492 ha) and mungbean (54,445 ha). These cover about 93% of the total pulse crop area (3). In 1969-74 pulse was planted in Bangladesh on an area of 212.4 thousand hectares with production of 61 thousand tones and yields 709.37 kg per hectare. In the year 2004-09 the pulse area was increased to 339.2 thousand hectares with an annual production of 115.8 thousand tones and yield 843.24 kgs per hectare. The highest area under pulses was 654.2 thousand ha during 1989-1994, and the yield was 713.59 kg/ha (25). Grasspea, lentil and chickpea are cultivated during winter (November-March). Mungbean is grown during the rainy season in the northern parts of the country and during late winter (January-April) in the southern parts. Cowpea is grown after rainy season in Chittagong Division only. Cultivation of grain legumes is mainly concentrated within the Gangetic floodplains in the northern districts and in some southern districts. Bangladesh faces an acute shortage of pulses. The country produces a total of 0.53 million tons against the demand of almost 2 million tons (22).The deficit is partly covered by imports.

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2.2.1.4 Morphological Characteristics of the Commodities

Lentil (*Lens culinaris* Medik.)

Taxonomic Position:

Kingdom: Plantae
Subkingdom: Viridiplantae
Infrakingdom: Streptophyta
Superdivision: Embryophyta
Division: Tracheophyta
Subdivision: Spermatophytina
Class: Magnoliopsida
Superorder: Rosanae
Order: Fabales
Family: Fabaceae
Genus: Lens Mill.
Species: Lens culinaris Medik. (3)

Lentils (English) in some other languages are called as Mercimek (Turkey), Messer (Ethiopia), Masser (India) and Musur (Bangladesh).It is now cultivated in most subtropical and also in the Northern hemisphere such as Canada and Pacific Northwest regions. During 2014, the top lentil producing countries were Canada, India, Australia, Turkey and Nepal (3).

Germination of lentil is hypogeal and this keeps the developing seedlings below ground level which reduces the effects of freezing and other desiccating environmental conditions (20).

The botanical features of *Lens culinaris* (cultivated lentil) can be described as annual bushy herb, slender almost erect or suberect, much-branched, softly hairy; stems slender, angular, 15-75 cm height (11,20). Stem colour, an important morphological character, varied from normal green to purple. Green stem colour was found in 45% of the accessions and the rest 55% were with purple stem. Most of the accessions originated from ICARDA were with purple stem. The stem colour of other accessions originated from India, Pakistan, Nepal and Ethiopia were either purple or green. The leaves are alternate, compound, pinnate, usually ending in a tendril or bristly; leaflets 4-7 pairs, alternate or opposite; oval, sessile, 1-2 cm long; stipules small, entire; stipules absent; pods oblong, flattened or compressed, smooth, to 1.3 cm long, 1-2-seeded; seed biconvex, rounded, small, 4-8 mm × 2.2-3 mm, lens-shaped, green, greenish-brown or light red speckled with black; the weight of 100 seeds range from 2 to 8 g; cotyledons red, orange, yellow, or green, bleaching to yellow, often showing through the testa, influencing its apparent color (11, 15, 21). Flowers are small, pale blue, purple, white or pink, in axillary 1-4-flowered racemes; 1-4 flowers are borne on a single peduncle and a single plant can produce upto 10-150 peduncles each being 2.5-5 cm long (20). Flowering proceeds acropetally. The size of seeds increase from the types grown in eastern regions to western types.Lentils are divided into two major types : macrosperma (large -seeded, or Chilean types) and microsperma (small-seeded , or Persian types) (8, 33). Large-seeded lentils have seeds up to 0.5 inch diameter with yellow cotyledons and little pigmentation in the flowers or vegetative structures. Small-seeded lentils have seeds up to 0.25 inch diameter with red, orange or yellow cotyledons and more pigmentation in the plant tissue. Small-seeded lentils are generally shorter and have smaller leaves and pods (22). The first one includes the Chilean or yellow cotyledon types while the latter includes the small seeded Persian or red cotyledon lentils (15). Lentil flowers in 6-7 weeks after planting with early cultivars ready to harvest in 80-110 days, late cultivars reach maturity in 125-135 days. In traditional agricultural systems plants are cut to ground level or pulled by hand when they turn golden yellow and left to dry for 5-10 days before being threshed and winnowed.

Chickpea (*Cicer arietinum L.*)

Taxonomic Position:
Kingdom: Plantae
Sub-kingdom: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Fabaceae (Leguminosae)
Subfamily: Faboideae(Papilionaceae)
Genus: Cicer
Species: *C. arietinum* (4)

Chickpea is the only domesticated species under the genus Cicer, which was originally classified in the tribe vicieae of the family Leguminosae and sub family, Papilionaceae. Based on the pollen morphology and vascular anatomy, Cicer is now set aside from the members of Vicieae and is classified in its own monogeneric tribe, Cicereae Alef. The tribe, Cicereae comes closer to the tribe, Trifolieae, which differs from the former in having hypogeal germination, tendrils, stipules free from the petiole, and nonpapillate unicellular hairs. The genus Cicer comprises 43 species and is divided into two subgenera. The subgenus, Pseudononis is characterized by small flowers (normally 5-10 mm), subregular calyx, with hardly gibbous base, with sublinear nearly equal teeth.

It comprises two sections:-

- Monocicer -annuals, with firm erect or horizontal stems branched from the base or at middle. The species *Cicer arietinum* is under this sub-section
- Chamaecicer -annuals or perennials, with thin creeping branched stem, and small flowers (32).

Chickpeas are classified based on seed size, shape and color. Two types are common: the small, angular, and colored seeds are classified as desi and the large, ram-head shaped and beige-colored seed are called kabuli (23, 26). The *desi* types predominate in the Indian subcontinent. The crop is grown in tropical, sub-tropical and temperate regions. Kabuli type is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics especially in the Indian sub-continent (18, 19).

Chickpea stems are branched, erect or spreading, sometimes shrubby much branched, 0.2-1 m tall, glandular pubescent, olive, dark green or bluish green in color. Root system is robust, up to 2 m deep, but major portion up to 60 cm. Leaves imparipinnate, glandular-pubescent with 3-8 pairs of leaflets and a top leaflet (rachis ending in a leaflet); leaflets ovate to elliptic, 0.6-2.0 cm long, 0.3-1.4 cm wide; margin serrate, apex acuminate to aristate, base cuneate; stipules 2-5 toothed, stipules absent. Flowers solitary, sometimes 2 per inflorescence, axillary; peduncles 0.6-3 cm long, pedicels 0.5-1.3 cm long, bracts triangular or tripartite; calyx 7-10 mm long; corolla white, pink, purplish (fading to blue), or blue, 0.8-1.2 cm long. The staminal column is diadelphous (9-1) and the ovary is sessile, inflated and pubescent" (10, 11, 29). Pod rhomboid ellipsoid, 1-2 with three seeds as a maximum, and inflated, glandular-pubescent. Seed color cream, yellow, brown, black, or green, rounded to angular, seedcoat smooth or wrinkled, or tuberculate, laterally compressed with a median groove around two-thirds of the seed, anterior beaked; germination cryptocotylar (10, 11, 29).

Chickpea is a self-pollinated crop. Cross-pollination is rare; only 0-1 % is reported (25, 27).

Mungbean (*Vignaradiata* (L.) R. Wilczek

Taxonomic Position:

Kingdom: Plantae
Subkingdom: Viridiplantae
Superdivision: Embryophyta
Division: Tracheophyta
Subdivision: Supermatophytina
Class: Mangnoliopsida
Superorder: Rosanae
Order: Fabales
Family: Fabaceae
Genus:Vigna
Species: Vigna radiata (L.) R. Wilczek (31)

The mungbean (*Vigna radiata* (L.) R. Wilczek) is a legume cultivated for its edible seeds and sprouts across Asia. There are 3 subgroups of *Vigna radiata*: one is cultivated (*Vigna radiata* subsp. *radiata*), and two are wild (*Vigna radiata* subsp. *sublobata* and *Vigna radiata* subsp. *glabra*) (12).

Mungbean is a deep rooted plant; the lateral branches of roots contain nodules, which contain nitrogen-fixing bacteria (2). It is a herbaceous annual, semi erect to erect or sometimes twining, deep- rooted herb, 15-125 cm tall (16). Stems branching at the base and covered with short, fine, brownish hairs. Leaves are alternate, trifoliate with long petioles. Each leaflets being large, ovate, rounded at the base and pointed at the apex sometimes with five leaflets with long petioles. Each leaflets being large, broadly ovate, sometimes lobbed, rounded at the base and pointed at the apex, 5 to 18 cm long, and 2 to 15 cm wide (2,14). The crop begins flowering 50 to 60 days after sowing, and then continue flowering for a few weeks. Flowers are self-fertile and highly self-pollinated. the leaves dry down but may not drop off completely. From 10 to 25 flowers are born in axillary clusters or racemes. Flowers are greenish to bright yellow with a grey tinged keel, 1-1.75 cm in diameter. Calyx is composed of 5 sepals more or less united in a tube and persistent, aestivation imbricates. Five petals form corolla, which are very unequal and papilionaceous (i.e.1-posterior petal is largest and called standard or vexillum, 2-lateral petals are lanceolate and slightly curved and called wings or alae and 2-anterior petals are asymmetrical and more or less united to form a boat shaped structure and called keel or karina); aestivation is vexillary i.e. standard covers the wings and the wings cover the keel; all petals have a claw at the base. Androecium is composed of 10 stamens, diadelphous, usually (9)+1,anthers are dithecous, introrse and dehisce by longitudinal slits. Monocarpellary gynoecium; ovary superior, unilocular; ovules numerous; marginal placentation; style and stigma simple. The pods are cylindirical, straight to strongly curved, pointed at the tip, and radiate horizontally in whorls. When mature, the pods are glabrous or have short hairs, light brown to black, 5 to 14 cm long and 4 to 6 mm wide, and may burst open when dry shaterring the seeds. Each pod contains 8 to 20 seeds, which are globose; glossy or dull; with green, yellow, twany brown, black or mottled testa. Dull seeds are coated with a layer of the pod inner membrane which may be translucid or pigmented and which covers a shiny testa. Seeds vary in weight from 15 to 85 milligrams, generally averaging 25 to 30 thousand seeds per kilogram. The hilum is round, flat (non-concave) and white. Pods mature in about 20 days after flowering. Rapid senscence does not occur (6). Seeds are small, slightly flattened, globular with green, yellow, tawny brown, black or mottled testa (2)

Grasspea (*Lathyrus sativus* L.)

Taxonomic position:

Class: Equisetopsida
Subclass: Magnoliidae
Superorder: Rosanae
Order: Fabales
Family: Leguminosae/Fabaceae - Papilionoideae
Genus: *Lathyrus*
Species: *Lathyrus sativus* L (17)

Grasspea (*Lathyrus sativus*) is an annual herb, branched extensively. The plant is 60-170 cm tall with a well developed taproot. It has a variable habit and can be trailing or climbing. The stem is slender, quadrangular and winged with leaves arranged alternately along it. The leaves are pinnate, opposite, composed of 1-2 pairs of leaflets and ends in a simple or branched tendril. The leaflets are sessile, linear-lanceolate, 5-7.5 cm long x 1 cm broad. Stipules (appendages at the base of the leaf) are narrowly triangular, prominent and leaf-like. The petiole (the part which connects the leaf to the stem) is usually winged and is up to 3.5 cm long. The flowers are solitary, borne on axillary shoots. They can be bright blue, reddish-purple, red, pink or white and papilionaceous, typical of species belonging to the Leguminosae subfamily Papilionoideae, and resemble, for example, the common garden pea (*Pisum sativum*) flower. Each flower has 10 stamens, 9 of which are fused into a partial tube, with the tenth stamen free. The ovary is positioned above the sepals, petals and stamens. The style is abruptly upturned and the stigma is spoon-shaped (13, 30). An oblong, laterally flattened pod about 2.5- 5.5 cm in length, 0.6-2 cm in width and slightly curved. Each pod contains 3- 7 seeds. The seeds are wedge-shaped, 4-7 mm in diameter and can be white, pale green, grey or yellow but spotted or mottled form(7, 13, 30).

Cowpea [*Vigna unguiculata* (L.) Walp]

Taxonomic Position

Kingdom: Plantae
Division: Angiosperms
Unmarked: Rosids
Order: Fabales
Family: Fabaceae (Leguminosae)
Subfamily: Faboideae (Papilionaceae)
Genus: Vigna
Species: *V. unguiculata* (4)

Cowpea *(Vigna unguiculata*) is an important grain legume in Africa, parts of the Americas and in Asia (24). Cowpea is grown for its edible seeds and pods, that exhibits a wide range of growth habits. Varieties may be short and bushy, prostrate, or tall and vine-like. Canopy heights can be 2–3 feet, depending on the variety (24). Still today the crop is widely popular in the diets of populations in India and East Asia (1).

Cowpea is a warm-season, annual legume that exhibits a wide range of growth habits. Varieties may be short and bushy, prostrate, or tall and vine-like. Canopy heights can be 2–3 feet, depending on the variety. The cowpea plant is usually erect with hollow hairless ribbed stem, roughly 1 cm wide. The stems of twining varieties are thinner. The 10 cm long and 8 cm wide leaves are three-parted, smooth trifoliate and arranged alternately on the stems. The two lateral leaves are asymmetrical, and the terminal leaf is symmetrical (24).

The plant produces clusters of flowers at the end of a peduncle (flower stalk). Flowering occurs in roughly 48 days (5), and earlier varieties will produce pods in roughly 60 days (26). The flowers can be purple or white. The lowermost whorl of leaves under the flower is bell-shaped. The lobes of the flower are fused, and the lateral petals are shorter than the upper petal. The seed pods are two-valved, smooth, cylindrical and curved, reaching up to 35 cm (10 in) in length, with distinctive coloration, usually green, purple or yellow having 6-13 seeds per pod. As the seeds reach maturity the pod changes color to tan or brown.

The kidney-shaped seeds can be white, cream, green, red brown or black in color or be a mottled combination. The seed may also possess an ‘eye’ where a lighter color is surrounded by one that is darker at the point of attachment. Cowpea can reach in excess of 80 cm (31.5 in) in height and, as an annual plant, lives for only one growing season before harvest. Cowpea may also be referred to as black-eyed pea, southern pea, crowder pea or field pea.

In addition, the plants can grow a taproot which is often in excess of 8 ft which allows the plant to access moisture deep down in the soil (9). This makes cowpea extremely resistant to drought, requiring little or no irrigation after the plants have become established. Both wild and cultivated plants naturally nodulate in a variety of soils (1).

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2.2.1.5 Climatic Requirements

Lentil is one of the less selective legumes in terms of climate and soil features. It can be grown to an altitude of 3000 meters. On the other hand the seed yield per area decreases when the altitude increases (12). However, rates of germination, emergence, and seedling growth are markedly affected by temperature. Optimum values for germination and growth vary with cultivar, age, and size of seeds. Smaller seeded cultivars germinate more rapidly than larger ones at temperatures between 15 °C and 25 °C and for better growth and yield the optimum temperature is 16-28 ^{o}C (1, 10). "Seeds will germinate at temperatures above freezing but best at the range of 18-21°C; temperatures above 27°C are harmful; optimum temperatures for growth and yields are around 24°C. Lentils are grown as a cool weather or winter crop in the semi-arid tropics, cultivated from sea level to 3,800 m, but are not suited to the humid tropics. They are less damaged by drought than by waterlogging (5). Lentils require a minimum of 350mm rainfall and a maximum of 550mm; in the higher rainfall areas good drainage is essential (4, 9).

Chickpea is usually grown as a rainfed cool-weather crop or as a dry climate crop in semi-arid regions. Optimum conditions include 18-26°C and 21-29°C night temperatures and annual rainfall of 600-1000 mm (3, 8, 11). The Palouse region of the states Washington and Idaho, appears to be well suited to chickpea and can be characterized as having 18-25°C during the day and 5-10°C during the night and a sufficiently long growing season (8). California is very suited to the chickpea crop and it has thrived in the coastal areas and in the Central Valley. Thrives on a sunny site in a cool, dry climate on well-drained soils and grows on a residual moisture in the post-rainy seasons of sub tropical winter or spring of the northern hemisphere (11). Daily temperature fluctuations are desired with cold nights with dewfall. Relative humidity of 21-41% is optimum for seed setting. Although spoken of as "day-neutral," chickpea is a quantitative long-day plant, but flowers in every photoperiod (11).

Mungbean is a fast-growing, warm-season legume. It reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28-30°C and always above 15°C. It can be sown during summer and autumn. It does not require large amounts of water (600-1000 mm rainfall/year) and is tolerant of drought but sensitive to waterlogging. High moisture at maturity tends to spoil the seeds that may sprout before being harvested (7). Mungbeans (if proper varieties are used) are adapted to the same climatic areas as soybean, drybean and cowpea. Mungbeans are responsive to length of daylight so short days hasten flowering and long days delay it. Varieties differ in their photoperiod response (9).

Grass pea is a spring crop in temperate areas and a winter crop in subtropical regions. It can be cultivated from sea level up to an altitude of 1200 m. and from 1700 m to 2700 m in Ethiopia, and more generally in areas where. *Lathyrus sativus* can be grown where rainfall averages 400-650 mm/year and average temperatures of 10-25°C is the best (13). It grows well in the subtropics as a winter crop. Grass pea thrives on a wide range of soil types from light sandy through loamy to heavy clay and acid, neutral or alkaline soils. It does not tolerate shade. Like other legumes, it improves the nitrogen content of soil (13).

Cowpea is a warm season crop and thrives in hot, moist conditions. Cowpeas have similar growth requirements to soybeans and should not be planted until after the last frost and only when the soil temperature has reached 18.3°C to prevent seeds rotting in the ground. The plants will be killed by frost. Cowpeas can be planted in a wide range of soils, from acidic (to pH 4) to neutral, as long as they are well-draining but the plants are not well adapted to alkaline soil. For best results, plant cowpeas in a well draining sandy loam with a pH between 5.5 and 6.5 in an area that receives full sun. Cowpeas are drought resistant and very heat tolerant which means they can be grown successfully in many areas. Cowpeas should be direct seeded when the soil temperature is consistently above 18.3°C. Cowpeas are drought resistant and very heat tolerant which means they can be grown successfully in many areas (13). Cowpea in more salt and drought tolerant than common bean. Although it can be grown under rainfed condition, performs better under irrigated condition (6).The base temperature for germination is 8,5 °C and for leaf growth 20 °C. Cowpea is a heat-loving and drought-tolerant crop. The optimum temperature for growth and development is around 30 °C. Varieties differ in their response to day length, some being insensitive and flowering within 30 days after sowing when grown at a temperature around 30 °C. The time of flowering of photosensitive varieties is dependent on time and location of sowing and may be more than 100 days. It can grow under rainfall ranging from 400 to 700 mm per annum. However it grows best in areas that have an annual rainfall between 750-1100 mm. Cowpeas are also have a great tolerance to waterlogging. Well-distributed rainfall is important for normal growth and development of cowpeas (2).

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2.2.1.6 Cultivation

Lentil is propagated by seed. Fields should be plowed and harrowed to a fine texture. Well drained soils on south-and east-facing slopes because these slopes get warmer during the early part of the growing season and as a result crop emergence will be faster (18). Yield advantages due to early planting can be substantial, provided seeds are not "mudded in" by attempting to plant when the soil is too wet (13). Seed may be either broadcast, or sown in drills at the rate of 25-90 kg/ha, in rows 20-30 cm apart. Recommended seeding rates for Palouse farmers are 67–79 kg/ha (60–70 lb/acre) for the most commonly grown cultivar 'Brewer' (16). Elsewhere, seeding rates vary from 15 kg/ha (13 lb/acre) in northern India to 115 kg/ha (103 lb/acre) for irrigated crops in Egypt (14). Studies indicate that a seeding depth of 4–5 cm (1.5–2 inches) is optimal for germination and growth, even though deeper plantings may have better access to soil moisture and improved protection from frost. Despite some success with deeper plantings, plant emergence may be poor due to soil compaction from farm machinery or heavy rains. Lentil seeds can germinate in the light or the dark and in constant or diurnally fluctuating temperature regimes. However, rates of germination, emergence, and seedling growth are markedly affected by temperature. Optimum values for germination and growth vary with cultivar, age, and size of seeds. Smaller seeded cultivars germinate more rapidly than larger ones at temperatures between 15 °C and 25 °C (20). Lentils are a cool season legume species and as such are grown as a summer annual in temperate climates and as a winter annual in subtropical climates. In India, the crop is grown both in Kharif and rabi season. The optimum time for seed sowing in kharif season is June-July and for rabi season October-November. The seed rate is 8 to 10 kg/ha maintaining 30 × 10 cm spacing. Before sowing seeds are treated with rhizobium culture. Sowing is done by drilling or broadcasting method. One weeding and two hoeing are usually sufficient for weed control during establishment. Application of FYM at 3 to 5 ton/ha and 25 kg P2O5 is enough for good crop. Generally lentil is grown under rainfed condition using residual soil moisture but irrigation at pod development stage helps getting more yields. Lentils is mainly cultivated in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar and West Bengal which together contribute more than 80% area and production of this crop. It is generally grown as rainfed crop during rabi season after rice, maize, pearl millet or *kharif fallow*. In North-eastern parts of the country, lentil is also cultivated as *paira* crop with rice. Bundelkhand region is known as 'lentil bowl' of the country. It is an ideal pulse crop for rice fallow situation of eastern part of the country (8, 23). In Bangladesh lentil is traditionally grown during the winter months on residual soil moisture under rainfed conditions. Optimum seed sowingtime is from mid October to mid November and harvesting from mid February to mid March (5). The major lentil growing areas are the greater districts of Faridpur, Jessore, Kustia, Pabna, Rajshahi and Comilla The major lentil oriented cropping patterns are broadcast aus;Fallow-Lentil, Jute-Fallow-Lentil, Broadcast aman-lentil-Fallow; T.Aman-lentil-Jute/Upland rice. It is grown both as a sole crop or as mixed crop. It also grown as intercropping with wheat, mustard, linseed or sugarcane in some parts of the country (2). Lentil is a well adapted plant that grows in a wide range of soil types with good drainage but best in deep, sandy loam soils (12, 19). They can tolerate moderate alkaline or saline conditions (17) and grow in soils with pH of 4.4 to 8.2, but are best adapted to soils with pH of 5.5 to 7.0 (1, 12, 21).

Chickpea

Land preparation for chickpea farming is based on soil type and cropping system followed. This crop grows well in clay to clay-loam soil. In case of heavy soil, a rough seedbed should be prepared to avaid packing of the cloddy surface due to winter rains and to accommodate soil aeration and easy seedling germination. Seed rate of 60 kg/ ha and plant density of 25-30 plants per square meter is ideal. In case of late sowing plant density should be higher. An average seed rate of 70-100 kg/ha is well enough for good stand of the crop. Ideal time of seed sowing is first and second week of October. The chickpea seeds are sown by local country plough or seed drill at a row spacing of 30-45 cm. Crop rotation with other cereal crops should be followed to control soil-borne diseases. In case of poor soil, this crop requires rotten farm yard manure, nitrogen, phosphorous and diammonium phosphate could be used before seed sowing at a depth of about 8 cm in the soil. Chickpea is cultivated mainly as rainfed crop. Good yield could be obtained under irrigated condition, which should be light as excessive watering result in profuse vegetative growth and lower grain yield. If no rain, one pre-sowing irrigation improves germination. For better harvest proper weeding and controlling diseases and insect pests is necessary (9). In Bangladesh, optimum time for seed sowing is from November to mid-January. For late sown crop irrigation facility should be there. Seed may be sown in line or by broadcasting methods. Seed rate for broadcasting is 60-68 kg/ha and 45-52kg/ha in case of line sowing. Before sowing seed should be mixed with rhizobium inoculums. Chickpea can also be grown as relay crop with rice. In such case seeds should be broadcasted in the rice field 3-4 weeks before harvesting rice (3).

Mungbean

In Bangladesh mungbean seed may be sown from 20 January to 30 March depending on the land topography and cropping systems. Seed rate depends on seed size and methods of sowing (Broadcasting or line sowing). For broadcasting, 1-2 passes of a power tiller followed hand broadcasting; followed by one more Pass is needed to incorporate seed into the soil. Seed sowing using seed drill is more convenient in such case row to row distance should be 30 cm. Mungbean can also be sown by bed planting. This machine tills the soil and place seed on top of a long bed that alternates with furrows that can be used for irrigation. Bed planting may require 1-2 passes of a power tiller before planting, especially where soils are heavier. Bed planting performs poorly in very heavy soils or where the soil is saline.

Mungbean can be cultivated on sandy loam, laterites, alluvial and heavy clay (black cotton) types of soils. The soil should be well drained since it is sensitive to waterlogging. Yields are best in deep, well drained alluvial loams, red loams and black soils (22).

Grasspea is extensively cultivated in Iraq, Iran, Afghanistan, Syria and Lebanon in Middle East, France and Spain in Europe and Algeria, Egypt, Ethiopia, Libya and Morocco in Africa (10). "It is propagated by seed. Some say inoculation is essential before sowing, especially in virgin soil; others say it appears unnecessary. In some temperate regions, grasspea is sown after rye, or on fallow land. Seeding rates vary from 45-90 kg per hectare depending on the method of cultivation, whether in pure stand or intercropped purpose of cropping (food or feed) and seed size. Seeds may be sown broadcast or in furrows about 3 cm apart in a well-prepared field. The crop comes up as a thick mass over the entire surface and under ideal conditions can smother out weeds. Except for lime on acid soils, other nutrients are rarely needed. Phosphorus application is recommended in India, Pakistan, Nepal and Bangladesh, the crop may be sown as pure or in mixed stand often into a standing rice crop one to two weeks before rice is ready to harvest. Grasspea is reported to add 67 kg per hectare of nitrogen to the soil from symbiosis with *Rhizobium* sp." (10, 11, 15).

Cowpea is a warm season crop and thrives in hot, moist conditions. Cowpeas have similar growth requirements to soybeans and planted when the soil temperature has reached above 18.3°C to prevent seeds rotting in the ground. The plants will be killed by frost. Cowpeas can be planted in a wide range of soils, from acidic (to pH 4) to neutral, as long as they are well-draining but the plants are not well adapted to alkaline soil. For best results, plant cowpeas in a well draining sandy loam with a pH between 5.5 and 6.5 in an area that receives full sun. Cowpeas are drought resistant and very heat tolerant which means they can be grown successfully in many areas (plantvillage). It is a direct seeded crop. It has a number of common names, including crowder pea, blackeyed pea, southern pea, and internationally as lubia, niebe, coupe or frijole (6). In Bangladesh it is popularly known as 'Felon'. Cowpea is suitable to grow at all regions of Bangladesh. Presently it is extensively cultivated in the southern parts in the rice based based cropping system after the harvest of T.Aman rice. It also grows well in the hilly regions of Bangladesh. Cowpea in more salt and drought tolerant than common bean. Although it can be grown under rainfed condition, performs better under irrigated condition (4).

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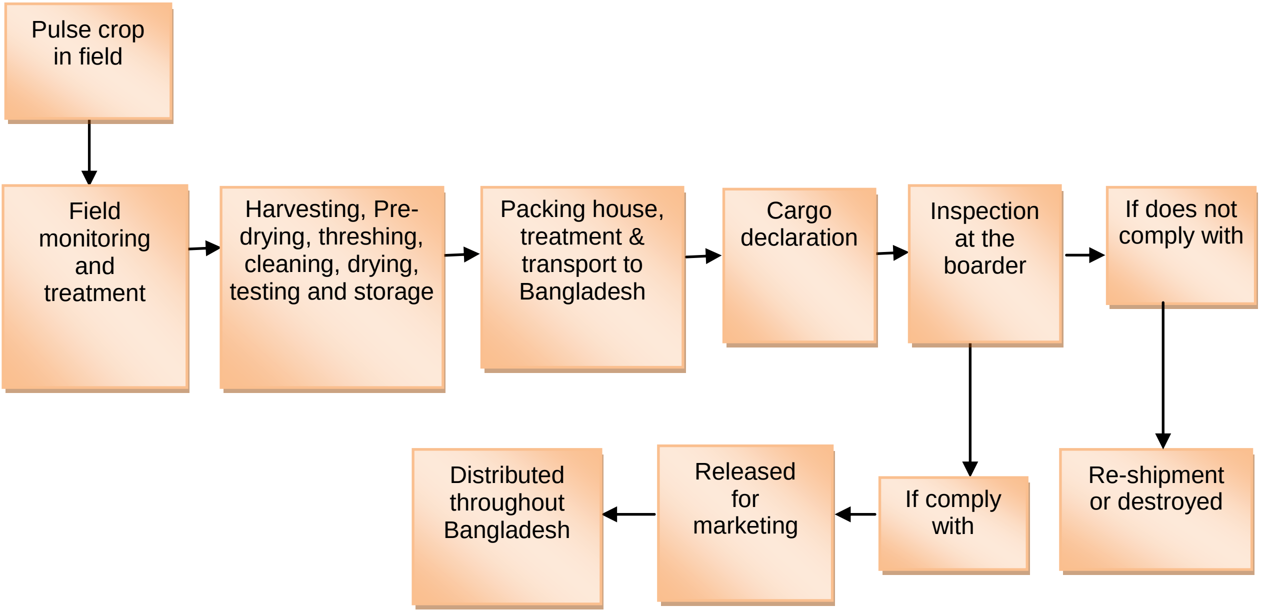
2.2.2 Description of Proposed Import Pathway

For the purpose of this risk analysis pulse grains are mainly imported from the countries such as Australia, Canada, China, India, Nepal and Turkey. To comply with existing Bangladesh import requirements for pulse, the commodity would need to be prepared for export to Bangladesh by ensuring certain pests (insect and mite pests, diseases, weeds or any other pests) are not associated with the product. Pulse grains from India and Nepal would be transported to Bangladesh by road through Landports and from other countries by sea/air freighted through two Sea ports and three Airports. However, it should be specified through which port the commodity would be imported.

In the port of entry after Biosecurity checking if found risk free clearance would be given for distribution to any markets, supermarkets, shops throughout the country for sale and consumption. Diagrammatic representation of import pathways of Pulses is shown in Figure 6.



Figrue 6. Diagrammatic Representation of the Import Pathways of Pulse Grians

- Pulses in Australia, Canada, China, India, Nepal and Turkey are being grown in the field, either as monocrop or mixed crop with others.
- Monitoring of the insect and mite pests, diseases, weeds or any other pests of pulse is done and appropriate control measures are applied if pests are observed.
- Harvesting is carried out when the pulse grains have reached the appropriate maturity. The most appropriate time of harvest is determined based upon the length of the growing cycles and also the degree of maturity of the grains.
- Pre-drying is the stage of the post-harvest system during which the harvested product is dried in order to undergo the next operation of threshing under the best possible conditions. At the time of harvesting, the cut portions of the plant may contain too much green plant matter and all the grains may not have reached a uniform degree of maturity and may have moisture content too high. This makes pre-drying is essential.
- Threshing operation may be carried out in the field or on the threshing floor, by hand or with the help of animals or machines. Threshing is done with care to avoid breakage of the grains or protective husks thus reducing the quality of the product and subsequent losses from the action of insects and moulds.
- After threshing the moisture content of the grains remains generally higher than the desired for safe storage of grains (13-14%). Drying is the phase of the post-harvest system during which the product is rapidly dried until it reaches the safe-moisture level.The aim of drying is to lower the moisture content of the grain for safe storage and further processing.
- Pulses can remain in edible condition for several years if properly stored. However, pulses are more difficult to store than cereals and suffer much greater damage from insects and microorganisms. Pulses are susceptible to infestation both in the field and during storage by bruchid, which cause serious deterioration in the nutritive value of the grain. Damage ranging from 30-70% of the grain has been reported in various publications [1, 2].

- Pulses are marketed as a raw whole and quality of product becomes a prime importance of marketing. Cleaned and well graded whole grains fetch higher prices.
- Proper packaging is an important element in reducing losses and pest infestation especially in the tropics. Climate considerably increases the risks of grain deterioration. Packaging allows easy handling and protects pulses from external attack by humidity, insects, sunlight, mould etc. Various types of packing are used for storage of pulses such as jute bag, polythene bag, cotton bag, PP woven bag etc.
- Pulse are inspected by a competent quarantine inspector for any quarantine pests and accompanied with phytosanitary certificate from the PPO of the country of origin and packing to be done for shipment to Bangladesh. Fumigation is being done either before or during transport of the pulses to Bangladesh.
- Pulses transport to Bangladesh by air or sea or land port. Pulse grains from India and Nepal would be transported to Bangladesh by truck or from other countries by sea/air freight.
- The consignment is inspected at border before entry of Bangladesh and must accompany appropriate certification, e.g. a phytosanitary certificate attesting to the identity of the grain/seed, any treatments completed, or other information required helping mitigate risks. Grains are examined (only visual inspection will not serve the purpose, pathogen/pest specific Standard Seed Health Test should be performed) at the border to ensure compliance with Bangladesh’s biosecurity requirements (e.g. found harbouring any quarantine pest) are either treated, re-shipped or destroyed. Consignment met all the requirements will be released for distribution throughout the country.

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2.2.3 Background Information of Exporting Countries

The geography and climate of the pulse exporting countriesl of Australia, Canada, China, India, Nepal and Turkey is described herein.

2.2.3.1 Australia

Geography and Climate

Geography and climate of of the pulse growing regions in Australia are briefly presented here. Out of six states of Australia the major pulse growing areas are in the four states namely Western Australia, South Australia, New South Wales and Victoria (4).

Western Australia is a state occupying nearly one third of Australia and lies between 26^0S and 121^0E. It is bounded by the Indian Ocean to the north and west, the Great Australian Bight and Southern Ocean to the south, the Northern Territory to the north-east and South Australia to the south-east. Western Australia is Australia's largest state with a total land area of 2,529,875 square kilometres, and the second-largest country subdivision in the world – however, a significant part of it is sparsely populated. The state has about 2.6 million inhabitants, around 11% of the national total. 92% of the population lives in the south-west corner of the state (2, 7).

The southwest coastal area has a Mediterranean climate. It was originally heavily forested, including large stands of karri, one of the tallest trees in the world. This agricultural region is one of the nine most bio-diverse terrestrial habitats, with a higher proportion of endemic species than most other equivalent regions. Average annual rainfall varies from 300 millimetres (12 in) at the edge of the Wheatbelt region to 1,400 millimetres (55 in) in the wettest areas near Northcliffe, but from November to March, evaporation exceeds rainfall, and it is generally very dry. Plants are adapted to this as well as the extreme poverty of all soils (7).

The central two-thirds of the state is arid and sparsely inhabited. The only significant economic activity is mining. Annual rainfall averages less than 300 millimetres (8–10 in), most of which occurs in sporadic torrential falls related to cyclone events in summer (1). An exception to this is the northern tropical regions. The Kimberley has an extremely hot monsoonal climate with average annual rainfall ranging from 500 to 1,500 millimetres (20–60 in), but there is a very long almost rainless season from April to November. Eighty-five percent of the state's runoff occurs in the Kimberley, but because it occurs in violent floods and because of the insurmountable poverty of the generally shallow soils, the only development has taken place along the Ord River (7).

In area, **South Australia** ranked 4th among states and territories of Australia. The geographic position is 32°7' - 37°49'S and 133°40'-140° 46' E Total area is 1,043,514 km^2 with 3,816 km coastline. Land borders: Western Australia, Northern Territory, Queensland, New South Wales, Victoria.*South Australia's south* coast is flanked by the Great *Australian* Bight and the Indian Ocean, although it is referred to locally as the Southern Ocean.

South Australia climate varies, from the mild wetter regions of the southeast coast and Mount Lofty Ranges to the hot and dry interior. Apart from droughts, South Australia weather hasn't generally got a lot of damaging events, such as violent storms or floods although it is the driest state in Australia. The most serious threat for South Australia is bushfires in summer. South Australia weather in the northern desert is very hot and dry, especially in summer, the temperature in the outback regularly reaches 40 degrees Celsius. The desert nights can be very cold. The South Australia climate of the southern coastal regions is "Mediterranean" with hot dry summers and cool mild wet winters. Kangaroo Island also has mild temperate weather, with warm dry summers and cool frequently sunny winter days (2).

The landscape of **New South Wales** ranges from the subtropical, rainforest clad regions of the north to the Snowy Mountains in the south, which contain Australia's highest point, Mt Kosciuszko (2,228m), prominent alongside glacial lakes and stunning valleys. It borders Queensland to the north, Victoria to the south, and South Australia to the west. It has a coast line with the Tasman Sea on its east side. There are over 1,300km of coastline and four UNESCO World Heritage sites including Lord Howe Island, the Greater Blue Mountains area, Willandra Lakes and the Gondwana Rainforests (6).

The major part of **New South Wales**, west of the Great Dividing Range, has an arid to semi arid climate. Rainfall averages from 150 millimetres (5.9 in) to 500 millimetres (20 in) a year throughout most of this region, and summer temperatures can be scorching hot while winter nights can be quite cold. Further east, along the western slopes of the Great Dividing Range, rainfall is higher, usually around 600 millimetres (24 in) and falls fairly evenly throughout the year. Peaks along the Great Dividing Range vary from 500 metres (1,640 ft) to over 2,000 metres (6,562 ft) above sea level. Temperatures can be cool to cold in winter with frequent frosts and snowfall, and are rarely hot in summer due to the elevation. Canberra has a climate typical of the range, as do the regional cities of Orange and Armidale. Rainfall is moderate, from 600 millimetres (24 in) to 1,500 millimetres (59 in), falling fairly evenly throughout the year; however, it peaks slightly in the north in the summer months on account of heavy thunderstorms and in the south in winter due to cold fronts moving across southern Australia. Snowfall is also common in the higher parts of the range, sometimes occurring as far north as the Queensland border. On the highest peaks of the Snowy Mountains, the climate can be subpolar oceanic with very cold temperatures and heavy snow (6).

The climate along the flat, coastal plain east of the range varies from cool oceanic in the south to humid subtropical in the far north of the state. Rainfall is highest in this area; however, it still varies from around 800 millimetres (31 in) to as high as 3,000 millimetres (120 in) in the wettest areas, for example Dorrigo. Along the southern coast, rainfall is heaviest in winter due to cold fronts, while in the far north, around Lismore, rain is heaviest in summer from tropical systems and occasionally even cyclones. Minimum temperature range from -23.0 – 5.6 ^{0}C and maximum from 30.5 to 49.7℃ (6).

Victoria is the southernmost mainland state of Australia. With an area of 227,594 km² (87,874.5 sq mi), it is Australia's sixth largest state or territory. The State is comparable in size to the US state of Utah or the island of Great Britain. It is bound to the northwest by South Australia, directly north by New South Wales, and also shares a maritime border with Tasmania to the south, across the Bass Strait. Most of Victoria's northern border lies along the Murray River. The eastern half of the state is dominated by the Great Dividing Range and the surrounding uplands, which also to a lesser extent extend far into the west of the state and ease off after The Grampians. By comparison the north and northwest of the state is extremely flat with little prominence. Approximately three quarters of Victoria's population lives on and around the coast of the Port Phillip and Western Port bays, chiefly in Melbourne, in Victoria's South Central region (5.

Climate range of Victoria is broad despite its small size, from the snowfields in the north east where the temperatures can be below freezing, to the dry semi-arid Mallee area of the north west where it can get very hot. The southern position of Victoria means it tends to be a bit cooler and wetter than the other Australian mainland states. The Victoria weather of the coastal plains and along the coast is generally mild and cool. This is the region of Victoria where Melbourne is located. The Great Dividing Range extends through the centre of Victoria and has a cooler mountain climate. The Victorian Alps are part of the Great Dividing Range and are the coldest part of the Victoria climate, in winter the temperature can get below 0 degrees Celsius in the highest parts of the ranges. The hottest Victoria weather region is the semi-arid north west where the average daily temperature in summer is over 30 degrees Celsius. Rain falls more frequently in winter than in summer in Victoria (3).

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2.2.3.2 Canada

Geography and Climate

InCanada 100% of the lentil and 88% of chickpea are produced in Saskatchewan province and the rest 12% of chickpea is grown in Alberta. Therefore, the geography and climate of Saskatchewan and Alberta are described here. Saskatchewan province lies within the coordinates of 50° 46' N to 59° 10' N / 104° 61' W to 106° 38' W (4) and Alberta between 49° 41' N to 59º 87' N/112° 50' W to 117º 09' W (3). The capital of Saskatchewan is Regina. It is a prairie and boreal province in west-central Canada, the only province without any natural borders. It has an area of 651,900 square kilometres (251,700 sq mi), nearly 10 percent of which (59,366 square kilometres (22,900 sq mi) is fresh water, composed mostly of rivers, reservoirs, and the province's 100,000 lakes. Saskatchewan is bordered on the west by Alberta, on the north by the Northwest Territories, on the east by Manitoba, to the northeast by Nunavut, and on the south by the U.S. states of Montana and North Dakota (4). As of December 2013, Saskatchewan's population was estimated at 1,114,170 (2). Residents primarily live in the southern prairie half of the province, while the northern boreal half is mostly forested and sparsely populated. Of the total population, roughly half live in the province's largest city, Saskatoon, or the provincial capital, Regina. Other notable cities include Prince Albert, Moose Jaw, Yorkton, Swift Current, North Battleford, and the border city Lloydminster (partially within Alberta) (1).

