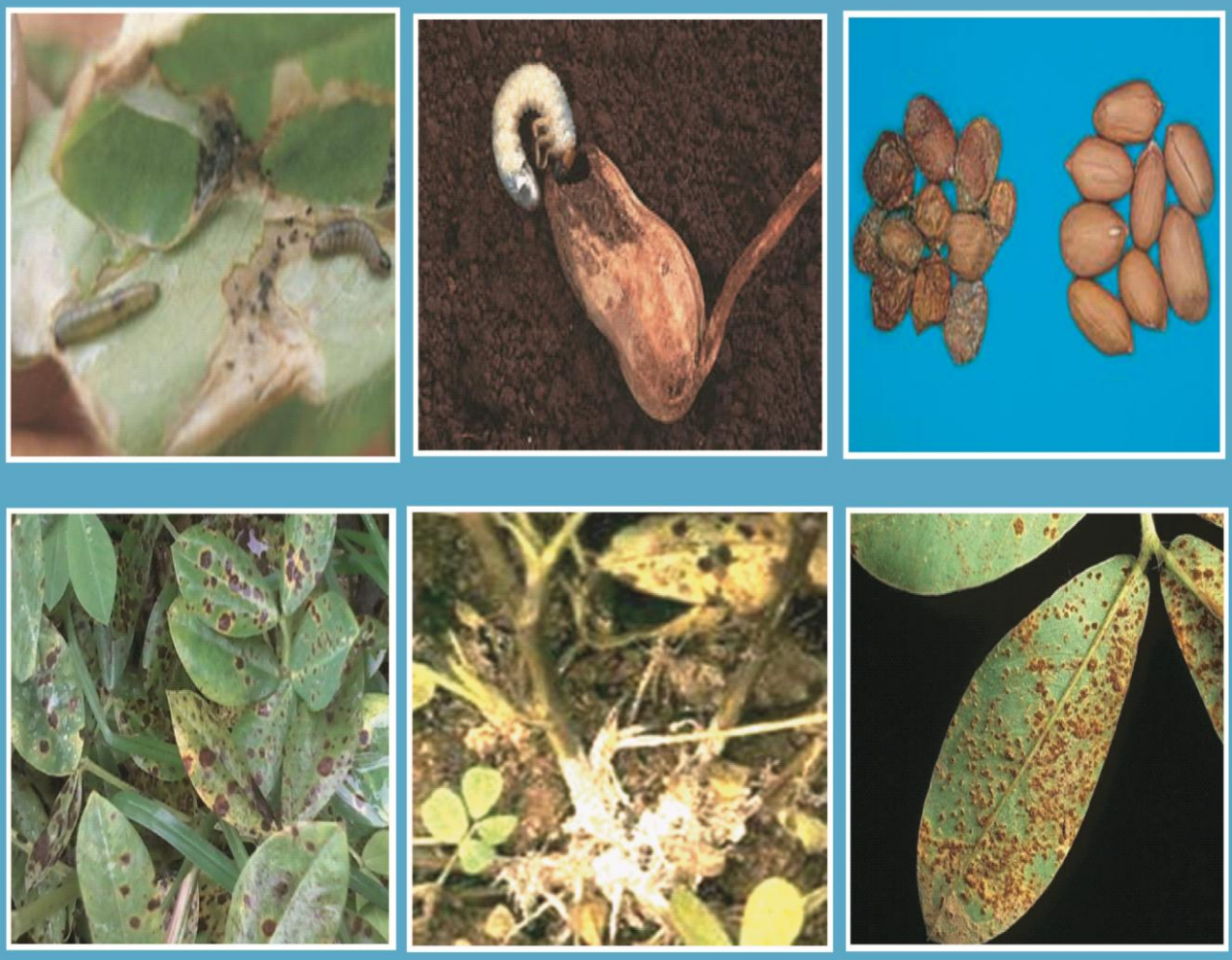
Pest Risk Analysis (PRA) of Groundnut in Bangladesh



Strengthening Phytosanitary Capacity in Bangladesh Project

Plant Quarantine Wing

Department of Agricultural Extension

Khamarbari, Farmgate, Dhaka.

June 2017

Pest Risk Analysis (PRA) of Groundnut 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 Groundnut 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 groundnut 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 28 major groundnut growing districts of Bangladesh for listing of pests of groundnut in Bangladesh. The study covered the interview of 7000 groundnut growers; 28 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 groundnut fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of groundnut including CABI & EPPO.