Saskatchewan receives more hours of sunshine than any other Canadian province. The province lies far from any significant body of water. This fact, combined with its northerly latitude, gives it a warm summer, corresponding to its humid continental climate in the central and most of the eastern parts of the province, as well as the Cypress Hills; drying off to a semi-arid steppe climate in the southwestern part of the province. Drought can affect agricultural areas during long periods with little or no precipitation at all. The northern parts of Saskatchewan – from about La Ronge northward – have a subarctic climate with a shorter summer season. Summers can get very hot, sometimes above 38 °C during the day, and with humidity decreasing from northeast to southwest. Warm southern winds blow from the plains and intermontane regions of the Western United States during much of July and August, very cool or hot but changeable air masses often occur during spring and in September. Winters are usually bitterly cold, with frequent Arctic air descending from the north.[16] with high temperatures not breaking −17 °C for weeks at a time. Warm chinook winds often blow from the west, bringing periods of mild weather. Annual precipitation averages 30 to 45 centimetres (12 to 18 inches) across the province, with the bulk of rain falling in June, July, and August (6).

With an area of 661,848 km^2, **Alberta** is bounded by the provinces of British Columbia to the west and Saskatchewan to the east, the Northwest Territories to the north, and the U.S. state of Montana to the south. Alberta is one of three Canadian provinces and territories to border only a single U.S. state and one of only two landlocked provinces. The states lyies between 49˚09' to 59˚09' N and 110˚.02' to N 119˚.23' E (5).

Alberta has a humid continental climate with warm summers and cold winters. The province is open to cold arctic weather systems from the north, which often produces extremely cold conditions in winter. Arctic air masses in the winter produce extreme minimum temperatures varying from −54 °C (−65 °F) in northern Alberta to −46 °C (−51 °F) in southern Alberta, although temperatures at these extremes are rare. Annual bright sunshine totals range between 1900 up to just under 2600 hours per year. Average high temperatures in January range from 0 °C (32 °F) in the southwest to −24 °C (−11 °F) in the far north. Annual precipitation ranges from 300 mm (12 in) in the southeast to 450 mm (18 in) in the north, except in the foothills of the Rocky Mountains where total precipitation including snowfall can reach 600 mm (24 in) annually. In the summer, the average daytime temperatures range from around 21 °C (70 °F) in the Rocky Mountain valleys and far north, up to around 28 °C (82 °F) in the dry prairie of the southeast. The northern and western parts of the province experience higher rainfall and lower evaporation rates caused by cooler summer temperatures. The south and east-central portions are prone to drought-like conditions sometimes persisting for several years, although even these areas can receive heavy precipitation and sometimes resulting in flooding (5).

In southwestern Alberta, the cold winters are frequently interrupted by warm, dry chinook winds blowing from the mountains, when the temperatures soared from −19 to 22 °C (−2.2 to 72 °F) in just one hour (5).

Northern Alberta is mostly covered by boreal forest and has a subarctic climate. The agricultural area of southern Alberta has a semi-arid steppe climate because the annual precipitation is less than the water that evaporates or is used by plants. The southeastern corner of Alberta, part of the Palliser Triangle, experiences greater summer heat and lower rainfall than the rest of the province, and as a result suffers frequent crop yield problems and occasional severe droughts. Western Alberta is protected by the mountains and enjoys the mild temperatures brought by winter chinook winds. Central and parts of northwestern Alberta in the Peace River region are largely aspen parkland, a biome transitional between prairie to the south and boreal forest to the north (5).

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2.2.3.3 China

Geography and Climate

China is located inEastern Asia at 35^0 00 N, 105^0 00 E (3). China is located in the eastern part of Eurasian continent, occupying the territory of 9,600,000 km2. The Chinese land frontier is 22,800 km long. China borders on the PDRK (1416 km) from north-east; on the RF (3,605 km and 40 km) from north-east and north, on Mongolia (4673 km) from north; on Kazakhstan (1,533 km) and Kyrgyzstan (858 km) from north-west; on Tajikistan (414 km), Afghanistan (76 km), Pakistan (523 km) from west; on India (3,380 km) from south-west and south; on Nepal (1,236 km), Bhutan (470 km), Myanmar (2,185 km), Laos (423 km) and Vietnam (1,281 km) from south. From east and south east, China has maritime boundaries with the Republic of Korea, Japan, Philippines, Brunei, Malaysia and Indonesia. (1).

The topography of China has been divided by the government into five homogeneous physical macro-regions, namely Eastern China (subdivided into the northeast plain, north plain, and southern hills), Xinjiang-Mongolia, and the Tibetan highlands. It is diverse with snow-capped mountains, deep river valleys, broad basins, high plateaus, rolling plains, terraced hills, sandy dunes manly other geographic features other landforms present in myriad variations. In general, the land is high in the west and descends to the east coast. Mountains (33 percent), plateaus (26 percent) and hills (10 percent) account for nearly 70 percent of the country's land surface. Most of the country's arable land and population are based in lowland plains (12 percent) and basins (19 percent), though some of the greatest basins are filled with deserts. The country's rugged terrain presents problems for the construction of overland transportation infrastructure and requires extensive terracing to sustain agriculture, but is conducive to the development of forestry, mineral and hydropower resources, and tourism (3).

For a country of China's size and its varied topography, the diverse weather patterns are an expected feature. There are primarily four seasons - Summer, Winter, Spring and Autumn. China has a subtropical climate and the temperatures can reach extremes in Summer and Winter. Spring and Autumn are very pleasant periods in almost all the regions. Weather in North China: The northern winters are especially unforgiving since temperatures drop as an impact of the cold and dry northerly winds. Northern areas like Inner Mongolia and Urumqui face intensely cold winters during the periods of January to March. The weather in Beijing is cold and sometimes snowy, but also dry and sunny. In the summer months from May to August, the weather is hot and humid. There is heavy rainfall in July and August. In winter, Beijing has an average temperature of 32 o F and below while in summer, temperature can rise to 100 ^{o}F and above (3). Weather in South China : Due to the typhoons that usually affect the coastal regions, the weather here remains humid from April through September. There is a short winter from January to March, and places like Guangzhou are pleasantly cool. However, the humidity factor persists and there can be occasional drizzles (2).

Weather in Central China : The Summers in Central China are very warm and very humid. In places like Shanghai , the summers can last from April to October. The areas of Nanjing, Chonqing and Wuhan get very uncomfortable and are called the "Three Furnaces". The winter months are also very cold, with freezing temperatures (2).

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2.2.3.4 India

Geography and Climate

Madhya Pradesh literally means "Central Province", and is located in the geographic heart of India, between latitude 21.2°N-26.87°N and longitude 74°02'-82°49' E. The state straddles the Narmada River, which runs east and west between the Vindhya and Satpura ranges; these ranges and the Narmada are the traditional boundary between the north and south of India. The highest point in Madhya Pradesh is Dhupgarh, with an elevation of 1,350 m (4,429 ft). The state is bordered on the west by Gujarat, on the northwest by Rajasthan, on the northeast by Uttar Pradesh, on the east by Chhattisgarh, and on the south by Maharashtra (en.Wikipedia). The climate of Madhya Pradesh is subtropical. Like most of north India, it has a hot dry summer (April–June), followed by monsoon rains (July–September) and a cool and relatively dry winter. The average rainfall is about 1,371 mm (54.0 in). The southeastern districts have the heaviest rainfall, some places receiving as much as 2,150 mm (84.6 in), while the western and northwestern districts receive 1,000 mm (39.4 in) or less (7).

Uttar Pradesh is garland by the two rivers, Ganga and Yamuna. On the East, Uttar Pradesh is surrounded by Bihar, on the South by Madhya Pradesh, on the West by Rajasthan, Delhi, Himachal Pradesh, Haryana and on the North by Uttaranchal. The Northern boarders of Uttar Pradesh are touched by Nepal. The area of the State is 2,36,286 sq km. It lies between latitude of 24 deg to 31 deg and longitude of 77 deg to 84 deg East. Area wise it is the fourth largest State of India (Indianetzone). Uttar Pradesh is generally under tropical monsoon but there appear to be variations in the seasons owing to the change in altitude. The Himalayan region is cold. The average temperature in the plains varies from 3 to 4 degree Celsius in January and 43 to 45 degree Celsius in May and June. There are 3 seasons in Uttar Pradesh. The state experiences cold season from October to January, summer season - is from March to mid June and rainy season - the Himalayan region experiences a rainfall of about 1000-2000mm (1).

Andhra Pradesh lies between 12°41' and 19.07°N latitude and 77° and 84°40'E longitude, and is bordered by Telangana, Chhattisgarh, and Orissa in the north, the Bay of Bengal in the East, Tamil Nadu to the south and Karnataka to the west. Among the other states, which are situated on the country's coastal area, Andhra Pradesh has got a coastline of around 974 km, which gives it the 2nd longest coastline in the nation.[1] Two major rivers, the Godavari and the Krishna run across the state. A small enclave 12 sq mi (30 km²), the Yanam district of Puducherry, lies in the Godavari Delta in the north east of the state. The state includes the eastern part of Deccan plateau as well as a considerable part of the Eastern Ghats. The climate of Andhra Pradesh is generally hot and humid. The summer season in this state generally extends from March to June. During these months the moisture level is quite high. The coastal areas have higher temperatures than the other parts of the state. In summer, the temperature generally ranges between 20 °C and 40 °C. At certain places the temperature is as high as 45 degrees on a summer day. The summer is followed by the monsoon season, which starts during July and continues till September. This is the season for heavy tropical rains in Andhra Pradesh. The major role in determining the climate of the state is played by South-West Monsoons. About one third of the total rainfall in Andhra Pradesh is brought by the North-East Monsoons around the month of October in the state. The winters in Andhra Pradesh are pleasant. This is the time when the state attracts most of its tourists. October to February are the winter months in Andhra Pradesh. Since the state has quite a long coastline, the winters are comparatively mild. The range of winter temperatures is generally from 13 °C to 30 °C (2).

Bihar is one of the most important Eastern states of India. The state lays between 25°8' & 27°31' North Latitude and 83°20' & 88°17' East Longitude occupying an area of 94,163 sq. km. The average elevation of the state is 173 feet above the sea level. North of it lies Nepal while on other sides it shares the border with Indian states of Jharkhand (South), West Bengal (East) and Uttar Pradesh (West). Topographically Bihar can be grouped into three regions: The northern mountainous region, Indo-Gangetic Plain and southern Plateau. The Northern mountainous region consists of Someshwar and the Dun hills in the extreme Northwest in Champarn district. These hills are offshoots of the Himalayans system. South of it lies the Tarai region a belt of marshy, swampy, sparsely populated and unhealthy region. The North Gangetic part of Bihar is just south of Tarai. This fertile alluvium tract is the product of various Himalayans and Peninsular rivers like Gandak, Budhi Gandak, Koshi, Mahananda, Bagmati, Gogra and Son and other small river and rivulets. The climate of Bihar is of mostly sub-tropical. Nevertheless region close to Tropic of Cancer experiences tropical climate during summer. Like all the Indian states Bihar also reels under hot summer season during months of March to May. Average temperature is 35-40 Celsius throughout the summer months. April and June are the hottest months of the year. December to January is the winter season in Bihar because of its location is Northern hemisphere. The winter in Bihar is mild with average temperature being 5 ^{o}C to 10 ^{o}C. Bihar gets its maximum rainfall during South-West monsoon season which prevails from June to September. The average rainfall of Bihar is around 1200mm (3).

Maharashtra is the third largest state (in area) in India after Rajasthan and Madhya Pradesh. It covers an area of 307,713 km^2 and is bordered by the states of Madhya Pradesh to the north, Chhattisgarh to the east, Telangana to the southeast, Karnataka to the south and Goa to the southwest. The state of Gujarat lies to the northwest, with the Union territory of Dadra and Nagar Haveli sandwiched between the borders. The Arabian Sea makes up Maharashtra's west coast. Maharashtra consists of two major relief divisions. The plateau is a part of the Deccan tableland and the Konkan coastal strip abutting on the Arabian Sea. **Maharashtra** enjoys a tropical monsoon climate; the hot scorching summer from March onwards yields to the rainy monsoon in early June. The rich green cover of the monsoon season persists during the mild winter that follows through an unpleasant October transition, but turns into a dusty, barren brown as the summer sets in again. The seasonal rains from the western sea-clouds are very heavy and the rainfall is over 4000mm on the Sahyadrian crests. The Konkan on the windward side is also endowed with heavy rainfall, declining northwards. East of the Sahyadri, the rainfall diminishes to a meagre 70 cm. in the western plateau districts, with Solapur-Ahmednagar lying in the heart of the dry zone. The rains increase slightly, later in the season, eastwards in the Marathwada and Vidarbha regions (6).

Rajasthan is the biggest state (3, 42,239sq.km) in the country of India and lies between 23°30' and 30° 11' N and 69° 29' and 78° 17' E. The state shares its north-western and western boundary with the Indo-Pakistan international border that extends about 1,070 km and touches the major districts Barmer, Bikaner, Ganganaga and Jaisalmer. Rajasthan is bordered by Pakistan in the west and northwest, the states of Punjab, Uttar Pradesh and Haryana in the north and northeast. The state of Madhya Pradesh lies in the southeast and Gujrat in the southwest. The huge portion of the state of Rajasthan is desiccated and houses the biggest Indian desert- the Thar Desert known as the 'Maru-kantar'. The oldest chain of fold mountains- the Aravali Range splits the state into two geographical zones- desert at one side and forest belt on the other. Only 9.36% of the total geographical region lies under forest vegetation. The Mount Abu is the only hill station of the state and houses the Guru Shikhar Peak that is the highest peak of the Aravali range with an elevation of 1,722 m. The capital city of Rajasthan is Jaipur. The weather or climate of the Rajasthan can be broadly classified into four distinct seasons. They are - Pre-monsoon, which is the hot season preceding the monsoon and extends from April to June, the Monsoon that occurs in the month of June in the eastern region and mid- July in the western arid regions, the Post-monsoon that commences from mid-September and continues till November and the Winter that extends from December to March, January being the coldest month of the year. The average temperature in winter ranges from 8° to 28 °C and in summer the average temperature range from 25° to 46 °C (2).

The Indian State of **Karnataka** is located 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude. It is situated on a tableland where the Western and Eastern Ghat ranges converge into the complex, in the western part of the Deccan Peninsular region of India. The State is bounded by Maharashtra and Goa States in the north and northwest; by the Arabian Sea in the west; by Kerala and Tamil Nadu States in the south and by the States of Andhra Pradesh and Telangana in the east. Karnataka extends to about 750 km from north to south and about 400 km from east to west. Karnataka is situated in the Deccan Plateau and is bordered by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Andhra Pradesh and Telangana to the east, Tamil Nadu to the southeast, and Kerala to the southwest. It is situated at the angle where the Western Ghats and Eastern Ghats of South India converge into the Nilgiri hills. The highest point in Karnataka is the Mukkayanagiri hill in Chikkamagaluru district which has an altitude of 1,929 metres (6,329 ft) above sea level. Karnataka has four seasons in the year. The winter season from January to February, summer from March to May, monsoon from May to September and post-monsoon season from October to December. The post-monsoon and winter seasons are generally pleasant over the entire state. The months April and May are hot, very dry and generally uncomfortable. Weather tends to be oppressive during June due to high humidity and temperature. The next three months (July, August and September) are somewhat comfortable due to reduced day temperature although the humidity continue to be very high. The highest recorded temperature was 45.6 °C at Raichur on May 23, 1928. The lowest recorded temperature was 2.8 °C (37 °F) C at Bidar on December 16, 1918. The state is divided into three meteorological zones:

- *Coastal Karnataka* is a region of heavy rainfall and receives an average rainfall of 3638.5 mm per annum. far in excess of rest of state.
- *North Interior Karnataka* is an arid zone and receives only 711.5 mm of average rainfall per annum.
- *South Interior Karnataka zone* receives 1064.8 mm of average rainfall per annum (4).

West Bengal is on the eastern bottleneck of India, stretching from the Himalayas in the north to the Bay of Bengal in the south. It lies between 85 degree 50 minutes and 89 degree 50 minutes east longitude, and 21 degrees 38 minutes and 27 degrees 10 minutes north latitude. The state has a total area of 88,752 square kilometres (34,267 sq mi). With Bangladesh, which lies on its eastern border, the state forms the ethno-linguistic region of Bengal. To its northeast lie the states of Assam and Sikkim and the country Bhutan, and to its southwest, the state of Orissa. To the west it borders the state of Jharkhand and Bihar, and to the northwest, Nepal. The topography of West Bengal alters as the Indo-Gangetic plain begins. The Gangetic plain is rich in alluvial soil and thus is very fertile. This kind of soil is suitable for agriculture. The climate of West Bengal varies from tropical savannah in the southern portions to humid subtropical in the north. The main seasons are summer, rainy season, a short autumn, and winter. While the summer in the delta region is noted for excessive humidity, the western highlands experience a dry summer like northern India, with the highest day temperature ranging from 38 °C to 45 °C. At nights, a cool southerly breeze carries moisture from the Bay of Bengal. In early summer brief squalls and thunderstorms known as "kal-baisakhi" often arrive from the north or northwest.[8] Monsoons bring rain to the whole state from June to September. West Bengal receives the Bay of Bengal branch of the Indian Ocean monsoon that moves in a northwest direction. Winter (December–January) is mild over the plains with average minimum temperatures of 15 °C. A cold and dry northern wind blows in the winter, substantially lowering the humidity level. However, the Darjeeling Himalayan Hill region experiences a harsh winter, with occasional snowfall at places (7).

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2.2.3.5 Nepal

Geography and Climate

Nepal is located between 28° 00' N and 84 ° 00' E in the Hindu Kush Himalaya Range of South Asia. Thecountry is lying along the southern slopes of the Himalayan mountain ranges. It is a landlocked country located between India to the east, south, and west and the Autonomous Tibet Region of China to the north. Its territory extends roughly 800 kilometres from east to west and 144 to 240 Km from north to south. The capital is Kāthmāndu. Administratively Nepal is divided into 75 districts. Physiographically, the country is divided into 5 regions: Terai, Siwalik, Middle Mountain, High Mountain, and High Himalaya. These regions have distinct geological, climatic, and hydrological characteristics that reflect in soils, vegetation, and land use pattern. The Terai region is part of the Indo-Gangetic Plain (IGP) to the south and represents only 14% of the total land area of Nepal, but contains about 46% of the gross cultivated area. The rice-wheat/ legumes cropping systems are mostly concentrated in Terai, with very little in the Siwalik and Middle Mountain physiographic regions (1).

The Terai plain comprises nearly level alluvial tracts, predominantly of medium- to fine-textured sediments. The major soils are imperfectly to poorly drained Haplaquepts in the southern parts; and well drained Hapludolls at the foot of the Churia range. The Haplaquepts are suited for rice in the rainy season and for upland crops including wheat and legumes in the dry season. Most of the Hapludolls are under forest vegetation. The inner Terai valleys (Chitwan, Dang-Deukhuri, and Surkhet valleys) are covered mainly by moderately coarse to medium-textured alluvial sediments. These valleys consist of series of terraces and flood plains. Most of the lands in these valleys are under intensive cultivation. The dominant soils are well to somewhat excessively drained Dystrochrepts, suited for upland crops. Drought in the dry season limits their agricultural use. However, the low-lying areas with imperfectly to poorly drained Udorthents and Haplaquents are best suited for rice cultivation. The level of organic matter in most cultivated soils in Terai and inner Terai where RWCS are concentrated (below 2,000 m) is low (<1%). This could represent a major constraint of soil fertility to a sustainable increase in rice-wheat productivity. At elevations above 2,000 m, the soils contain 2-3% organic matter. Cooler climatic conditions and more vegetation coverage are contributing factors to higher organic matter accumulation in this region (2). Generally, the soils of Nepal are deficient in nitrogen (N), with phosphorus (P) being the second most important plant nutrient limiting crop yield. Soil tests for potassium (K) generally indicate high levels, but K deficiency has also been reported in recent years (3, 4). There is very little evidence of calcium (Ca) and magnesium (Mg) deficiency limiting rice-wheat production. However, soil content of sulfur (S) has been reported low in most of the soils of Nepal indicating that S is a potential limiting nutrient to the growth of legumes, as legumes are susceptible to S deficiency. Micronutrient deficiencies such as zinc (Zn) in rice; boron (B) in wheat, legumes, and vegetables; and molybdenum (Mo) in vegetables and legumes are increasingly observed. An annual rainfall of 1200-2000 mm occurs in the main rice-wheat/ legumes growing areas of the Terai. About 80% of total annual rainfall occurs in the monsoon season between June and September which is the main rice-growing period. Nepal also receives some winter rains through the westerly weather system. It occurs more in the western part of the Terai and contributes to some extent to winter crops, including wheat and legumes. Some premonsoon rains occur during the drier period of April-June (2).

In general, the trend in seasonal variations of temperature is similar throughout the country, although the topographic effects influence significantly at the micro-level. Temperatures rise steadily from minimum values in winter during January-February to maximum values during April-May and then fall slightly during the monsoon period due to presence of heavy clouds and rain. Temperatures then drop sharply to winter minimum values. The maximum temperature rises very sharply in spring (March-May) while the rise of minimum temperature is gradual. The mean maximum temperature in subtropical agroecological zones where rice-wheat and legumes are cropped is in the range 25-35°C (2).

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2.2.3.6 Turkey

Geography and Climate

Turkey is situated in Anatolia (97%) and the Balkans (3%), bordering the Black Sea, between Bulgaria and Georgia, and bordering the Aegean Sea and the Mediterranean Sea, between Greece and Syria. The geographic coordinates of the country lie at: 39°00′N35°00′E. The area of Turkey is 783,562 km^2 (302,535 sq mi); land: 770,760 km^2 (297,592 sq mi), *water:* 9,820 km^2 (3,792 sq mi). Turkey extends more than 1,600 km (994 mi) from west to east but generally less than 800 km (497 mi) from north to south. The total area (of about 783,562 km^2 (302,535 sq mi)) consists of about 756,816 km^2 (292,208 sq mi) in Western Asia (Anatolia) and about 23,764 km^2 (9,175 sq mi) in Southeastern Europe (Thrace) (1).

Anatolia (Turkish: *Anadolu*) is a large, roughly rectangular peninsula, situated bridge-like between Europe and Asia. The Anatolian part of Turkey accounts for 97% of the country's area. It is also known as Asia Minor, Asiatic Turkey or the Anatolian Plateau. The term Anatolia is most frequently used in specific reference to the large, semiarid central plateau, which is rimmed by hills and mountains that in many places limit access to the fertile, densely settled coastal regions (1).

The European portion of Turkey, known as Thrace (Turkish: *Trakya*), encompasses 3% of the total area but is home to more than 10% of the total population. Istanbul, the largest city of Thrace and Turkey, has a population of 11,372,613. Thrace is separated from Anatolia (the Asian portion of Turkey) by the Bosphorus, the Sea of Marmara, and the Dardanelles; which collectively form the strategic Turkish Straits that link the Aegean Sea with the Black Sea. Mount Ararat, Turkey's tallest mountain with an elevation of 5,137 m (16,854 ft), is the legendary landing place of Noah's Ark and is located in the far eastern portion of the country (1).

Turkey's diverse regions have different climates, with the weather system on the coasts contrasting with that prevailing in the interior. The Aegean and Mediterranean coasts have cool, rainy winters and hot, moderately dry summers. Annual precipitation in those areas varies from 580 to 1,300 millimeters (22.8 to 51.2 in), depending on location. Generally, rainfall is less to the east. The Black Sea coast receives the greatest amount of precipitation and is the only region of Turkey that receives high precipitation throughout the year. The eastern part of that coast averages 2,500 millimeters (98.4 in) annually which is the highest precipitation in the country (1).

The Anatolian Plateau is much more subject to extremes than are the coastal areas. Winters on the plateau are especially severe. Temperatures of −30 to −40 °C can occur in the mountainous areas in the east, and snow may lie on the ground 120 days of the year. In the west, winter temperatures average below 1 °C. Summers are hot and dry, with temperatures above 30 °C. Annual precipitation averages about 400 millimeters (15.7 in), with actual amounts determined by elevation. The driest regions are the Konya Ovasi and the Malatya Ovasi, where annual rainfall frequently is less than 300 millimeters (11.8 in). May is generally the wettest month and July and August the driest (1).

The climate of the Anti-Taurus Mountain region of eastern Turkey can be inhospitable. Summers tend to be hot and extremely dry. Winters are bitterly cold with frequent, heavy snowfall. Villages can be isolated for several days during winter storms. Spring and autumn are generally mild, but during both seasons sudden hot and cold spells frequently occur (1).

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2.2.4 Background Information of Bangladesh

Geography and Climate

Bangladeshlies between latitudes 20° and 27°N, and longitudes 88° and 93°E (1). The country has an area of approximately 147,540 square kilometer in the south Asian region. The country is surrounded by India completely in the West, North, and partially in the East sharing a total of 4,053 kilometer border, while the rest 193 kilometer of the Eastern side is bordered by Myanmar. The Bay of Bengal retains its boundary In the South with 580 kilometer of coastline. About half the total area is actively deltaic and never higher than 10m from mean sea level. This flat low lying land is very fertile and is suitable for rice cultivation. The vast river delta area is home to the dominant plains culture. In the northeast and the southeast the land is more hilly and dry, and tea is grown. The hilly areas of the northeast and southeast are occupied by much smaller tribal groups. Ganges and Brahmaputra are the two main rivers of Bangladesh, carrying tones of silts from the mighty Himalayans that eventually fertile the plain. Apart from these two rivers, we have hundreds of others comprising a very wide and complex river system. Sundarbans, the largest mangrove forest of the world, is situated in the southwest. The Chittagong Hill Tracts have extensive hardwood forests. Lawachara is a semi-evergreen forest situated in the northeast in Sri Mangal. The Sal forest is spread around in various parts of the country, like Bhawal and Modhupur National Park (2).

Bangladesh has tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from June to November; and a warm-hot, dry winter from December to February. In general, maximum summer temperatures range between 38 and 41 °C (100.4 and 105.8 °F). April is the hottest month in most parts of the country. January is the coolest (but still hot) month, when the average temperature for most of the country is 16–20 °C (61–68 °F) during the day and around 10 °C (50 °F) at night. Winds are mostly from the north and northwest in the winter, blowing gently over the country. From March to May, violent thunderstorms, called northwesters, produce winds of up to 60 kilometers per hour (37.3 mph) (2).

Heavy rainfall is characteristic of Bangladesh that helps irrigation in the rice field during the burning months of June – August. About 80 % of Bangladesh's rain falls during the monsoon season. Most parts of the country receive at least 2,300 mm (90.6 in) of rainfall per year, but because of its location just south of the foothills of the Himalayas, Sylhet in northeastern Bangladesh receives the greatest average precipitation. Annual rainfall in that region ranges between 3,280 and 4,780 mm (129.1 and 188.2 in) (2).

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2.2.5 International Transportation of Commodity

For the purpose of this risk analysis pulsesare presumed to be imported from anywhere in Australia, Canada, China, India, Nepal and Turky. Grains would be imported by sea or terrestrial and seed by air freighted to Bangladesh through any of the ports mentioned below:

Land ports- Darsana, Chuadanga; Benapole, Jessore; Sonamoszid, C. Nawabganj; Hili, Dinajpur; Burimari,Lalmonirhat; Tamabil, Sylhet; Bhomra, Satkhira; Rohonpur, C. Nawabgonj; Zakiganj, Sylhet; Birol,Dinajpur; Banglabandha, Panchagarh; ICD Kamlapur, Dhaka; Kamalpur, Jamalpur; Belunia, Feni; Betuli, Moulvibazar; Chatlapur, Moulvibazar; Haluaghat, Mymensingh

Sea ports-Chittagong and Mongla;

Airports-Hazrat Shahajalal International.Airport, Dhaka; Shah Amanat International Airport, Chittagong and Osmani International Airport, Sylhet or through

River port- Narayanganj

However, it should be specified through which port the commodity would be imported. The imported commodity, after Biosecurity checking if found risk free clearance would be given for distribution to any markets, supermarkets, shops throughout the country for sale and/or consumption.

Growers intend to export their wheat should be enrolled with the Plant Protection Department of their respective countries and need to specify the location of the field, total area, frequent monitoring for the occurrence of pest and diseases and record the measures taken for pest management. The growing area must be free from the specified quarantine pest or disease and the freedom of the specified pest/disease must be ascertained through field inspection, sampling and testing of seed/grain. This information must be made available to the Govt. inspectors on demand.

The harvesting of the crop will be done at full maturity followed by threshing, cleaning, dryingand seed health testingto be done at an accredited laboratory. Pulse seed or grainfor export will then be transported to packing housewhere necessary grading and cleaning will be done. It should beensured that seed/grain should not contain any plant parts, weed seed or soil clods.The commodity must be inspected by a competent quarantine inspector for any quarantine pests and provide treatment (hot water) and accompanied with phytosanitary certificatefrom the PPO of the country of origin and packing to be done for shipment to Bangladesh.

The consignment must accompany appropriate certification, e.g. a phytosanitary certificate attesting to the identity of the grain/seed, any treatments completed, or other information required helping mitigate risks. Grains/seeds are to be examined at the border (only visual inspection will not serve the purpose, pathogen/pest specific Standard Seed Health Test should be performed) to ensure compliance with Bangladesh's biosecurity requirements. If, for example quarantine pest is found harbouring with any consignment then decision to be made wheather this will be released after necessary treatment. If effective treatment is not available then the consignment to be re-shipped or destroyed. Consignment met all the requirements will be released for distribution throughout the country.

2.3 Hazard Identification

2.3.1 Introduction

Hazard identification is the essential step conducted prior to a risk assessment. Unwanted organisms or diseases which could be introduced by risk goods into Bangladesh and are potentially capable of causing unwanted harm, must be identified.

2.3.2 Potential Hazard Groups

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

This list is further refined and species removed or added to the list depending on the strength of the association and the information available about its biology and life cycle. Each pest or pathogen is assessed mainly on its biological characteristics and its likely interaction with the Bangladesh environment and climate. Hitch-hiker organisms sometimes associated with a commodity, but which do not feed on it or specifically depend on that commodity in some other way are also included in the analysis. This is because there may be economic, environmental and human health consequences of these organisms entering and/or establishing.

2.3.3 Organism Interceptions on Commodity from Existing Pathways

As reported by the Plant Quarantine Wing (PQW) under Department of Agricultural Extension (DAE), Bangladesh, during inspection in port of entry of pulses from the exporting counties, not a pest had been intercepted yet today on the pulses imported into Bangladesh.

2.3.4 Other Risk Characteristics of the Commodity

Although many pests dealt with in this risk analysis had adequate information for assessment still in some cases adequate information was not available. Moreover, the pests are dynamic, the status of pests might change with the change in climatic factors, variety grown and production practices, therefore, we cannot predict future risk or even the present risks that currently escape detection for a variety of reasons.

3.4.4.1 Unlisted Pests

These include pests that are not yet identified. With a trend towards decreasing use of chemical products in agriculture and further reliance on Integrated Pest Management strategies it is assumed that new pests enter the system at some time in the future. Prolonged use of large doses of pesticides and fertilizers can lead to previously non pest species becoming economically important through resistance to pest treatments. Any of these types of organism could initially appear in very small numbers associated with the commodity, and may not be identified as hazards before their impacts become noticeable.

3.4.4.2 Symptomless Micro-organisms

Pests such as microbes and fungi infect grain/seed before transit and may not produce symptoms and mislead the lot as healthy. However, the pathogen introduced as symptomless with the commodity become apparent only when they reach a suitable climate to sporulate or reproduce. Many fungi can infect grains after arrival making it difficult to distinguish the origin of saprobes and pathogens without adequate identification. Consumers tend to throw away rotten grains and or plant debris associated with the pulses rather than taking it to a diagnostic laboratory so there is little data on post entry appearance of “invisible organisms”.

2.4 Assumptions and Uncertainties

2.4.1 Introduction

The major uncertainties encountered in this risk analysis are identified here. The assumptions made to take account of them are explicitly identified where relevant in the text. 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 assumptions and uncertainties are covered in these sections rather than individually in each pest risk assessment.

2.4.2 Hazard Biology and Identification

The biology of insect pests and pathogens those have been reared in the laboratory for several generations is often different to wild counterparts established in field conditions. Aspects such as life cycle, pre-oviposition period, fecundity and flight ability, 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 aphids in a greenhouse was longer and higher than those in a growth chamber with similar conditions.

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 colonizing new hosts or the consequences of its establishment and spread on the natural environment. Where indigenous plants are discussed as potential hosts this is extrapolated from the host range (at genus and family level) overseas and is not intended as a definitive list.

Where there is uncertainty about the identity of an organism, e.g. *Rhopalosiphum maidis* vs *R. padi*, the more serious pest is considered in the PRA. The conclusions may need to be revisited if evidence to the contrary becomes available. There is uncertainty around the efficacy of risk management measures for many of the hazards identified in this Risk Analysis. In some cases efficacy data for similar species has had to be used.

2.4.3 Assumption Regarding Transit Time of Grains

An assumption is made around the time the grains take to get from the field in Australia/Canada/China/Turkey transported to Bangladesh by ship. It is assumed that the harvesting, processing, packing and transit to Bangladesh from imported countries mentioned above, inspection and release in Bangladesh will take a minimum of 30-35 days. On the other hand, time required for importing from India and Nepal by road may take 10-15 days.

2.4.4 Assumption and Uncertainty Around Disposal

It is not known what proportion of imported pulses is discarded during cleaning before crushing. It is assumed that a portion of grains that might have infested or contaminated will be disposed-off in a manner that exposes any potential hazard organisms on that grains to suitable hosts. Disposal would include discarding grains or plant debris on urban or rural roadsides, in bush reserves, in open rubbish bins in public places, and on open composts in domestic areas.

2.4.5 Assumption and Uncertainty around Risk Management Measures

A lot of uncertainty exists around the efficacy of risk management measures. Interception data is one way of estimating efficacy, as records of live and dead organisms indicate the success of a treatment and the thresholds for growth and development of each individual organism. A sample audit is required to monitor efficacy. The teliospores of kernel bunt of wheat remain associated with seeds/grains. None of the registered fungicide could kill the spores; rather inhibit germination when tested after treatment. However, KB spore will germinate once the chemical is washed off of the spore.

This approach makes the following assumptions, that:

- The consignment is homogeneous (grains/seeds are harvested inspected and packaged in similar conditions, and have received similar treatments before arrival into Bangladesh). Heterogeneous or non-randomly distributed consignments would require a higher sampling rate to achieve the same confidence levels. Level of sampling depends on the degree of heterogeneity;
- The samples are chosen randomly from the consignment;
- The inspector is 100 percent likely to detect the pest if it is present in the sample. Because of uncertain distribution of pests within the consignment some pests will not be detected if they are present outside the sample. Some pests are difficult to detect because of their small size and behaviours;
- It is acceptable that the sampling system is based on a level (percentage) of contamination rather than a level of surviving individuals;
- Interception records can rarely be used quantitatively because of limitations in the identification and recording processes.
- There is a paucity of information on the efficacy of the available risk mitigation options in managing the hazards associated with pulses. In the absence of efficacy data, assumptions are made on the basis of data for similar species or similar treatments.

2.5 Review of Management Options

2.5.1 Introduction

This chapter provides background information on possible measures to mitigate the biosecurity risk associated with importing pulses from Australia, Canada, China, India, Nepal and Turkey.

2.5.2 Production and post-harvest measures

It is necessary to provide information about the production and post harvest procedures that pulse growers are expected to use.

2.5.3 Monitoring Programmes in Production Areas

Regular monitoring in field, pest and pathogens is the key to optimizing production while reducing pest and/or disease-related problems, for instance:

- insect pests- regular inspection of leaves, stems, pods, grains etc. of pulses in field to monitor invertebrate population levels eg: coloured sticky boards (white, blue or yellow are attractive to thrips) are commonly used to sample thrips populations; inspection in store ho
- disease organisms – inspection for presence of symptoms.
- Weeds – regular inspection for presence of weeds in field.

Knowledge of pest levels allows for timely and appropriate control measures to be implemented, thus adding to risk reduction.

2.5.4 In-Field Sanitation

In-field sanitation requires the removal of plant debris, weeds, alternate hosts and diseases infested plant that can harbour disease or pests from pulse field. Any infected plant, leaves or plant parts should be cut or removed from the field. Regular inspection and removal of infected plants, weeds facilitate the health and growth by reducing the incidence of various fungal and viral diseases, weeds and allowing in more sunlight.

2.5.5 Pest Control Measures in Field

When pests or diseases reach a volume over a set percentage in field, the grower will use insecticide, fungicide or mineral oil sprays for control. Other forms of control that can be used are pheromone disruption for specific invertebrates such as certain moth species or scale insects, and the introduction of biocontrol agents such as entomophagic fungi or parasitizing invertebrates.

Insecticidal and/or fungicidal dips can be used as part of the packhouse process. New treatments are always becoming available. For instance, Limonene (an extract from *Citrus* peel) has promise as an in-field spray treatment or post harvest dip against mealy bugs and scale as it can penetrate the insect's waxy covering. The limiting factor is phytotoxicity to certain plants and as yet *Citrus* leaves and fruit have not been tested.

2.5.6 Selection of Grains from Areas Free of Pests (Area Freedom)

Several species identified as of quarantine concern to Banglaesh appear to have restricted distributions in the importing countries. If it is possible to guarantee the source of grain, obtaining it from more northerly areas will reduce the risk of importation of these species, although it will not completely eliminate the risk. Other species identified as of quarantine concern however, are appear to be widely distributed and it will not be possible to identify pulse producing regions free of these pests. In general however, infestation pressure declines as one move into more northerly grain growing areas. If wheat is to be sourced using the principles of area freedom, this will require detection, monitoring and delimiting surveys for pests of quarantine to be carried out annually, also the dedication and monitoring of rail cars. This is unlikely to be commercially acceptable in the USA as this is not normal practice.

2.5.7 Grain quality

Risk of infestation increases with decline in grain quality, measured in terms of its physical condition (eg.% brokens, immature or mouldy grains), temperature and moisture content, and extent of admixture of trash and other material. Many insect species find it much easier to become established in grain consignments containing admixture and damaged grains. Grain moisture content should be less than 14%, which is independent of grade. Stored grain pests are adversely affected by low moisture content. Complete removal of admixture of pulses reduces the risk of some species being imported to negligible levels. Sieving and grain cleaning will remove most weed and other incidental contaminants. Lower grades of pulse grains are notoriously difficult to fumigate as regions of bulk cargo can be very high in trash and fines – this material tends to segregate during handling and transport of the grain and forms pockets and layers through which fumigants may have difficulty passing. This results in non-uniform distribution of gas and an increased risk of fumigant survivors. These problems are compounded if fumigation is undertaken in ship. Clean grain is much easier to fumigate properly.

2.5.8 Prevention of Infestation during Transportation, Storage and Handling

A number of species identified of quarantine concern, notably *Callosobruchus* spp., and the and *Trogoderma* species, are not host specific and can be pests infesting residues present in grain handling systems. Such species can infest pusle grain when handled through contaminated facilities. Use of well managed handling and transportation systems will reduce this risk. Fumigation is a non residual treatment and will not confer protection of the grain during subsequent handling and transportation.

Ships used for the importation of pulses need to be ‘fit for purpose’. Vessels can become infested with insects of quarantine concern from previous cargoes and not necessarily only those associated with maize. This could include species which are not established in North America including the khapra beetle, *Trogoderma granarium*. Prior to loading grain, ships must be clean and free of infestation, at least to the standard expected of vessels which handle Australian grain exports. This includes not only the hold, but all other areas of the vessel including crew quarters and engine room and related areas from which infestation could arise.

2.6 Disinfestation Treatments

Disinfestation treatments are treatments that remove or kill hazard organisms that may be contaminating commodities. Some of the treatments discussed are usually considered “stand alone” disinfestation treatments but these can also be integrated into a systems approach. This depends on a number of variables, such as the commodity type, its tolerance for the treatment/s, the biology of associated hazard organisms and what is available to the exporting country.

2.6.1 Heat Treatment

Heat can be used for the processing or devitalisation of grain and may be insecticidal. Temperatures above 50°C are insecticidal, and become rapidly more insecticidal as temperature increases above this. All storage pests are killed by a few minutes actual exposure to either wet or dry heat of 65°C[3]. Time allowance needs to be made for the heat to penetrate the grain kernel to this temperature. Responses of stored product insects to various temperatures are presented in Table 2.

Table 2. Responses of Stored Product Insects to Various Temperatures [3]

Zone	Temperature reanges (^{0}C)	Effect(s)
Lethal	>62	Death in <1 min
	50-62	Death in <1 h
	45-50	Death in <1 day
	35-42	Populations die out, mobile insects seek cooler environment
Suboptimal	35	Maximum temperature for reproduction
	32-35	Slow population increase
Optimal	25-32	Maximum rate of population increase
Suboptimal	13-25	Slow population increase
Lethal	5-13	Slowly lethal
	1-5	Movement ceases
	-10 to -5	Death in weeks, or monthe if acclimated
	-25 to -15	Death in <1 h

2.6.2 Fumigation

Fumigation is the act of releasing and dispersing a toxic chemical so it reaches the target organism in a gaseous state. Chemicals applied as aerosols, smokes, mists, and fogs are suspensions of particulate matter in air and are not fumigants. Fumigants should be used with extreme care, as they are toxic to all forms of life including humans and animals. The normal practice used by the USA or Canada for grain shipments is for grain to be treated with phosphine at US label rates as an in-ship treatment for the duration of the voyage.

2.6.2.1 Phosphine Fumigants

Phosphine fumigants sold as solid aluminum or magnesium phosphide, both of which give off the highly toxic phosphine gas. Phosphine fumigants provide control of all stages of stored grain insect pests. The fumigants are available as tablets or pellets. Tablets begin release phosphine gas in 2-4 hours after being exposed to the atmosphere, whereas pellets begin evolving phosphine gas in only 1-2 hours. In addition to phosphine, which has no odour or colour, the fumigant also releases ammonia, various diphosphines, and methanethiol. The latter two gases are responsible for the characteristic garlic (or rotten fish) odour associated with grain fumigation. The ammonia has the added benefit of reducing the potential for spontaneous ignition.