The study findings revealed that in Bangladesh, 41 insect and mite pests of groundnut were recorded of which 29 species were field pests and 12 species were storage pests. Number of diseases and weeds of groundnut recorded in Bangladesh was 28 and 29 respectively. From the analysis 13 insect pests, 5 diseases and 3 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 groundnut 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 groundnut.

(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 Groundnut 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 Groundnut 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 groundnut, 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 groundnut 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 Groundnut in Bangladesh"**. The Report has been prepared based on the past four months (January 2017 to April 2017) activities of the survey study in 28 major Groundnut 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**
PQW	**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

The study on Pest Risk Analysis (PRA) of groundnut (*Arachis hypogea*) was undertaken following IPPC Rules and Regulations. Bangladesh is importing groundnut from four countries namely China, India, Myanmar and Vietnam. PRA is the pre-requisite for safe movement of plant and plant products internationally. As a member of IPPC, Bangladesh has to perorm PRA for different commodities to arrive at the decision under which category a particular pest will fall and to take appropriate phytosanitary measures to prevent or restrict the movement of the pest. For safe international trade of plant and plant materials and for food security such PRA is needed for all sorts of commodities included in export/import trade. 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 NGO/Private Organizations who has qualified personnel following open bidding process. Center for Resource Development Studies Limited (CRDS), qualifying all requirements has been awarded to conduct the PRA of groundnut in Bangladesh.

In Bangaldesh, the acreage of groundnut crop, in 2014-15 cropping year, was about 0.31 lac hectares, while the production was about 0.57 lac metric tons. The crop is grown throughout the country in both rabi and kharif seasons. The production is much lower than the requirement and the deficit is fulfilled by importing the pod/seeds from other countries.

The major objectives of the project included recording of major and minor insect pests, diseases and weeds groundnut crops in Bangladesh and selected four groundnut exporting countries and listing of quarantine insect pests, diseases and weeds of groundnut. The study also included detail information on pests and pathogens, their entry, establishment and multiplication, 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 70 upazilas under 28 districts were selected and visited during March-April, 2017. In each upazila 100 farmers (10 blocks and 10 farmers from each block) were selected for data collection. Although the selected 28 districts were used for primary data collection, the entire Bangladesh was considered as the PRA area for groundnut crop, 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 China, India, Myanmar and Vietnam as well as Bangladesh. At the same time the geography and climate of the four 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 groundnut crops in Bangladesh and four 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, 41 insect and mite pests of groundnut were recorded of which 29 species were field pests and 12 species were storage pests. Number of diseases and weeds of groundnut recorded in Bangladesh was 28 and 29 respectively. Separate lists for insect and mite pests, diseases and weeds of four selected groundnut 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 13 insect pests, 5 diseases and 3 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 was done for quarantine pests. Out of 13 identified quarantine insect pests 9 species, namely *Phenacoccus solenopsis, Caliothrips indicus, Caryedon serratus, Oryzaephilus mercator, Alphitobius diaperinus, Araecerus fasciculatus, Tenebroides mauritanicus,Sitophilus granarius* and*Plodia interpunctella,* and out of five diseases 4 diseases namely yellow mold, peanut bud necrosis, peanut stripe disease, peanut mottle disease and Indian peanut clump disease, and 3 weed species (*Amaranthus retroflexus*, *Boerhavia diffusa*, and *Euphorbia geniculata*)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 16 quarantine pests of groundnut with specific approaches and methods in detail. Thus it is suggested to follow the recommended quarantine practices while importing groundnut from the aforesaid exporting countries.

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 groundnut from China, India, Myanmar and Vietnam because of deficit of groundnut for consumption in Bangladesh. But there is no pest risk analysis of imported groundnut. So, there is a scope of introducing alien pests into Bangladesh which may potentially damage our groundnut crops. So, the analysis will contribute to review of existing phytosanitary requirements for import of groundnut. 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 groundnut pests is required. Hence the present activities were taken up. Here pests are referred to insect pests, diseases and weed of groundnut and the PRA areas are the selected 28districts 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 and mite pests, diseases, weeds and other organisms of groundnut in Bangladesh and to ascertain the potential hazard organisms associated with groundnut imported from the China, India, Myanmar and Vietnam. is imported mainly for food 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 groundnut 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 Groundnut

Pest Risk Analysis (PRA) of groundnut 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 groundnut crop is grown almost all over the country. Moreover groundnut is imported through different land and sea ports which are located at all regions of Bangladesh. However, survey on insect and mite pests, diseases, weeds and other hazard organisms was done in major groundnut 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 groundnut crop.The process and methodology for undertaking import risk analyses are shown in Figure 1.