The rate of decomposition of the tablets or pellets varies depending on the grain moisture and temperature. The higher the temperature and moisture of the grain, the faster the fumigant will be evolved. Conversely, the lower the temperature and moisture, the slower the fumigation. However, when the temperature of the grain is below 5ºC, fumigation is not permitted because the reaction is too slow for effective fumigation. However, aluminum phosphide will react and release phosphine gas even at -40ºC. After complete decomposition, a fine grey-white non-poisonous powder remains.

Aluminum phosphide pellets and tablets are prepared in two spherical shapes. The rounded tablets weigh approximately 3 grams and release 1 gram of phosphine gas. They are about 16 mm in diameter and are bulk packaged in resealable aluminum flasks containing 30, 100 or 500 tablets each. The pellets weigh approximately 0.6 grams and release 0.2 gram of phosphine gas.

Phosphine treatment helps to provide non-infested material for the food industry with a relatively quick treatment time [1, 7].

2.6.2.2 Dosage and Exposure Time

To determine the dosage and exposure time, always read the label. Dosage and exposure time varies with temperature and the tightness of bin, or other grain storage facility. Increasing dosage cannot compensate for a shortened exposure. Dosage, exposure time and temperature of phosphine fumigation against important stored products pests are given in Table 3.

Table 3. Dose, Exposure Time and Temeperature of Phosphine Fumigation against Important Stored Product Pests [2]

Active substance	Dose g PH_3m^{-3}	Minimum exposure time		Minimum temperature
		Bag-stacks (seeds, stored products)	Bulk storage, silo (stored products)	
Aluminium phosphine	3	10 days	12 days	10^0C
Magnesium phosphine	3	9 days	11 days	10^0C
Aluminium phosphine	3	7 days	9 days	20^0C
Magnesium phosphine	3	5 days	8 days	20^0C

The table above gives the minimum exposure periods in days for a dosage of 3 g PH_3 per m^3. One day should be added to the exposure times to allow for development and distribution of the fumigant. The dose may need to be increased to 5 g PH_3 per m^3 if the fumigation conditions are poor (e.g. not very gas tight conditions, or low relative humidity) or if resistant species are found or believed to be present. However, good practice is to perform phosphine fumigation only in gas tight conditions [2].

Fumigation to control *Trogoderma granarium* should follow EPPO Standard PM 10/22. Because of the high level of resistance of diapausing larvae of this pest, treatments require a longer exposure time [6].

Additionally, the fumigation period should be long enough to allow for almost complete reaction of phosphine products with moisture in the products so that little or no non-reacted phosphine products remain [5].

2.7 Visual Inspection at the Border of Bangladesh

Visual inspection by a trained inspector can be used in three main ways for managing biosecurity risks on goods being imported into Bangladesh, as:

- a biosecurity measure, where the attributes of the goods and hazard organism provide sufficient confidence that an inspection will be able to achieve the required level of detection efficacy;
- an audit, where the attributes of the goods, hazard organisms and function being audited provide sufficient confidence that an inspection will confirm that risk management has achieved the required level of efficacy;

- a biosecurity measure in a systems approach, where the other biosecurity measures are not able to provide sufficient efficacy alone or have significant levels of associated uncertainty.

In the case of inspection for audits, this is considered a function of assurance and is part of the implementation of the identified measures. Inspection as a biosecurity measure uses the direct comparison of required efficacy to manage risk versus actual efficacy of an inspection (maximum pest limit versus expected measure efficacy).However in practice it is not possible to precisely define either efficacy or pest limits.

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2.8 Review of Earlier PRA

No PRA on pulse crops has been done in Bangladesh earlier. Moreover PRA on pulse crops in abroad is not found. However PRA on few insect pests of pulse have been done elsewhere which helps preparation of this PRA report.

3.0 IDENTIFICATION OF PESTS

Pests include insects, mites, diseases organisms, weeds and other organisms which may cause damage to crops. Pests of pulses in Bangladesh as well as exporting countries are discussed herein.

3.1 Insect pests, Diseases and Weeds of Pulses in Bangladesh

3.1.1 Insect pests of Pulses

Insect pests of major pulses in Bangladesh such as chickpea, lentil, mungbean, grasspea and cowpea are included in this section. Insect pests of Pulses recorded during Field Survey are shown in Appendices IV & VII.

3.1.1.1 Insect pests of Lentil

In Bangladesh, eight species of insect pests have so far been recorded on lentil of which aphid (*Aphis craccivora)* and pod borer (*H. armigera*) were major pests in field while *Callsobruchus chinensis* and *C. maculatus* were major insect pests in storage (Table 4). Aphid is a major pest during vegetative to flowering phase of lentil while pod borer during podding stage [1]. Red flour beetle (*Tribolium castaneum*) is a major pest of cereal grains but attacks lentil as alternate host [3].

Table 4. List of Insect pests of Lentil with Infested Plant Parts and Pest Status in Bangladesh

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
01.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
02.	Whitefly	*Bemisia tabaci* (Gennadius)	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
03.	Green stink bug	*Nezara viridula* Linn.	Hemiptera: Pentatomidae	Suck sap from shoot and pods	Minor
04.	Thrips	*Megalurothrips distalis* (Karny)	Thysanoptera: Thripidae	Cause flower drop	Minor
05.	Pod borer	*Helicoverpa armigera* (Hübner)	Lepidoptera: Noctuidae	Bore into the pods and feed on seeds	Major
06.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus	Coleoptera: Bruchidae	Feed on grain by boring	Major
07.	Cowpea bruchid	*Callosobruchus maculatus* Fabricius	Coleoptera: Bruchidae	Feed on grain by boring	Major
08.	Red flour beetle	*Tribolium castaneum*	Coleoptera: Tenebrionidae	Adult and larvae feed on grains	Minor

3.1.1.2 Insect pests of Chickpea

Eleven species of insect pests of chickpea have been recorded in Bangladesh of which nine species attack in field and two species attack in storage (Table 5). Among the field insect pests pod borer, *Helicoverpa armigera*, is a serious major and serious in most of the chickpea growing areas in Bangladesh [2]. A countrywide survey indicated that an average of 30-40 percent pods was found to damage by pod borer [11]. Eleven insect pests of chickpea also reported in

Bangladesh [5]. Peak population of pod borer was observed in April [6, 7]. Two bruchids, *Callsobruchus chinensis* and *C. maculatus* were reported to attack chickpea in storage which were major pests all over the country. Rice weevil (*Sitophilus oryzae*), lesser grain borer (*Rhyzopertha dominica*) and rice meal moth (*Corcyra cephalonica*)are the major pests of cereal grains but they attack mungbean as alternate host [3].

Table 5. List of Insect pests of Chickpea with Infested Plant Parts and Pest Status in Bangladesh

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
01.	Black cut worm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Cut the base of seedlings	Minor
02.	Common cutworm	*Spodoptera liturua* (Fabricius)	Lepidoptera: Noctuidae	Cut the base of seedlings	Minor
03.	Green semilooper	*Plusia signata* Fabricius	Lepidoptera: Noctuidae	Damage foliage and young plants	Minor
04.	Green stink bug	*Nezara viridula* Linn.	Hemiptera: Pentatomida e	Suck sap from shoot and pods	Minor
05.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
06.	Whitefly	*Bemisia tabaci* (Gennadius)	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Minor
07.	Pod borer	*Helicoverpa armigera (*Hübner)	Lepidoptera: Noctuidae	Bore into the pods and feed on seeds	Major
08.	Bean pod borer	*Maruca testulalis* Geyer	Lepidoptera: Crambidae	Bore into the flowers, pods and feed on seeds	Major
09.	Gram blue butterfly	*Euchrysops cnejus* (Fabricius)	Lepidoptera: Lycaenidae	Bore into the flowers, pods and feed on seeds	Minor
10.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus	Coleoptera: Bruchidae	Feed on grain by boring	Major
11.	Cowpea weevil	*Callosobruchus maculatus* Fabricius	Coleoptera: Bruchidae	Feed on grain by boring	Major
12.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Adult and larvae feed on grains	Minor
13.	Lesser grain borer	*Rhyzopertha dominica* (Fabricius)	Coleoptera: Bostrichidae	Adult and larvae feed on grains	Minor
14.	Rice meal moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Pyralidae	Larvae feed on grain making web	Minor

3.1.1.3 Insect pests of Mungbean

Eighteen species of insect pests were reported from mungbean in Bangladesh (Table 6). Among themstem fly, *Ophiomyia phaseoli* [11], aphid, *Aphis carccivora*, whitefly, *Bemisia tabaci* [10], thrips, *Megalurothrips distalis* [8, 11], hairy caterpillar, *Spilarctia oblique* [10] and pod borers (*Euchrysops cnejus*, *Maruca* testulalis, *Helicoverpa armigera*) [10,8] were important pests in field. Stem fly infestation on mungbean varied 50-100% over space and time depending on weather condition [7]. Thrips was the most important pest during flower stage which caused flower shedding and significant yield loss [6]. Pod borer damages flowers, flower buds and developing pods [5]. *Callosobruchus chinensis* and *C. maculatus* were major pests in storage. Rice weevil (*Sitophilus oryzae*), lesser grain borer (*Rhyzopertha dominica*)and rice meal moth (*Corcyra cephalonica*)are the major pests of cereal grains but attack mungbean as alternate host [3].

Table 6. List of Insect pests of Mungbean with Infested Plant Parts and Pest Status in Bangladesh

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
01.	Stem fly	*Ophiomyia phaseoli* Tryon	Diptera: Agromyzidae	Bore into stem and feed on internal tissues	Major
02.	Whitefly	*Bemisia tabaci* (Gennadius)	Homoptera: Aleyrodidae	Suck sap from twigs, flowers and pods	Major
03.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Suck sap and transmit virus disease	Major
04.	Green jassid	*Empoasca kerri* Pruthi	Homoptera: Jassid	Suck sap from shoots and pods	Minor
05.	Green stink bug	*Nezara viridula* Linn.	Hemiptera: Pentatomidae	Suck sap from shoots and pods	Minor
06.	Thrips	*Megalurothrips distalis* (Karny)	Thysanoptera: Thripidae	Cause flower drop	Major
07.	Hairy caterpillar	*Spilarctia obliqua (*Walker)	Lepidoptera: Arctiidae	Feed on leaves	Major
08.	Stripped flea beetle	*Phyllotreta striolata* Fabricius	Coleoptera: Chrysomelidae	Feed on leaves	Minor
09.	Crucifer flea beetle	*Phyllotreta cruciferae* (Goeze)	Coleoptera: Chrysomelidae	Feed on leaves	Minor
10.	White spotted leaf beetle	*Monolepta signata* Olivier	Coleoptera: Chrysomelidae	Feed on leaves	Minor
11.	Pod borer	*Helicoverpa armigera (*Hübner)	Lepidoptera: Noctuidae	Bore into the pods and feed on seeds	Major
12.	Bean pod borer	*Maruca testulalis* Geyer	Lepidoptera: Crambidae	Bore into the flowers, pods and feed on seeds	Major
13.	Gram blue butterfly	*Euchrysops cnejus* (Fabricius)	Lepidoptera: Lycaenidae	Bore into the flowers, pods and feed on seeds	Major
14.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus	Coleoptera: Bruchidae	Feed on grain by boring	Major
15.	Cowpea bruchid	*Callosobruchus maculatus* Fabricius	Coleoptera: Bruchidae	Feed on grain by boring	Major
16.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Adult and larvae feed on grains	Minor
17.	Lesser grain borer	*Rhyzopertha dominica* (Fabricius)	Coleoptera: Bostrichidae	Adult and larvae feed on grains	Minor
18.	Rice meal moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Pyralidae	Larvae feed on grain making web	Minor

3.1.1.4 Insect pests of Grasspea

Five insect pests were found to infest grasspea in field and storage of which three insect pests attack in field and two pests were in storage (Table 7). Aphid (*Aphis craccivora*) infestation occurred during vegetative to flowering stage of the crop and considered as the major pest in field [5]. Both*Callosobruchus chinensis* and *C. maculatus* were major pests in storage.

Table 7. List of Insect pests of Grasspea with Infested Plant Parts and Pest Status in Bangladesh

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
01.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Major
02.	Green stink bug	*Nezara viridula* Linn.	Hemiptera: Pentatomidae	Suck sap from shoot and pods	Minor
03.	Thrips	*Megalurothrips distalis* (Karny)	Thysanoptera: Thripidae	Cause flower drop	Minor
04.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus	Coleoptera: Bruchidae	Feed on grain by boring	Major
05.	Cowpea weevil/ Cowpea bruchid	*Callosobruchus maculatus* Fabricius	Coleoptera: Bruchidae	Feed on grain by boring	Major

3.1.1.5 Insect pests of Cowpea

In Bangladesh, elenven insect pests were recorded from cowpea (Table 8). Among them six specie were found to attack in field and five species infested in storage. Jassid (*Empoasca kerri*) an pod borer (*Maruca testulalis*)were reported as the major pest in field [5]. Bruchids, *Callosobruchus chinensis* and *C. maculatus* were major damaging pests in storage. Rice weevil (*Sitophilus oryzae*), lesser grain borer (*Rhyzopertha dominica*)and rice meal moth (*Corcyra cephalonica*)are the major pests of cereal grains but they attack mungbean as alternate host [3].

Table 8. List of Insect pests of cowpea with infested plant parts and pest status in Bangladesh

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
01.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Suck sap from twigs, flowers and pods	Minor
02.	Green jassid	*Empoasca kerri* Pruthi	Homoptera: Jassid	Suck sap from shoots and pods	Major
03.	Green stink bug	*Nezara viridula* Linneaus	Hemiptera: Pentatomidae	Suck sap from shoot and pods	Minor
04.	Thrips	*Megalurothrips distalis* (Karny)	Thysanoptera: Thripidae	Cause flower drop	Minor
05.	Galerucid beetle	*Madurasia obscurella* Jacoby	Coleoptera: Chrysomelidae	Damage leaves	Minor
06.	Bean pod borer	*Maruca testulalis* Geyer	Lepidoptera: Crambidae	Bore into the flowers, pods and feed on	Major

Sl. No.	Common Name	Scientific Name	Order: Family	Infested Plant Parts	Status
				seeds	
07.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus	Coleoptera: Bruchidae	Feed on grain by boring	Major
08.	Cowpea weevil/ Cowpea bruchid	*Callosobruchus maculatus* Fabricius	Coleoptera: Bruchidae	Feed on grain by boring	Major
09.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Adult and larvae feed on grains	Minor
10.	Lesser grain borer	*Rhyzopertha dominica* (Fabricius)	Coleoptera: Bostrichidae	Adult and larvae feed on grains	Minor
11.	Rice meal moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Pyralidae	Larvae feed on grain makingweb	Minor

Photographs of some major Insect pests of five major pulses in field and storage insect pests are shown in Figure 7 and 8.

Aphid infested twig

Jassid on leaf

Whitefly on leaves

Stripped flea beetle on leaves

White spotted leaf beetle

Hairy caterpillars infested leaves

Thrips on flower

Thrips on leaves

Green semilooper

Helicoverpa armigera pod borer

Gram blue butterfly

Figure 7. Some Important Field Insect pests of Pulses in Bangladesh

Pulse beetle infested mungbean

Pulse beetle

Rice weevil

Lesser grain borer

Figure 8. Some Important Insect pests of Pulses in Storage

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3.1.2 Diseases of Pulses

Diseases of pulses are discussed herein and diseases recorded during field urvey are shown in Appendices V& VII and also the symptoms of some important diseases are presented in Figure 9.

3.1.2.1 Diseases of Lentil

Diseases of five selected pulses crops along with the causal organism and plant parts infected are shown in Tables 9-13. In lentil, out of 20 diseases 15 diseases are caused by fungal pathogens, 3 cused by viruses/mycoplasma and 2 caused by nematodes. Among the 15 fungal diseases, three, namely stemphylium blight (*Stemphylium sarciniformis)*, Foot & Root rot (*Sclerotium rolfsii, Fusarium oxysporum, Fusarium solani)* andRust (*Uromyces fabae*) are of major importance. Bushy stunt disease caused by mycoplasma is also a major disease. The status of all other diseases in lentilis minor.Among the major diseases only Foot & root rot disease caused infection to the root system and base of the plant. All other diseases caused infection to the above ground parts of the plant. Stemphylium blight is a seed-borne and seed-transmitted disease and seed may be contaminated with rust spores (Table 9).

Table 9. List of Diseases of Lentil (*Lens calinaris Medik.)* in Bangladesh

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Ref.
01	Stemphylium blight	*Stemphylium sarciniformis*	Major	All aerial parts, seed	7, 8
02	Foot & Root rot	*Sclerotium rolfsii, Fusarium oxysporum, Fusarium solani*	Major	Root, collar	2, 7, 8
03	Rust	*Uromyces fabae*	Major	All aerial partds and seed	7, 8
04	Fusarium wilt	*Fusarium oxysporum f.sp. lentis*	Minor	Root, lower stem (Vascular tissue)	7, 8
05	Cercospora leaf spot	*Cercospora cruenta*	Minor	Leaf, seed	7, 8
06	Leaf spot/ Leaf blight	*Alternaria* sp.	Minor	Leaf, seed	7, 8
07	Leaf rot	*Choanephora* sp.	Minor	Leaf, seed	7, 8
08	Powdery mildew	*Erysiphe polygoni* De C./ *Oidium* sp.	Minor	All aerial parts	7, 8
09	Downy mildew	*Peronospora* sp.*, P. viciae*	Minor	All aerial parts	7, 8
10	Pod blight	*Alternaria* sp.	Minor	Pod	7, 8
11	Seedling damping-off	*Fusarium* sp., *Pythium* sp.	Minor	Collar, root	7, 8
12	Botrytis grey mould	*Botrytis cinerea*	Minor	All aerial parts, seed	8, 11
13	Collar rot	*Sclerotium rolfsii*	Minor	Collar, root	6, 4
14	Anthracnose	*Colletotrichum truncatum*	Minor	All aerial parts, pod, seed	12
15	Sclerotinia rot	*Sclerotinia sclerotiorum* (Lib.) de Bary	Minor	Stem, leaf, flower, pod	1
16	Bushy stunt	*Mycoplasma*	Major	Aerial plant parts	7, 8
17	Yellow mosaic	*Bean Yellow mosaic virus*	Minor	Aerial plant parts, seed	7, 8
18	Leaf roll	*Bean (Pea) leaf roll virus*	Minor	Leaves, twigs	7, 8

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Ref.
19	Nematode disease	*Giconemoides* sp., *Tylenchus* sp.	Minor	Root	7, 8
20	Root Knot	*Meloidogyne javanica, M. incognita*	Minor	Root	7, 8

3.1.2.2 Diseases of Chickpea

In Bangladesh, so far 19 diseases were recorded to inflict chickpea crop (Table 10).Among the diseases 14, 3 and 2 diseases are caused by fungi, virus and nematodes, respectively. All the 5 diseases caused by virus and nematodes are of minor importance, however, among the 14 fungal diseases 4 diseases namely Botrytis grey mould (BGM) (*Botrytis Cinerea*) Fusariun wilt (*Fusarium oxysporum f.sp. ciceri*), Collar rot (*Sclerotium rolfsii, Rhizoctonia solani*) and seed rot caused by *Phoma* sp. are considered as major. Most of the fungal diseases caused infection to the aerial parts of the chickpea plant (Table 10).

Table 10. List of Diseases of Chickpea (*Cicer arietinum* L.) in Bangladesh

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Refer ence
01	Botrytis Grey Mould	*Botrytis cinerea*	Major	All aerial parts, seed	7
02	Wilt	*Fusarium oxysporum f.sp. ciceri*	Major	Root, lower stem (Vascular tissue)	7
03	Collar rot	*Sclerotum rolfsii, Rhizoctonia solani*	Major	Collar, root	7
04	Dry root rot	*Macrophomina phaseolina/ Rhizoctonia bataticola*	Minor	Roots	7
05	Foot rot	*Fusarium oxysporum & Sclerotium rolfsii*	Minor	Roots	7, 8
06	Stemphylium blight	*Stemphylium sarciniformis*	Minor	All aerial parts, seed	13
07	Rust	*Uromyces ciceris-arietini*	Minor	All aerial parts, seed	7
08	Leaf spot/blight	*Alternaria* sp.	Minor	All aerial parts, seed	7
09	Ascochyta blight	*Ascochyta rabiei*	Minor	All aerial parts, seed	7
10	Powdery mildew	*Oidium* sp.	Minor	All aerial parts	7
11	Stem rot	*Sclerotinia sclerotiorum*	Minor	All aerial parts, seed, roots	8
12	Root rot	*F. solani* and *S. rolfsii*	Minor	Root	2
13	Seed rot	*Phoma* sp.	Major	Stem, seed	8
14	Seed rot & germination failure	*Fusarium oxysporum*	Minor		8
15	Chickpea Stunt	*Bean (Pea) leaf roll virus*	Minor	All aerial parts	7
16	Chickpea Stunt	*Chickpea chlorotic dwarf*	Minor	All aerial parts	8

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
		virus			
17	Yellow mosaic	*Bean yellow mosaic virus*	Minor	Leaves, twigs, seed	7
18	Root knot	*Meloidogyne javanica, M. incognita, Belonolaimus* sp.	Minor	Root	7
19	Nematode disease	*Trichodorus* sp.		Root	7

3.1.2.3 Diseases of Mungbean

Major fungal diseases of mungbean in Bangladesh are Cercospora leaf spot (CLS) and Powdery mildew caused by *Cercospora cruenta* and *Erysiphe polygoni*, respectively. Another major disease is mungbean yellow mosaic caused by Mungbean Yellow Mosaic Virus. So far, a total of 21 diseases are recoded to inflict mungbean. Out of 21 diseases 13 are caused by fungi, 1 by bacteria, 5 by virus and mycoplasma and 2 by nematode pathogens. List of mungbean diseases occur in Bangladesh along with their causal agent, plant parts infected and their economic status are shown in Table 11.

Table 11. List of Mungbean (*Vigna radiata* (L.) Wilczek) Diseases in Bangladesh

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Cercospora leaf spot	*Cercospora cruenta*	Major	Leaves, seed	7, 10
02	Powdery mildew	*Oidium* sp. *Erysiphe polygoni*	Major	All aerial parts	3, 4
03	Sclerotinia blight	*Sclerotinia sclerotiorum* (Lib.) de Bary	Minor	All aerial parts, seed, root	7
04	Leaf blight	*Leptosphaerulina trifolii, Phoma medicaginis* Malbr. & Roumeguere	Minor	All aerial parts, seed	7
05	Stem rot	*Macrophomina phaseolina(Tassi)* Goidanich	Minor	Stem, root	7
06	Wilt	*Fusarium oxysporum* Schlecht.:Fries emend. Snyder & Hansen f. sp *ciceris* (Padwick) Matuo & Sato	Minor	Root, lower stem (Vascular tissue)	7
07	Anthracnose	*Colletotrichum lindemuthianum, Colletotrichum dematium*	Minor	All aerial parts, seed	7
08	Leaf spot	*Myrothecium* sp.	Minor	All aerial parts, seed	7
09	Leaf spot	*Rhizoctonia solani*	Minor	Leaf, root	3
10	Target spot	*Corynespora cassicola*	Minor	All plant parts, seed	8
11	Foot & root rot	*Fusarium oxysporum, Sclerotium rolfsii*	Minor	Root	7

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
12	Germination reduction	*Aspergillus flavus & Aspergillus clavatus*	Minor		8
13	Seed rot &germination failure	*Fusarium oxysporum, F. solani, F. equisetii*	Minor		8
14	Bacterial leaf blight	*Xanthomonas phaseoli*	Minor	Leaf	7
15	Yellow mosaic	*Mungbean yellow mosaic virus*	Major	All aerial parts	3
16	Leaf crinkle	*Virus*	Minor	All aerial parts	3
17	Little leaf	*Mycoplasma*	Minor	Aerial parts	3
18	Yellowing	*Virus/Mycoplasma*	Minor	Aerial parts	3
19	Bean common mosaic	*Bean common mosaic virus*	Minor	Leaves, seed	4
20	Root knot	*Meloidogyne incognita*	Minor	Root	3
21	Nematode disease	*Helicotylenchus* sp. *Hoplolaimus indicus* *Aphelenchoides* sp.	Minor	Root	3

3.1.2.4 Diseases of Grasspea

A total of 14 diseases were recorded on grasspea in Bangladesh. Out of which 11, 1 and 2 are caused by fungi, virus and nematode pathogens, respectively. Among the 14 diseases only Downy mildew caused by *Perenospora viciae* causes economic damage to the crop and consider as a major disease.The pathogen causes infection to the leaves only (Table 12).

Table 12. List of Grasspea (*Lathyrus sativus* L.) Diseases in Bangladesh

Sl. No.	Disease	Causal Organism	Status	Plants Parts Infected	References
01	Downy mildew	*Peronospora viciae*	Major	Leaves	7
02	Foot and root rot	*Fusarium oxysporum*	Minor	Root	7
03	Ashy stem blight	*Macrophomina phaseolina*	Minor	All plant parts	8
04	Rust	*Uromyces* sp.	Minor	All aerial parts	7
05	Cercospora leaf spot	*Cercospora cruenta*	Minor	All aerial parts, seed	7
06	Ascochyta blight	*Ascochyta trifolii*	Minor	All aerial parts, seed	7
07	Leptosphaerulina blight	*Leptosphaerulina trifolii*	Minor	All aerial parts, seed	7
08	Powdery mildew	*Oidium* sp.	Minor	All aerial parts	7
09	Wilt	*Verticillium* sp., *Fusarium oxysporum*	Minor	Root, stem base (Vascular tissue)	7
10	Seed discolouration & germination reduction	*Aspergillus* spp., *Penicillium* sp.	Minor		8
11	Seed rot &germination	*Fusarium* spp.	Minor		8

Sl. No.	Disease	Causal Organism	Status	Plants Parts Infected	References
	failure				
12	Leaf curl	Leaf curl virus	Minor	Leaf, twig	7
13	Root knot	*Meloidogyne javanica, M. incognita*	Minor	Root	7
14	Nematode disease	*Tylenchorhynchus* sp.	Minor	Root	7

3.1.2.5 Diseases of Cowpea

One fungal disease, CLS caused by *Cercospora cruenta/canescens* and one virus disease, Yellow mosaic caused by Cowpea Yellow Mosaic Virus are major out of 15 diseases reported to occur on Cowpea in Bangladesh. Out of 15 diseases reported on this crop10 are caused by fungi, 2 by virus, one by mycoplasma, one by bacteria and one by nematode. Of the two major diseases CLS is is a fungal and Yellow mosaic is a virus disease (Table 13).

Table 13. List of Cowpea [*Vigna unguiculata* (L.) Walp.] Diseases in Bangladesh

Sl.No.	Disease	Causal Organism	Status	Plant Parts Infected	References
01	Cercospora leaf spot	*Cercospora cruenta/canescens*	**Major**	All aerial parts, seed	7, 8
02	Ashy stem blight	*Macrophomina phaseolina*	Minor	All aerial parts, seed	7
03	Foot & root rot	*Fusarium oxysporum*	Minor	Root	7
04	Leaf rust	*Uromyces appendiculatus*	Minor	All aerial parts	7
05	Stem rot	*Macrophomina phaseolina*	Minor	All aerial parts, seed	7
06	Powdery mildew	*Erysiphe polygoni*	Minor	All aerial parts	7
07	Wilt	Fusarium udum	Minor	Root, lower stem (Vascular tissue)	7
08	Leptosphaerulina leaf spot	*Leptosphaerulina trifolii*	Minor	All aerial parts, seed	7
09	Anthracnose	*Colletotrichum dematium/ Glomeralla lindemuthianum*	Minor	All aerial parts, seed	7
10	Dieback	*Vermicularia capsici*	Minor	All aerial parts, seed	7
11	Yellow mosaic	Cowpea yellow mosaic Virus	**Major**	Leaf, twig	7, 8
12	Little leaf	Mycoplasma	Minor	Leaf, twig	7
13	Cowpea aphid-borne mosaic	Cowpea aphid-borne mosaic virus	Minor	Leaf	9
14	Bacterial leaf blight	*Xanthomonas vignicola*	Minor	Leaf	7
15	Nematode disease	*Helicotylenchus* sp.	Minor	Root	7

Stemphylium blight of lentil

Botrytis grey mould of lentil

Ascochyta blight of chickpea

Botrytis grey mould of chickpea

Mungbean yellow mosaic disease

Figure 9. Symptoms of Some Important Diseases of Pulse Crops in Bangladesh.

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3.1.3 Weeds of Pulses

In Bangladesh 19 weed species are recorded in pulse crops representing 11 families. The highest number of species is under Poaceae (6-species) followed by Asteraceae (3-species), Fabaceae (2-species) and rests of the families represented one species each (Table 14). Among the 19 weeds 15 are of major concern for pulse cultivation (1, 2) in Bangladesh. Most of the weeds were predominated in lentil alone or lentil and other species of pulses. Bon moshure and Bindi are the major weeds only in lentil field. Chapra and Katanote were major in Mungbean field. In Grasspea the major weeds were Phulkaghash, Green foxtail, Chhotoshama and Bon Shimul. Bathua and mashure chana were predominant in lentil, Chickpea and Grasspea. Foshka begun were predominated in chickpea, mungbean and Grasspeaand Durba in all the pulse crops (Table 14). Results in Table 14 showed that Durba is the most predominant weed across the pulse crop fields in Bangladesh followed by Fuska begun. Weeds of pulses recorded during field urvey are shown in **Appendices VI**. Few important weeds are presented in Figure 10.

Table 14. Common Weeds of Pulse Crops in Bangladesh

Sl.No.	Local name	Scientific name	Family	Status	Reference
01	Kantanote	*Amaranthus spinosus* L.	Amaranthaceae	Major[2]	5
02	Titlia	*Sonchus oleraceus* L.	Asteraceae	Major[4]	5
03	Parthenium	*Parthenium hysterophorus* L.	Asteraceae	Minor	5
04	Bon Shimul	*Saussurea affinis* Spreng. ex DC.	Asteraceae	Major[3]	1
05	Bathua	*Chenopodium album* L,	Chenopodiaceae	Major[6]	5
06	Bindi	*Convolvulus arvensis* L.	Convolvulaceae	Major[1]	5
07	Mutha	*Cyperus rotundas* L.	Cyperaceae	Major[5]	5
08	Boon moshure	*Vicia sativa* L	Fabaceae	Major[1]	5
09	Moshure chana	*Vicia hirsuta* (L) S.F. Grav	Fabaceae	Major[6]	5
10	Kash	*Saccharum spontaneum* L.	Gramineae	Minor	4
11	Dondokalos	*Leucas aspera* Spreng.	Lamiaceae	Major[4]	5
12	Durba	*Cynodon dactylon* (L.) Pers.	Poaceae	Major[8]	5
13	Phulkaghash	*Panicum paludosum* Roxb.	Poaceae	Major[3]	5
14	Baranda	*Panicum repens* L.	Poaceae	Minor	3
15	Green foxtail	*Setaria viridis* Beauv.	Poaceae	Major[3]	5
16	Chhotoshama	*Echinochloa colona* Link	Poaceae	Major[3]	5
17	Chapra	E*leusine indica* Gaertn.	Poaceae	Major[2]	5
18	Bon palong	*Rumex maritimus* L.	Polygonaceae	Minor	5
19	Foshka begun	*Physalis heterophylla* Nees.	Solanaceae	Major[7]	5

[1]Major in lentil; [2]Major in mungbean; [3]Major in Grasspea; [4]Major in lentil & chickpea; [5]Major in lentil, chickpea & mungbean; [6]Major in lentil, chickpea &Grasspea; [7]Major in chickpea, mungbean &Grasspea; [8]Major in all

Polygonum aviculareae (common knotweed) is present in Bangladesh though not yet recorded in pulse field (2, 6).*Panicum repens* is an introduced weed in Bangladesh

Amaranthus spinosus **(Katanote)**

Physalis heterophylla **(Foskabegun)**

Saussurea affinis *(*Bon Shimul*)*

Vicia sativa (*Bon mosur*)

Figure 10. Some Important Weeds of Pulses in Bangladesh.

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3.2 Insect pests, Diseases and Weeds of Pulses in Selected Exporting Countries

Bangaldesh imports pulse grains from Australia, Canada, China, India, Nepal and Turkey. Insect pests, diseases and weeds of the pulse exporting countries are discussed herein.

3.2.1 Insect pests of Pulses in Exporting Countries

Thirty two species of insect pests were found to attack pulses in the world of which 21 species attack in field and 11 species cause infestation in storage (Table 15). Different filed insect pests feed on leaves, stems, and shoots of pulses, suck the cell sap from different parts of the plant, and bore the pods and bore stems during seedling stage and cause damage. Storage insect pests mainly cause infestation on stored pulse grains although different bruchids attack pulse grains from filed. Sucking insect pests inject toxic substance during sucking and some sucking insect pests transmit viral diseases. Among the field insect pests, 14 species were major and 7 species were minor. On the other hand six species of insect pests are major and 5 species are minor in storage.

Table 15. List of Insect pests of Pulses, their Hosts, Infested Plant Parts, Pest Status and Distribution in Exporting Countries and Bangladesh

Sl. No.	Common Name	Scientific Name (Order: Family)	Host Plants	Infested Plant Parts	Status	Distribution	Bangladesh Status	Reference
Field insect pests								
01.	Stem fly	*Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae)	Mungbean, blackgram, cowpea, limabean	Maggots bore into stem and feed on internal tissues	**Major pest of mungbean**	Australia Bangladesh, China, India, Nepal, Turkey and Sri Lanka	Yes	1, 5, 8, 17, 23
02.	Pod fly	*Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae)	Pigeon pea, mungbean, cowpea	Maggots bore into pods and feed on seeds	**Major pest of pigeon pea**	Australia , China, India, Nepal	**No**	9,15,16, 17,28,29, 32, 31, 35
03.	Soybean fly	*Melanagromyza sojae* (Zehntner) (Diptera: Agromyzidae)	Soybean, mungbean, black gram, cowpea,	Maggots bore into stem and feed on internal tissues	**Major pest of soybean**	Australia, China, India	**No**	2, 14, 33, 37,34,36
04.	Black cut worm	*Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae)	Chickpea	Cut the base of seedlings	Minor	Australia, Bangladesh, Canada, China, India, Turkey	Yes	1, 5, 8, 23
05.	Common cutworm	*Spodoptera liturua* (Fabricius) (Lepidoptera: Noctuidae)	Chickpea, mungbean, cowpea, blackgram	Cut the base of seedlings	Minor	Australia, Bangladesh, Canada, China, India, Nepal, Turkey	Yes	1, 5, 8, 23
06.	Green semilooper	*Plusia signata* Fabricius (Lepidoptera: Noctuidae)	Chickpea	Damage foliage and young plants	Minor	Bangladesh, India	Yes	1, 5, 8, 23
07.	Hairy	*Spilarctia obliqua* (Walker)	Mungbean,	Feed on leaves	**Major**	Bangladesh,	Yes	1, 5, 8,

Sl. No.	Common Name	Scientific Name (Order: Family)	Host Plants	Infested Plant Parts	Status	Distribution	Bangladesh Status	Reference
	caterpillar	(Lepidoptera: Arctiidae)	blackgram, soybean			China, India, Nepal,		23
08.	Crucifer flea beetle	*Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae)	Mungbean, blackgram	Feed on leaves	**Major pest of blackgram**	Bangladesh, China, India, Nepal, Canada	Yes	1, 5, 8, 23
09.	Stripped flea beetle	*Phyllotreta striolata* Fabricius (Coleoptera: Chrysomelidae)						
10.	White spotted leaf beetle	*Monolepta signata* Olivier (Coleoptera: Chrysomelidae)	Mungbean, blackgram	Feed on leaves	Minor	Bangladesh, China, India, Nepal	Yes	1, 5, 8, 17 23
11.	Galerucid beetle	*Madurasia obscurella* Jacoby (Coleoptera: Chrysomelidae)	Blackgram, cowpea	Feed on leaves	Minor Vector of bean southern mosaic virus	Bangladesh, China, India, Nepal	Yes	1, 5, 8, 23
12.	Aphid	*Aphis craccivora* Koch (Homoptera: Aphididae)	Lentil, chickpea, mungbean, blackgram, grasspea	Suck sap from twigs, flowers and pods	**Major**	Australia, Bangladesh, Canada, China, India, Nepal, Turkey	Yes	1, 5, 8, 23
13.	Whitefly	*Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae)	Mungbean, blackgram	Suck sap and transmit virus disease	**Major**	Australia, Bangladesh, Canada, China, India, Nepal, Turkey	Yes	1, 5, 8, 23
14.	Green jassid	*Empoasca kerri* Pruthi (Homoptera: Jassid)	Mungbean, cowpea, blackgram	Suck sap and damage leaves	**Major pest of cowpea**	Bangladesh , India	Yes	1, 5, 8,17 23
15.	Green bug	*Nezara viridula* Linneaus (Hemiptera: Pentatomidae)	Lentil, mungbean	Suck sap from shoots and	Minor	Australia, Bangladesh,	Yes	1, 5, 8, 17, 23

Sl. No.	Common Name	Scientific Name (Order: Family)	Host Plants	Infested Plant Parts	Status	Distribution	Bangladesh Status	Reference
				pods		China, India, Nepal, Turkey		
16	Thrips	*Megalurothrips distalis* (Karny) (Thysanoptera: Thripidae)	Lentil, grasspea, mungbean, pigeonpea	Adult and nymph cause flower drop	**Major pest of mungbean**	Australia, Bangladesh, China, India, Nepal, Turkey	Yes	1, 5, 8, 17, 23
17.	Gram pod borer/ Pod borers	Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae)	Chickpea, lentil, blackgram, pigeonpea	Young larvae feed on foliage & later bore into the pods and feed on seeds	**Major**	Australia, Bangladesh, China, India, Nepal, Turkey	Yes	1,5, 8, 17, 21, 22, 23
18.	Bean pod borer	*Maruca testulalis* Geyer (Lepidoptera: Crambidae)	Mungbean, cowpea, blackgram, pigeonpea	Larvae feed on flowers & bore into the pods and feed on seeds	**Major**	Australia, Bangladesh, China, India, Nepal, Turkey	Yes	1,5, 8, 17, 21, 22, 23
19.	Gram blue butterfly	*Euchrysops cnejus* (Fabricius) (Lepidoptera: Lycaenidae)	Mungean, cowpea, blackgram, pigeonpea	Larvae feed on flowers & bore into the pods and feed on seeds	**Major pest of mungbean**	Bangladesh, India	Yes	1, 5, 8,17, 23
20.	Spiny pod borer	*Etiella zinckenella* (Treitschke) (Lepidoptera: Phycitidae)	Lentil, greenpea, Mungbean	Larvae feed on flowers & bore into the pods and feed on seeds	**Major pest of lentil in India**	Australia, Canada, China, India, Nepal, Turkey	**No**	6, 12, 13, 19, 26
21.	Plume moth	*Exelastis atomosa* (Walsingham) (Lepidoptera: Pterophoridae)	Red gram (Arhar), chickpea	Larvae bore into the pods & feed on seeds	**Major pest of red gram**	India, Nepal	**No**	8, 38

Sl. No.	Common Name	Scientific Name (Order: Family)	Host Plants	Infested Plant Parts	Status	Distribution	Bangladesh Status	Reference
Stored grain pests								
22.	Chinese bruchid	*Callosobruchus chinensis* Linnaeus (Coleoptera: Bruchidae)	Chickpea, lentil, grasspea, mungbean, blackgram, pigeonpea	Adult & larva feed on grain by boring	**Major**	Australia, Bangladesh, Canada, India, Nepal, Turkey,	Yes	1, 8,17, 23
23.	Cowpea weevil/ Cowpea bruchid	*Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae)	Chickpea, lentil, grasspea, mungbean, pigeonpea	Adult & larva feed on grain by boring	**Major**	Australia, Bangladesh, Canada, India, Nepal	Yes	1, 8, 17, 23
24.	Bean weevil	*Callosobruchus analis* Fabricius (Coleoptera: Bruchidae)	Chickpea, mungbean, blackgram, cowpea	Larva feed on grain by boring	**Major pest of cowpea**	India, Myanmar	**No**	8, 30
25.	Bruchid	*Callosobruchus phaseoli* (Gyllenhal) (Coleoptera: Bruchidae)	Mungbean, cowpea, chickpea, blackgram	Larva feed on grain by boring	**Major pest of mungbean**	India	**No**	8
26.	Bean bruchid	*Acanthoscelides obtectus* (Say) (Coleoptera: Bruchidae)	Pigeonpea, chickpea, grasspea	Larva feed on grain by boring	**Major pest of pigeon pea**	Australia, Canada, India, Turkey	**No**	7, 24, 25
26.	Khapra beetle	*Trogoderma granarium* Everts (Coleoptera: Dermestidae)	Chickpea, cowpea,	Adult and larvae feed on grains	Minor	India, Turkey	**No**	3, 4, 18, 20, 27
27.	Rice weevil	*Sitophilus oryzae* (Linnaeus) (Coleoptera: Curculionidae)	Chickpea, mungbean,	Adult and larvae feed on	Minor	Australia, Bangladesh,	Yes	8, 17

Sl. No.	Common Name	Scientific Name (Order: Family)	Host Plants	Infested Plant Parts	Status	Distribution	Bangladesh Status	Reference
			cowpea	grains		Canada, China, India, Nepal		
28.	Granary weevil	*Sitophilus granarius* Linnaeus (Coleoptera: Curculionidae)	Chickpea	Adult and larvae feed on grains	Minor	Australia, Canada, India, Turkey	**No**	10, 11
29.	Red flour beetle	*Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae)	Lentil, peas	Adult and larvae feed on grains	**Major**	Australia, Bangladesh, Canada, China, India, Nepal, Turkey	Yes	8, 17
30.	Lesser grain borer	*Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae)	Chickpea, blackgram, mungbean, cowpea	Adult and larvae feed on grains	Minor	Australia, Bangladesh, Canada, China, India, Nepal, Turkey	Yes	8,17
31.	Rice meal moth	*Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae)	Chickpea, mungbean, cowpea	Larvae feed on grain making web	Minor	Australia, Bangladesh, Canada, China, India, Nepal	Yes	8,17

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3.2.2 Diseases of Pulses in Exporting Countries

3.2.2.1 Lentil Diseases

Altogether records of 10 diseases were found to occur on lentil in Australia. Amomg these 4 are fungal disease and rests 6 diseases are caused by viruses. Out of 4 fungal diseases Ascochyta blight (*Ascochyta lentis*) and Botrytis grey mould (*Botrytis cinerea*) are major concern for lentil production in Australia. Among the 6 virus diseses Alfalfa mosaic (*Alfalfa mosaic virus (*AMV*)*) and Bean leaf roll (*Bean leaf roll virus* (BLRV)) are major. *Alfalfa mosaic virus* is seed-borne in lentil. Another virus disease, Cucumber mosaic disease caused by *Cucumber mosaic virus* is occasionally major to the crop. List of lentil diseases in Australia along with their causal organisms, status, plant parts infected and references are shown in Table 16.

Table 16. List of Lentil (*Lens culinaris* Medik.) Diseases in Australia

Sl. No.	Disease	Causal Agent	Status	Plant Parts Affected	Reference
01	Ascochyta blight	*Ascochyta lentis*	**Major**	All aerial parts	10, 15, 31
02	Botrytis grey mould	*Botrytis cinerea*	**Major**	All aerial parts	10, 15, 31
03	Anthracnose	*Colletotrichum truncatum*	Minor	All aerial parts	10
04	Sclerotinia stem rot	*Sclerotinia sclerotiorum*	Minor	All aerial parts	15
05	Alfalfa mosaic	*Alfalfa mosaic virus*	**Major**	Leaf, seed	8, 10
06	Cucumber mosaic	*Cucumber mosaic virus*	Occasionally major	Aerial parts, seed, seed	8, 10
07	Beet western yellows	*Beet western yellows virus*	Minor	Whole plant	8, 10
08	Bean leaf roll	*Bean leafroll virus*	**Major**	Leaf,	8
09	Bean yellow mosaic	*Bean yellow mosaic virus*	Minor	Leaf, seed	8
10	Pea seed-borne mosaic	*Pea seed-borne mosaic virus*	Minor	Leaf, seed	8

In Canada, altogether records of 11 diseases of lentil were found through extensive searches of literatures and records. Out of these 10 are caused by fungi and one by virus. All the 4 major diseases of lentil are caused by fungal pathogens in Canada. The major diseases are Ascochyta blight, Stemphylium blight, Botrytis grey mould and Anthracnose (Table 17).

Table 17. List of Diseases of Lentil (*Lens culinaris* Medik.) in Canada

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Aschochyta blight	*Ascochyta lentis* Bond. and Vassil,	**Major**	Leaf, stem & pod, seed	5, 6, 11,
02	Stemphylium blight	*Stemphylium botryosum* Wallr	**Major**	All aerial parts, seed	5, 6, 25
03	Botrytis grey mould	*Botrytis cinerea* (Pers. Fr.)	**Major**	Seed, stem, pod, seed	5, 6, 11

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
					25
04	Anthracnose	*Colletotrichum truncatum* (Schwein.) Andrus and Moore *Colletotrichum lentis*	**Major**	Stem, leaf, pod, seed	3, 5, 6, 11,
05	Rust	*Uromyces viciae-fabae* (Pers.) Schroel	Minor	All aerial partds and seed	14
06	Wilt	*Fusarium oxysporum* Schlecht. Emend. Snyder & Hansen *f.sp. lentis* Vasudeva and Srinivasan	Minor	Root, lower stem, seed	35
07	Seedling blight	*Rhizoctonia solani*	Minor	Seedling collar	11
08	White mould	*Sclerotinia sclerotiorum*	Minor	Roots, base of plant	5, 11
09	Stem & root rot	*Rhizoctonia solani, Fusarium sp*. and *Botrytis* sp.	Minor	Root, Stem	11
10	Root rot	*Pythium aphanidermatum* (Edson) Fitzp., *Fusariumsolani,*	Minor	Root	5, 6

Exploring different sources we could found the record of only 4 major diseases affecting lentil in China. The diseases are Rust, Fusarium wilt, Stemphylium blight and Faba bean necrotic yellows. The former three are caused by fungal pathogens and the later is a virus disease (Table 18).

Table 18. List of Lentil (*Lens culinaris* Medik.) Diseases in China

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Rust	*Uromyces viciae-fabae* (Pers.) de Bary	**Major**	All aerial parts	7
02	Fusarium wilt	*Fusarium oxysporum* Schlecht. Fr. *f.sp. lentis* Vasudeva & Srinivasan	**Major**	Root, lower stem	17
03	Stemphylium blight	*Stemphylium botryosum*	**Major**	All aerial parts, pod, seed	17
04	Faba bean necrotic yellows	*Faba bean necrotic yellows virus* (FBNYV)	**Major**	Leaves	17

Out of 21 diseases of lentil recorded in India, 17 are fungal disease of them 4 diseases namely Fusarium wilt, Botrytis grey mould, rust and Ascochyta blight are the major concern for lentil production. The status of all the 3 virus diseases and 3 nematode diseases are minor (Table 19)

Table 19. List of Lentil (*Lens culinaris* Medik.) Diseases in India

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Fusarium wilt	*Fusarium oxysporum* Schlecht. Fr. *f.sp. lentis* Vasudeva & Srinivasan	**Major**	Root, lower stem (Vascular tissue)	1, 2, 4, 9, 21, 34
02	Botrytis grey mould	*Botrytis cinerea*	**Major**	All aerial parts, seed	2, 4, 34
03	Rust	*Uromyces viciae-fabae* (Pers.) de Bary	**Major**	All aerial partds and seed contamination	2, 4, 9, 34
04	Ascochyta blight	*Ascochyta fabae f.sp. lentis*	**Major**	All aerial parts, seed	2, 4, 34
05	Stemphylium blight	*Stemphylium botryosum*	Minor	All aerial parts, seed	2
06	Cercospora leaf spot	*Cercospora cruenta*	Minor	Leaf, seed	29
07	Powdery mildew	*Erysiphe polygoni* De C./ *Oidium* sp. and *Leveillula taurica*	Minor	Foliage, stem, pod	2, 9, 32, 34
08	Collar rot	*Sclerotium rolfsii*	Minor	Collar region	2, 32
09	Wet root rot	*Rhizoctonia solani* Kiihn *Fusarium* sp.	Minor	Root	34
10	Alternaria blight	*Alternaria alternata*	Minor	Leaves	1, 2
11	Downy mildew	*Peronospora lentis*	Minor	Leaves	2, 34
12	Sclerotinia stem rot	*Sclerotinia sclerotiorum*	Minor	All aerial parts	2, 34
13	Dry root rot	*Macrophomina phaseolina*	Minor	Roots	2,
14	Black root rot	*Fusarium solani*	Minor	Roots	2
15	Pythium damping-off	*Pythium aphanidermatum*	Minor	Base of the plant, root	2
16	Pythium root rot	*Pythium ultimum*	Minor	Base of the plant, root	2
17	Anthracnose	*Colletotrichum truncatum*	Minor	Aerial plant parts, seed	2
18	Yellows	*Luteoviruses*	Minor	Leaves, twigs	2
19	Yellow mosaic	*Bean Yellow mosaic virus*	Minor	Leaves, twigs	2
20	Cucumber mosaic	*Cucumber mosaic virus*	Minor	Leaves, twigs	2
21	Root Knot	*Meloidogyne incognita, M. javanica*	Minor	Root	2

In total 12 diseases of lentil caused by fungi, viruses and nematodes are reported from Nepal. Most of the diseases are caused by fungal pathogens others are caused by virus and nematode. Among the diseases four fungal diseases cause economic damage to the crops and placed under major category. The major diseases are Fusarium wilt, Collar rot, Botrytis grey mould and Rust (Table 20).

Table 20. List of Lentil (*Lens culinaris* Medik.) Diseases in Nepal

Sl. No.	Disease	Causal Organism	Status	Plant Parts Affected	References
01	Fusarium wilt	*Fusarium oxysporum* f.sp. lentis	**Major**	Roots, base of the plants (vascular tissue)	24
02	Collar rot	*Sclerotium rolfsii*	**Major**	Collar rigion	28
03	Rust	*Uromyces viciae-fabae*	**Major**	Aerial plant parts, seed	24, 29
04	Botrytis grey mould	*Botrytis cinerea*	**Major**	Aerial plant parts, seed	28
05	Stemphylium blight	*Stemphylium botryosum* Walr	Minor	Aerial plant parts, seed	12, 18, 27, 33
06	Dry root rot	*Macrophomina phaseolina*	Minor	Root	24
07	Black root rot	*Fusarium solani*	Minor	Root	30
08	Alternaria blight	*Alternaria alternata*	Minor	Leaves, seed	30
09	Wet root rot	*Rhizoctonia solani*	Minor	Root	30
10	Cucumber mosaic virus	*Cucumber Mosaic Virus*	Minor	Leaf	26
11	Pea seed-borne mosaic virus	*Pea seed-borne mosaic virus potyvirus*	Minor	Leaf	19, 20
12	Nematodes	*Helicotylenchus, Tylenchus, Criconemoides*	Minor	Root	23

In Turkey 6 diseases are of major concerns for lentil production. Among these 4 are caused by fungi and 2 by viruses. The major fungal diseases are Fusarium wilt (*Fusarium oxysporum f.sp. lentis*), Phoma blight (*Phoma medicaginis*), Sclerotinia rot (*Sclerotinia sclerotiorum*) and Rust (*Uromyces fabae)* and the major virus diseases are Faba necrotic yellows (*Faba bean necrotic yellows virus (FBNYV) Nanovirus*) and Bean yellow mosaic (*Bean yellow mosaic virus* (*BYMV*) Disease reported on lentil including the major diseases are listed in Table 21.

Table 21. List of Lentil (*Lens culinaris* Medik.) Diseases in Turkey

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Ref.
01	Fusarium wilt	*Fusarium oxysporum f.sp. lentis*	**Major**		13
02	Phoma blight	*Phoma medicaginis*	**Major**	All aerial parts, seed	13
03	Sclerotinia rot	*Sclerotinia sclerotiorum* (Lib.) de Bary	**Major**	Stem, leaf, flower, pod	13
04	Rust	*Uromyces fabae*	**Major**	All aerial	13

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Ref.
				parts	
05	Botrytis grey mould	*Botrytis cinerea* Pers.	Minor	All aerial parts	16
06	Faba bean necrotic yellows	*Faba bean necrotic yellows virus (FBNYV)Nanovirus*	**Major**	Leaf	13, 22
07	Pea seed-borne mosaic	*Pea seed-borne mosaic (PSbMV) Potyvirus*		Seed	13,
08	Bean yellow mosaic	*Bean yellow mosaic (BYMV) Potyvirus*	Minor	Leaf	13, 22
09	Bean leaf roll	*Bean leaf roll virus (BLRV) Luteovirus*	**Major**	leaf	22

From the Tables it could be seen that the number of major diseases is low compared to the total number of diseases. Fangal pathogens are more predominant over other groups of pathogen. Across the countries Fusarium wilt and Botrytis grey mould are the most prevalent disease followed by Ascochyta blight.

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3.2.2.2 ChickpeaDiseases

In Australia, chickpea crop suffers from 9 fungal diseases of which, Ascochyta blight is the most damaging disease. Other major diseases are Botrytis grey mould, Sclerotinia white mould and Phoma blight/stem rot. All these diseases cause infection to the aerial parts of chickpea. Except Sclerotinia white mould all other major diseases cause seed infection. Phytophthora root rot is another major disease occurs only in norther part of New SouthWalesstate. Among the four viral diseases AMV and BWMV are major (Table 22).

Table 22. List of Chickpea *(Cicer arietinum* L.) Diseases in Australia

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Ascochyta blight	*Ascochyta rabiei* (Passerini) Labrousse	Major	All aerial parts, seed	8, 7, 21
02	Botrytis grey mould	*Botrytis cinerea*	Major	All aerial parts, seed	8, 7, 21
03	Botrytis seedling disease	*Botrytis cinerea*	Major	Seedling	5
04	Sclerotinia white mould	*Sclerotinia sclerotiorum*	Major	All aerial parts	9, 7
05	Phoma stem rot/blight	*Phoma medicaginis* Malbr. & Roumeguere *var. pinodella*	Major	All aerial parts, seed	8, 21
06	Phytophthora root rot	*Phytophthora medicaginis*	Major in NSW	Root	8, 7, 21
07	Damping-off	*Pythium* spp.	Minor	Collar, root	8
08	Wet root rot	*Rhizoctonia solani* Kuhn	Minor	Root	8, 21
09	Dry root rot	*Macrophomina phaseolina (Tassi)* Goidanich	Minor	Root	21
10	Alfalfa mosaic	*Alfalfa mosaic virus*	Major	Leaf, seed	8, 27
11	Cucumber mosaic	*Cucumber mosaic virus*	Minor	Aerial parts, seed	8, 27
12	Beet western yellows	*Beet western yellow virus*	Major	Aerial parts,	8, 27
13	Bean leaf roll	*Bean leaf roll virus*	Minor	Leaf	27

Chickpea in Canada was found to be attacked by 11 fungal pathogens. Among the diseases, four such as Botrytis blight, Ascochyta blight, Fusarium wilt and Sclerotinia white mould are the major problem for chickpea production. Fusarium wilt is a vascular disease causes infection to the roots and vascular system of lower part of the stem.All other diseases are minor (Table 23).

Table 23. List of Chickpea (*Cicer arietinum* L.) Diseases in Canada

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Botrytis blight	*Botrytis cinerea* Persoon:Fries	Major	All aerial parts	2, 16,
02	Ascochyta blight	*Ascochyta rabiei* (Passerini) Labrousse	Major	All aerial parts	2, 16,

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
03	Fusarium wilt	*Fusarium oxysporum f.sp. ciceris*	Major	Vascular tissue of lower stem	21
04	Sclerotinia white mould	*Sclerotinia sclerotiorum*	Major	All aerial parts	2, 3, 21
05	Phoma blight	*Phoma medicaginis*	Minor	Leaf, stem collar, root	14
06	Seedling blight & root rot	*Rhizoctonia solani, Fusarium*	Minor	Seedling base, root	2, 3, 21
07	Root rot	*Pythium ultimum* Trow.	Minor	Root	2
08	Rust	*Uromyces fabae*	Minor	All aerial parts	3
09	Powdery mildew	*Erysiphe polygoni*	Minor	All aerial parts	3
10	Stemphylium blight	*Stemphylium botryosum*	Minor	All aerial parts	2
11	Phytophthora root rot	*Phytophthora* sp.	Minor	Root	3

Four fungal and one virus diseases were found in China. Among the diseases Ascochyta blight and Fusarium wilt are major and rest of the diseases are of minor concern (Table 24).

Table 24. List of Chickpea (*Cicer arietinum* L.) Diseases in China

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Ascochyta complex	*Ascochyta rabiei* (Passerini) Labrousse	Major	All aerial parts	22
02	Fusarium wilt	*Fusarium oxysporum f.sp. ciceris*	Major	Vascular tissue of lower stem	22
03	Dry root rot	*Macrophomina phaseolina(Tassi)* Goidanich *= Rhizoctonia batatico/a* (Taubenhaus) Butler	Minor	Root	22
04	Root rot	*Fusarium solani* (Martius) Saccardo	Minor	Root	22
05	*Leaf roll disease*	*Bean (pea) leaf roll virus*	Minor	Leaf	22

Among the six pulses exporting countries to Bangladesh the highest numbers of diseases (23) were found in India. Among the diseases 17 are fungal disease, one bacterial, 3 virus and one disease is caused by nematode Five fungal diseases viz., Fusarium wilt, dry root rot, collar rot, Ascochyta blight and Boreytis grey mould are of major concern in India. Rust, Stemphylium blight and Colletotrichum blight are major in particular states. The only bacterial disease, bacterial blight is minor. Out of four virus diseases one disease only one (chickpea stunt) is major (Table 25).

Table 25. List of Chickpea (*Cicer arietinum* L.) Diseases in India

Sl.No.	Disease	Pathogen	Status	Plant Parts Affected	Refere nce
01	Fusarium wilts	*Fusarium oxysporum* Schlecht:Fries emend. Snyder & Hansen f. sp *ciceris* (Padwick) Matuo & Sato.	Major	Vascular tissueof lower stem	1,6, 23
02	Dry root rot	*Macrophomina phaseolina(Tassi)* Goidanich = *Rhizoctonia batatico/a*	Major	Root	6
03	Wet root rot	*Rhizoctonia solani* Kuhn	Major	Root	1, 6
04	Collar rot	*Sclerotium rolfsii* Saccardo	Major	Collar	6
05	Ascochyta blight	*Ascochyta rabiei* (Passerini) Labrousse	Major	All aerial parts	1, 6
06	Botrytis grey mould	*Botrytis cinerea* Persoon:Fries	Major	All aerial parts	1, 6
07	Stem rot/ Sclerotinia blight	*Sclerotinia sclerotiorum* (Lib.) de Bary	Minor	All aerial parts	4
08	Powdery mildews	*Erysiphe polygoni*	Minor	Leaf	4
09	Rust	*Uromyces ciceris-arietini* (Grogn.) Jacz. & Beyer	Major in Bihar, U.P. Karnataka	All aerial parts	10
10	Stemphylium blight	*Stemphylium sarciniforme* (Cavara) Wiltshire	Major in U.P., Bihar, Karnataka	All aerial parts	1, 10
11	Colletotrichum blight	*Colletotrichum dematium* (Persoon) Grove	Major in M.P.	All aerial parts	20
12	Colletotrichum blight	*Colletotrichum capsici* (Sydow) Butler & Bisby	Major in A.P.	All aerial parts	19
13	Alternaria blight	*Alternaria alternata* (Fries:Fries) Keissler	Minor	Leaf stem branches	21
14	Phoma blight	*Phoma medicaginis* Malbr. & Roumeguere	Minor	All aerial parts	21
15	Black root rot	*Fusarium solani* (Martius) Saccardo	Minor	Root	12
16	Phytophthora root rot	*Phytophthora medicaginis* Hans & Maxwell	Minor	Root	21
17	Pythium root & seed rot	*Pythium ultimum* Trow	Minor	Root	21
18	Bacterial blight	*Xanthomonas campestris*pv. cassiae Kulkarni et al.	Minor	Leaf	21
19	Chickpea Stunt	Bean (pea) leaf roll virus	Major	All aerial parts	6
20	Pea seed-borne mosaic	*Pea seed-borne mosaic virus*	Minor	Leaf, seed	18

Sl.No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
21	Mosaic	Alfalfa mosaic virus	Minor	Leaf, seed	21
22	Proliferation	Cucumber mosaic virus	Minor	All aerial parts	21
23	Root knot	*Meloidogyne incognita* Gold *M. javanica*	Minor	Root	10

In Nepal 14 diseases were revorded on chickpea, of which 12 are fungal diseases one virus and one nematode disease. Botrytis grey mould and Fusarium wilt are the two major fungal diseases. Besides, collar rot and Black root rot caused by *Sclerotium rolfsii* and *Fusarium solani* respectively are occasionally major disease of chickpea in Nepal. All other diseases are of minor importance (Table 26).

Table 26. List of Chickpea (*Cicer arietinum* L.) Diseases in Nepal

Sl. No	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Botrytis grey mould	*Botrytis cinerea*	Major	All aerial parts, seed	24, 25
02	Fusarium wilt	*Fusarium oxysporum* Schlecht.:Fries emend. Snyder & Hansen f. sp *ciceris* (Padwick) Matuo & Sato.	Major	Root, xylem vessels	24, 25
03	Collar rot	*Sclerotium rolfsii* Saccardo	Major*	Collar region	25
04	Black root rot	*Fusarium solani* (Martius) Saccardo	Major*	Roots	25
05	Dry root rot	*Macrophomina phaseolina(Tassi)* Goidanich	Minor	Roots	24, 25
06	Ascochyta leaf spot	*Ascochyta rabiei* (Passerini) Labrousse	Minor	All aerial parts, seed	24
07	Wet root rot	*Rhizoctonia solani* Kuhn	Minor	Roots	24
08	Alternaria blight	*Alternaria* sp.	Minor	Leaf	22, 25
09	Sclerotinia stem rot	*Sclerotinia sclerotiorum* (Lib.) de Bary	Minor	Leaf, stem, root, seed contaminatio n	22, 24,25
10	Damping-off/ Pythium root & seed rot	*Pythium ultimum* Trow	Minor	Roots	24
11	Stemphylium blight	*Stemphylium sarciniforme* (Cavara) Wiltshire	Minor	Leaf, stem	22
12	Rust	*Uromyces ciceris-arietini* Jaczewski in Boyer	Minor	Leaf, petiole, twig and pod	22

Sl. No	Disease	Pathogen	Status	Plant Parts Affected	Reference
		&Jaczewski			
13	Stunt	Bean (pea) leaf roll virus (BLRV)	Minor	leaf, Phloem	25
14	Root knot	*Meloidogyne* spp.	Minor	Roots	26

***Occasionally major**

In total 12 diseases were recoded on chickpea in Turkey. Amomg the diseases 10 are caused by fungi, one by bacteria and one by virus. Five diseases namely Ascochyta leaf spot (*Ascochyta rabei*), Fusarium wilt (*Fusarium oxysporum f.sp. ciceris*), Dry root rot (*Macrophomina phaseolina*), Botrytis grey mould (*Botrytis cinerea*) and Stemphylium blight (*Stemphylium sarciniforme)* are the major diseases of chickpea.Other 7 diseases are minor in Turkey (Table 27).

Table 27. List of Chickpea (*Cicer arietinum* L.) Diseases in Turkey

Sl. No.	Disease	Pathogen	Status	Plant Parts Affected	Reference
01	Ascochyta leaf spot	*Ascochyta rabiei* (Passerini) Labrousse	Major	All aerial parts	17
02	Fusarium wilt	*Fusarium oxysporum*Schlecht.:Fries emend. Snyder & Hansenf. sp*ciceris*(Padwick) Matuo & Sato.	Major	Root, vascular tissue of lower stem	11
03	Dry root rot	*Macrophomina phaseolina(Tassi)* Goidanich = *Rhizoctonia batatico/a* (Taubenhaus) Butler	Major	Root	11, 21
11	Botrytis grey mould	*Botrytis cinerea*	Major	All aerial parts	21
	Powdery mildew	*Erysiphe polygoni*		Leaf	15
04	Black root rot	*Fusarium solani* (Martius) Saccardo	Minor	Root	11
05	Wet root rot	*Rhizoctonia solani* Kuhn	Minor	Root	11
06	Collar rot	*Sclerotium rolfsii* Saccardo	Minor	Collar	11
07	Sclerotinia blight	*Sclerotinia sclerotiorum* (Lib.) de Bary	Minor	All aerial parts	11
08	Pythium root & seed rot	*Pythium ultimum* Trow	Minor	Base, root	11, 21
09	Stemphylium blight	*Stemphylium sarciniforme* (Cavara) Wiltshire	Major	All aerial parts	21
10	Rust	*Uromyces ciceris-arietini* (Grogn.) Jacz. & Beyer	Minor	All aerial parts	21
11	Bacterial blight	*Xanthomonas campestris*pv. cassiae Kulkarni et al.		Leaf, seed	22
12	Stunt	Bean leaf roll luteovirus (BLRV)	Minor	Whole plant	13

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3.2.2.3 Mungbean Diseases

Among the six selected countries disease records of mungbean was available from Australia, China, India, and Nepal. In Australia 8 diseases were reported to occur on mungbean, of which, six are caused by fungi and 2 by bacteria.

Among the fungal diseases Cercospora leaf spot (*Pseudocercospora cruenta & Cercospora canescens*) and Powdery mildew (*Erysiphe polygoni*) are of major concern. Both the bacteril diseases viz., Tan spot (*Curtobacterium flaccumfaciens pv. flaccumfaciens*) and Halo blight (*Pseudomonas savastanoi pv. phaseolicola*) are major on mungbean in Australia (Table 28).

Table 28. List of Mungbean (*Vigna radiata* L.) Diseases in Australia

Sl. No.	Disease	Causal Organism	Status	Plant Parts Affected	References
01	Cercospora leaf spot	*Pseudocercospora cruenta Cercospora canescens*	Major	All aerial parts	3
02	Powdery mildew	*Erysiphe polygoni*	Major	Leaf	2, 3
03	Fusarium wilt	*Fusarium* spp.	Minor	Root,vascular tissue of lower stem	3
04	Dry root rot	*Macrophomina phaseolina*	Minor	Root	5
05	Charcoal rot	*Macrophomina phaseolina*	Minor	Root, stem	2, 3
06	Sclerotinia white mould	*Sclerotinia sclerotiorum*	Minor	Root vascular tissue of lower stem	3
07	Tan spot	*Curtobacterium flaccumfaciens* pv. *flaccumfaciens*	Major	Leaf, stem pod, seed	2
08	Halo blight	*Pseudomonas savastanoi pv. phaseolicola*	Major	Leaf, pod, seed	2

Seven diseases were recorded to occur on mungbean in China, of which 6 are caused by fangal pathogen and one each by bacteria, virua and nematode.Two fungal diseases viz., Cercospora leaf spot and Powdery mildew and the virus disease Yellow mosaic caused by Mung bean yellow mosaic virus are of major importance for this crop (Table 29).

Table 29. List of Mungbean (*Vigna radiata* L.) Diseases in China

Sl. No.	Disease	Causal Organism	Status	Plant Parts Affected	References
01	Cercospora leaf spot	*Pseudocercospora cruenta Cercospora canescens*	Major	All areal parts	9
02	Powdery mildew	*Erysiphe polygoni*	Major	Leaf	9
03	Anthracnose	*Colletotrichum lindemuthianum*		All areal parts	7

Sl. No.	Disease	Causal Organism	Status	Plant Parts Affected	References
04	Dry root rot	*Macrophomina phaseolina*	Minor	Root	15
05	Halo blight	*Pseudomonas syringae* pv. *phaseolicola*	Major	Leaf, pod, seed	14
06	Yellow mosaic	*Mung bean yellow mosaic virus*	Major	Leaf	9
07	Root knot	*Meloidogyne incognita, M. javanica*	Minor	Root	6

As per the available sources mungbean in India suffers from 8 diseases of which 6, 1 and 1 are caused by fungi, virus and nematode, respectively. The major diseases are CLS, Powdery mildew and Yellow mosaic (Table 30).

Table 30. List of Mungbean (*Vigna radiata* L.) Diseases in India

Sl. No.	Disease	Causal organism	Status	Plant Parts Affected	References
01	Cercospora leaf spot	*Pseudocercospora cruenta Cercospora canescens*	Major	All areal parts	1
02	Powdery mildew	*Erysiphe polygoni*	Major	Leaf	1
03	Anthracnose	*Colletotrichum lindemuthianum*	Minor	All areal parts	11
04	Dry root rot	*Macrophomina phaseolina*	Minor	Root	8
05	Web blight	*Rhizoctonia solani*	Minor	Stem	13
06	Wet root rot	*Rhizoctonia solani*	Minor	Root	11
07	Yellow mosaic	*Mung bean yellow mosaic virus*	Major	Leaf	1
08	Root knot	*Meloidogyne incognita, M. javanica*	Minor	Root	1

In Nepal four diseases were found to occur on mungbean of which 3 are caused by fungal pathogens and 1 virus disease. Out of 3 fungal diseases CLS and Powdery mildew are major and the only virus disease Yellow mosaic in also major (Table 31).

Table 31. List of Mungbean (*Vigna radiata* L.) Diseases in Nepal

Sl.No.	Disease	Causal organism	Status	Plant Parts Affected	References
01	Cercospora leaf spot	*Cercospora* sp	Major	All areal parts	10, 12
02	Powdery mildew	*Erysiphe polygoni*	Major	Leaf	10, 12
03	Web blight	*Rhizoctonia solani*	Minor	Stem	12
04	Yellow mosaic	*Mung bean yellow mosaic virus*	Major Occassionally	Leaf	10, 12

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3.2.2.4 Grasspea Diseases

Grasspea is grown as a crop in Bangladesh, China, India and Nepal but grown as green manure in Australia and Canada. However, records of two diseases in India and only one disease in Nepal were found and shown in Table 32.Powdery mildew was found as major disease in both countries.

Table 32. Diseases of Grasspea in India and Nepal

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Downy mildew	*Peronospora viciae*	Minor	Leaf	1
02	Powdery mildew	*Erysiphe* spp	Major	Vascular tissue	1
	Nepal				
	Powdery mildew	*Erysiphe* spp	Major	Leaf	1

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3.2.2.5 Cowpea Diseases

Among the six selected countries disease records onCowpea was available from Australia, China and India.

Available sources revealed the occurrence of 8 diseases on Cowpea in Australia caused by fungal, bacterial and nematode. Among the five fungal diseases only one disease- Phytophthora stem rot caused by *Phytophthora vignae* is the major concern for mungbean production in Australia. The other major disease is Tan spot caused by a bacterium *Curtobacterium flaccumfaciens* subsp. *flaccumfaciens*. Rest 6 diseases are minor (Table 33).

Table 33. List of Cowpea (*Vigna unguiculata*) Diseases in Australia

Sl. No.	Disease	Pathogen	Status	Plant Parts Infected	Reference
01	Phytophthora stem rot	*Phytophthora vignae*	Major	Stem	3
02	Powdery mildew	*Oidium* sp. (*Erysiphe polygoni)*	Minor	Leaf	3
03	Fusarium Wilt	*Fusarium oxysporum* f.sp. *tracheiphilum* (E.F.Sm.) Snyder & H.N. Hansen	Minor	Root, Vascular tissue of lower stem	5, 12
04	Charcoal rot	*Macrophomina phaseolina*	Minor	Stem	5
05	Sclerotinia	*Sclerotinia sclerotiorum,*	Minor	All areal parts	5
06	Tan spot	*Curtobacterium flaccumfaciens* subsp. *flaccumfaciens*	Major	Leaf, stem pod, seed	3, 4 5
08	Root knot	*Meloidogyne incognita, M. javanica*	Minor	Root	15

Alltogether five diseases were recorded on cowpea in China. Among these 2 are caused by fungi, 1 by bacteria and 2 caused by viruses. The only major disease is CLS on cowpea in China (Table 34).

Table 34. List of Cowpea (*Vigna unguiculata*) Diseases in China

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Cercospora leaf spot	*Cercospora canescens Pseudocercospora cruenta*	Major	All aerial parts	11
02	Target spot	*Corynespora cassiicola*	Minor	Leaf	10
03	Bacterial blight	*Xanthomonas axonopodis* pv.*vignicola* (Burkh.) Vauterin et al.	Minor	All aerial parts	7
04	Mosaic and malformation	Peanut stunt cucumovirus	Minor	Leaf	6
05	Tomato spotted wilt	*Tomato spotted wilt virus*	Minor	Leaf, seed	16

In India altogether 15 diseases were recorded to occur on cowpea. Among these 11, 1, 2, and 1 diseases are caused by funfal, bacterial, viral and nemic pathogens. Major fungal diseases are Fusarium wilt (*Fusarium oxysporum* f.sp. *tracheiphilum*), CLS and powdery mildew. The other major disease is cowpea severe mosaic caused by virus (Table 35).

Table 35. List of Cowpea (*Vigna unguiculata*) Diseases in India

Sl. No.	Disease	Causal Organism	Status	Plant Parts Infected	Reference
01	Brown Rust	*Uromyces appendiculatus*	Minor	Leaves	9
02	Fusarium wilt	*Fusarium oxysporum* f.sp. *tracheiphilum* (E.F.Sm.) Snyder & H.N. Hansen	Major	Vascular tissue	9, 13
03	Charcoal rot/ Root rot	*Macrophomina phaseolina*	Minor	Root, lower stem	9
04	Septoria leaf spot	*Septoria vignae* Henn.	Minor	Leaf, seed	8
05	Cercospora leaf spot	*Cercospora canescens* *Pseudocercospora cruenta*	Major	Leaf, seed	1, 8,9
06	Anthracnose	*Colletotrichum lindemuthianum*	Minor	Leaf, stem, branches, seed	8, 9, 14
07	Powdery mildew	*Erysiphe polygoni* De C.	Major	Leaf	9
08	Lamb's tail pod rot	*Choanephora cucurbitarum* (Berk. & Ravenel) Thaxt	Minor	Pod	14
09	Pythium soft stem rot	*Pythium aphanidermatum*	Minor	Lower stem	8
10	Seedling damping-off	*Pythium aphanidermatum*	Minor	Lower stem	8
11	Seedling root rot	*Rhizoctonia solani*	Minor	Root	8
12	Bacterial blight	*Xanthomonas campestris pv. vignicola* *X. axonopodis pv vignicola*	Minor	All aerial parts	9
13	Cowpea severe mosaic	Cowpea severe mosaic virus	Major	Leaf, seed	8
14	Cowpea yellow mosaic	Cowpea yellow mosaic virus	Minor	Leaf, seed	1, 8, 9
15	Root Knot	*Meloidogyne javanica, M. incognita*	Minor	Root	2

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3.2.3 Weeds of Pulses in Exporting Countries

In Australia a total of 16 weed species were found in pulse fields representing 7 families viz., Asteraceae, Brassicaceae, Convolvulaceae, Fabaceae, Poaceae, Polygonaceae, and Rubiaceae. Among the 16 weed species 9 are major (Table 36).

Table 36. Common Weeds of Pulse Crops in Australia

Sl.No.	Local Name	Scientific Name	Family	Status	References
01	Common sowthistle	*Sonchus oleraceus* L.	Asteraceae	Major[1]	7
02	Prickly lettuce	*Lactuca serriola* L.	Asteraceae	Major	7
03	Muskweed	*Myagrum perfoliatum* L.	Brassicaceae	Major	7
04	Pennycress	*Thlaspi arvense* L.	Brassicaceae	Major	4
05	Hoary cress	*Cardaria draba* L. Desv.	Brassicaceae	Minor	7

Sl.No.	Local Name	Scientific Name	Family	Status	References
06	Bindweed	*Convolvulus arvensis* L.	Convolvulaceae	Minor	5
07	Common vetch	*Vicia sativa* L	Fabaceae	Major[1]	7
08	Hairy vetch	*Vicia hirsuta (*L.) S.F.Grav	Fabaceae	Minor	1
09	Crowfoot grass	*Dectyloctenium aegyptium* (L.) Wild.	Poaceae	Minor	6
10	Rigid ryegrass	*Lolium rigidum* Gaudin	Poaceae	Major[1]	7
11	Torpedo grass	*Panicum repens* L.	Poaceae	Minor	2
12	Phalaris	*Phalaris minor* Retz.	Poaceae	Major	1
13	Green foxtail	*Setaria viridis* Beauv.	Poaceae	Minor	2
14	Junglerice	*Echinochloa colona* Link	Poaceae	Minor	2
15	Common Knotweed	*Polygonum aviculare* L.	Polygonaceae	Major[1]	7
16	Bedstraw	*Galium tricornutum* Dandy	Rubiaceae	Major[1]	3, 7

[1]Associated with seedof lentil and chickpea (7)

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Seven weed species under 6 families were found in pulse crops in Canada. Among these four are major. Common names of the weeds along with scientific name and family name are shown in Table 37.

Table 37. Common Weeds of Pulse Crops in Canada

Sl.No.	Common Name	Scientific Name	Family	Status	References
01	Sowthistle	*Sonchus oleraceus* L.	Asteraceae	Minor	4
02	Hoary cress	*Cardaria draba* L. Desv.	Brassicaceae	Major	1
03	Stinkweed	*Thlapsi arvense*L.	Brassicaceae	Major	1
04	Bindweed	*Convolvulus arvensis* L.	Convolvulaceae	Minor	1
05	Green foxtail	*Setaria viridis* Beauv.	Poaceae	Minor	2
06	Common Knotweed	*Polygonum aviculare* L.	Polygonaceae	Minor	2
07	Bedstraw	*Galium tricornutum* Dandy	Rubiaceae	Major	3

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Records of 9 weed species representing 7 families in pulse crops were obtained from China. Among the weed species 4 were recorded as major (Table 38).

Table 38. Common Weeds of Pulse Crops in China

Sl.No.	Common Name	Scientific Name	Family	Status	References
01	Spiny amaranth	*Amaranthus spinosus* L.	Amaranthaceae	Minor	6
02	Parthenium	*Parthenium hysterophorus* L.	Asteraceae	Minor	1
03	Lamb's quarter	*Chenopodium album* L,	Chenopodiaceae	Major	7
04	Bindweed	*Convolvulus arvensis* L.	Convolvulaceae	Minor	5
05	Common vetch	*Vicia sativa* L	Fabaceae	Minor	4
06	Bermuda grass	*Cynodon dectylon* (L.) Pers.	Poaceae	Major	2
07	Crow's foot grass	*Dectyloctenium aegyptium* (L.) Wild.	Poaceae	Major	2

Sl.No.	Common Name	Scientific Name	Family	Status	References
08	Torpedo grass	*Panicum repens* L.	Poaceae	Minor	2
09	Bedstraw	*Galium tricornutum* Dandy	Rubiaceae	Major	3

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In India pulse crops were affected by 13 weed species representing 11 families. Among the weed species 8 were major (Table 39).

Table 39. Common Weeds affecting Pulse Crops in India

Sl.No.	Local Name	Scientific Name	Family	Status	References
01	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Minor	2
02	Bathua	*Chenopodium album* L.	Chenopodiaceae	Major	4
03	Khartua	*Chenopodium murale* L.	Chenopodiaceae	Minor	4
04	Mautha or Koko	*Cyprus rotundus* L.	Cyperaceae	Minor	4
05	Hiran khuri	*Convolvulus arvensis*	Convolvulaceae	Major	2, 4
06	Common vetch	*Vicia sativa* L	Fabaceae	Minor	4
07	Patharchata	*Boerhavia diffusa*	Nyctaginaceae	Minor	5
08	Kans or tigergrass	*Saccharum spontaneum* L.	Gramineae	Major	5
09	Phalaris	*Phalaris minor* Retz.	Poaceae	Major	4
10	Makada	*Dectyloctenium aegyptium*	Poaceae	Major	6

Sl.No.	**Local Name**	**Scientific Name**	**Family**	**Status**	**References**
		(L.) Wild.			
11	Rigid ryegrass	*Lolium rigidum* Gaudin	Poaceae	Major	1
12	Krishnaneel	*Anagalis arvensis*	Primulaceae	Major	7
13	Bedstraw	*Galium tricornutum* Dandy	Rubiaceae	Major[1]	3

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Weed species occurring in pulse field in Nepal were listed and shown in Table 40. In total 11 species under 8 families were found, of which 4 were of major concern.

Table40.Common Weeds of Pulses in Nepal

Sl.No.	**Common Name**	**Scientific Name**	**Family**	**Status**	**Ref**
01	Motha; nut grass	*Cyperus rotundus* L.	Gramineae	Major	2
02	Bermuda grass	*Cynodon dactvlon* (*L.*) Pers. *Duvo*	Gramineae	Major	2
03	Pimpernal	*Anagalis arvensis* L.	Primulaceae	Minor	2
04	Shepherd's purse	*Capsella bursa-pastoris* (L.) Moench)	Cruciferae	Minor	2
05	Lamb's quarters	*Chenopodium album* L.	Chenopodiaceae	Major	2
06	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Minor	1
07	Corn-spurry	*Spergula arvensis* L.	Caryophyllaceae	Minor	2
08	Swinecress	*Sciene-biera pinnatifida*	Crucifereae	Minor	2
09	Tiny vetch	*Vicia hirsuta* S.F. Grav	Fabaceae	Minor	2
10	Spring vetch; common vetch	*Vicia sativa* L.	Fabaceae	Major	2
11	Phalaris	*Phalaris minor* Ritz.	Gramineae	Minor	2

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Weed species occurring in pulse field in **Turkey** were listed and shown in Table 41. In total 10 species under 7 families were found, of which 8 were of major concern.

Table 41. Common Weeds of Pulse Crops in Turkey

Sl.No.	Common Name	Scientific Name	Family	Status
01	*Motha;* nut grass	*Cyperus rotundus* L.	Gramineae	Major
02	Bermuda grass	*Cynodon dactvlon* (*L.*) Pers. *Duvo*	Gramineae	Major
03	Rigid ryegrass	*Lolium rigidum* Gaudin	Poaceae	Major
04	Hoarycress	*Cardaria draba* L. Desv.	Brassicaceae	Major
05	*Pennycress*	*Thlaspi arvense* L.	Brassicaceae	Major
06	Lamb's quarters	*Chenopodium album* L.	Chenopodiaceae	Major
07	Bedstraw	*Galium tricornutum* Dandy	Rubiaceae	Major
08	Spiny amaranth	*Amaranthus spinosus* L.	Amaranthaceae	Minor
09	Green foxtail	*Setaria viridis* Beauv.	Poaceae	Minor
10	Spring vetch; common vetch	*Vicia sativa* L.	Fabaceae	Major

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4.0 QUARANTINE PESTS FOR BANGLADESH

Quarantine pests includes insect pests, diseases, weeds and other organisms which are absent in Bnaglaedesh. These organisms are likely to invade in Bangldesh with imported poulse grains or other modes of transmission in international trade and transport. The pests for Bangladesh associated with pulse grains are discussed herein.

4.1 Quarantine Insect pests

List of quarantine insect pests of pulse grains for Bangladesh is prepared comparing the list of insect pests in Bagladesh and Australia, Canda, China, India, Nepal and Turkey from where different pulse grains are imported. Eight species of insect pests such as pod fly (*Melanagromyza obtusa*), soybean fly (*M. sojae*), spiny pod borer (*Etiella zinckenella*), plume moth (*Exelastis atomosa*), bean weevil (*Callosobruchus analis*), bruchid (*C, phaseoli), bean bruchid (Acanthoscelides obtectus)* and granary weevil (*Sitophilus granaries*)are absent in Bangladesh and they are considered as quarantine pests of pulses for Bangladesh (Table 42) Among them, four species viz., pod fly (*Melanagromyza obtusa*), soybean fly (*M. sojae*), spiny pod borer (*Etiella zinckenella*) and plume moth (*Exelastis atomosa*)attack pulse corps in field which are considered as field insect pests of pulses. On the other hand, five insect species such as bean weevil (*Callosobruchus analis*), bruchid (*C, phaseoli), bean bruchid (Acanthoscelides obtectus)* and granary weevil (*Sitophilus granaries*) attack pulse grains in storage and they are considered as storage pests of pulses. Egg, larvae and pupae of storage insect pests of pulses are transported with infested grains in international trade. However, larva and pupa of pod fly may be transported with infested seeds. Larvae of spiny pod borer and plume moths are carried through infested pods.

Among the nine quaranatine insect pests, all are present in India, and four insect pests like pod fly, soybean fly, spiny pod borer and plume moth are reported from Nepal (Table 42). Five insect pests like pod fly, soybean fly, spiny pod borer, bean bruchid and granary weevil are reported from Australia. Only pod fly and spiny pod borer are present in China. In Canada spiny pod borer, bean bruchid and granary weevil are present, and three insect pests like bean bruchid, khapra beetle and granary weevil are reported from Turkey.

Egg, larvae and pupae of storage insect pests of pulses are transported with infested grains in international trade [Table 42]. However, larva and pupa of pod fly may be transported with infested seeds. Larvae of spiny pod borer and plume moths are carried through infested pods. Only pulse grains imported from the above six countries so phytosanitary measures must be taken to prohibit entry of the pests with pulse grains from the exported countries.

Table 42. List of Quarantine Insect pests for Bangladesh in Exporting Countries and Plant Parts are Likely to carry these Pests

Sl. No.	Name of Pests	Scientific Name	Distribution to Pulse Exporting Countries	Plant Parts that likely carry the Pest
01.	Pod fly	*Melanagromyza obtusa* (Malloch)	Australia, China, India, Nepal]	Larvae and pupae move with infested seeds
02.	Soybean fly	*Melanagromyza sojae* (Zehntner)	Australia, China, India, Nepal	Eggs, larvae and pupae borne leaves and seedlings
03.	Spiny pod borer	*Etiella zinckenella* (Treitschke)	Australia, Canada, China, India, Nepal, Turkey	Larvae are borne internally with infested pods
04.	Plume moth	*Exelastis atomosa* Walsingham	India, Nepal	Larvae are borne internally with infested pods
05.	Bean weevil	*Callosobruchus analis* Fabricius	India, Myanmar	Eggs, larvae and pupae are transported with grains
06.	Bruchid	*Callosobruchus phaseoli* (Gyllenhal)	India	Eggs, larvae and pupae are transported with grains
07.	Bean bruchid	*Acanthoscelides obtectus* (Say)	Australia, Canada, India, Turkey.	Eggs, larvae and pupae are transported with grains
08.	Granary weevil	*Sitophilus granarius* Linnaeus	Australia, Canada, India, Turkey	Eggs, larvae and pupae are transported with grains

4.2 Quarantine Diseases

All together 13 diseases have been identified in six selected pulse exporting countries which are absent in Bangladesh. Among the diseases 3, 3 and 7 disease are caused by fungi, bacteria and viruses, respectively. Distribution of the quarantine diseases among six pulse exporting countries is shown in Table 43.

Table 43. Quarantine Diseases of Pulses for Bangladesh and Their Distribution in Six Pulse Exporting Countries

Sl. No.	Disease	Causal organism/Scientific name	Crops Parts Infected/ Infested	Exporting Countries					
				Australia	Canada	China	India	Nepal	Turkey
01	Ascochyta blight	*Ascochyta lentis*	Lentil (all aerial parts + seed)	Present	Present		Present		Present
02	Phytophthora root rot	*Phytophthora medicaginis*	Chickpea (root)	Present	Present		Present		
03	Septoria leaf spot	*Septoria vignae* Henn.	Cowpea (leaf, seed)				Present		
04	Tan spot	*Curtobacterium flaccumfaciens* pv. *flaccumfaciens*	Mungbean, Cowpea (leaf, stem, pod, seed)	Present					
05	Halo blight	*Pseudomonas savastanoi pv. phaseolicola*	Mungbean (leaf, pod, seed)	Present		Present			
06	Bacterial blight	*Xanthomonas campestris*pv. cassiae Kulkarni et al.	Chickpea (leaf)				Present		Present
07	Alfalfa mosaic	*Alfalfa mosaic virus*	Lentil, Chickpea (leaf, seed)	Present					
08	Beet western yellows	*Beet western yellows virus*	Lentil, Chickpea (aerial parts+seed)	Present					
09	Pea seed-borne mosaic	*Pea seed-borne mosaic virus*	Lentil, Chickpea (leaf, seed)	Present				Present	Present
10	Faba bean necrotic yellows	*Faba bean necrotic yellows virus* (FBNYV)	Lentil (leaf)			Present			Present
11	Mosaic and malformation	Peanut stunt cucumovirus	Cowpea (leaf)			Present			
12	Tomato spotted wilt	*Tomato spotted wilt virus*	Cowpea (leaf, seed)			Present			
13	Cowpea severe mosaic	Cowpea severe mosaic virus	Cowpea (leaf, seed)				Present		

4.3 Quarantine Weeds

The distribution of 6 weed species, such asBedstraw, Rigid ryegrass, Hogweed, Small canary grass, Pennycress and Hoary cress wereidentified as quarantine weed for Bangladesh. Distribution of this six quarantine weed in six pulse exporting countries is shown in Table 44. It reveals from the table that all the 6 weed species are present in Australia. Quarantine weeds present in Canada include Bedstraw, Pennycress and Hoary cress. Bedstraw, Hogweed and Pennycress are present in China. Quarantine weeds present in India are Bedstraw, Rigid ryegrass, Hogweed and Small canary grass In Nepal only hogweed is present among the quarantine weeds for Bangladesh. In Turkey quarantine weds present are Bedstraw, Rigid ryegrass, Pennycress and Hoary cress (Table 44).

Table 44. Quarantine Weeds of Pulses for Bangladesh and Their Distribution in Six Pulse Exporting Countries

Sl. No.	Name of Weed	Botanical Name	Host Crop(s) (Seed as Contaminant)	Exporting countries					
				Australia	Canada	China	India	Nepal	Turkey
01	Bedstraw	*Galium tricornutum* Dandy	Chickpea, lentil	Present	Present	Present	Present		Present
02	Rigid ryegrass	*Lolium rigidum* Gaudin	Chickpea, lentil	Present			Present		Present
03	Hogweed	*Boerhavia diffusa*	Cowpea	Present		Present	Present	Present	
04	Small canary grass	*Phalaris minor* Retz.	Chickpea, lentil	Present			Present		
05	Pennycress	*Thlaspi arvense* L.	Chickpea, lentil	Present	Present	Present			Present
06	Hoary cress	*Cardaria draba* L.) Desv.	Lentil	Present	Present				Present

5.0 PEST RISK ASSESSMENT

5.1 Insects pests

5.1.1 Pod fly (*Melanagromyza obtusa*)

5.1.1.1 Hazard Identification

Common name: Pod fly
Scientific name: *Melanagromyza obtusa* (Malloch)
Synonyms: Bean pod fly, pod fly [8], pigeon pea pod fly [19], tur-pod fly (India) [1]. Other scientific names are *Agromyza obtusa* Malloch, *Melanagromyza brevigena* Garg, *Melanagromyza weberi* Meijere [1].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Agromyzidae
Genus: *Melanagromyza*
Species: *Melanagromyza obtusa* (Malloch)

Bangladesh status: Not present in Bangladesh [9]. It presence in Bangladesh has been reported [1] with no details information [15]. It is documented as A1 pest of CPPC in 1990 and alert list of NAPPO in 2001 [7].

EPPO code: MEAGOP [6].

5.1.1.2 Biology

Eggs (around 40 per female) are laid in the seed chamber of young pods, up to seven per pod (average four). After about 3 days the first-instar larvae emerge and attach to the soft seeds where they feed on the surface. After a few hours they mine into the seed [23].

The developing larva feeds initially under the epidermis and then deep into the seed, seldom moving to a second seed; a development time of 6-10 days is dependent on temperature. The third instar larva leaves the seed and eats a partial hole in the pod wall to enable future escape by the adult. Pupariation takes place adjacent to this partial hole or in the groove of the seed and normally coincides with the ripening and drying of the pod; pupariation takes 30-80 days dependent on temperature. In India, there are up to three generations a year with the main period of activity in March to April.

Laboratory study indicates that the mean longevity of the adult pod fly was 6.59 ± 0.38 days. The incubation period varies from 2.5 to 3.5 days, the average being 2.99 ± 0.16 days. There were three larval instars which took 7.75 ± 0.53 days to enter into pupal stage. The pupal period lasted for about 9 to 13 days with an average of 11.38 ± 0.74 days. The life cycle of *M. obtusa* was completed in 41.74 ± 0.81 days [26]. Higher incubation period (3.35 to 4.82 days) was observed on the resistant variety SL12-1 as compared to Bahar (2.14 to 4.62 days) and NA1 (2.2 to 3.8 days), the susceptible varieties of pigeon pea [4].

The narrow host range and feeding niche of the pigeonpea pod fly govern its population dynamics. In India, pigeonpea pods are available in the field from approximately October to April, and infestations increase rapidly over a relatively short period. Fewer eggs are laid in December and January when temperatures are low. Populations increase as temperatures rise. Long-duration pigeonpea crops which mature in March or April can be heavily damaged [19].

The main activity period of the pigeonpea pod fly is March-April and up to three generations can be completed in this period. The first flies of the autumn generation appear around mid-October [23]. In contrast, the maximum infestation around Agra occurs in January; the level remains almost the same in February but declines by March [21].

The pigeonpea pod fly may survive the off-season on alternate hosts, such as *Rhyncosia minima*, which have been found to be infested with eggs, larvae, and/or pupae between April and November [19].

5.1.1.3 Hosts

M. obtusa is a legume pod borer, attacking the seed pods of Fabaceae. Its principle economic host is *Cajanus cajan* and it can also attack chickpea [8], mungbean (*Vigna radiata*) [23], cowpea (*Vigna unguiculata*) [6, 7]. It has a preference for oviposition into pure green pods rather than streaked pods [20, 28], and prefers varieties with a low sugar content [22].

M. obtusa has also been recorded from *Flemingia macrophylla*, a food plant of the lac insect, *Kerria lacca* [16]. Wild legumes can also act as reservoir populations or alternative hosts for generations when *C. cajan* is unavailable [10, 11]. According to the FAO document Plant Pests of Quarantine Importance to the Caribbean, the main host is pigeonpea, while alternate hosts are chickpea, cowpea and others [8]. *M. obtusa* was shown to use the legume weed *Rhyochosia minima* as an alternative food plant in Haryana, India.

5.1.1.4 Geographic Distribution

M. obtusa is a south Asian species which is also found in a few isolated areas of South-East Asia [1] found all over the India [5, 7, 14, 18] and also recorded from China [17, 27]. It is a major pest of pigeon pea in Nepal [2, 13] and reported from Australia but no details information [2, 3].

Agromyzids have the “well-known ability to cross substantial water gaps” [24, 25]. Long-distance dispersal is likely with the movement of infested seeds. The larvae and pupae could move easily in infested seed [12].
Eggs, larvae and pupae are borne internally with infested pods which are visible to naked eye. Seedlings, stems, roots, leaves, branches, inflorescences, calyx, flowers and true seeds (grains) are not known to carry the pest in trade and transport [1].

5.1.1.5 Hazard Identification Conclusion

Considering the fact that *M. obtusa* –

- is not known to be present in Bangladesh [9];
- is not likely potentially economic important to Bangladesh because it is not an important pest of major pulses in India, China and Nepal from where pulse grains are imported in Bangldesh [1];
- is likely to have spread with pulse grains through international trade and should be able to establish and cause unwanted consequences in Bangladesh.

M. obtusa is a **quarantine pest for Bangladesh** and is considered as a **potential hazard** for this risk analysis.

5.1.1.6 Risk Assessment

5.1.1.6.1 Entry assessment

Agromyzids have the "well-known ability to cross substantial water gaps" [24, 25]. Long-distance dispersal is likely with the movement of infested seeds. The larvae and pupae could move easily in infested seed [12]. Thus the potential of entry of *M. obtusa* with imported pulse grains are medium.

5.1.1.6.2 Exposure Assessment

M. obtusa is a polyphagous and major pest of pigeon pea but minor pest of important pulses in Baqngladesh. Thus its hosts are fairly common in Bangladesh. So potential of exposure of this pest is medium.

5.1.1.6.3 Establishment Assessment

Its major host *Cajanus cajan*is not common in Bangldesh but other hosts are common and climate is similar to the places where it has been found. But it has not been invaded and established in several new countries in recent years. Therefor establishment potential is medium.

5.1.1.6.4 Determination of Likelihood of the Pest Establishing Via This Pathway in Bangladesh

Table 1: Which of these descriptions best fit of the pest?

Description	The Establishment Potential is:
Has this pest been established in several new countries in recent years? NO – *M. obtusa* is a south Asian species which is also found in a few isolated areas of South-East Asia [1] found all over the India [5,7,14,18] and also recorded from China [17, 27]. It is a major pest of pigeon pea in Nepal [2,13]. But it has not been established in several new countries in recent years. **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES – Agromyzids have the "well-known ability to cross substantial water gaps" [24, 25]. Long-distance dispersal is likely with the movement of infested seeds. The larvae and pupae could move easily in infested seed [12]. **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**NO - Its major host is *Cajanus cajan* which is not a major crop in Bangladesh. But its other hosts like chickpea [8], mungbean [24] and cowpea [6] are common in Bangladesh [1, 7] and climate of Bangladesh is also favourable to its development and establish.	High
• Not as above or below	**Moderate**
• This pest has not established in new countries in recent years, and YES- The pest has not been established in several new	Low

Description	The Establishment Potential is:
countries in recent years. • The pathway does not appears good for this pest to enter in Bangladesh and establish, NO- The pathway is fairly good for this pest to enter in Bangladesh and establish. • Its host(s) are not common in Bangladesh and its climate is not similar to places it is established. YES- Its major host *Cajanus cajan* is not common in Bangldesh but other hosts are common and climate is similar to the places where it is established.	

5.1.1.7 Consequence Assessment

5.1.1.7.1 Economic

M. obtusa was identified as the major pests of pigeon pea during a survey at 7 sites in Nepal in 1994-95 [13]. Damaged seeds are unfit for human consumption and are not viable for germination. Damage levels of up to 100% of pods and up to 87% of grains have been recorded [25]. The FAO document Plant Pests of Quarantine Importance to the Caribbean [8] mentions the pigeonpea pod fly; in addition, this document comments on the importance of the pigeonpea pod fly: "Can be very serious. Up to 100% pod damage and up to about 85% seed damage reported in India. Damaged seed unfit for human consumption".

In India, the pigeonpea pod fly is a more serious pest in northern and central areas than in other parts of the country. Damage levels in farmers' fields range from 10% to 50%. In Vietnam, the pigeonpea pod fly is a key pest, causing seed losses of more than 90%. In Taiwan, damage of 43% occurs [19].

5.1.1.7.2 Environmental

No direct environmental impact of this pest is reported so far. However, the establishment of this pest could trigger chemical control programs by using different chemical insecticides which are hazardous for human health and environment.

5.1.1.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2: Which of these descriptions best fit of the pest?

Description	Consequence
• This is a serious pest of an important crop for Bangladesh. NO - it is a serious pest of pigeonpea [1],which is not an important crop in Bangladesh. • This is a minor pest of several important pulse crops (chickpea, mungbean, cowpea) for Bangladesh	High
• Not as above or below	**Moderate**
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.1.1.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh

Establishment Potential	X	Consequence Potential	=	Risk

Table 3: **Calculation of risk**

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

CALCULATED RISK RATING – Moderate

Considering all these *M. obtusa* has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.1.9 Phytosanitary Measures

- Seeds of *Cajanus cajan* and *Vigna* spp. are probably not commonly transferred between regions and so no specific quarantine measures are documented. However, if seeds of *M. obtusa* hosts were to be transported to areas where *M. obtusa* is unknown it would be prudent to treat them with suitable larvicides [1].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of this pest.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.2 Soybean fly (*Melanagromyza sojae*)

5.1.2.1 Hazard Identification

Common name: Soybean fly

Scientific name: *Melanagromyza sojae* (Zehntner)

Synonyms: Soyabean stem miner, asparagus miner, bean stem miner, soyabean stem borer, soybean stem miner, Soybean fly and soya miner. Other scientific names are *Melanagromyza prolifica* Malloch, *Melanagromyza producta* Henning, *Agromyza producta* Malloch [7], *Agromyza sojae* Zehntner [9].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Agromyzidae
Genus: *Melanagromyza*
Species: *Melanagromyza sojae*

Bangladesh status: Not present in Bangladesh [12].

EPPO code: MEAGSO [7, 9]

5.1.2.2 Biology

Eggs are always laid on the underside of the young leaves; on a unifoliate leaf if the plant has only two leaves, or on fully opened trifoliate leaves, at the basal part of the leaf lamina, near the petiole. Numerous feeding punctures are made on the upper side of the leaves. The egg measures 0.34 ± 0.02 mm in length and 0.15 ± 0.01 mm in width (Wang, 1979). The egg is whitish, partly transparent. One leaflet usually receives 1 or 2 eggs, however, that number may reach 5 or 6 depending upon adult population density. Egg hatch commences in 2 days, peaks in 3 days and can last up to 7 days after oviposition [9].

Immediately after emergence, the larva burrows through the mesophyll tissue into the closest vein, disappearing downwards in the leaf, eventually tunneling through the petiole and ending up in the stem. In the stem, the larva burrows into the pith reaching the root-shoot junction. It burrows further into the thickened tap root, turns around, and moves upward into the pith, thus widening the original tunnel. It gnaws through xylem and phloem tissues to the epidermis, making a hole to the outside, closes it with debris and pupates in the stem [25].

The larva is nearly colourless and attracts very little attention when the stem is cut open for observation. There are three larval instars. the duration of three instars at 32 ± 2°C and 70% RH as follows: first instar 22 h, second instar 43 h and third instar 98 h. The total duration of larval stage was 7 days [20]. Natural mortality of larvae is very high. Despite the large number of eggs a maximum of only two larvae were found [25]. Larval mortality was reported 62, 24 and 20% in 1st, 2nd and 3rd instars, respectively [26]. The total larval period was 9 to 11 days in Indonesia [25], 8 to 9 days in June in Northern Taiwan [17] a similar period in Central Taiwan [26] and 7 days under laboratory conditions (30 ± 2.Oc, 70% RH) in India [20].

The pupa is always located in the pith tunnel, often at the level of unifoliate leaves of younger plants and usually near the fly escape hole, seen as a dark depression. It is cylindrical, golden yellow, and measures 2.75 mm long and 1.00 mm wide. The duration of the pupal period in the laboratory at 30 ± 2°C and 70% RH was 190 h [20]. At an average temperature of 27°C, the pupal stage lasts 6-9 days in June in northern Taiwan [17]. In Indonesia, reported a pupal period of 9-10 days [25].

The majority of adults emerge during the morning and early hours of the day. The total development time from egg to adult is 16-26 days with an average of 21 days, in lowland Indonesia. The freshly emerged fly has moist, crumpled wings and very faint pigmentation on the abdomen and legs. Progressive darkening and hardening of the body wall and legs occurs for first 30 minutes, during which time the wings also become smooth and dry. Soon the fly develops its metallic black colour and seeks soya bean and other host plants. *M. sojae* adults are weak fliers and their activity is strongly influenced by the weather. They feed on plant juices from oviposition and feeding holes made in the leaves by females, dew drops and other similar moist materials. Copulation occurs 3-5 days after adult emergence. The insect copulates only in the morning hours from 0700 to 1000 h. Oviposition begins soon after copulation and lasts for 19 days [26]. Eggs are laid in the leaves. In Taiwan, the insect laid 171 ± 115 eggs per female throughout its life. It laid 1-34 eggs per day, and 50% of eggs were laid within the first 9 days [26].

The lifespan of adults in the laboratory was found 15-36 days with an average of 23 days for females and 10-46 days with an average of 26 days for males [25]. This lifespan, according to the same study, was longer than it is under field conditions. In Taiwan, the lifespan was reported as 6-19 days for adult flies [26]. In India, average lifespan was slightly more than 4 days at 30 ± 2°C and 70% RH [20].

The mean incubation, larval and pupal period were 5.0, 9.5 and 10.30 days, respectively in India. The adult longevity of male and female were 10.50 and 13.00 days, respectively. The total life cycle of stem fly ranged between 23-41 days [14].

5.1.2.3 Hosts

M. sojae is a highly polyphagous pest attacking many plant species of the family Fabaceae, including soybean and other beans [3] but soyabean (*Glycine max*) is the major host. Pigeon pea (*Cajanus cajan*), common bean (*Phaseolus vulgaris*), pea (*Pisum sativum*), black gram (*Vigna mungo*), mung bean (*Vigna radiata*), cowpea (*Vigna unguiculata*) and other beans are minor hosts [7].

5.1.2.4 Geographic Distribution

The insect was first recorded and described from Australia (New South Wales and Queensland) [8] where it was reported as a serious pest of beans (*Phaseolus vulgaris*) [25]. *M. sojae* is widespread in India [20], Indonesia [25], Japan [15], South Korea [16], Philippines [13], China [2] and present in Australia [18] and with restricted distribution [7]. It is regarded as one of the most important pests in soybean fields in parts of Russia [21], in Asia including China [27], India and Nepal [23], North East Africa (Egypt), in parts of South East Asia (e.g., Indonesia) [24], and Australia [6].

Eggs and larvae of *M. sojae* are borne internally with leaves which are visible under light microscope. Eggs, larvae and pupae are borne internally with seedlings or micropropagated plants visible to naked eye [7]. Flowers, pods and seeds are not known to carry the pest in trade and transport.

5.1.2.5 Hazard Identification Conclusion

Considering the fact that *M. sojae* –

- is not known to be present in Bangladesh [12].
- is potentially economic important to Bangladesh. It is a major pest of soybean in India, China, Nepal and Australia from where pulse grains are imported in Bangladesh.
- is not likely to become established in Bangladesh through importation of pulse grains because seeds are not known to carry the pest in trade and transport.

*M. sojae*is a **quarantine pest for Bangladesh** and **not likely considered** as a potential hazard for this risk analysis.

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5.1.3 Spiny pod borer (*Etiella zinckenella*)

5.1.3.1 Hazard Identification

Common name: Spiny pod borer

Scientific name: *Etiella zinckenella* (Treitschke)

Synonyms: Spiny pod borer, pea pod borer, lima bean pod borer [2]. Other scientific names *Etiella schisticolor* (Zeller), *Phycis zinckenella* Treitschke [2].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Phycitidae
Genus: *Etiella*
Species: *Etiella zinckenella*

Bangladesh status: Not present in Bangladesh [8]

EPPO code: ETIEZI [2, 5].

5.1.3.2 Biology

The eggs of *E. zinckenella* are laid either singly or in batches of between two and 12, on young pods, the calyx or on leaf stalks. A single female lays between 60 and 200 eggs during her lifetime [9]. Incubation lasts between 3 and 16 days, depending on temperature.

There are five larval instars. First-instar larvae are 1 mm long with a yellowish body and a black head. These larvae move about on the pod for half an hour; they then spin a small web, bore through the pod pericarp, which is covered by the web, and begin feeding on the developing seeds.

A number of larvae may enter the pod, but cannibalism reduces this number to only one or two. If the food supply in a pod is inadequate, the larvae migrate to another. The larvae wriggle violently if their pod is opened and they are disturbed. Just before pupation, the larvae become green with dark-pink stripes. Larval development lasts 20 days.

Full-grown larvae are 15 mm long [9] when they leave the pod to pupate in a cocoon in the soil, 2-4 cm below the surface. The pupal stage lasts for between 1 and 9 weeks, depending on the temperature. After emergence, the moths live up to 20 days. The moths are brownish-grey with a white stripe along the leading edge of the narrow forewings. The wingspan is 24-27 mm [7].

5.1.3.3 Hosts

E. zinckenella attacks cultivated legumes including cowpea (*Vigna unguiculata*), garden pea (*Pisum sativum*), lima bean (*Phaseolus lunatus*), mung bean (*Vigna radiata*), blackgram (*Vigna mungo*), chickpea (*Cicer arietinum*), lentil (*Lens culinaris* ssp. *culinaris*), pigeon pea (*Cajanus cajan*), common bean (*Phaseolus vulgaris*), and groundnut (*Arachis hypogaea*) and soyabean (*Glycine max*). Soyabean is the preferred host [2].

The eggs of *E. zinckenella* are laid either singly or in batches of between two and 12, on young pods, the calyx or on leaf stalks.

5.1.3.4 Geographic Distribution

E. zinckenella is a cosmopolitan pest of worldwide distribution [13]. It is widespread in China [3], India [1, 10], Sri Lanka [4], Thaiand [14], Egypt [4], South Korea [12] and USA [4]. It is also present in many countries of the world including Australia [6] Canada [4], Nepal [4], Turkey [4] and others [2].

Eggs of *E. zinckenella* are borne externally with young pods, calyx and leaf stalks. Larvae are borne internally with infested pods. Stem, roots, branches, seedlings, seeds are not known to carry the pest in trade and transport [2].

5.1.3.5 Hazard Identification Conclusion

Considering the fact that *E. zinckenella*–

- is not known to be present in Bangladesh [12].
- is potentially economic important to Bangladesh. It is a major pest of important pulses chickpea, lentil, mungbean, blackgram and groundnut in Australia, India, China, Canada, Nepal and Australia from where pulse grains are imported in Bangladesh.
- is not likely to become established in Bangladesh through importation of pulse grains because seeds are not known to carry the pest in trade and transport [CABI 2007].

*E. zinckenella*is a **quarantine pest for Bangladesh** and is not considered as a **potential hazard** for this risk analysis.

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5.1.4 Plume moth (*Exelastis atomosa*)

5.1.4.1 Hazard Identification

Common name: Plume moth

Scientific name: *Exelastis atomosa* Walsingham

Synonyms: Plume moth, pigeon pea leaf webber, red gram plume moth [2]. Other scientific name -*Aciptilia atomosa* Walsingham, *Marasmarcha atomosa*Walsingham[2, 4]

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Pterophoridae
Genus: *Exelastis*
Species: *Exelastis atomosa*

Bangladesh status: Not present in Bangladesh [5]. The larvae are a serious pest of pigeon pea. They damage seeds as well as cause flowers, buds and pods to drop. It is reported that on an average, the pod damage in pigeon pea to plume moth was 8.9% and grain damage was 4.0% [6].

EPPO code: EXELAT [4].

5.1.4.2 Biology

Eggs were pale green in colour and oval in shape. They were laid singly on the pods sometimes on flower buds and occasionally on leaves as well. Oviposition usually took place at night. The mean longevity of the adult was 6.59±0.38 days. The average number of eggs laid by an adult female was 93 to 101 eggs hatched in 2.92 to 3.02 days. There were five larval instars which took 23.12±0.93 days to enter into pupal stage. Pupation took place on pod surface or entrance of hole or in the burrow of infested pods and the pupal period lasted for about 7.97±0.33 days. The life cycle of *E. atomosa* was completed in 40 to 42 days [6].

5.1.4.3 Hosts

Pigeon pea (*Cajanus cajan*), chickpea (*Cicer arietinum*), hyacinth bean *(Lablab purpureus*) [2].

5.1.4.4 Geographic Distribution

India [2], Nepal [7], Indonesia [1], Iran [7] and Sri Lanka [4].

Eggs of *E. atomosa* are borne externally with pods, flower buds and leaves. Larvae are borne internally with infested fruits/pods. Stems (above ground), shoots, trunks, branches and seeds are not known to carry the pest in trade or transport [3].

5.1.4.5 Hazard Identification Conclusion

Considering the fact that *E. atomosa* –

- is not known to be present in Bangladesh [5].
- is not potentially economic important to Bangladesh. It is a major pest of pigeon pea in India, China, Nepal and Australia from where pulse grains are imported in Bangladesh.
- is not likely to become established in Bangladesh through importation of pulse grains because seeds are not known to carry the pest in trade and transport.

*E. atomosa*is a **quarantine pest for Bangladesh** and **not likely considered** as a potential hazard for this risk analysis.

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5.1.5 Bean weevil (*Callosobruchus analis*)

5.1.5.1 Hazard Identification

Common name: Bean weevil

Scientific name: *Callosobruchus analis* Fabricius

Synonyms: Pulse weevil, other scientific names- *Bruchus analis* Fabricius, *Bruchus jekelii* (Allibert), *Callosobruchus jekelii*(Allibert) [5],*Bruchus glaber* Allibert, *Bruchus jekelii* Allibert, *Bruchus obliquus* Allibert, *Bruchus ciceri* Rondani [2].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera

Family: Bruchidae
Genus: *Phenacoccus*
Species: *Callosobruchus analis*

Bangladesh status: Not present in Bangladesh [7]. *C. analis* is considered A2 pest in China and APPEC [5].

EPPO code: CALSAN [5].

5.1.5.2 Biology

C. analis is an Asian species. It is an important pest in India and recent observations in Indonesia show that it is common in this country [6]. The species frequently attacks cowpeas (*Vigna unguiculata*) and green gram (Vigna radiata). The adult beetles, which do not feed on stored products, are very short lived (usually no more than 15 days under optimum conditions) and during this time the females lay many eggs (up to 200). Oviposition may be depressed in the presence of previously infested seeds. The optimum temperature for oviposition is 30-35°C. As the eggs are laid they are firmly glued to the surface of the host seed. Upon hatching the larva bites through the base of the egg, through the testa of the seed and into the cotyledons. Detritus produced during this period is packed into the egg as the insect hatches, turning the translucent egg white and making it clearly visible to the naked eye.

The developing larva feeds entirely within a single seed, excavating a chamber within the cotyledons as it grows. The optimum development conditions for *C. analis* breeding on cowpeas are 30-35°C and 70% relative humidity, when the mean development period is ca 27 days. There is minimal development below 18°C or above 35°C, and the development period is extended to 94 days at 20°C and 70% relative humidity [2].

Infestation can begin in the field where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus dry peas stored in pods are quite resistant to attack, whereas threshed peas are susceptible to attack throughout storage [2].

C. analis females have the capacity to store sperm during their entire lives and mate with several males during this period. The beetles will mate within an hour of emergence. They do not feed as adults, therefore reserves accumulated during larval development are crucial for survival and reproduction. Larval competition within seeds is reflected in increased larval mortality and reduced fecundity of offspring.

5.1.5.3 Hosts

Major hosts of *C. analis* are chickpea (*Cicer arietinum*), black gram (*Vigna mungo*), mung bean (*Vigna radiata*), cowpea (*Vigna unguiculata*) and soyabean (*Glycine max*). But lentil (*Lens culinaris* subsp. *Culinaris*) pigeon pea (*Cajanus cajan*), and other pulses, and groundnut (*Arachis hypogaea*), sesame (*Sesamum indicum*) are minor hosts [2, 5, 8].*C. analis* as an important storage pest of cowpea (*Vigna unguiculata*) and green gram (*Vigna radiata*), that commonly also infests chickpea (*Cicer arietinum*), urd (*Vigna mungo*) and moth bean (*Vigna aconitifolia*), and that is occasionally found on pigeon pea (*Cajanus cajan*), lentil (*Lens culinaris*) and other pulses [6]. There appears to be some geographical variation in host preference though this is probably related to the abundance of the different hosts. In northern India, *C. analis* is reported to predominantly infest lentils and chickpeas [9], and in Indonesia, *C. analis* appears to be exclusively associated with green gram and white soyabean (*Glycine max*), it being the only bruchid infesting (and causing significant damage to) the latter commodity [6].

5.1.5.4 Geographic Distribution

There is a high degree of uncertainty about the true origin of *C. analis*[10]. It is recorded from India [2, 9], Myanmar and Indonesia [2].

Eggs, larvae, pupae and adults are borne internally or externally through fruits (including pods) which are visible under light microscope. Eggs, larvae, pupae and adults are borne internally or externally through true seeds which are visible under light microscope [2]. Adults can spread by flying. Long distance dispersal can occur while larvae are still inside seeds [8]. Plant parts like bark, bulbs/tubers/corms/rhizomes, growing medium, accompanying plants, flowers/inflorescences/cones/Calyx, leaves, seedlings/micropropagated plants, roots, stems (above ground)/shoots/trunks/branches) and wood are not known to carry the pest during trade and transport [2].

5.1.5.5 Hazard Identification Conclusion

Considering the fact that *C. analis*–

- is not known to be present in Bangladesh [4];
- is potentially economic importance to Bangladesh because it is an important pest of chickpea, black gram, mungbean, cowpea, soybean, lentil, pigeon pea, and other pulses, and groundnut and sesame in India [2, 9] and from where pulses are imported to Bangladesh;
- is likely to have spread through international trade of pulse grains [2] and should be able to establish and cause unwanted consequences in Bangladesh.

C. analis is a **quarantine pest for Bangladesh** and is considered as a **potential hazard** for this risk analysis.

5.1.5.6 Risk assessment

5.1.5.6.1 Entry Assessment

C. analis is a major pest of chickpea, blackgram, mungbean and soybean in India [2, 9]. Eggs, larvae, pupae and adults are borne internally or externally through pods or true seeds [2]. Long distance dispersal can occur while larvae are still inside seeds [8]. So probability of entry through importation of pulse grain from India is high.

5.1.5.6.2 Exposure Assessment

*C. analis*is a primary and highly polyphagous pest of stored chickpea, black gram, mung bean, cowpea, soyabean, lentil, pigeon pea, and other pulses, and groundnut and sesame [2, 5, 8]which are important grains in Bangladesh. There would be no shortage of potential hosts in Bangladesh throughout the year. So dispersal of any stage of*T.granarium*may expose to its potential hosts that will enhance its establishment in Bangladesh. Thus the probability of exposure to its potential is high.

5.1.5.6.3 Establishment Assessment

The beetle prefers hot, dry conditions and can be found in areas where grain and other potential food is stored. The optimum development conditions for *C. analis* breeding on cowpeas are 30-35°C and 70% relative humidity that prevail in Bangladesh [2].Therefore the probability of establishment of *C. analis* in Bangladesh is high.

5.1.5.6.4 Determination of Likelihood of the Pest Establishing Via this Pathway in Bangladesh

Table 1: Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
Has this pest been established in several new countries in recent years? YES – It is a serious pest of major pulses in the world and has been established in many countries of the world [1, 2] • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES - Egg, larva and pupa can easily be transported with pulse grainsin international trade and transport [2]. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**YES - Its major hosts are chickpea, mungbean blackgram, cowpea which are available in Bangladeshand climate of Bangladesh is similar to places it been established.	**High**
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter in Bangladesh and establish, • Its host(s) are not common in Bangladesh and its climate is not similar to places it is established.	Low

5.1.5.7 Consequence Assessment

5.1.5.7.1 Economic

*C. analis*is an important primary pest of major pulses. Infestation may start in the pods before harvest and carry over into storage where substantial losses may occur [2]. Infestation commonly begins in the field, where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus dry seeds stored in their pods are quite resistant to attack, whereas the threshed seeds are susceptible to attack throughout storage.In storage,he developing larva feeds entirely within a single seed, excavating a chamber as it grows. Infested grains are unfit for human consumption. The adult beetles, which do not feed on stored produce, are very short-lived, usually no more than 12 days under optimum conditions.

5.1.5.7.2 Environmental

No environmental impact of this pest is reported so far. However, the establishment of this pest could trigger chemical control programs by using different fumigants that are hazardous for human health and environment.

5.1.5.7.3 Determination of Consequence of the Pest Establishing Via this Pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
• **Is this a serious pest of an important crop in Bangladesh?** YES - It is serious pest of mungbean which is an in important pulse in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES – It is a major pest of chickpea, blackgram and cowpea which are alos important pulses for Bangladesh.	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.1.5.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of Risk

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

CALCULATED RISK RATING – **High**

Considering all these *C. analis*has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.5.9 Possible Risk Management Measures

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene.All spillage should be removed and all cracks and crevices filled [3].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [4] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.6 Bruchid (*Callosobruchus phaseoli*)

5.1.6.1 Hazard Identification

Common name: Red gram pod fly
Scientific name: *Callosobruchus phaseoli* (Gyllenhal)
Synonyms: *Bruchus phaseoli* Gyllenhal, *Pachymerus phaseoli* Gyllenhal, *Bruchus conicicollis* Fairmaire [3].
Taxonomic tree
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Bruchidae
Genus: *Callosobruchus*
Species: *Callosobruchus phaseoli*

Bangladesh status: Not present in Bangladesh [3,6].

EPPO code: CALSPH [2].

5.1.6.2 Biology

The adult beetles, which do not feed on stored produce, are very short-lived, usually no more than 12 days under optimum conditions. During this time the females lay many eggs (*C. maculatus* up to 115, *C. chinensis* up to 70), although oviposition may be reduced in the presence of previously infested seeds [8].

The life cycle of the most economically important species is relatively short. Under optimal conditions complete development takes place in as little as 22-25 days. The optimum temperature for oviposition is high in *C. maculatus*, about 30-35°C and low in *C. chinensis*, 23°C. As the eggs are laid, they are firmly glued to the surface of the host seed, smooth-seeded varieties being more suitable for oviposition than rough-seeded varieties [8]. The eggs are domed structures with oval, flat bases. When newly laid they are small, translucent grey and inconspicuous. Eggs hatch within 5-6 days of oviposition [7]. Upon hatching, the larva bites through the base of the egg, through the testa of the seed and into the cotyledons. Detritus produced during this period is packed into the empty egg as the insect hatches, turning the egg white and making it clearly visible to the naked eye.

The developing larva feeds entirely within a single seed, excavating a chamber as it grows. The optimum development conditions for *C. maculatus* and *C. chinensis* are around 32°C and 90% RH; the minimum development period for *C. maculatus* is about 21 days, and 22-23 days for C. chinensis. At 25°C and 70% RH the total development period of *C. maculatus* breeding on seeds of *V. unguiculata* is about 36 days, pupation taking place within the seed 26 days after oviposition [7]. Relatively little is known about *C. phaseoli* although the optimum temperature for development is within the range 30-32.5°C [7].

Infestation commonly begins in the field, where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus dry seeds stored in their pods are quite resistant to attack, whereas the threshed seeds are susceptible to attack throughout storage.

5.1.6.3 Hosts

Mungbean (*Vigna radiata*), cowpea (*Vigna unguiculata*), hyacinth bean (*Lablab purpureus*) are the major hosts of *C. phaseoli* and chickpea (*Cicer arietinum*) and black gram (*Vigna mungo*) and other pulses are reported as alternate hosts [3, 9].

5.1.6.4 Geographic Distribution

C. phaseoli is found in East and West Africa, South Asia, Central and South America and Southern Europe. It is apparently the dominant species in tropical South America [10]. It is widespread in India, Indonesia, Italy, Kenya, Nigeria, Uganda, and Brazil [1, 3].
Egg, larva and pupa can easily be transported with pulse grains. Bark, bulbs/tubers/corms/rhizomes, fruits (inc. pods), growing medium accompanying plants, flowers/inflorescences/cones/calyx, leaves, seedlings/micropropagated plants, roots, stems (above ground)/shoots/trunks/branches and wood are not known to carry the pest in trade and transport [3].

5.1.6.5 Hazard Identification Conclusion

Considering the fact that *C. phaseoli* –

- is not known to be present in Bangladesh;
- is potentially economic importance to Bangladesh because and it is an important pest of stored pulses like mungbean, cowpea, chickpea, blackgram in India from where pulses are imported to Bangladesh.
- is likely to have spread through international trade and should be able to establish and cause unwanted consequences in Bangladesh.

*C. phaseoli*a **quarantine pest for Bangladesh** and is considered as a **potential hazard** for this risk analysis.

5.1.6.6 Risk Assessment

5.1.6.6.1 Entry Assessment

C. phaseoli is a serious pest of pulses in many countries of the world. Its infestation may start in the pods before harvest and carry over into storage where substantial losses may occur. Egg, larva and pupa can easily be transported with pulse grains in international trade. About 25 days are required to complete its life cycle [7]. There is a great chance of surving larva, pupa and adult of *C. phaseoli* during transportation from India to Bangladesh. Thus the probability of entry is high.

5.1.6.6.2 Exposure Assessment

Mungbean (*Vigna radiata*), chickpea (*Cicer arietinum*), black gram (*Vigna mungo*) cowpea (*Vigna unguiculata*), are the common hosts of *C. phaseoli* which are available all over Bangldesh. When infested grains will distribute in different regions of Bangladesh it will be find its host grains easily. Moreover, adult beetle can lay eggs on pods in filed. Thus the probability of exposure is also high.

5.1.6.6.3 Establishment assessment

C. phaseoli is a polyphagous and primary pest of major pulses in Bangladesh. The optimum development conditions for *C. phaseoli* is around 30-32.5°C and 90% RH [7] which prevail in Bangladesh. So probability of establishment of *C. phaseoli* is high.

5.1.6.6.4 Determination of Likelihood ofthe Pest Establishing Via this Pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	The Establishment Potential is:
Has this pest been established in several new countries in recent years? YES – It is a serious pest of major pulses in the world as well as in Bangldesh and has been established in many countries of the world [1, 3]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES - Egg, larva and pupa can easily be transported with pulse grainsin international trade and transport [3]**.** • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**YES - Its major hosts are chickpea, mungbean blackgram, cowpea which are available in Bangladeshand climate of Bangladesh is similar to places it been established.	**High**
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter in Bangladesh and establish, • Its host(s) are not common in Bangladesh and its climate is not similar to places it is established.	Low

5.1.6.7 Consequence Assessment

5.1.6.7.1 Economic

*A.phaseoli*is an important primary pest of major pulses. Infestation may start in the pods before harvest and carry over into storage where substantial losses may occur [3]. Infestation commonly begins in the field, where eggs are laid on maturing pods. As the pods dry, the pest's ability to infest them decreases. Thus dry seeds stored in their pods are quite resistant to attack, whereas the threshed seeds are susceptible to attack throughout storage.In storage,he developing larva feeds entirely within a single seed, excavating a chamber as it grows. Infested grains are unfit for human consumption. The adult beetles, which do not feed on stored produce, are very short-lived, usually no more than 12 days under optimum conditions.

5.1.6.7.2 Environmental

No environmental impact of this pest is reported so far. However, the establishment of this pest could trigger chemical control programs by using different fumigants that are hazardous for human health and environment.

5.1.6.7.3 Determination of Consequence of the Pest Establishing Via this Pathway in Bangladesh

Table 2: Which of these descriptions best fit of the pest?

Description	Consequence
• **Is this a serious pest of an important crop in Bangladesh?** YES - It is serious pest of mungbean which is an in important pulse in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES – It is a major pest of chickpea, blackgram and cowpea which are alos important pulses for Bangladesh.	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.1.6.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3: Calculation of Risk

Establishment potential	Consequence potential	Risk rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **High**

Considering all these *C. phaseoli* has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.6.9 Possible Risk Management and Phytosanitary Measures

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene.All spillage should be removed and all cracks and crevices filled [4].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of bruchid.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [5] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.7 Bean bruchid (*Acanthoscelides obtectus)*

5.1.7.1 Hazard Identification

Common name: Bean bruchid

Scientific name *Acanthoscelides obtectus* (Say)

Synonyms: bean weevil, dried bean weevil, bean beetle, *Bruchus obtectus* Say, *Bruchidius obsoletus*, *Bruchus irresectus, Larra irresectus*, *Mylabris obtectus* Say, *Bruchidius obtectus* Say *Laria obtectus* Say, *Bruchus fabae* Riley, *Acanthoscelides irresectus* Fåhraeus, *Bruchus tetricus* Gyllenhal, *Acanthoscelides tetricus* Gyllenhal, *Bruchus obsoletus* (Say) [2, 11, 21].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Bruchidae
Genus: *Acanthoscelides*
Species: *Acanthoscelides obtectus* (Say)

Bangladesh status: Not present in Bangladesh [5]. *A. obtectus* (Say) is a serious pest of kidney beans, *Phaseolus vulgaris* originated in the neotropics [20].

EPPO code: ACANOB [1].

5.1.7.2 Biology

Freshly emerged adults copulate at any time from about one hour after their emergence. During copulation the male normally raises its fore and middle legs to hold the female. Copulation lasts for 4-5 min gravid females lay eggs on and around the host seeds. Eggs are usually deposited singly and unlike other bruchids this pest does not stick its eggs to pods and seeds but scatters them irregularly among host seeds. Eggs are ellipsoidal in shape and oviposition lasts for 6-9 days and the rate of egg lying is high on first day of oviposition period. Freshly laid eggs are milky white, but become transparent before the larvae hatch. Larvae possess three pairs of legs, are white in colour and are covered with white shining setae of variable size. The first instar larva has a large golden head and white elongated body that can be seen through the transparent egg shell. The incubation period is about 9-14 d and first instar larvae bore into the host seed with the help of an 'H' shaped prothoracic plate. Since the eggs are not glued onto seeds it is essential for freshly hatched first instar larva to find the host seeds for food. Entrance holes into the host seed later become plugged by faecal matter and further development of successive larval instars inside the host seed, under favourable conditions, can be completed in 3-4 wk. Pupal development is completed in 18-26 days during March - September but hibernating larvae and pupae take 4-5 months during winter (October - February) and then emerge as adults during March and April the following year. The pest is multivoltine and completes three to four overlapping generation in a year [20].

The eggs are laid loosely (in contrast to *Callosobruchus* and *Zabrotes*), but are often lodged under cracks in the bean testa. Infestation may begin in the field, where eggs are laid on ripening pods. Although optimum conditions for development are around 30°C and 70% RH, the species is nevertheless capable of surviving fairly low temperatures and will breed slowly at 18°C. As a result of its wide temperature tolerance, *A. obtectus* is present in cool highland areas of the tropics, and in the hotter lowland tropics, as well as in some temperate regions. The minimum development period is very short (22.5 days) at optimum conditions, resulting in a high potential population growth [6]. The larvae pupate inside the seed, taking 9 to 29 days. The life cycle of a single generation takes from 100 to 110 days. If the seeds are stored in a warm place multiple generations can be produced one after another [2].

5.1.7.3 Hosts

Pigeon pea (*Cajanus cajan*), beans (*Phaseolus*), lima bean (*Phaseolus lunatus*), common bean (*Phaseolus vulgaris*) are the major of hosts of *A. obtectus* and cowpea (*Vigna unguiculata*) is a minor host. Weevils also attack chickpea (*Cicer arietinum*) and grasspea (*Lathyrus sativus*) [2]. It is serious pest of kidney beans, *Phaseolus vulgaris*[20].

5.1.7.4 Geographic Distribution

A. obtectus originated in tropical South America, but has spread to most other warm and hot regions with the possible exception of Australia. It has also spread into some temperate zones. It is less common in those parts of South and South-East Asia where grams, peas and lentils are more commonly grown than beans (*Phaseolus*) [2].

A. obtectus (Say) (Coleloptera: Bruchidae) a bruchid beetle of neotropical origin, is a serious pest of kidney bean *Phaseolus vulgaris* L. (Fabaceae) and various other pulses in Africa [13,19], Australia [9, 10], Europe [14, 18] and America [7, 8, 12]. *A. obtectus* is widespread in India [1] and present in Canada and Turkey [1].

Originating in Central America they have been inadvertently spread around the world in grain shipments[22]. Egg, larva and pupa can easily be transported with pulse grains. Bark, bulbs/tubers/corms/rhizomes, fruits (including pods), growing medium accompanying plants, flowers/inflorescences/cones/calyx, leaves, seedlings/micropropagated plants, roots, stems (above ground)/shoots/trunks/branches and wood are not known to carry the pest in trade and transport [2].

5.1.7.5 Hazard Identification Conclusion

Considering the fact that *A. obtectus* –

- is not known to be present in Bangladesh;
- is potentially economic importance to Bangladesh because and it is an important pest of stored pulses like cowpea, chickpea, lentil in Australia, Canada, India and Turkey from where pulses are imported to Bangladesh.
- is likely to have spread with imported pulse grains through international trade and should be able to establish and cause unwanted consequences in Bangladesh.

*A. obtectus*a **quarantine pest for Bangladesh** and is considered as a **potential hazard** for this risk analysis.

5.1.7.6 Risk Assessment

5.1.7.6.1 Entry Assessment

Larvae and pupae develop entirely within grain legumes. Originating in Central America they have been inadvertently spread around the world in grain shipments [22]. Thus the probability of entry with imported pulse grains is high.

5.1.7.6.2 Exposure Assessment

The major hosts of *A. obtectus*are pigeon pea (*Cajanus cajan*), beans (*Phaseolus*), lima bean (*Phaseolus lunatus*), common bean (*Phaseolus vulgaris*) which are not important crops for Bangladesh. But minor hosts are available in Bangladesh. Thus the probability of exposure is medium.

5.1.7.6.3 Establishment Assessment

Originating in Central America they have been inadvertently spread around the world through grain shipments [22]. Its minor hosts are chickpea, grasspea, cowpea are available in Bangladeshand climate of Bangladesh is similar to places it been established. So probability of establishment is high.

5.1.7.6.4 Determination of Likelihood of the Pest Establishing Via This Pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
Has this pest been established in several new countries in recent years? YES - Originating in Central America they have been inadvertently spread around the world through grain shipments[22]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES - Egg, larva and pupa can easily be transported with pulse grains[2]**.** • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**YES - Its minor hosts are chickpea, grasspea, cowpea are available in Bangladeshand climate of Bangladesh is similar to places it been established.	**High**
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter in Bangladesh and establish, • Its host(s) are not common in Bangladesh and its climate is not similar to places it is established.	Low

5.1.7.7 Consequence Assessment

5.1.7.7.1 Economic

The beetle poses a threat to our agriculture produce and causes serious loss to grain legumes both in fields and stores. It reduces the quality and quantity of beans, rendering them unfit for human consumption and germination [2].

Since the first instar larvae bore into the seed and then feed, grow and moult into successive instars entirely within the seed, no evidence of their presence appears except circular windows that are created when the last instar larvae gnaw close to the seed coat in preparation for adult emergence. Pulses with such hidden infestations move across the geographical boundaries in import /export consignments and may pose a great phytosanitary threat in new ecological niches due to the absence of natural enemies. This internal mode of life protects them from variations of temperature and humidity and enables them to be carried unnoticed during trade across the international boundaries. All the larval instars are voracious feeders and develop at the cost of legume proteins so that heavily infested beans are often reduced to empty shells [20].

The bean weevil is a significant pest in some parts of the world, especially in areas such as Australia where it is non-native. It damages crops both *in situ* and when stored in warehouses, and can potentially reduces crop yields by 60%as the larvae develop at the expense of the seeds [22].

5.1.7.7.2 Environmental

No environmental impact of this pest is reported so far. However, the establishment of this pest could trigger chemical control programs by using different fumigants that are hazardous for human health and environment.

5.1.7.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
• **Is this a serious pest of an important crop in Bangladesh?** NO - It is serious pest of kidney beans, *Phaseolus vulgaris*[20] which is not in important pulse in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** NO – It is a major pest of pigeon pea (*Cajanus cajan*), beans (*Phaseolus*), lima bean (*Phaseolus lunatus*), common bean (*Phaseolus vulgaris*) which are not important crops for Bangladesh.	High
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh. YES – It is not an important pest of major pulses like chickpea, lentil, mungbean, grasspea, blackgram, cowpea in Bangladesh.	**Low**

5.1.7.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High

Establishment potential	Consequence potential	Risk rating
Moderate	High	High
High	**Low**	**Moderate**
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **Moderate**

Considering all these *M. obtusa* has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.7.9 Possible Risk Management Measures

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene. All spillage should be removed and all cracks and crevices filled [3].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of bean bruchid.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [4] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.8 Granary weevil (*Sitophilus granarius*)

5.1.8.1 Hazard Identification

Common name: Granary weevil
Scientific name: *Sitophilus granarius* Linnaeus
Synonyms: Grain weevil, *Calandra granaria* Linnaeus, *Calendra granaria* (Linnaeus), *Curculio granarius* Linnaeus [1]. *S. oryzae*and S*. zeamais* are similar species of *S. granaries*.

Taxonomic tree
Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Curculionidae
Genus: *Sitophilus*
Species: *Sitophilus granarius*

Bangladesh status: Not known to be present in Bangladesh [7].

EPPO code: CALAGR [3].

5.1.8.2 Biology

The biology and behaviour of *S. granarius* is similar to the tropical species *S. oryzae* and *S. zeamais*, except that it cannot fly [9]. Adults live for 7 to 8 months on average. Females usually lay around 150 eggs, and up to 300 eggs, throughout their lives**.** Eggs are laid individually in cavities that the female bores in the grain kernels. Cavities are sealed by a waxy egg plug, which the female secretes. Eggs incubate for about 4-14 days before hatching, depending on temperature and humidity. One larva develops in each infested kernel. Feeding larvae excavate a tunnel and may keep feeding until only the hull remains. There are four larval instars. Pupation occurs inside the grain. The newly emerged adult chews its way out of the grain, leaving a characteristic exit hole. In warm summer conditions the life cycle can be completed within 4 to 6 weeks, but can take as long as 17 to 21 weeks in the winter. Adults can survive for a month or more without food in cooler conditions. Life cycle is completed within 27 days at 30^0C and 70% relative humidity [11].
Optimum conditions for development are similar to other tropical species of *Sitophilus*, about 30°C and 70% RH [11], but in tropical areas it is apparently not able to compete with *S. oryzae* and *S. zeamais* [1]. It seems that its distribution is limited more by its commodity associations with cool climate crops than by its direct response to temperature. However, it can develop at temperatures down to 11°C, and is therefore successful in temperate regions that are too cool for other *Sitophilu*s species [8]. Being flightless, *S. granarius* cannot usually infest crops in the field before harvest.

5.1.8.3 Hosts

Wheat (*T. aestivum*) and barley (*H. vulgare*) and dried stored products are the main host of *S. granarius*. It can attack other cereals such as oat (*Avena sativa*), rye (*Secale cereale*), maize (*Zea mays*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), groundnut (*Arachis hypogaea*), chickpea (*Cicer arietinum*) and faba bean (*Vicia faba*) are alternate hosts [1].

5.1.8.4 Geographic Distribution

S. granarius is distributed throughout the temperate regions of the world. In tropical countries it is rare, being limited to cool upland areas [1]. The FAO global survey of insecticide susceptibility recorded it from the UK, France, Italy, Spain, Denmark, Sweden, Poland, Algeria, Iraq, Canada, USA, Chile, Argentina, Swaziland, South Africa, Australia, Russia and Thailand [2]. It is also known from Yemen [6]. It is also reported from India [1] and Turkey [1].

Egg, larva and pupa can easily be transported with pulse grains without any visible symptom. Bark, bulbs/tubers/corms/rhizomes, fruits (inc. Pods), growing medium accompanying plants, flowers/inflorescences/cones/calyx, leaves, seedlings/micropropagated plants, roots, stems (above ground)/shoots/trunks/branches and wood are not known to carry the pest in trade and transport [1].

5.1.8.5 Hazard Identification Conclusion

Considering the fact that *S. granarius* –

- is not known to be present in Bangladesh;
- is potentially economic importance to Bangladesh because it is an important pest of stored cereals and other stored products, chickpea, faba bean in Australia, India, Canada and Turkey from where pulses are imported to Bangladesh.
- is likely to have spread with pulse grains through international trade and should be able to establish and cause unwanted consequences in Bangladesh although it is a pest temperate regions.
- It has capability to cause direct economic and ecological damage to many valuable stored products.

*S. granarius*is a **quarantine pest for Bangladesh** and is considered as a **potential hazard** for this risk analysis.

5.1.8.6 Risk Assessment

5.1.8.6.1 Entry Assessment

Egg, larva, pupa and adult are transported with grains and stored products but adult cannot fly. Larvae of granary weevil develop inside the grain and it is difficult to detect the pest by visual inspection unless its numbers are very high and plant parts are not known to carry the pests in transport or trade [1]. Thus probability of entry of *S. granaries* through this pathwayis high.

5.1.8.6.2 Exposure Assessment

S. granarius is a polyphagous and primary insect pest which infests different stored grains such as wheat, rice, maize, groundnut, chickpea, etc. [1] which are important food grains in Bangladesh. There would be no shortage of potential hosts in Bangladesh and will be available throughout the year. So dispersal of any stage of *S. granarius* during transport, storage and marketing may expose to its potential hosts that will help its establishment in Bangladesh. So probability of exposure is high.

5.1.8.6.3 Establishment Assessment

In temperate climates it establishment potential is high but in tropical climate that is low due to competition with two other similar species, *S. oryaze* and *S. zeamais* [1]. Hosts are available in Bangladesh throughout the year. Thus the probability o establishment of *S. granaries* is medeium.

5.1.8.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	The Establishment Potential is:
• **Has this pest been established in several new countries in recent years?** NO. • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES, Egg, larva and pupa can easily be transported with pulse grains without any visible symptom [1]. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**YES Its major host, wheat and other hosts, rice, maize, chickpea are common in Bangladesh [1] and climate is also favourable for its development [12] although it is a serious pest of temperate regions [1].	High
• Not as above or below	**Moderate**
• **This pest has not established in new countries in recent years, and**YES • The pathway does notappears good for this pest to enter in Bangladesh and establish, and (**NO**, pathway is good for this pest to enter into Bangladesh and establish) • Its host(s) are**not** common in Bangladesh and its climate is **not** similar to places it is established. **NO,** hosts are common in Bangladesh [1] and climate also favourable [12].	Low

5.1.8.7 Consequence Assessment

5.1.8.7.1 Economic

S. granarius is a serious pest of stored cereal grains in cool climates, whether in temperate or tropical latitudes it can also cause serious damage under hot conditions before populations die out [1]. Larval stages feed inside the grain on the kernels, leaving only the hulls. Severe infestations can reduce stored grain to a mass of hulls and frass.

5.1.8.7.2 Environmental

No environmental impact of this pest is reported so far. However, the establishment of this pest could trigger chemical control programs by using different fumigants that are hazardous for human health and environment.

5.1.8.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
• **Is this a serious pest of an important crop in Bangladesh?** YES- This is serious pest wheat [1] which is an important crop in Bangladesh.	**High**

Description	Consequence
• **Is this a serious pest of several important crops for Bangladesh?** YES - This is a serious pest of rice, maize, chickpea, groundnut [1] which are important crops for Bangladesh	
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.1.8.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **HIGH**

Considering all these *M. obtusa* has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.8.9 Possible Risk Management and Phytosanitary Measures

- Good storage hygiene plays an important role in limiting infestation by *S. granarius*. The removal of infested residues from the previous season's harvest is essential. All spillage should be removed and all cracks and crevices filled.
- Ensuring grain is well dried at intake is very important. Moisture content of 10-12% is desirable [1].

- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [4] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains or infested grain can be treated with hot air, at an inlet temperature of 300-350°C, as an alternative to fumigation. Good weevil control has been obtained by this method, with heat exposure times (around 6 seconds) that do not unduly harm the grain [10].
- Fumigation of *S. granarius* pupae with phosphine at 20°C resulted in a LT_{95} of 3.9 days (at 0.5 g/m²) and 100% mortality after 10 days [5].
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived. Because the granary weevil larvae develop inside the grain it is difficult to detect the pest by visual inspection unless its numbers are very high.

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5.2 DISEASES

FUNGUS

5.2.1 Ascochyta blight of lentil (*Ascochyta lentisVassiljevsky (Anamorph*)

5.2.1.1 Hazard Identification

Disease: Ascochyta blight of lentil

Pathogen: *Ascochyta lentis*Vassiljevsky (Anamorph)

Didymella lentis W.J. Kaiser, B.C. Wang & J.D. Rogers (Teleomorph)

Synonym: *Ascochyta fabae f. sp. lentis*

Taxonomic position:
Kingdom: Fungi
Phylum: Ascomycota
Class: Dothideomycetes
Subclass: Dothideomycetidae
Order: Incertae sedis
Family: Incertae sedis
Genus: *Ascochyta*
Species: *A. fabae f.sp. lentis* Gossen, Sheard, C.J. Beauch. & Morrall, (9).

Bangladesh Status: Not present in Bangladesh

5.2.1.2 Biology

Ascochyta lentis as a pathogen of lentils has been identified for the first time in Russia in 1938 (4). The spores overwinter on crop residues and do not survive in soil. The disease is carried on the seed or infected stubble. Ascochyta spores, formed in fruiting bodies on infected crop debris, can be spread by wind to neighboring fields. Later in the summer and within fields, it is mainly spread by splashing rain. Infected plants produce infected seed and stubble. Wet weather in late summer can result in extensive pod and seed infection (2).

Ascochyta blight of lentil is caused by the fungal pathogen *Ascochyto lentis*. It causes grey to tan spots or lesions on leaflets, stems, flowers and pods, with dark margins and often with tiny black fruiting bodies (pycnidia) in the centers. Lesions first appear on lower leaflets close to soil surface and spread up the plant canopy. Lesions on stems can girdle the plant resulting in wilting. Leaves may turn brown and die off (3).

Heavy infestations of ascochyta blight will cause premature leaflet drop and stem dieback at the growing tips giving plants a blighted appearance. Pod infection can lead to seed infection and discolouration of the seed. Infected seed generally has brown patches on the seed surface, but may show no symptoms at all. Compared to healthy seed, heavily infected seed is purplish-brown, shrivelled and reduced in size (1).

The fungal pathogen can survive in infected seed, and in previously infected lentil stubble. Seed can remain infected for several years. Sowing infected seed can give rise to infected seedlings, and the appearance of symptoms at the seedling stage. Previously infected stubble is an important source of fungal inoculum. Spores are produced on old stubble and are spread to plants by rain splash. Further spread from plant to plant within crops then occurs through rain splash. The development of ascochyta blight epidemics is largely determined by the prevailing environmental conditions, especially the presence of moisture. Infection can occur at any stage of plant growth but become most problematic from flowering to maturity. Wet conditions late in the season, provides ideal conditions for pod infection which can result in seed discoloration. Disease is favored by cool, moist weather. An extended period of leaf wetness is required for disease development, with maximum disease developing occurring after 24 to 48 hours of leaf wetness. Temperatures between 10°C and 20°C are highly favorable for disease development, and maximum disease development occurs at approximately 15°C (6). The highest infection frequency occurs with a wetness period of 24 or 48 h. The latent period is shortest at 20 C and longest at 10 C. Temperature has little effect on lesion size and number of pycnidia per lesion, but infection frequency is higher at 10 C and 15 C than at 25 C (14).

5.2.1.3 Hosts

The pathogen *Ascochyta lentis* is very much host specific. No host other than lentil was found so far for this pathogen (8, 12).

5.2.1.4 Geographical Distribution

This pathogen is reported to present in Argentina, Australia, Brazil, Canada, Chile, Cyprus, Ethiopia, Greece, India, Iran, Jordan, Nepal, New Zealand, Pakistan, The Russian Federation, Spain, Syria and USA (5, 10, 11, 13).

5.2.1.5 Hazard Identification Conclusion

Considering the facts that:

- *Ascochyta lentis* is not known to be present in Bangladesh;
- It is present in Australia, Canada, India, and Nepal and can be carried by infected seed and infected aerial plant parts
- *Ascochyta lentis is* considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.1.6 Risk Assessment

5.2.1.6.1 Entry Assessment

Ascochyta lentis is reported to be a seed-borne pathogen. It also causes infection to any above ground parts of lentil plant. Seed infection sometimes remains symptomless. The pathogen can survive in the seed for several years. Therefore, there is high probability of entering this organism through this pathway.

5.2.1.6.2 Exposure assessment

Bangladesh is importing huge amount of lentil every year mostly from countries where the presence of *Ascochyta lentis* has been reported. Similarly, lentil germplasms are being imported from ICARDA and ICRISAT situated in Syria and India from where the diseases has been reported. After entry, the seeds are transported to different parts of the country. During handling and transport operations of the infected or contaminated grain or infected plant parts associated with seed there is high risk of spilled and exposed to the environment. Besides, the symptomless seeds might escape and exposed to the environment when sown in the field. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.2.1.6.3 Establishment assessment

The inoculum of *A. lentis* once exposed to the environment may not get its host readily other than the plant grown from the infected seed. Because lentil is the only known host for this organism. Therefore, the establishment potential of this organism in the PRA area is medium.

5.2.1.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No** -). • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, lentil seed, or infected plants are the means of dispersal of this pest* [1, 2, 6, 10]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***No*** The fungus is host specific and lentil is the only known host (8, 12)	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.1.7 Consequence Assessment

5.2.1.7.1 Economic Impact

Ascochyta blight has the potential to occur in almost all areas where lentils are grown. The foliar infection has caused yield losses of up to 40%, but in Canada economic losses from infected seed may reach more than 70% (7).

Pod infection by the pathogen can discolor seed, which can reduce the market value of the crop significantly. This is particularly important in green lentils grown for the whole seed market, which requires high seed quality.

5.2.1.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism.

5.2.1.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh **(Yes)** Lentil is the important crop in Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.1.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3: Calculation of Risk

Establishment potential	**Consequence potential**	**Risk rating**
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **High**

5.2.1.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing lentil for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Ascochyta lentis*
- Each pulse crop is affected by a specific ascochyta blight fungus. Thus, ascochyta from one pulse crop will not infect a different pulse crop in a rotation. With lentils, follow at least a 3 year rotation (i.e., a 2 year break) using a cereal, oilseed, or other pulse crop.
- Seed health test should be conducted at the port of entry.

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5.2.2 Phytophthora root rot of chickpea (*Phytophthoramedicaginis*)

5.2.2.1 Hazard Identification

Disease: Phytophthora root rot of chickpea

Pathogen: *Phytophthoramedicaginis*Hans & Maxwell

Other Scientific Names

- *Phytophthora megasperma* Drechsler
- *Phytophthora megasperma* f.sp. *medicaginis* T.L. Kuan & Erwin
- *Phytophthora sojae* f.sp. *medicaginis* Faris (11)

Taxonomic position:

Domain: Eukaryota
Kingdom: Chromista
Phylum: Oomycota
Class: Oomycetes
Order: Peronosporales
Genus: Phytophthora
Species: *Phytophthora medicaginis* (11)

Bangladesh Status: Not known to be present in Bangladesh

5.2.2.2 Biology

Infection by *P. medicaginis* can occur at any growth stage, causing seed decay, pre- and post-emergence damping off, loss of lower leaves, and yellowing, wilting and death of older plants. Symptoms are sometimes delayed if temperatures are cool and the soil is moist. Lateral roots and tap root die, or dark brown/black lesions often girdle the taproots. On young plants the lesions may extend up the stem for 10 mm or more above ground level (1). The roots of infected plants develop a dark-brown rot and soon lose their efficiency in nutrient and water transport resulting in additional symptoms of yellowing of leaves, wilting, stunting and finally death. Large areas of plants in low lying locations or poorly drained soil are affected and often die (3, 7) causing considerable economic loss.

The long-term survival strategy of *P. medicaginis* is through the production of thick-walled oospores. These may survive for up to 3.5 years in the soil (8, 9). The fungus may also survive as chlamydospores in infected plant tissue 2). According to a report from Australia Oospores can survive in soil for at least 10 years (1). In saturated soil the exudates from the roots of chickpea and other hosts stimulate the oospores to germinate and produce lemon-shaped sporangia. Inside these sporangia, zoospores develop and are released into the soil and surface water, where they are carried by moving water and 'swim' towards the roots and collars of chickpea plants. Zoospores encyst on the root surfaces and germinate to produce hyphae that invade the roots. New sporangia develop from infected roots enabling further cycles of infection to occur. Later, oospores are formed in the infected roots (1).

Zoospores are only capable of 'swimming' for a few millimetres, so long distance dispersal of *P. medicaginis* is by physical movement of soil and water infested with oospores, sporangia, zoospores and/or chlamydospores during floods and irrigation or by machinery (1).

5.2.2.3 Hosts

Phytophthora medicaginis has a narrow host range in nature and is primarily a pathogen of the family Fabaceae. Lucerne (*Medicago sativa*) is the primary host (4). Other species of Medicago, notably the annual species, are also susceptible under field test conditions (5). Chickpea (*Cicer arietinum*) is susceptible and damaged in the field in USA, Australia (6) and India (10).

5.2.2.4 Geographical Distribution

Asia: India, Japan, Pakistan, Turkey; Africa: South Africa; North America: Canada, Mexico, USA South America: Argentina; Europe: Croatia, Greece, Hungary, Ireland, Sicily, Norway, Russian Federation; Oceania: Australia (10, 11)

5.2.2.5 Hazard Identification Conclusion

Considering the facts that:

- *Phytophthora medicaginis* is not known to be present in Bangladesh;
- It is present in Australia, Canada, India, and Turkey
- It is a soil-borne pathogen causing infection to the roots
- *Phytophthora medicaginis is* considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.2.6 Risk Assessment

5.2.2.6.1 Entry assessment

Through the present pathway the possibility of introduction of this organism into Bangladesh is negligible as this disease does not affect aerial parts of the plant although base of the stem may be affected (1). Therefore, seed and aerial plant parts are not the carrier of this organism. Admixture of soil particle having the organism may be mixed with the commodity, however, the probability of entering this organism into Bangladesh is very low and as such not considered for further assessment.

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5.2.3 Septoria leaf spot of cowpea (*Septoria vignicoia*)

5.2.3.1 Hazard Identification

Disease: Septoria leaf spot of cowpea

Pathogen: *Septoria vignicoia* V.G. Rao

Taxonomic position:

Kingdom: Fungi
Division: Ascomycota
Class: Dothidiomycetes
Order: Capnodiales
Family: Mycosphaerellaceae
Genus: *Septoria*
Species: Septoria vignicola V.G. Rao

Bangladesh Status: Not known to be present in Bangladesh

5.2.3.2 Biology

Growth of *Septoria vignicola* on artificial media was restricted, the colony diameter of an eight-day-old culture being 4.9 mm and 4.5 mm on cowpea dextrose agar and potato dextrose agar, respectively. The optimum temperature for its growth in culture was 22-24^{o}C and the maximum and minimum temperatures were above 30 and below 18 ^{o}C, respectively. Conidium of *S. vignicola* germinated by cell elongation and budding. The fungus produced one or two germ tubes that emerged from one conidium, and the budded cells germinated independently. It penetrated the host tissue passively through the stomata and directly through the cell wall of the epidermis. The fungus attacked all parts of the plant above the ground except the flowers and pods. Septoria vignicola was found to be host specific to *Vigna unguiculata* (cowpea). The fungus caused severe leaf spotting and defoliation of most of the cowpea genotypes in the field. None of the genotypes was found to be immune or resistant to the disease (3). The fungus produces conidia in pycnidia. Conidia are septate. The pathogen is seed-borne and seed transmitted (1). The disease may cause serious economic crop losses (2, 3).The disease is severe during rainy weather and results in defoliation. It is favoured by high humidity. Rain splash disperse the conidia and the disease apread. Cuticle thickness in resistant variety ranged from 13.6 to 18.6µ as compared to 8.1 to 10.9µ in susceptible varieties. The cuticle of the resistant varieties act as a barrier by resisting entrance of the pathogen (4). Sohi and Rawal found more of free aminoacids and total soluble proteins in resistant varieties. The pathogen is favored by high sugar contents while phenols do not appear to have any role in resistance. The disease resistance is controlled by single dominant gene (5).

5.2.3.3 Hosts

The only major host recorded is *Vigna unguiculata* (cowpea).

5.2.3.4 Geographical Distribution

Among the selected exporting countries this disease is present only in India. Among other countries it has been reported to be present in East Africa, Savannah zones of tropical Africa, Nigeria (1).

5.2.3.5 Hazard Identification Conclusion

Considering the facts that:

- *Septoria vignicola*is not known to be present in Bangladesh;
- It is present in India, and Turkey
- The pathogen causes infection to seed or aerial plant parts
- *Septoria vignicolais* considered to be a potential hazard for this commodity in this risk analysis.

5.2.3.6 Risk Assessment

5.2.3.6.1 Entry Assessment

Septoria vignicola is reported to be a seed-borne and seed transmitted pathogen. It also causes infection to any above ground parts of cowpea. The pathogen can survive in the seed for long time. Therefore, there is high probability of entering this organism through this pathway.

5.2.3.6.2 Exposure assessment

Cowpea seed/grain after entry, transported to different parts of the country including village markets. During handling and transport operations of the infected or contaminated grain or infected plant parts associated with seed might fall to the ground and exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is medium.

5.2.3.6.3 Establishment assessment

The inoculum of *Septoria vignicola* once exposed to the environment may not get its host readily other than the plant grown from the infected seed. Because the pathogen is almost host specific and cowpea is the only known host for this organism. Therefore, the establishment potential of this organism in the PRA area is low.

5.2.3.6.4 Determination of Likelihood of the Pest Establishing Via This Pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No** -). • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, lentil seed, or infected plants are the means of dispersal of this pest* [1, 2, 6, 10]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established**.** ***No***	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.3.7 Consequence Assessment

5.2.3.7.1 Economic Impact

Septoria leaf spot is a major disease in cowpea in Africa and caused upto 40% yield loss. Therefore it is an economically significant disease.

5.2.3.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism.

5.2.3.7.3 Determination of Consequence of the Pest Establishing Via This Pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh. This can cause infection to cowpea which is not a major crop in Bangladesh	High

• Not as above or below	**Moderate**
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.3.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	**Moderate**	**Moderate**
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **Moderate**

5.2.3.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Septoria vignicola*
- Seed health test should be conducted at the port of entry.

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BACTERIA

5.2.4 Tan spot (*Curtobacterium flaccumfacienspv. Flaccumfaciens*)

5.2.4.1 Hazard Identification

Disease: Tan spot of mungbean and cowpea

Pathogen: *Curtobacterium flaccumfaciens*pv. *flaccumfaciens* (Hedges) Collins & Jones.

Synonym: *Corynebacterium flaccumfaciens* subsp. *flaccumfaciens* (Hedges) Dowson

Taxonomic position

Kingdom: Bacteria
Phylum: Actinobacteria
Order: Actinomycetales
Suborder: Micrococcineae
Family: Microbacteriaceae
Genus: *Curtobacterium*
*Species: Curtobacterium flaccumfaciens*pv. *flaccumfaciens*

Bangladesh Status: Not present in Bangladesh\

5.2.4.2 Biology

*Curtobacterium flaccumfaciens*pv.*flaccumfaciens* is gram-positive, yellow-pigmented, and coryneform (7) and is one of the most destructive bacterial diseases in legumes (3, 8, 10). Symptoms included tan spots and interveinal necrotic lesions surrounded by chlorotic irregular margins. In general, there is no water-soaking of stems and leaves, In fact, all the seeds in a pod may be infected, while the pod remains apparently healthy. This is due to the pathogen infecting the seed via the vascular system, following the sutures of the pods. Seeds of white-seeded cultivars, when infected systemically, are bright yellow, while the coloration is less intense in cultivars with coloured seed coats. There may be a small amount of yellow slime at the hilum, and seeds may be shriveled (1).The disease appeared to be most severe in rain-grown crops suffering from moisture stress. Tan spot is seed borne, and while it may develop in the seedling stage, the disease is more commonly seen from the second trifoliate leaf stage onwards. The bacterium is spread from infected seedlings to other plants in the crop by wind-blown rain (particularly hail) and mechanical damage (machinery and abrasion from dust storms). Symptoms develop rapidly if the crop is subjected to adverse growing conditions, such as heat or moisture stress. The pathogen survives in contaminated crop residues, soil and seed (4, 6, 9).*Curtobacterium flaccumfaciens* pv. *flaccumfaciens* survived up to 240 days on bean residues retained on the soil surface, but 30 days only when these were incorporated 20 cm deep into the soil (9).

5.2.4.3 Host

The major host of *Curtobacterium fluccumfaciens pv. flaccumfaciens*is*Phaseolus vulgaris*. Other hosts include *Lablab purpureus*, *Glycine max*, *Phaseolus coccineus*, *P. lunatus*, *Pisum sativum*, *Vigna angularis*, *Vigna mungo*, ***Vigna radiata*** and ***Vigna unguiculata*** (2, 5).

5.2.4.4 Geographic Distribution

Among the selected pulse exporting countries to Bangladesh the organism is reported to cause disease on mungbean and cowpea only in Australia. Besides it is present in Mauritius, Tunisia, Brazil, Colombia, USA (13 States), only Iran among Asian countries, Rumania and Russia. The bacteria is reported on Phaseolus bean from Canada and in the EPPO region. The causal agent, *C. flaccumfaciens pv. flaccumfaciens*, is considered as an A2 quarantine pest in European and Mediterranean countries (1, 2, 5)

5.2.4.5 Hazard Identification Conclusion

Considering the facts that:

- *Curtobacterium fluccumfaciens pv. flaccumfaciens* is not known to be present in Bangladesh;
- It is present in Australia among the selected pulse exporting countries to Bangladesh
- The pathogen causes infection to seed or aerial plant parts
- The organism is considered to be a potential hazard organism for this commodity and considered for risk analysis.

5.2.4.6 Risk Assessment

5.2.4.6.1 Entry Assessment

*Curtobacterium fluccumfaciens pv. flaccumfaciens*is reported to be a seed-borne and seed transmitted pathogen. It also causes infection to any above ground parts of cowpea and mungbean. The pathogen can survive in the seed for long time. Therefore, there is high probability of entering this organism through this pathway.

5.2.4.6.2 Exposure Assessment

Cowpea or mungbean seed/grain after entry, transported to different parts of the country including village markets. During handling and transport operations of the infected or contaminated grain or infected plant parts associated with seed might fall to the ground and exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is medium.

5.2.4.6.3 Establishment Assessment

The inoculum of the bacterium once exposed to the environment might get any of its leguminous hosts other than the plant grown from the infected seed. The environmental conditions in Bangladesh are favorable for the initiation and development of the disease. Therefore, the establishment potential of this organism in the PRA area is medium.

5.2.4.6.4 Determination of Likelihood of the Pest Establishing Via This Pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No)**. • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, mungbean and cowpea* [1, 2, 5]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***Yes***	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.4.7 Consequence Assessment

5.2.4.7.1 Economic Impact

Curtobacterium flaccumfaciens pv. flaccumfaciens is considered a serious pathogen of beans (Phaseolus) in parts of Europe and North and South America, where it causes death of seedlings and yield loss in surviving plants. It is becoming a serious, but sporadic, pathogen of soyabeans, cowpeas and mung beans in the USA, Russia and Australia. Sporadic yield losses of up to 19% in soyabeans have been recorded in the USA. Pasture establishment of the legume Zornia spp. is seriously affected in Colombia (5).

5.2.4.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism.

5.2.4.7.3 Determination of Consequence of the Pest Establishing Via This Pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate

• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.4.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – High

5.2.4.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing mungbean and cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Curtobacterium flaccumfaciens pv. flaccumfaciens*
- Seed health test should be conducted at the port of entry.

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5.2.5 Halo Blight of mungbean and cowpea (*Pseudomonas savastanoipv. Phaseolicola*)

5.2.5.1 Hazard Identification

Disease: Halo Blight of mungbean and cowpea

Pathogen: *Pseudomonas savastanoi*pv. *phaseolicola*

Other Scientific Names

Taxomonic Position

Domain: Bacteria
Phylum: Proteobacteria
Class: Gammaproteobacteria
Order: Pseudomonadales
Family: Pseudomonadaceae
Gennus: Pseudomonas
Species: *Pseudomonas savastanoi*pv. *phaseolicola*(3)

Bangladesh Status: Not Present in Bangladesh

5.2.5.2 Biology

Halo blight is a seed-borne bacterial disease caused by *Pseudomonas avastanoi*pv. *phaseolicola*. Halo blight has caused significant losses in all areas and can be particularly severe in spring-sown crops (2).Halo blight of mungbean was first recorded in Queensland in the early 1980's. Overseas, there are at least 9 strains (races, pathotypes) of the bacterium, which has serious implications for resistance breeding. Symptoms take 7-10 days to appear after infection. On young infected leaves there is an extensive yellow halo surrounding a small (1-2mm) dark, water-soaked (shiny) spot, while on older leaves the halo is not apparent. On infected pods a shiny circular lesion develops, and a cream-coloured drop containing millions of bacterial cells may ooze from the lesion.*P.s.phaseolicola*, like the tan spot pathogen, can survive between growing seasons on alternative hosts, on and in infected seeds, and to a limited extent on infected plant residues. Overseas, infected seed is considered to be the major mode of survival and spread of the pathogen, and work with French bean has shown that only 1 infected seed in 10,000 is needed to start an outbreak, assuming the weather conditions are right. *P.s.phaseolicola* is spread during wet, windy weather, with infection occurring through natural openings (leaf stomates) or wounds when there is free moisture (from dew, rainfall or irrigation). Temperatures in the range 18-25ºC are most conducive for infection and disease development, meaning that spring-planted crops are at the greatest risk. There is no evidence that the halo blight pathogen moves inside the plant from infected leaves into the pods (1).

5.2.5.3 Hosts

Cajanus cajan (pigeon pea), French bean, *Glycine max* (soyabean), *Lablab purpureus* (hyacinth bean), *Mercurialis annua*, *Neonotonia wightii* (perennial soybean), *Phaseolus acutifolius* (tepary bean), *Phaseolus coccineus* (runner bean), *Phaseolus lunatus* (lima bean), *Phaseolus vulgaris* (common bean), *Pisum sativum* (pea), *Pueraria montana* var. *lobata* (kudzu), *Solanum nigrum* (black nightshade), *Sonchus oleraceus* (common sowthistle), *Vigna angularis* (adzuki bean) ***Vigna radiata* (mung bean) and *Vigna unguiculata* (cowpea)**(1; 4).

5.2.5.4 Geographical Distribution

Among the selected pulse exporting countries to Bangladesh the disease is present in Australia, Canada, China, India and Turkey. It has also been reported to many other countries like Japan, Russia, Pakistan, Saudi Arabia, Israel, many countries in European, Africa and America (3, 4).

5.2.5.5 Hazard Identification Conclusion

Considering the facts that:

- *Pseudomonas savastanoi*pv. *phaseolicola* is not known to be present in Bangladesh;
- It is present in Australi, Canada, China, India and Turkey
- *Pseudomonas savastanoi*pv. *phaseolicola*is considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.5.6 Risk Assessment

5.2.5.6.1 Entry Assessment

*Pseudomonas savastanoi*pv.*phaseolicola* is reported to be present in most of the pulse exporting countries to Bangladesh. The organisom cause infection to aerial plant parts as well as seed. It is also a seed transmitted pathogen. The pathogen can survive in the seed for long time. Therefore, there is high probability of entering this organism through this pathway.

5.2.5.6.2 Exposure Assessment

Cowpea or mungbean seed/grain after entry, transported to different parts of the country including village markets. During handling and transport operations of the infected or contaminated grain or infected plant parts associated with seed might fall to the ground and exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is medium.

5.2.5.6.3 Establishment Assessment

The inoculum of the bacterium once exposed to the environment might get any of its leguminous hosts or other host including some weeds. The environmental conditions in Bangladesh are favorable for the initiation and development of the disease. Therefore, the establishment potential of this organism in the PRA area is high.

5.2.5.6.4 Determination of Likelihood of the Pest Establishing Via This Pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No)**. • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, mungbean or cowpea seed or infected plants are the means of dispersal of this pest* [1; 4]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***Yes***	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.5.7 Consequence Assessment

5.2.5.7.1 Economic Impact

Halo blight is a major disease of bean crops throughout the world. Epidemics have been recorded in Wisconsin and other parts of the USA. In four plot experiments in which various Phaseolus vulgaris lines were infected by inculation with P. savastanoi pv. phaseolicola, losses in seed yield were in the range 2.8-55.4%. Yield losses of 43% in the UK and between 23 and 43% in Michigan, USA have been obtained under experimental conditions. In the UK, green beans are mainly used for processing. Reduction in quality due to pod lesions can thus be considered economically important (4). In Australia, preliminary studies indicated a yield loss of 70% is possible (1).

5.2.5.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism. However, chemicals used for controlling the disease may create negative impact to the environment.

5.2.5.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.5.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – High

5.2.5.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing mungbean and cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Pseudomonas savastanoi*pv. *phaseolicola*
- Seed health test should be conducted at the port of entry.

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5.2.6 Bacterial blight of chickpea and lentil (*Xanthomonas campestrispv. cassiae*)

5.2.6.1 Hazard Identification

Disease: Bacterial blight of chickpea and lentil

Pathogen: *Xanthomonas campestris*pv. *cassiae* Kulkarni et al.

Synonym:
Xanthomonas campestris pv campestris (Dowson) *Dye, et al.*
Xanthomonas campestris (Pammel) Dowson
Bacillus campestris Pammel
Pseudomonas campestris (Pammel) Smith
Bacterium campestris (Pammel) Smith
Phytomonas campestris (Pammel) Bergey et al. (1)

Taxonomic Position
Domain: Bacteria
Phylum: Proteobacteria
Class: Gammaproteobacteria
Order: Xanthomonadales
Family: Xanthomonadaceae
Genus: *Xanthomonas*
Species: *Xanthomonas campestris*
Trinomial name: *Xanthomonas campestris* pv*cassiae* (1)

Bangladesh status: Not present in Bangladesh

5.2.6.2 Biology

Bacterial blight caused by *Xanthomonas campestris pv. cassiae* is commonly seen in chickpea. At the beginning the disease is characterized by water-soaked angular translucent lesions between the veins. As the tissue dries, the lesions turn from light green, water-soaked lesions to dry, brown, papery tissues which, if lesions occur at leaf edges, can cause tearing. On adult plants, lesions are initially water soaked and soon turn into dark brown spots, 1-2 mm in diameter with chlorotic halos. As the disease advances, the spots coalesce causing severe chlorosis of the leaflet and producing typical leaf blight symptoms. Disease symptoms can also occur on stems, petioles, and pods. The disease can progress very rapidly and the leaves dropped under wet and warm (30°C) conditions (3).Cloudy droplets of bacteria along the edges of lesions could be seen, which become crystalline and flake off as the leaves dry. The progress of the lesion stopped when the weather conditions become warm and dry after infection. The pathogen is seed-borne, and contaminated seed is considered the most important source of inoculum for field epidemics. The pathogen also survives on stubble and in the soil (3, 4). The disease is considered to be of minor importance.

5.2.6.3 Hosts

The known natural hosts include *Cassia fistula,* chickpea, pea and lentil (2, 3).

5.2.6.4 Geographical Distribution

Bacterial blight caused by *Xanthomonas campestris* pv*. cassiae* is reported only from India and USA (3, 4).

5.2.6.5 Hazard Identification Conclusion

Considering the facts that:

- *Xanthomonas campestris pv. cassia* is not known to be present in Bangladesh;
- It is present in India only and can be entered into Bangladesh through infected seed
- *Xanthomonas campestris pv. cassiae*is considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.6.6 Risk Assessment

5.2.6.6.1 Entry Assessment

Xanthomonas campestris pv. cassiae reported to be a seed-borne pathogen in lentil, chickpea and fieldpea. Bangladesh imports pulses from India where the disease has been reported (2). Similarly, germplasms are also being imported from ICRISAT situated in India. Therefore, there is high probability of entering this organism through this pathway.

5.2.6.6.2 Exposure Assessment

After entry, the seeds are transported to different parts of the country. During handling and transport operations the infected seed or plant parts associated with seed may be spill over and exposed to the environment. Besides, when infected seeds are sown in the field the virus is exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.2.6.6.3 Establishment Assessment

No information was available on the seed transmission rate of this bacterium. The secondary spread of the disease occurs under wet and warm condition. The disease progress stopped at lower temperature at lower humidity. Chickpea and lentil are grown during winter season in Bangladesh and the season is more or less dry and cool. Under such circumstances in the PRA area the probability of establishment of this disease in low.

5.2.6.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No)**. • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, mungbean or cowpea seed or infected plants are the means of dispersal of this pest* [1; 4]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***Yes***	High
• Not as above or below	Moderate
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	**Low**

5.2.6.7 Consequence Assessment

5.2.6.7.1 Economic Impact

Bacterial blight is reported to be a minor disease with negligible economic impact.

5.2.6.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism.

5.2.6.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	High
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	**Low**

5.2.6.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	**Low**	**Low**

CALCULATED RISK RATING – Low

Based on low probability of establishment and likely negligible economic and environmental impact this organism is not considered to be a hazard in this risk analysis.

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VIRUS

5.2.7 Pea seed-borne mosaic (*Pea seed-borne mosaic virus*)

5.2.7.1 Hazard Identification

Disease: Pea seed-borne mosaic

Pathogen: Pea seed-borne mosaic virus

Synonym:

pea fizzle top virus
pea leaf roll mosaic virus
pea leaf rolling mosaic virus
pea leaf rolling virus
pea seed-borne mosaic potyvirus
pea seed-borne symptomless virus
PSbMV

Taxonomic Position

- Domain: Virus
  - Group: "Positive sense ssRNA viruses"
    - Group: "RNA viruses"
      - Family: Potyviridae
        - Genus: Potyvirus

Bangladesh Status: Not present in Bangladesh

5.2.7.2 Biology

Pea seed-borne mosaic virus (PSbMV) is seed-borne and seed-transmitted, and it is introduced into new regions through the movement of virus-infected seed. Seed transmission rates as high as 100 percent have been reported for PSbMV in field peas, with transmission rates as high as 30 percent commonly observed. Seed transmission rates as high as 44 percent have been reported for PSbMV in lentils, although the efficiency of seed transmission of PSbMV in lentils may differ by the strain of the virus (1, 2). In Victoria, the DEPI has detected PSbMV at low levels in commercial chickpea seedlots (0.4% of seed) and at higher levels in field pea and lentil seedlots (greater than 2% of seed). In the USA, PSbMV infection has been reported in 3% pea seedlots and 32-40% in lentil seedlots (1).

The progression of symptoms on susceptible pea cultivars was accelerated at higher temperature but the final severity of the symptoms was not significantly affected by temperature. Vein clearing, the most striking early symptom, reached maximum severity 3 days after inoculation at 28 °C, 4 days at 24 °C and 5 days at 20 and 16 °C. The apical malformation was evident at all temperatures within 4 weeks after inoculation, but was apparent first at higher temperature (14). Beside this, symptomless infections are also common. The virus may be present without inducing symptoms in 5 to 10% of the plants from infected seed lots (8). Symptomless infection has been observed in breeding lines in USA (7, 9) and also in plants raised in quarantine from pea seeds imported from Sweden into Australia (12).

Secondary spread of PSbMV is facilitated by aphids. Aphids transmit the virus from diseased to healthy plants within fields, and they can spread the virus to neighboring fields. When aphid populations are high, even low levels of infected seed can result in severe PSbMV epidemics. More than 20 aphid species, including the pea aphid (*Acyrothosiphon pisum*), are known to transmit PSbMV. Aphids transmit the virus in a nonpersistent manner, obtaining and transmitting the virus in short feeding periods (2). The virus is also transmitted mechanically (1). The virus also can be introduced to fields from infected volunteers and other infected hosts (3).

5.2.7.3 Hosts

The natural host range of PSbMV is limited to the Fabaceae family. The virus infects temperate pulses (chickpea, faba bean, field pea, lentil) other legumes (garden pea, narbon bean, lathyrus, vetch) and legume pastures. A number of PSbMV pathotypes have been recognised by their ability to infect a number of pea differential genotypes (1). PSbMVhas a moderate host range of 47 plant species belonging to 12 families. However, the main hosts of economic importance are pea, bean and lentil (4).

5.2.7.4 Geographical Distribution

Pea seed-borne mosaic virus is almost worldwide distribution. Among the selected exporting countries it has been reported to be present in Australia, Canada, India, Nepal and Turkey (5). Since 1995, PSbMV has been listed by Argentina and Brazil as an A1 quarantine pathogen (6). The pathogen is on the 'Harmful Organism List' for nine countries: Australia, Costa Rica, Georgia, Japan, Namibia, Nauru, South Africa, Taiwan and Uruguay (13).

5.2.7.5 Hazard Identification Conclusion

Considering the facts that:

- *Pea seed-borne mosaic virus* is not known to be present in Bangladesh;
- It is present in many countries in the world including Australia, Canada, India, Nepal and Turkey and can be entered into Bangladesh through infected seed
- *Pea seed-borne mosaic virus is* considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.7.6 Risk Assessment

5.2.7.6.1 Entry Assessment

Pea seed-borne mosaic virus is reported to be a seed-borne pathogen in lentil, chickpea, fieldpea etc. It also causes infection to the above ground parts of the plant. Pulses are imported from Australia, Canada, India, Nepal and Turkey from where the disease has been reported (6, 10). Similarly, germplasms are also being imported from ICARDA and ICRISAT situated in Syria and India, respectively where the occurrence of this disease is also reported (11). Seed infection sometimes remains symptomless. The pathogen can survive in the seed for a long period. Therefore, there is high probability of entering this organism through this pathway.

5.2.7.6.2 Exposure Assessment

Bangladesh is importing huge amount of lentil every year mostly from countries where the presence of *Pea seed-borne mosaic virus* has been reported. After entry, the seeds are transported to different parts of the country. During handling and transport operations the infected grain or infected plant parts associated with seed may be spill over and exposed to the environment. Besides, the virus with the symptomless seeds might escape and when sown in the field the virus is exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.2.7.6.3 Establishment

As the seed transmission rate of the virus is very high, up to 100% in pea and 44% in lentil it is obvious that the virus will be transmitted to the plant from the infected seed. The secondary spread of the virus is caused by 21 species of aphids. Some of which is present in Bangladesh. Under such circumstances in the PRA area the probability of establishment of this disease in high.

5.2.7.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**Yes** – 1; 15) • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**, lentil seed, or infected plant parts are the means of dispersal of this pest [15]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	**High**
• Not as above or below	Moderate
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.7.7 Consequence Assessment

5.2.7.7.1 Economic Impact

In peas and lentils, PSbMV can cause economically important losses in seed yield and quality. Seed quality losses associated with PSbMV are most pronounced in peas, where PSbMV causes seed discoloration, cracked seed coats, shriveling of seeds and reductions in seed size (16).

Seed quality losses associated with PSbMV are less pronounced in lentils, where PSbMV-related seed discoloration is less common. Yield losses are proportional to levels of seed-borne infection and the timing of secondary virus transmission, with the most severe losses occurring when the secondary spread of the virus occurs before or during flowering. PSbMV-related yield losses are caused by a combination of reduced seed number and reduced seed weight (16).

In field trials conducted in Australia on field peas, yield losses of 15 to 21 percent were observed when initial levels of seed-borne PSbMV infection were low (1 to 2 percent) and when aphids arrived at or shortly before bloom. At higher levels of seed-borne PSbMV infection (6.5 to 8 percent), yield losses of 13 percent or more were observed irrespective of when aphids arrived (16).

5.2.7.7.2 Environmental Impact

So far, no information is available on direct environmental impact of the organism.

5.2.7.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.7.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – HIGH

5.2.7.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.

- Use of disease resistant varieties for growing mungbean and cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *PSbMV*
- Seed health test should be conducted at the port of entry.

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5.2.8 Beet Western Yellows (*Beet Western Yellows Virus*)

5.2.8.1 Hazard Identification

Disease: Beet Western Yellows

Pathogen: Beet Western Yellows Virus (BWYV)

Other Scientific Names

brassica virus 5
malva yellows virus
radish yellows virus
turnip mild yellows virus
turnip yellows luteovirus
Vergilbungsvirus der Stoppelrübe

Taxonomic Position:

Domain: Virus
Group: "Positive sense ssRNA viruses"
Group: "RNA viruses"
Family: Luteoviridae
Genus: Polerovirus
Species: Beet western yellows virus (http://www.cabi.org/isc/datasheet/10259)

Bangladesh Status: Not present in Bangladesh

5.2.8.2 Biology

Beet western yellows virus (BWYV) persists over summer in weed or summer pasture hosts. The virus is not seed-borne, and is spread from host plants into crops by aphids, which act as the vector for transmission of the virus. BWYV is transmitted by several aphid species in a persistent manner. Persistent viruses are carried in the aphid's body, and can be transmitted to healthy plants during feeding. The aphids will remain infective throughout their life. In southern Australia many aphid species were found to transmit BWYV. They include cowpea aphid (*Aphis craccivora*), foxglove aphid (*Aulacorthum solani*), cabbage aphid (*Brevicoryne brassicae*), ornate aphid (*Myzus ornatus*), green peach aphid (*Myzus persicae*), lucerne blue green aphid (*Acyrthociphon kondoi*), sowthistle green aphid (*Hyperomyzus lactucae*) and spotted alfalfa aphid (*Therioaphis trifolii forma maculata*) (7).

5.2.8.3 Host

The host range of BWYV is extremely wide. Hosts include pulses (chickpea, faba bean, lentil, field pea and vetch), pasture legumes (clover, medics and lucerne), and many common weeds, tropical legumes such as French bean and soybean, as well as other field crops like canola, and sunflower. Horticultural crops like crucifers and lettuce are also infected by the virus. Infected weeds and forage brassicas and clover are of particular importance, as they host BWYV over the summer and in the early autumn (7, 8).

5.2.8.4 Geographical Distribution

Among the Asian countries this disease has been reported from **China** (12), Iran (13), Israel (10), Japan (11), Lebanon (6), Pakistan (9), Syria (6), **Turkey** (6) and Yemen (1). This disease is widespread in USA (4), Czech Republic (2), Germany (3) and UK (5). Beet Western yellows disease is also present in **Australia** (9).

5.2.8.5 Hazard Identification Conclusion

Considering the facts that:

- *Beet western yellows virus* is not known to be present in Bangladesh;
- It is present in many countries in the world including Australia, China, and Turkey
- BWYV is not seed-borne and transmitted through different species of aphids, which persist throughout the life of the vector insect.
- There is no possibility of entering live viruliferous ahpids into Bangladesh along with the pathway.

Therefore BWYV *is* not considered to be a potential hazard organism for this commodity in this risk analysis.

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5.2.9 Alfalfa Mosaic (*Alfalfa mosaic virus*)

5.2.9.1 Hazard Identification

Disease: Alfalfa Mosaic

Pathogen: Alfalfa mosaic virus

Other Scientific Names
alfalfa mosaic alfamovirus
alfalfa virus 1 and 2
lucerne mosaic virus
Marmor medicaginis
potato calico virus

International Common Names
English: tomato necrotic tip curl

Taxonomic Position
Domain: Virus
Group: "Positive sense ssRNA viruses"
Group: "RNA viruses"
Family: Bromoviridae
Genus: Alfamovirus
Species: Alfalfa mosaic virus (1)

Bangladesh status: Alfalfa mosaic disease is not known to be present in Bangladesh

5.2.9.2 Biology

The first visible symptoms of mosaic in the field are chlorosis of the terminal bud and twisting, followed by necrosis, and the subsequent proliferation of secondary branches. Such new secondary branches are stiff and erect, with smaller leaflets that show a mild mottle. Mosaic is clearly seen in kabuli type chickpeas, which have larger leaflets. Very few pods are produced.but is often remain symptomless, especially during summer, and is most prevalent in old crops. Infected lentils develop necrotic tip growth, twisting and deformation of leaves and stunting. Field peas develop chlorosis and necrosis of the new shoots. Necrotic spots or streaking on older leaves and plant stunting may occur. Pods may be malformed and fail to develop peas.

Premature drying is common. Terminal bud necrosis can also be caused by iron deficiency, but proliferation of branches is not seen in iron deficient plants. Wilting is seen when cultivars such as EC-10 are inoculated at the seedling stage. It is possible, therefore, that seedlings that wilt without internal or external discoloration may be affected by the mosaic virus (11). The virus is readily sap-transmissible, is seed-transmissible in some hosts and is transmitted in the non-persistent manner by aphids to a very wide range of host plants. Transmitted in the non-persistent manner by at least 14 aphid species (4). There is no latent period in the aphid and frequency of transmission is increased by starving the aphids before acquisition of virus (12). AMV survives in infected seed or plant hosts. It does not persist in stubble or soil. Aphids spread the viruses from seed-infected plants to healthy plants. Seed transmission rates of 0.1-5% in lentils and 0.1-1% in chickpeas have been recorded (8). In Western Australia, seed transmission of AMV was detected in *Lathyrus cicera* (2%), *Lathyrus sativus* (0.9-4%), *Vicia benghalensis* (0.9%), *Vicia narbonensis* (0.1%) and *Vicia sativa* (0.7%) (9).

5.2.9.3 Host

This virus has a wide host range and infects over 305 spp. in 47 dicotyledonous families (6). Among these the cultivated legumes are pigeon pea, **chickpea**, soybean, hyacinth bean, **lentil**, lucerne, bean, common bean, pea, crimson clover, purple clover, white clover, subterranean clover, faba bean, adzuki bean, **mungbean** and **cowpea**. Potato, tomato, kenaf, lettuce, cucurbits, coriander, peppers, beet and celery are other important crop species affected by alfalfa mosaic virus (6).

5.2.9.4 Geographical Distribution

Alfalfa mosaic is reported to be present in 22 countries in Asia, 12 countries in Africa, in Canada, Mexico and USA in North America, 6, 28 and 2 countries in South America, Europe and Oceania. This disease is widespread in Jordan, Lebanon, Canada, USA, Bulgaria, Germany, Hungary Italy and Russia Federation. The disease is present in all the selected pulse exporting countries such as Australia, Canada, China, India, Nepal and Turkey (2, 3, 5, 10, 11, 13, 14).

5.2.9.5 Hazard Identification Conclusion

Considering the facts that:

- *Alfalfa mosaic virus* is not known to be present in Bangladesh;
- It is present in many countries in the world including Australia, Canada, China, India, Nepal and Turkey
- AMV is both aphid-borne and seed-borne and transmitted through different species of aphids, which persist throughout the life of the vector insect.

AMV *is* considered to be a potential hazard organism for this commodity in this risk analysis.

5.2.9.6 Risk Assessment

5.2.9.6.1 Entry Assessment

Alfalfa mosaic virus is reported to be a seed-borne and seed transmitted pathogen in lentil, chickpea, fieldpea etc. The disease is present in Australia, Canada, China, India, Nepal and Turkey from where Bangladesh imported pulses. Therefore, there is high probability of entering this organism through this pathway.

5.2.9.6.2 Exposure Assessment

Bangladesh is importing huge amount of pulses every year mostly from countries where the presence of *Alfalfa mosaic virus* has been reported. After entry, the seeds are transported to different parts of the country. During handling and transport operations the infected grain may be spill over and exposed to the environment. Besides, infected imported seed when sown in the field the virus become exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.2.9.6.3 Establishment

Although the seed transmission rate of the virus is low, 0.1-5.0% in lentils, 0.1-1.0% in chickpea and 0.9-4.0% in khesari. Still if only few plants get infected by the seed transmitted virus the secondary spread will be caused by aphid vector which is available in Bnagladesh. Under such circumstances the probability of establishment of this disease is high in the PRA area.

5.2.9.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No**) • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**, lentil seed, or infected plant parts are the means of dispersal of this pest [8]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.9.7 Consequence Assessment

5.2.9.7.1 Economic Impact

In plants of lentil, infection with AMV decreased shoot dry weight by 74-76%, seed yield by 81-87% and individual seed weight by 10-21% (8). Early infection with AMV killed plants of chickpea while later infection decreased shoot dry weight by 50%, seed yield by 98% and individual seed weight by 90% (9). These facts indicate the significant economic impact of AMV.

5.2.9.7.2 Environmental Impact

The virus has a wide host range therefore natural biodiversity will be in danger once it is established in Bangladesh as well as endanger some important crop species like potato, tomato, cucurbits etc. To control the vector insect will need to use additional pesticides leading to pulution to the environment and hazard to beneficial insects and users.

5.2.9.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.9.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – HIGH

5.2.9.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection.
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing mungbean and cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Alfalfa mosaic virus.*
- Seed health test should be conducted at the port of entry.

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5.2.10 Faba bean necrotic yellows (*Faba bean necrotic yellows virus*)

5.2.10.1 Hazard Identification

Disease: Faba bean necrotic yellows on food legumes

Pathogen: Faba bean necrotic yellows virus

Synonym: faba bean necrotic yellows nanavirus

Taxonomic position:

Domain: Virus
Group: "ssDNA viruses"
Group: "DNA viruses"
Family: Nanoviridae
Genus: Nanovirus
Species: Faba bean necrotic yellows virus (5)

Bangladesh Status: Not present in Bangladesh

5.2.10.2 Biology

One-week-old faba bean plants show retarded growth as early as 5 days after inoculation. At 2 weeks after inoculation, the plants are usually severely stunted. The leaves become thick and brittle and show interveinal chlorotic blotches starting from the leaf margins. The uppermost young leaves remain very small and cupped upwards, whereas the older leaves are rolled downward. New shoots, leaves and flowers develop poorly. About 3-4 weeks after infection, interveinal chlorosis usually turns necrotic and infected plants die within 5-7 weeks after infection. Similar symptoms were also observed in other susceptible host plants. Some infected *Trifolium* and *Medicago* species, however, develop leaf reddening instead of, or in addition to, chlorosis (6). The virus is not infective in expressed plant sap. The genome is circular ssDNA. Ten DNA components have been isolated from virus preparations; individual molecules, each of which appears to be encapsidated in a separate particle, are approximately 1 kb in size. The aphid species *Acyrthosiphon pisum, Aphis craccivora* and *A. fabae* have been reported as FBNYV vectors. The efficiency of transmission by aphids was found to be high for the first two species and very poor for *A. fabae* (1, 3, 6). The information on its aphid transmission indicates that FBNYV has features typical of a persistently transmitted virus which circulates but does not multiply in the vector insects. Aphids require long acquisition and inoculation feeding periods to become efficient vectors, and FBNYV persists in the aphids for almost their entire life (3). As with all phloem-limited viruses, FBNYV is not known to be transmitted by seed or mechanical means. Since all its hosts are propagated by true seed, the only method of natural spread of FBNYV is by aphid vectors.

5.2.10.3 Hosts

FBNYV has a relatively narrow host range, mostly restricted to leguminous species. Faba bean is the main natural host, but other legume crops such as chickpea, lentil, dry bean, pea and cowpea are also natural hosts of FBNYV (1, 7). The virus also occurs naturally in the wild legume species *Lathyrus sativus, L. gorgonei, L. annuus, L. hierosolyminatus, Medicago polymorpha, M. praecox, M. rigidula, M. rotata, M. scutellata, Melilotus officinalis, Tetragonolobus purpureus, Trifolium arvense, T. hirtum, T. lappaceum, T. subterraneum, Vicia ervilia, V. hybrida, V. palaestina* and *V. sativa*, as well as in perennial species of the genus *Onobrychis* and in *Medicago sativa*; the virus also occurs naturally in some non-leguminous species including *Amaranthus blitoides, A. retroflexus* and *A. viridis* (2, 8).

5.2.10.4 Geographical Distribution

Among the selected pulse exporting countries to Bangladesh Faba Bean Necrotic Yellows disease has been reported only from Turkey. Among other countries this disease has been reported from some countries in the middle-east, and from some African countries. The disease is widespread in Jordan and Egypt (5).

5.2.10.5 Hazard Identification Conclusion

Considering the facts that:

- Faba bean necrotic yellows is not known to be present in Bangladesh;
- It is present only in Turkey among the selected pulse exporting countries to Bangladesh.
- FBNYV is transmitted through different species of aphids, which persist throughout the life of the vector insect.

FBNYV *is* not considered to be a potential hazard organism for this commodity in this risk analysis.

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5.2.11 Tomato spotted wiltdisease on Cowpea (*Tomato spotted wilt virus*)

5.2.11.1 Hazard Identification

Disease: Tomato spotted wilt disease on Cowpea

Pathogen: *Tomato spotted wilt virus*

International Common Names

English: tomato necrotic tip curl

Taxonomic Position

Kingdom: Viruses
Phylum: Viruses
Class: Single-stranded, negative-sense, RNA (Group V)
Order: Unassigned single stranded negative-sense RNA viruses
Family: Bunyaviridae
Genus: Tospovirus
Subject: Tospovirus TSWV (3)

Bangladesh status: Tomato spotted wilt disease is not known to be present in Bangladesh

5.2.11.2 Biology

Nine species are reported as vectors: *Frankliniella occidentalis* (western flower thrips); F *schultzei, F fusca* (tobacco thrips); *Thrips tabaci* (onion thrips); *T setosus, T moultoni; F tenuicornis, Lithr~ps dorsalis,* and *Scirtothrips dorsalis.* The first four are considered the most important vectors because of their wide distribution and the overlapping host ranges of these species and TSWV. Eggs of this species are inserted into leaf or petal tissue, which protects them from insecticides. The eggs hatch into larvae that usually remain protected in flower buds or terminal foliage. The insect passes through two larval stages, both of which feed in these protected areas. The first larval stage lasts 1-2 days, the second 24 days. Toward the end of the second larval stage, the insect stops feeding and usually moves down into the soil or leaf litter to pupate; a few may pupate on the plant The insect passes through prepupal and pupal stages of 1-2 days and 1-3 days in duration, respectively, when no feeding and little movement occur. The adults, which can survive 30-45 days and lay 150-300 eggs, feed primarily in protected areas of the plant such as flowers and terminals (4).

5.2.11.3 Host

Tomato spotted wilt virus (TSWV) causes serious diseases of many economically important plants representing 35 plant families, including dicots and monocots. The important crops included Tobacco, Tomato, Celery, Peanut, Pepper, Bean, Potato, **Cowpea**, Eggplant, Spinach, Lettuce, Cucumber and Cauliflower. Besides many ornamentals are also the hosts of this virus (4).

The principal ornamental hosts are Alstroemeria, Anemone, Antirrhinum, Araceae, Aster, Begonia, Bouvardia, Calceolaria, Callistephus, Celosia, Cestrum, Columnea, Cyclamen, Dahlia, Dendranthemax grandiflorum, Eustoma, Fatsia japonica, Gazania, Gerbera, Gladiolus, Hydrangea, Impatiens, Iris, Kalanchoe, Leucanthemum, Limonium, Pelargonium, Ranunculus, Saintpaulia, Senecio cruentus, Sinningia, Tagetes, Verbena, Vinca and Zinnia. Weeds such as Amaranthus spp., Conyza bonariensis, Galinsoga spp.,

Polygonum lapathifolium, Portulaca oleracea, Senecio vulgaris, Solanum nigrum, Sonchus spp., Stellaria media, Taraxacum officinale, etc. may be important reservoirs of TSWV (1).

5.2.11.4 Geographical Distribution

The disease is present in all the selected pulse exporting countries such as Australia, Canada, China, India, Nepal and Turkey (1, 2).

5.2.11.5 Hazard Identification Conclusion

Considering the facts that:

- *Tomato spotted wilt virus* (TSWV) is not known to be present in Bangladesh;
- It is present in all the selected pulse exporting countries to Bangladesh such as Australia, Canada, China, India, Nepal and Turkey
- TSWV is transmitted by different species of thrips and once acquired the virus it can transmit the disease through its life.

TSWV *is* not considered to be a potential hazard organism for this commodity in this risk analysis.

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5.2.12 Peanut stunt disease on cowpea (*Peanut stunt cucumovirus*)

5.2.12.1 Hazard Identification

Disease: Peanut stunt disease on cowpea

Pathogen: *Peanut stunt cucumovirus*

Synonyms

Robinia mosaic virus
black locust true mosaic virus
clover blotch virus

Taxonomic position:

Group: Group IV ((+)ssRNA)
Order: *Unassigned*
Family: *Bromoviridae*
Genus: *Cucumovirus*
Species: *Peanut stunt virus* (1)

Bangladesh Status: This disease is not present in Bangladesh

5.2.12.2 Biology

The virus infected cowpea plants develop leaf chlorosis symptom. The virus is transmitted by species of aphid like *Aphis craccivora, A. spiraecola* and *Myzus persicae*, but not *Aphis gossypii*.

The disease is transmitted in a non-persistent manner. Virus is also transmitted by mechanical inoculation and transmitted by seed (0.1% in *Arachis hypogaea*) but this is not considered to be very important to the spread of this virus (1, 2).

5.2.12.3 Hosts

The hosts of peanut stunt cucumovirus include *Robinia pseudoacacia*, *Trifolium repens, T. pratense, T. vesiculosum, T. incarnatum, T. subterraneum, Medicago sativa* , *Phaseolus* spp., *Arachis hypogaea*, *Vicia* sp. , *Glycine max, Pisum sativum, Vigna angularis, Coronilla varia, Tephrosia* sp., *Nicotiana tabacum, Apium graveolens* and *Lupinus luteus* (1, 2).

5.2.12.4 Geographical Distribution

The disease is present in **China**, Japan, Korea D.P.R. (North), Korea Republic, Morocco, Poland, Spain, France and the USA (3).

5.2.12.5 Hazard Identification Concusion

Considering the facts that:

- *Peanut stunt cucumovirus* is not known to be present in Bangladesh;
- It is present only in China among the six selected pulse exporting countries to Bangladesh
- *Peanut stunt cucumovirus* is transmitted by different species of aphids in a non-persistent manner.

Peanut stunt cucumovirusis is not considered to be a potential hazard organism for this commodity in this risk analysis.

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5.2.13 Cowpea severe mosaic disease on cowpea (*Cowpea severe mosaic virus*)

5.2.13.1 Hazard Identification

Disease: Cowpea severe mosaic disease on cowpea

Pathogen: *Cowpea severe mosaic virus*

Synonyms: Puerto Rico cowpea mosaic virus

Taxonomic Position

Kingdom: Viruses
Phylum: ssRNA viruses
Class: ssRNA positive-strand viruses, no DNA stage
Order: Picornavirales
Family: Comovirinae
Genus: Comovirus
Species: Cowpea severe mosaic virus (6)

Bangladesh Status: This disease is not present in Bangladesh

5.2.13.2 Biology

Cowpea severe mosaic virus causes crinkling and severe mottling of newly emerging leaves and, in severe cases, results in the overall stunting of the plant (10). CPSMV is transmitted by chrysomelid beetles, primarily *Cerotoma arcuata* (8). The disease causes reduction in leaf area index, leaf area duration, or vegetative dry matter. The pod number is also reduced (1).Systemic symptoms are mottle or mosaic, often with severe blistering and distortion of leaflets. Some hosts show systemic necrosis and the plants may collapse. Cowpea and bean varieties differ in severity of symptoms, some bean varieties reacting with necrotic local lesions only (12). Transmitted by a vector; an insect; *Ceratoma arcuata, C. ruficornis, C. trifurcata, C. variegata, Chalcodermus bimaculatus, Diabrotica balteata, D. speciosa, D. virgifera, D. undecimpunctata, Diphaulaca* sp., *Epilachna varivestis, Acalymma vittatum*; Coleoptera. Virus transmitted by mechanical inoculation; transmitted by seed (10% in *V. unguiculata*, varies with strain and cultivar); transmitted by pollen to the seed (5).

5.2.13.3 Host

Only leguminous plants are reported as natural hosts. Experimental host range includes many species of Leguminosae but relatively few hosts from other families (12). Jack bean, Dolichos ensiformis, Sunn hemp, Soybean, Glycine hispida, Kidney bean, French bean, Winged bean, Dolichos tetragonolobus, Vigna unguiculata (Cowpea), Desmodium, Calopogonium mucunoides and Mung bean are also the host for CPSMV (6).

5.2.13.4 Geographical Distribution

Cowpea severe mosaic virus (CPSMV), a comovirus, is considered the most important virus of cowpea in the Caribbean (9). It is a major problem in El Salvador, Venezuela (3), Costa Rica (11), and Northeast Brazil (7), and also occurs in Peru, Surinam, the United States (2) and in **India** (4.).

5.2.13.5 Hazard Identification Conclusion

Considering the facts that:

- Cowpea severe mosaic virus (CPSMV) is not known to be present in Bangladesh;
- It is present in India and some other countries in the world
- CPSMV is transmitted by different species of beetles, of which *Cerotoma arcuata* is the main vactor. Seed transmissionup to 10% has been recorded in cowpea.
- CPSMV *is* considered to be a potential hazard for this commodity in this risk analysis.

5.2.13.6 Risk Assessment

5.2.13.6.1 Entry Assessment

Cowpea severe mosaic virus is reported to be a insect (beetle) borne as well as seed-borne and seed transmitted pathogen in cowpea, mungbean, france bean, kidney bean, soybean etc. The disease is present in India, among the pulse exporting countries to Bangladesh. There is high probability of entering this organism through this pathway especially cowpea and mungbean from India is high.

5.2.13.6.2 Exposure Assessment

After entry, the seeds are transported to different parts of the country. During handling and transport operations the infected grain may be spill over and exposed to the environment. Besides, infected imported seed when sown in the field the virus become exposed to the environment. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.2.13.6.3 Establishment

As the seed transmission rate of this virus is quite high, the virus will transmit systemically and cause infection to the plant. From the virus infected plants it may be transmitted by insect vactor and also cause further seed infection by wind blown infected pollen to a long distance (5). Under such circumstances the probability of establishment of this disease is high in the PRA area.

5.2.13.6.4 Determination Of Likelihood Of The Pest Establishing Via This Pathway In Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No**) • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**, mungbean or cowpea infected seed if imported from India as it is seed transmitted (5.)]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.2.13.7 Consequence Assessment

5.2.13.7.1 Economic Impact

The yield losses caused by cowpea severe mosaic virus ranged from 2-85% depending on the time of infection. Earlier the infection higher is the yield loss in cowpea (1).

5.2.13.7.2 Environmental Impact

No information on this issue is available

5.2.13.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	**High**

Description	**Consequence**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.2.13.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – HIGH

5.2.13.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin for export purpose.
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection.
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing mungbean and cowpea for export purpose.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Cowpea severe mosaic virus.*
- Seed health test should be conducted at the port of entry.

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5.3 WEEDS

5.3.1 Rigid ryegrass (*Lolium rigidum L.*)

5.3.1.1 Hazard Identification

Name of weed: *Lolium rigidum* L.

Common name: Rigid ryegrass

English name: annual ryegrass; stiff darnel; Swiss ryegrass; Wimmera ryegrass

Taxonomic Position:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Monocotyledonae
Order: Cyperales
Family: Poaceae
Genus: Lolium
Species: Lolium rigidum (5)

Bangladesh Status: Not present in Bangladesh

5.3.1.2 Biology

Lolium rigidum is an annual herb which reproduces solely by seed. The dominant habit is erect, but the species is variable in habit, ranging from dense prostrate to more open erect types. Geniculate stems, fibrous root system, up to 1 m high. Reddish-purple coloration at base of stems extends upwards as the plant matures. Leaf blades dark green, hairless, flat, upper surface evenly ribbed, lower surface smooth and shiny, 5-25 cm long, 3-5 mm wide. Young leaves rolled in bud. Auricles small and narrow.Ligule, white, translucent, shorter than wide.Leaf sheath hairless, with fine longitudinal ribs as in leaf blades, reddish-purple at base. Inflorescence is a spike up to 30 cm in length; spikelets edge on to the rachis. Rachis is recessed opposite each spikelet, which more or less fits into the recess. Spikelets of 10-12 florets, laterally flattened, green, 10-25 mm long. Only the terminal spikelet has two more or less equal glumes. Otherwise only one glume subtending each spikelet, lanceloate, 10-15 mm long, two-thirds to three-quarters as long as the spikelet, outer surface fine-veined, ribbed like the upper surface of the leaf blade. No awn. Lemma lanceolate, about 5 mm long, five nerved, usually with no awn, but terminal awns occasionally found, probably as a result of hybridization. Palea similar to lemma in shape and size, two nerves with tiny hairs along them. Anthers three, yellow in color (5). It is highly competitive with crops and is a prolific seed producer and reported to prduce 31,000-45,000 seeds per m² in a wheat crop (7). The weed is highly adaptable to different environments.

It displays a high degree of genetic variability, enabling it to rapidly adapt to a range of climatic, edaphic and agricultural situations (6). In Australia, *L. rigidum* populations with large differences in phenological development have been documented, demonstrating adaptation to local environments since the species introduction to that continent (3).The optimum temperature for germination is 11°C for buried seeds and 27° for surface seeds (1). Buried seeds germinate faster than those on the soil surface with the optimum position being 2cm deep.

5.3.1.3 Host

Chickpea, lentil, barley, oats, rape, beetroot, lupin, faba bean, European olive and wheat are the known host for this weed (5).

5.3.1.4 Geographical Distribution

Rigid ryegrass is present in **Australia**, **India** and **Turkey** among the selected pulse exporting countries to Bangladesh. Other countries include Afghanistan, Armenia, Azerbaijan, Georgia, Iran Iraq, Israel, Jordan, Kuwait, Lebanon, Pakistan, Saudi Arabia, Syria, Turkmenistan, Uzbekistan In Asia; Algeria, Egypt, Libya, Morocco, South Africa and Tunisia in Africa; Mexico and USA in North America; Argentina and Chile in South America; Albania, Bulgaria, France, Greece, Italy, Portugal, Russian Federation, Spain, Switzerland and Ukraine in Europe (5).

5.3.1.5 Hazard Identification Conclusion

Considering the facts that:

- *Lolium rigidum* is not known to be present in Bangladesh;
- It is present in many countries in the world including Australia, India, and Turkey
- Lolium rigidum seed has been reported to be associated with pulse seed/grain
- Therefore *L. rigidum* is identified as a potential hazard organism for this commodity in this risk analysis.

5.3.1.6 Risk Assessment

5.3.1.6.1 Entry Assessment

Studies in Australia showed that a high proportion of seeds of *L. rigidum* associated with farmers lentil and chickpea seed (8). The weed is present in Australia and there high probability of entering this organism through this pathway from Australia or other countries where this weed is present.

5.3.1.6.2 Exposure Assessment

After entry, the seeds are transported to different parts of the country. During handling and transport operations the weed seed may be fall on the ground and exposed to the environment. It also exposed to the environment if contaminated imported seeds are sown. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.3.1.6.3 Establishment

Once exposed to the environment the seed will germinate under optimum condition. The optimum temperature for germination is 11°C for buried seeds and 27° for surface seeds. Under such circumstances the probability of establishment of this weed is high in the PRA area.

5.3.1.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**Yes**)[5] • The pathway appears good for this pest to enter Bangladesh and establish, and (**Yes**, In Australia farmers saved lentil and chickpea seed were found contaminated with annual ryegrass seed (8)]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	**High**
• Not as above or below	Moderate
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.1.7 Consequence Assessment

5.3.1.7.1 Economic Impact

It has significant economic impact on crop production. Experiments conducted with *L. rigidum* at 300 plants m^{-2} showed the yield losses of different crops as: oats (*Avena sativa* L.), 2–14%; cereal rye (*Secale cereale* L.), 14–20%; and triticale (×*Triticosecale*), 5–24%; followed by oilseed rape, (*Brassica napus* L.), 9–30%; spring wheat (*Triticum aestivum* L.), 22–40%; spring barley (*Hordeum vulgare* L.), 10–55%; and, lastly, field pea (*Pisum sativum* L.), 100%, and lupin (*Lupinus angustifolius* L.), 100% (4).

5.3.1.7.2 Environmental Impact

Lolium rigidum is susceptible to ergot fungus (*Clavibacter purpurea*) and the inflorescences infected with the plant pathogen produce corynetoxins toxic to man and livestock. In Australia, between 1968 and 1999, annual ryegrass toxicity resulted in the deaths of an estimated 147,000 sheep and 500 cattle (2).

5.3.1.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.1.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table3.Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **High**

5.3.1.9 Phytosanitary Measures

- Pulse seeds to be used for growing the crop for export purpose should free from annual ryegrass seed.
- Prevent seed production for several consecutive years.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of annual ryegrass.
- Declare in Phytosanitary certificate that the consignment is free from annual ryegrass seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially from Australia, India and Turkey origin,

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5.3.2 Bedstraw (*Galium tricornutum*)

5.3.2.1 Hazard Identification

Scientific Name of the weed: *Galium tricornutum* Dandy

Common name: Bedstraw, rough corn bedstraw, roughfruit corn bedstraw, and corn cleavers

Synonyms: *Ga*

*lium spurium*Huds.,*Valantia triflora* Lam., *Valantia spuria* Pers., *Galium tricorne* var. *microcarpum* Gren. & Godr. , *Galium tricorne* var. *laeve* Texidor, *Horneophyton tetracoccum* Philbin, *Galium borbonicum*Cordem.,*Galium kurramensis* Nazim., *Galium tricornutum* subsp. *longipedunculatum* Nazim.

Taxonomic position:
Kingdom: Plantae
Subphylum: Euphyllophytina
Subclass: Magnoliidae
Superorder: Asteranae
Order: Gentianales
Family: Rubiaceae
Tribe: Rubieae
Genus: Galium
Species: *G. tricornutum* (5)

Bangladesh status: Not present in Bangladesh

5.3.2.2 Biology

Galium tricornutum is an annual herb with trailing or climbing stems usually 50 centimeters in length can be up to one metre long. Stems covered with downwardly pointing prickles, especially along the ribs. The stems are sometimes nearly square in cross-section. Leaves are arranged in whorls of 6 to 8 about the stem and are narrow, pointed, and bordered with prickles. Flowers appear in thin clusters of white corollas. The fruits are spherical nutlets hanging in pairs at the leaf axils. This plant is sometimes a weed of grain fields. Native range is from Europe to central Asia. A widespread but relatively uncommon weed of cultivated land and other disturbed areas in temperate parts of the world, including south east Australia.In Australia it is mainly found in fields that have been cropped for a number of years. Appears worse in areas that have pulse crops incorporated in to the rotation. Principally occurring on alkaline soils with annual rainfall from 300-550 millimetres, but also found on other soil types (6).

Seed germination was considerably higher under an alternating day/night temperature range of 13/7 C compared with 20/12 or 25/15 C day/night temperature. Germination was inhibited by light; however, when seeds were subsequently transferred to complete darkness they germinated readily (1).

5.3.2.3 Host

The weed has been recorded in cereals, pulses and oilseed crops (6).

5.3.2.4 Geographical Distribution

Afghanistan, **Australia**, Austria, Belgium, Bulgaria, **Canada, China**, Czechoslovakia, Cyprus, Egypt, France, Germany, Greece, Hungary, **India**, Indonesia, Iraq, Iran, Ireland, Israel, Italy, Japan, Jordan, Kirgizistan, Lebanon, Libya, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Romania, Spain, Sweden, Switzerland, **Turkey**, Ukraine, United Kingdom, United States, Uzbekistan (4).

5.3.2.5 Hazard Identification Conclusion

Considering the facts that:

- *Galium tricornutum* is not known to be present in Bangladesh;
- It is present in many countries in the world including Australia, Canada, China, India and Turkey
- *Galium tricornutum* seed has been reported to be associated with pulse seed/grain
- Therefore this weed is identified as a potential hazard organism for this commodity in this risk analysis.

5.3.2.6 Risk Assessment

5.3.2.6.1 Entry Assessment

Studies in Australia showed that a high proportion of seeds of *Galium tricornutum* associated with farmers' lentil and chickpea seed (7). The weed is present in Australia, Canada, China, India and Turkey and there is high probability of entering this organism through this pathway.

5.3.2.6.2 Exposure Assessment

After entry, the seeds are transported to different parts of the country. During handling and transport operations the weed seed may be fall on the ground and exposed to the environment. It also exposed to the environment if contaminated imported seeds are sown. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

5.3.2.6.3 Establishment

Once exposed to the environment the seed will germinate under optimum condition. The optimum day/night temperature for germination is 13/7 C but can germinate at 20/12 or 25/15 C day/night temperature (1). Such conditions are available in the PRA area. Under such circumstances the probability of establishment of this weed in Bangladesh is high.

5.3.2.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	The Establishment Potential is:
• This pest has established in several new countries in recent years, and (**Yes**)[2] • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**, Pulse seed is reported to be contaminated with Bedstraw seed (7)]). • Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established. ***YES*** [This weed is a pest in cereals, pulses and oilseed crops common in Bangladesh (6).	**High**
• Not as above or below	Moderate
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.2.7 Consequence Assessment

5.3.2.7.1 Economic Impact

Bedstraw can cause a significant yield loss in crops. It has major impact on quantity and quality of produce (5-20%) (3).

5.3.2.7.2 Environmental Impact

Exact impacts on threatened flora have not been determined, but are unlikely to be great. Prickles present at certain times of year, may be injurious to fauna. Doesn’t provide harbour for serious pest species, may provide for minor pests (3).

5.3.2.7.3 Determination of Consequence of the Pest Establishing Via This Pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh (6)	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.2.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	**Consequence potential**	**Risk rating**
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – **High**

5.3.2.9 Phytosanitary Measures

- Pulse seeds to be used for growing the crop for export purpose should free from bedstraw seed.
- Preferably grow the crop for export purpose in areas free from bedstraw weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of bedstraw.
- Declare in Phytosanitary certificate that the consignment is free from bedstraw seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially if the consignment is Australia, Canada, China, India or Turkey origin.

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5.3.3 Small canarygrass (*Phalaris minor Retz*)

5.3.3.1 Hazard Identification

Name of weed: *Phalaris minor* Retz.

Common name: Small canarygrass, little seed canarygrass

Taxonomic position:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Monocotyledonae
Order: Cyperales
Family: Poaceae
Genus: Phalaris
Species: Phalaris minor (4)

Bangladesh Status: Not present in Bangladesh

5.3.3.2 Biology

Phalaris minor is a winter annual propagated by seeds. It is erect or decumbent, caespitose, more-or-less slender with stems up to 90 cm tall. Leaves long, linear, acuminate; sheath smooth; ligule an oblong hyaline membrane, about 5 mm long (3, 6). Panicle more-or-less protruding or entirely protruding from the uppermost swollen leaf sheath, ovate to oblong, 5-8 cm long, green; spikelets green, broadly lanceolate on short pedicels, shining, not as conspicuously striped as in P. brachystachys, 4-5 mm long, strongly laterally compressed. Glumes 4-6 mm long, fertile lemma lanceolate about 3 mm long, more or less lustrous; sterile lemma solitary, about 1 mm long. Glumes acute, but not mucronate, with a minutely toothed wing.Hermaphrodite florets with palea villous with applied hairs, and with very small filiform residue of a neutral floret at the base.

The seeds germinate best at a temperature range of 10-20°C (1). No germination occurs at temperatures below 5°C or above 30°C. Alternating temperatures of 20/10°C gave the highest germination, and light had no effect on P. minor germination (7). The seeds do not exhibit dormancy but require ca 4-5 months of after-ripening to attain maximal germination (7). The seeds retain viability for 5-6 years when stored under room conditions (2), but their fate in soil is not known. The seeds are reported to undergo secondary dormancy under anaerobic conditions (5).

5.3.3.3 Hosts

Allium cepa (onion), Brassica juncea var. juncea (Indian mustard), ***Cicer arietinum* (chickpea**), *Hordeum vulgare* (barley), ***Lens culinaris* subsp. *culinaris* (lentil)**, *Linum usitatissimum* (flax), *Pisum sativum* (pea), *Solanum tuberosum* (potato), *Trifolium alexandrinum* (Berseem clover), *Triticum aestivum* (wheat) (4)

5.3.3.4 Geographic Distribution

Asia: Afghanistan, Bhutan, **India**, Indonesia, Iran, Iraq, Israel, Jordan, Lebanon, Saudia Arabia, Pakistan,

North America: Mexico, USA

Africa: Egypt, Morocco, South Africa, Zimbabwe

Central/Caribbean: Bolivia, El-Salvador,

South America: Argentina, Brazil, Equador, Colombia. Uruguay.

Europe: Spain, Italy, Portugal, France, Greece, UK

Oceania: **Australia** (4)

5.3.3.5 Hazard Indentification Conclusion

Considering the facts that:

- *Phalaris minor* Retz. is not known to be present in Bangladesh
- is present in Australia and India
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

*Phalaris minor*is considered to be a potential hazard organism in this risk analysis.

5.3.3.6 Risk Assessment

5.3.3.6.1 Entry Assessment

The weed is reported from Australia, India, Mexico, Pakistan, and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

5.3.3.6.2 Exposure Assessment

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that before milling the grains are generally cleaned and disposed the light weighted or unfilled grains along with dirt which may contain the weed seed. The probability of exposure to the nature is high.

5.3.3.6.3 Establishment Assessment

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. Seed can germination in a wide range of environmental conditions. The environmental condition in Bangladesh is favorable for it growth. Therefore the probability of establishment in the PRA area is high.

5.3.3.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No**)[] • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**,). • Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established. ***YES*** [This weed is a pest in cereals, pulses and oilseed crops common in Bangladesh	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.3.7 Consequence Assessment

5.3.3.7.1 Economic Consequence

Phalaris minor is a very competitive weed in several winter crops in many Mediterranean countries, the Middle East, Asia, Australia and South Africa. Yield losses vary depending on crop, climate and management practices. The losses are maximum in crops of short stature. In India, yield losses in wheat due to this weed ranging from 15-50% (Gill et al., 1978). Cudney and Hill (1979) recorded 40-60% reduction in wheat yield

5.3.3.7.2 Environmental Consequence

Not known

5.3.3.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	Consequence
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.3.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – High

5.3.3.9 Phytosanitary Measures

- Pulse seeds to be used for growing the crop for export purpose should free from bedstraw seed.
- Preferably grow the crop for export purpose in areas free from bedstraw weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of bedstraw.
- Declare in Phytosanitary certificate that the consignment is free from bedstraw seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially if the consignment is Australia or India origin.

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5.3.4 Pennycress (*Thlaspi arvense*)

5.3.4.1 Hazard Identification

Scientific name of weed: *Thlaspi arvense* L.

Common name: Pennycress, field pennycress, bastardcress, fan weed, stink weed

Taxonomic position:

Kingdom: Plantae
Class: Dicotyledonae
Order: Capparidales
Family: Brassicaceae
Genus: Thlaspi
Species: Thlaspi arvense (1)

5.3.4.2 Biology

Thlaspi arvense is an annual or winter annual. The entire plant is glabrous and bright green, with an unpleasant odour when bruised. Stems are erect, 18 to 80 cm tall, simple or branched above. The leaves are alternate, with basal leaves narrowly obovate, petioled and soon withering, the middle and upper leaves are oblong, entire or irregularly toothed and clasp the stem by two ear-lobes, 1 to 1.5 mm long. The flowers are initially in a small, flat cluster at the top of the leafy stem with racemes becoming elongated when in fruit, perfect, regular with four sepals, four white petals, 3 to 4 mm long; six stamens, two shorter than others. The silicule is pod-like, borne on slender, upward curving stalks, bright green to yellowish to greenish-orange. As the seeds ripen they are easily seen in crop fields, almost circular, 1.25 cm across, strongly flattened and winged. The very short style persists in a deep, narrow notch at the top of the wings, dehiscent, the two-winged locules each with 4 to 16 seeds. The seeds are ovoid, 1.2 to 2.3 mm long and 1 to 1.5 mm wide, reddish or purplish-brown to black, unsymmetrically oval in outline, somewhat flattened with several concentric ridges resembling a finger print, each face with a narrow groove extending from the hilum to the centre of the seed.*T. arvense* is a prolific seed producer, with yields as high as 20,000 seeds/plant and seed germinate well at 10-25°C (1, 2).

5.3.4.3 Hosts

Allium cepa, A. porrum, Asparagus officinalis, Avena sativa, Beta vulgaris, Brassica napus var. napus, Carthamus tinctorius, ***Cicer arietinum****, Daucus carota, Glycine max, Gossypium* spp., *Helianthus annuus, Hordeum vulgaris,* ***Lens culinaris****, Linum usitatissimum, Medicago sativa, Oryza sativa, Phaseolus* spp., *Pisym sativum, Solanum tuberosum, Triticum aestivum, Visia fabam Zea mays (1).*

5.3.4.4 Geographic Distribution

Asia: Afghanistan, Argentina, Armenia, Bhutan Azerbaijan, **China**, Colombia, Georgia, Iran, Ireland, Israel, Italy, Japan, Jordan, Korea (DPR), Korea (Republic), Pakistan, Russia Federation, Tajikistan, **Turkey**, Turkmenistan.

Africa: Spain, South Africa, Tunisia.

America: **Canada**, Greenland, USA

Europe: Austria, Albania, Belarus, Belgium, , Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Latvia, Lebanon, Lithuania, Luxembourg, Mongolia, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland, UK.

Oceania: Australia, New Zealand (1).

5.3.4.5 Hazard Indentification Conclusion

Considering the facts that:

- *Thlaspi arvense* L. is not known to be present in Bangladesh;
- is present in Australia, Canada, China and Turkey from where Bangladesh imports pulse;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

Thlaspi arvense is considered to be a potential hazard organism in this risk analysis.

5.3.4.6 Risk Assessment

5.3.4.6.1 Entry Assessment

The weed is reported from Australia, Canada, China and Turkey from where Bangladesh is importing pulses. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with the grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

5.3.4.6.2 Exposure Assessment

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that before using the grains are generally cleaned and disposed the light weighted or dirts which may contain the weed seed. The probability of exposure to the nature is high.

5.3.4.6.3 Establishment Assessment

The environmental condition in Bangladesh Is suitable for the growth of *T. arvense.*The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. The seeds are winged and wind dispersal may carry the seed for distances of up to 1 km or more. Therefore the probability of establishment in the PRA area is high.

5.3.4.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**No**)[] • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**,). • Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established. ***YES*** [This weed is a pest in cereals, pulses and oilseed crops common in Bangladesh	High
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.4.7 Consequence Assessment

5.3.4.7.1 Economic Consequence

Thlaspi arvense is a weed of 30 crops in 45 countries and is classified as a serious or principal weed in 12 countries. In Saskatchewan in 1988 and 1989, mean seed yield per plant of lentil has been increased up to 930% when the weed was controlled (3).

5.3.4.7.2 Environmental Consequence

Thlaspi arvense acts as an alternative host to a range of crop pests and diseases and may be toxic to cattle.

5.3.4.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.4.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – High

5.3.4.9 Phytosanitary Measures

- Pulse seeds to be used for growing the crop for export purpose should free from bedstraw seed.
- Preferably grow the crop for export purpose in areas free from bedstraw weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of bedstraw.
- Declare in Phytosanitary certificate that the consignment is free from bedstraw seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially if the consignment is Australia, Canada, China and Turkey origin.

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5.3.5 Hogweed (*Boerhavia diffusa L*.)

5.3.5.1 Hazard Identification

Scientific name of weed:*Boerhavia diffusa* L.

Common name: Hogweed; red spiderling, pigweed; spreading hogweed

Taxonomic position:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Caryophyllales
Family: Nyctaginaceae
Genus: Boerhavia
Species: *Boerhavia diffusa* (1)

Bangladesh Status: Not present in Bangladesh

5.3.5.2 Biology

The genus *Boerhavia* can be recognised by its erect or diffused herbaceous habit, funnel-shaped, plicate limb of the perianth and paniculate inflorescence. Prostrate or ascending herb, to 50 cm long, many-branched from a taproot; twigs cylindrical, glabrous. Leaves in unequal pairs; blades 1.2-5.5 × 1.3-4 cm, ovate to wide ovate, chartaceous, sparsely pilose, especially on veins, lower side glaucous, the apex rounded to acute, shortly apiculate, the base rounded, truncate to nearly cordate, the margins wavy, ciliate; petioles pilose, 0.5-3 cm long. Flowers nearly sessile, 2-4-7) in terminal, subcapitate clusters on axillary racemes or terminal panicles, 10-30 cm long; the axes glabrous; bracts and bracteoles lanceolate. Calyx base 0.5-1.5 mm, puberulent, the limb funnel-shaped, red or violet, 0.6-1 mm long; stamens usually 2, slightly exserted. Anthocarp sessile, green, glandular pubescent, sticky, short club-shaped, 2-2.5 mm long, 5-ribbed.*B. diffusa* is a tropical species growing in various soil types in waste places, along roadsides, near habitations, in and along cultivated fields and in open cleared patches in forests. The weed is also noted in dry waste lands, cultivated land and pasture. In China it is found in open places near sea, and in dry and warm river valleys, at 100-1900 m. *B. diffusa* propagates by root stocks and by seed, although seeds only account for 21% of reproduction. It flowers and fruits throughout the year (6) a weed in ruderal areas, preferring sunny sites, sandy soils and a slightly seasonal climate, from sea-level up to 1900 m altitude. It is also a weed in cultivated land and grazing pasture. It prefers soils with pH ranging from 6.6 to 7.8 (8).

5.3.5.3 Host

Cowpea, groundnut, Indian mustard, cassava, tobacco, rice, sugarcane, date-plam, pearl millet and black mustard are the natural main host for this weed. *B. diffusa* is reported as one of the predominant weeds of cassava in Venezuela (9). It is the most common principal weed of date palm orchards in India (3) and is one of the most problematic weeds in mustard in India (10), where it is also recorded as a weed in tobacco, pearl millet and groundnut (7, 11, 12). In Nigeria it is also recorded as a main weed in upland rice (4). In Hawaii this species is a common weed spreading rapidly principally in coastal areas, disturbed places, and disturbed forests (13).

5.3.5.4 Geographical Distribution

Boerhavia diffusa has been reported tobe present in China, India, Nepal and Australia among the selected pulse exporting countries to Bangladesh. The weed is widespread in India and China. This is also present in most of the countries in Asia, African, Central America and Caribbean and South America (1).

5.3.5.5 Hazard Indentification Conclusion

Considering the facts that:

- *Boerhavia diffusa* L. is not known to be present in Bangladesh;
- is present in Australia, China, India and Nepal;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of cowpea or other host species as contaminant; and thus

Boerhavia diffusa is considered to be a potential hazard organism in this risk analysis.

5.3.5.6 Risk Assessment

5.3.5.6.1 Entry Assessment:

The weed is reported from Australia, China, India and Nepal from where Bangladesh imports pulses especially cowpea. However as the cowpea plant is taller than the weed there is less possibility of mixing weed seed with cowpea seed. Therefore the probability of entry into Bangladesh is considered as low.

5.3.5.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. The probability of exposure to the nature is medium.

5.3.5.6.3 Establishment Assessment: High

The environmental condition in Bangladesh is suitable for the growth of *Boerhavia diffusa.*The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. Therefore the probability of establishment in the PRA area is high.

5.3.5.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	**The Establishment Potential is:**
• This pest has established in several new countries in recent years, and (**Yes** –[2]) • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**,]). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	**High**

Description	**The Establishment Potential is:**
• Not as above or below	Moderate
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.5.7 Consequence Assessment

5.3.5.7.1 Economic Impact

B. diffusa is reported as one of the predominant weeds of cassava in Venezuela (9). It is the most common principal weed of date palm orchards in India (3) and is one of the most problematic weeds in mustard in India (10), where it is also recorded as a weed in tobacco, pearl millet and groundnut (7, 11, 12). In Nigeria it is also recorded as a main weed in upland rice (4). In Hawaii this species is a common weed spreading rapidly principally in coastal areas, disturbed places, and disturbed forests (12).*B. diffusa* indirectly limits crop production by serving as an alternative host to crop pests; the weed provides food, shelter and reproductive sites for insects, nematodes and pathogens (5).

5.3.5.7.2 Environmental Impact

Boerhavia diffusa is a first growing weed. It can reduced native biodiversity, cause modification of successional patterns and negatively impacts agriculture

5.3.5.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh.

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.5.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	X	Consequence Potential	=	Risk

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	**High**	**High**
High	Moderate	High
Moderate	High	High
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – HIGH

5.3.5.9 Phytosanitary measures

- Pulse seeds to be used for growing the crop for export purpose should free from bedstraw seed.
- Preferably grow the crop for export purpose in areas free from bedstraw weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of bedstraw.
- Declare in Phytosanitary certificate that the consignment is free from bedstraw seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially if the consignment is Australia, China, India or Nepal origin.

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5.3.6 Hoary cress (*Cardaria draba*)

5.3.6.1 Hazard Identification

Scientific name of weed: *Cardaria draba* (L.) Desv.

Synonym*: Lepidium draba* L.

Common name: Hoary cress, heart- podded, thanet cress, white top, white weed, perennial peppergrass

Taxonomic position:

Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Capparidales
Family: Brassicaceae
Genus: Cardaria
Species: Cardaria draba(5)

Bangladesh Status: Not present in Bangladesh

5.3.6.2 Biology

Cardaria draba is an annual or perennial herb (6), Stems are erect, subglabrous or grey-pubescent. Height approximately 10-50 cm, with a deep tap root or branched woody rootstock. Stems simple or branched above, covered with shallowly-toothed ovoid leaves clasping the stem with arrow-shaped bases, erect, arising from branching, woody stock. Basal leaves petioled, spatulate to narrowly-obovate, dentate-repand. The upper part of the stem branches into several many-flowered, long-stalked racemes of white flowers. Leaves up to 10 x 4.5 cm, the radial ones more or less petiolate, spatulate or obovate-oblong, entire or dentate-repand, sometimes lyrately-lobed; stem leaves sessile, lanceolate to ovate with downward-pointed lobes at base, usually acute, dentate or entire, spreading to erect, oblong-lanceolate to broadly elliptical or ovate, sagittate-amplexicaul, acute or obtuse, entire or dentate.

The inflorescence is a dense flat-tapped corymbose panicle, terminal, pedicels 2-10 mm long (6). Flowers are white and measure 3-4 mm. Sepals 1.5-2 x 1 mm, spreading, glabrous, scarious-white-margined. Petals twice as long as sepals, white; anthers yellow. Fruiting racemes elongated with pedicels 8-12 mm long; about 2-3 times as long as fruit, more or less horizontal ascending or spreading, teretefiliform. Fruits are pale brown, cordate-silicate, up to 5 mm, unwinged, transversely ovoid-cordate or heart-shaped, tipped by about 1 mm long persistent style and capitate stigma, sometimes one of the two cells rudimentary, valves reticulate, glabrescent, somewhat turgid, netted when dry, do not break open but break up into one-seeded portions which are then dispersed two-valved. Seeds solitary, ovoid, 2 mm long, 1.5 mm wide, slightly compressed, ellipsoidal, reddish-brown (1).One plant can eventually result in a large colony and push out other vegetation to form a monoculture.One plant can produce from 1,200-4,800 seeds (3). Buds at or below the soil surface may become subterranean roots that are able to produce shoot buds later, whereas buds higher up the plant become rosettes. New crowns form rapidly from adventitious buds on upper roots if the crown is damaged. In this way, dense colonies of the weed can easily exclude other vegetation (4).

The minimum temperature for germination was 0.5°C, the maximum was 40°C, and the optimum was between 20 and 30°C (2). Seeds buried at a depth of 10-15 cm for 3 years rapidly decreased in viability; however, they were reported to retain viability in the soil for about 2 years (3).

5.3.6.3 Hosts

Avena sativa, Beta vulgaris, Citrus spp., Fragaria ananassa, Gossypium hirsutum, Helianthus annus, Hordeum vulgaris, ***Lens culinaris****, Medicago sativa, Nicotiana tabacum, Pyrus communis, Quercus spp., Secale cereale*, *Solanum tuberosum, Triticum aestivum, Vitis vinifera, Zea mays* (5).

5.3.6.4 Geographic Distribution

Asia: Afghanistan, Argentina, Iran, Iraq, Israel, Jordan, Lebanon, Pakistan, Russia Federation, Saudi Arabia, Spain, Syria, **Turkey**,

Africa: Egypt, South Africa, Tunisia, Zimbabwe.

North America: Canada, Mexico, USA

Central and Caribbean: Guatemala.

South America: Chile.

Europe: Bulgaria, Czech republic, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, UK.

Oceania:Australia, New Zealand (5)

5.3.6.5 Hazard Indentification Conclusion

Considering the facts that:

- *Cardaria draba* (L.) Desv. is not known to be present in Bangladesh;
- is present in Australia, Canada, and Turkey;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of lentil as contaminant; and thus

Cardaria draba is considered to be a potential hazard organism in this risk analysis.

Bangladesh Status: Not present in Bangladesh

5.3.6.6 Risk Assessment

5.3.6.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada and Turkey from where Bangladesh is importing pulses. If the pulses are not cleaned properly before seed formation, there is every possibility of becoming mixed with the grain during harvesting. Therefore the probability of entry into Bangladesh is considered high.

5.3.6.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that using the grains are generally cleaned and disposed the light weighted or dirts which may contain the weed seed. The probability of exposure to the nature is high.

5.3.6.6.3 Establishment Assessment: High

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. The seed remains viable in the soil for three years. Therefore the probability of establishment in the PRA area is high.

5.3.6.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

Table 1. Which of these descriptions best fit of the pest?

Description	The Establishment Potential is:
• This pest has established in several new countries in recent years, and (**No** –) • The pathway appears good for this pest to enter Bangladesh and establish, and (**Yes**,]).	High

Description	**The Establishment Potential is:**
• Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES***	
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and • Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established	Low

5.3.6.7 Consequence Assessment

5.3.6.7.1 Economic Consequence

Heart-podded hoary cress is the least weedy of the three hoary cresses in Canada. It is most troublesome in the Prairie Provinces, particularly in southern Manitoba and southern Alberta, and is probably the weediest hoary cress found in the United States. In Australia it causes considerable economic loss and has seriously reduced the value of pulses.

Cereal crops may experience significant yield losses where dense infestations of hoary cress are present. Pasture quality is degraded, and fodder and small seed products (egg Lucerne and clover) may be contaminated by hoary cress seed.

It has the allelopathic potential and reduces germination of wheat and some other crop seed.

5.3.6.7.2 Environmental Consequence

No information is available

5.3.6.7.3 Determination of consequence of the pest establishing via this pathway in Bangladesh

Table 2. Which of these descriptions best fit of the pest?

Description	**Consequence**
This is a serious pest of an important crop for Bangladesh	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.3.6.8 Risk Estimation

Calculation of risk of this pest via this pathway in Bangladesh.

Establishment Potential	**X**	**Consequence Potential**	**=**	**Risk**

Table 3. Calculation of risk

Establishment potential	Consequence potential	Risk rating
High	High	High
High	Moderate	High
Moderate	**High**	**High**
High	Low	Moderate
Low	High	Moderate
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – HIGH

5.3.6.9 Phytosanitary Measures

- Pulse seeds to be used for growing the crop for export purpose should free from bedstraw seed.
- Preferably grow the crop for export purpose in areas free from bedstraw weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of bedstraw.
- Declare in Phytosanitary certificate that the consignment is free from bedstraw seed.
- Test the sample at the port of entry for the presence of annual ryegrass seed especially if the consignment is Australia, Canada or Turkey origin.

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6.0 RISK MANAGEMENT

6.1 Risk Management Options and Phytosanitary Procedures for the Potential Pests

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests assessed to pose an unacceptable level of risk to Bangladesh via the importation of pulse grains from Australia, Canda, China, India, Nepal and Turkey or any other countries of pulses export (i.e. produced under standard cultivation, harvesting and packing activities). Plant Quarantine Wing of Bangladesh will consider the risk management measures proposed below is commensurate with the identified risks.

6.1.1 Pre-harvest Management Options

6.1.1.1 Use of Pest Resistant Varieties

The use of resistant varieties is a common and effective component in reducing pest risk.

6.1.1.2 Chemical Spray Program

Pre-harvest chemical sprays may be used to control pests within production fields, for example, the use of nematicides to control the root knot nematode.

6.1.1.3 Crop Rotation

Certain pulse insects, diseases and weeds can survive from season to season in the field. Depending on the type of pathogen, it may survive in the resting form in the soil or in debris, or in a living form in alternate hosts. On occasion, diseased grains are the sources of contamination for the current season crops. Therefore, a crop rotation to minimize soil disease problems is recommended.

6.1.1.4 Control of Insects

Sucking and chewing insects may transmit many diseases. For example the mungbean yellow mosaic virus disease was found to transmit by whitefly. The control of these insects and the rouging of infected plants as early as possible from the crop filed may prevent spread of diseases in the field.

6.1.1.5 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 pulse production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of insects, diseases and weeds detected.

6.1.2 Post-harvest Management Options

6.1.2.1 Sanitization of Equipment and Storage Material

All machinery, transport and storage surfaces that the pulse grains will contact should be cleaned and disinfected prior to receiving new grains. 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.

6.1.2.2 Disposal of Infected Grians

All insect infested or diseases infected grians should be discarded away from production site.

6.1.2.3 Cleaning and Grading

Pulse grains should be cleaned properly. Plant parts and weed seeds must be removed from the grains. Broken grians should be separated which enhance pest's infestation especially red flour beetle.

6.1.2.4 Drying

After threshing the moisture content of the grains remains generally higher than the desired for safe storage of grains (13-14%). Drying is the phase of the post-harvest system during which the product is rapidly dried until it reaches the safe-moisture level. The aim of drying is to lower the moisture content of the grain for safe storage and further processing. Ensuring grain is well dried at intake is very important. Moisture content of grains must be reduced to 10-12%.

6.1.3 Phytosanitary Measures

6.1.3.1 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. Establishment and maintenance of pest-free areas or production sites should be in compliance with international standards [30].

6.1.3.2 Clean and Dry Grains

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.

6.1.3.3 Accept only Certified Pulse Seeds for Crop Production

This measure is highly effective in mitigating pest risk, because it ensures the absence of specific pests, particularly pathogens, or a defined low prevalence of pests at planting. The main components of seed certification include: sampling and testing of production areas to ensure free from viruses; approval of land and seed to be multiplied; inspection of crops for variety purity and crop health; inspection of pulse grains; and sealing and labeling of certified seed. Shipments Traceable To Place of Origin in Exporting Countries

A requirement that pulse seeds to be packed in containers with identification labels indicating the place of origin, variety and grade is necessary to ensure traceability to each production site.

6.1.3.4 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 requirements of Bangladesh. If quarantine pests of pulses with high risk potential are found during inspection, the phytosanitary procedures should be maintained.

Consignments of pulses from countries where these pests occur should be inspected for symptoms of infestation and those suspected should be observed carefully in order to look for immature stages of insects. EPPO recommends [33] that grains should come from an area where khapra beetle or bruchid do not occur and where routine intensive control measures are applied.

Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.

Ethylene dibromide was previously widely used as a fumigant but is now generally withdrawn because of its carcinogenicity; Fumigation should be done with aluminium phosphide for disinfestation of grains or infested grain [33].

6.1.3.5 Requirement of Phytosanitary Certification from Country Of Origin

The phytopathological service of the country of origin should ensure that pulses of the consignment was not grown in the vicinity of pests free areas and was inspected by a duly authorized official/phytopathological service and the crops have been produced in areas within the country free from all pests and diseases.

6.1.3.6 Port-of-entry Inspection and Treatment

Upon arrival in Bangladesh, each consignment of pulse grains should be inspected to detect pests, with export phytosanitary certificate and seed certificate. Sampling of grains 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.

6.2 Risk Management for Specifice Quarantine Insect pests, Diseases and Weeds of Pulses

Insect pests, diseases organisms and weeds are transported with pulse grains. Thus risk management is essential. Manament practices for quarantine pests associated with grains trade and transportation are discussed herein.

6.2.1 Risk Management for Insect pests

Among the eight quarantine insect pests identified in the present analysis, five was found to have significant risk to enter into the PRA area through the present pathway. So, risk management options of these five insect pests have been discussed herein.

6.2.1.1 *Melanagromyza obtusa*

- Seeds of *Cajanus cajan* and *Vigna* spp. are probably not commonly transferred between regions and so no specific quarantine measures are documented. However, if seeds of *M. obtusa* hosts were to be transported to areas where *M. obtusa* is unknown it would be prudent to treat them with suitable larvicides [30].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of this pest.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.2 *Callosobruchus analis*

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene. All spillage should be removed and all cracks and crevices filled [32].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [34] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.3 *Callosobruchus phaseoli*

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene. All spillage should be removed and all cracks and crevices filled [32].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of bruchid.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [34] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.4 *Acanthoscelides obtectus*

- Good store hygiene plays an important role in limiting infestation by these species. The removal of infested residues from last season's harvest is essential, as is general hygiene. All spillage should be removed and all cracks and crevices filled [32].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of bean bruchid.
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [34] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.5 *Sitophilus granarius*

- Good storage hygiene plays an important role in limiting infestation by *S. granarius*. The removal of infested residues from the previous season's harvest is essential. All spillage should be removed and all cracks and crevices filled.
- Ensuring grain is well dried at intake is very important. Moisture content of 10-12% is desirable [31].
- Grain should be kept in dry condition for maintaining moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [5] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains or infested grain can be treated with hot air, at an inlet temperature of 300-350°C, as an alternative to fumigation. Good weevil control has been obtained by this method, with heat exposure times (around 6 seconds) that do not unduly harm the grain [36].
- Fumigation of *S. granarius* pupae with phosphine at 20°C resulted in a LT_{95} of 3.9 days (at 0.5 g/m²) and 100% mortality after 10 days [35].
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived. Because the granary weevil larvae develop inside the grain it is difficult to detect the pest by visual inspection unless its numbers are very high.

6.2.2 Risk Management for Diseases

Out of 13 quarantine diseases identified in the present analysis, seven was found to have significant risk to enter in the PRA area through the present pathway. These include two fungi (*Ascochyta lentis* and *Septoria vignicola*), two bacteria (*Curtobacterium flaccumfaciens* pv. *flaccumfaciens* and *Pseudomonas savastanoi* pv. *phaseolicola*) and three viruses (*Pea seed-borne mosaic virus*, *Alfalfa mosaic virus* and *cowpea severe mosaic virus*). Therefore, risk management options of these seven diseases have been enumerated here.

6.2.2.1 Ascochyta blight of lentil

- Planting of certified/healthy/treated seed in the country of origin for export purpose. Because the pathogen is seed-borne [2, 19].
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seeds to be grown in certification schemes.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing lentil for export purpose [13].
- In areas of high risk it may be necessary to apply foliar fungicides to protect crops [2].
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *Ascochyta lentis*
- Observe a 4 to 5 year crop rotation and do not plant lentils near fields that were infected during the previous season [17].
- Seed health test should be conducted at the port of entry.
- Integrated approach includes use of disease-free seed, destruction or avoidance of inoculum sources, manipulation of sowing dates, seed and foliar fungicides, and cultivars with improved resistance [11].

6.2.2.2 Septoria leaf spot of cowpea

- Clean cultivation, removal and burning of left over plant debris and crop rotation are useful to avoid early breakout of the disease [28].
- Foliar spray of fungicide (Antracol and Kocide 101) effectively controlled Septoria leaf spot [20].
- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection [12].
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing cowpea for export purpose.

6.2.2.3 Tan spot of mungbean and cowpea

- Regular field inspection by competent authority for the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.
- Follow crop rotation to minimize the disease [14].

- As the pathogen is seed-borne [14], seed health test should be conducted previous to shipment to confirm that the lot is free from infection such test should also be conducted at the port of entry.
- Proper seed cleaning to remove other plant parts.
- Use of disease resistant varieties for growing cowpea and mungbean for export purpose.

6.2.2.4 Halo blight of mungbean and cowpea

- Use of disease resistant varieties for growing cowpea and mungbean
- Use disease free seeds for sowing.
- Deep-ploughing or removal of infected debris to reduce initial inoculum sources.
- Crop rotation with cereals such as wheat, barley, oat and maize for 3 or more years is recommended [14].

6.2.2.5 Pea seed-borne mosaic

- Use of disease resistant varieties for growing.
- The use of virus free seed is the most effective strategy for managing pea seed-borne mosaic disease and is the best method for controlling the disease.
- Monitoring and minimising the spread of the disease by controlling aphids with insecticides but proves only partial control [29].
- Crop rotation with cereals.

6.2.2.6 Alfalfa mosaic disease

AMV is spread by sowing infected seed or by movement of aphid vectors from infected plants to healthy plants. Low levels of seed infection in pulses may lead to spread of AMV during years with high rainfall, and a subsequent early build up of large aphid populations.

- Planting of certified/healthy seed in the country of origin.
- Chemical control of aphids is not an effective method for controlling AMV.
- Sowing healthy seed, managing weeds and other cultural practices to minimise AMV spread are recommended.
- Retaining stubble is thought to reduce aphid landing rates and therefore virus spread, as aphids are attracted to bare ground.
- Sowing early, and at optimal seeding rates, will generate early canopy closure. Early canopy closure will shade out weak plants grown from infected seed, and reduce in crop spread of AMV by aphids [1].

6.2.2.7 Cowpea severe mosaic virus

- Plant resistant varieties wherever available.
- Use disease- free healthy seeds.
- Crop rotation with non-legumes for 4-5 seasons.
- Remove the infected plants at the first instance, weeds and alternate hosts.
- Management of vectors through insecticide sprays to prevent secondary infection.
- Periodic field inspection should be done by competent authority to confirm the presence of the disease.
- Seeds/grain for export should be collected from areas free from the disease.

6.2.3 Risk management for Weeds

Among the weeds six species were identified as quarantine pests having significant risk entering the PRA area through the present pathway and management option of these six weed species are enumerated in this chapter.

6.2.3.1 *Lolium rigidum*

Prevent seed production for several consecutive years to deplete the seed bank. Knowledge of the biology and ecology of annual ryegrass is essential for effective management. Ensure good farm hygiene to prevent new infestations and minimise weed spread. Use of herbicide is the most common practice to control this weed. Use of an integrated weed management program will help to delay or manage herbicide resistance. Burning residues, mouldboard ploughing, pasture spray topping, manuring crops and pastures are some other practices for controlling rigid ryegrass [10]. Late spring grazing can reduce annual ryegrass seed production by 95% [25]. Crop rotation [23] and fallowing [26] is effective to control the weed.

6.2.3.2 *Galium tricornutum* (Bedstraw)

Bedstraw is a competitive climbing plant that can form dense tangled clumps in crops. There are effective herbicides for cereal crops and grass pastures, but it is more difficult to control bedstraw in canola, pulses and legume-based pastures. Integrated Pest Management plan using a range of biological, chemical, mechanical, physical or cultural control methods. Imazethapyr provided acceptable control of bedstraw in faba beans, field peas and chickpeas when applied pre-emergence, and in field peas post-emergence. Chickpea and faba beans were intolerant to imazethapyr applied post-emergence. Flumetsulam applied post-emergence gave effective control of bedstraw seed production in chickpeas and field peas. Faba beans were intolerant to flumetsulam. Bentazone, pyridate, diflufenican, simazine and metribuzin failed to give adequate control of bedstraw in pulse crops. Preventing seed set in the year prior to growing lentil is very important. Delaying sowing is an option in most areas except the lower rainfall areas (below 350 mm). This strategy can enable several weed kills before sowing. Delayed sowing is practical for shorter season varieties [5].

6.2.3.3 *Phalaris minor*

Mechanical removal is very effective and useful if done during the initial growth stages of the crop. However, this is not always practical because of the morphological similarities of P. minor to wheat, in which it is a major weed. The stale seed-bed technique involves encouraging emergence of P. minor by irrigating the field, then later eliminating the weed either by shallow cultivation or by use of non-residual foliage-acting herbicides. Competitive crops such as rape, mustard, barley, etc. are useful. Rotations with fodder crops such as oats or berseem (*Trifolium alexandrinum*) and cultivation of sugarcane have been found to be effective in checking weed growth [3, 8].

Phalaris minor is highly sensitive to phenylureas. Clorotoluron, isoproturon, methabenzthiazuron and metoxuron have been widely used in India, Pakistan and the Mediterranean countries [9, 15]. Isoproturon, however, has remained as the most stable and reliable herbicide available for use in India. Excellent control of several species of Phalaris including *P. minor* has been reported with post-emergence application of diclofop-methyl [9].

6.2.3.4 *Thlaspi arvense* (Pennycress)

Populations of *T. arvense* decreased under zero tillage [4].*Thlaspi arvense* is one of the most resilient weeds, and harrowing achieved only 0-34% control, compared with 100% for herbicide treatments. *Thlaspi arvense* is a poor competitor with certain forage crops, including *Agropyron cristatum* and *Bromus inermis*. Densities of this weed could be reduced from 2000 plants/m² at 24 days after emergence to none at 82 days after emergence when grown with these crops[21]. A number of herbicides are effective for controlling T. arvense. A number of competitive wheat varieties effectively reduced the vigour of *T. arvense* individuals [6].

6.2.3.5 *Boerhavia diffusa* (Hogweed)

Methods that are commonly used to control perennial herbs and that can be used for *B. diffusa* include preparation of a clean seed bed, crop rotation, tillage methods and physical methods (hand weeding and spade digging). Seedlings are relatively susceptible to 2,4-D and some control of established plants can also be expected [18]. There is little other direct information on susceptibility of *B. diffusa* to herbicides, but those which have been noted to give good control of mixed weed populations, including *B. diffusa*, include fluchloralin and oxyfluorfen in tobacco [24] and atrazine in fodder maize [27].

6.2.3.6 *Cardaria draba* (Hoary cress)

Soil cultivation can prevent reproduction of *C. draba* by creeping roots [22], A combination of hoeing and glyphosate or weed removal when above-ground biomass was at a maximum in August and September, followed by glyphosate application in February, was the most effective strategy for control of *C. draba* [7]. In Canada, *C. draba* was eliminated in 3 years following intensive tillage (24 operations at 2-week intervals) with disc or sub-surface cultivators [16]. In lentil, prometryn provided the best control of different broadleaved weeds including *C. draba*, and gave the highest crop yields.

Cost effective herbicide regimes are available for the short term control of hoary cress. Long term eradication is often cost prohibitive, and technically difficult. A combination of cultural, herbicidal and mechanical measures may be required to reduce the impacts of hoary cress on production, which may become expensive.

Management of hoary cress is most commonly achieved through a combination of herbicides and introduction or encouragement of competitive species.

6.3 Uncertainties in Risk Management

Some quarantine pests may exist in field during management. New insect pest’s infestation may occur during post-harvest management, storage and transport. Stored grains pests infestation may occur during shipment of grains which may be unnoticed. Microorganism’s infection may occur without any visible symptoms.

6.4 Risk Management Conclusions

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

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