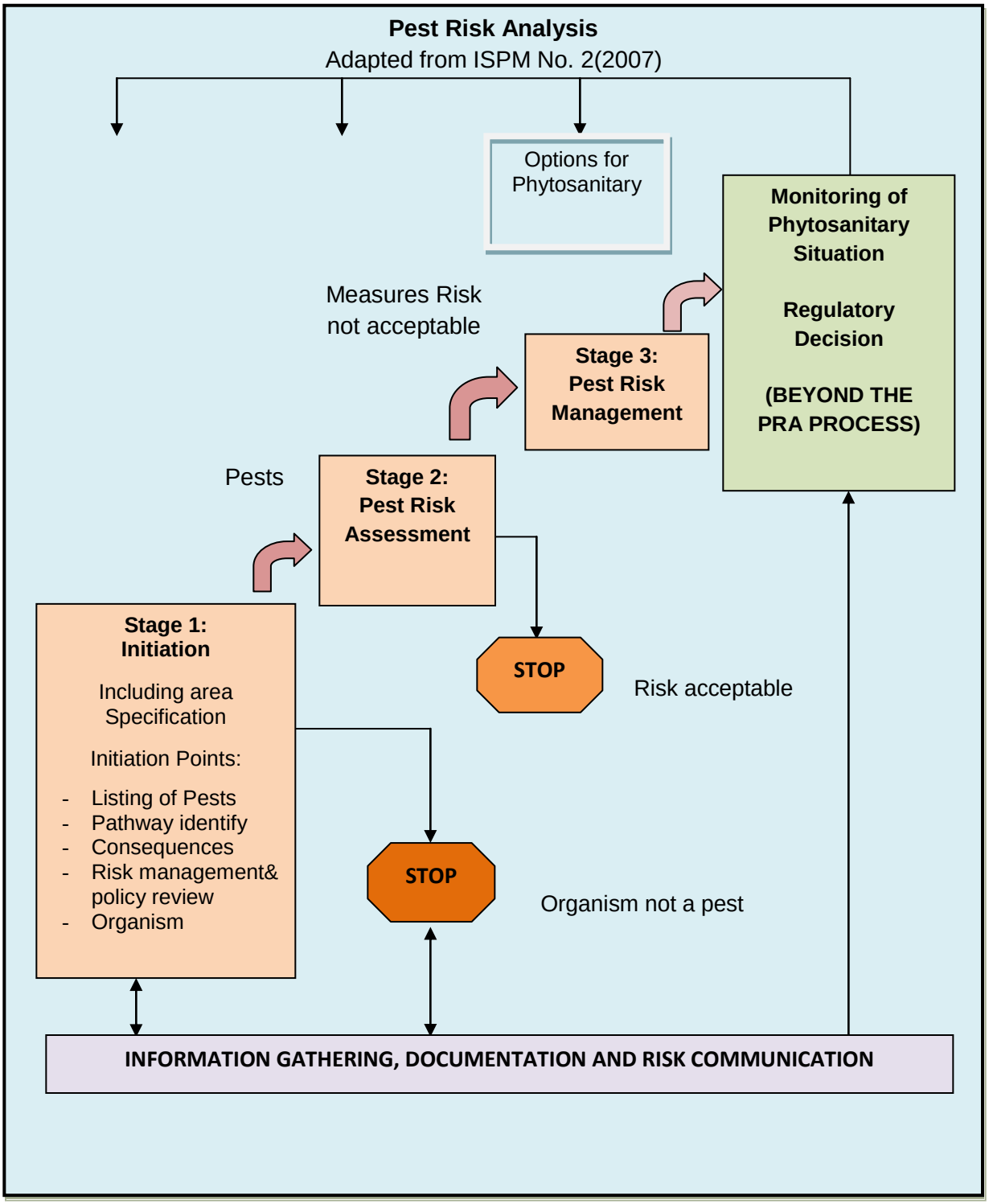


Figure 1.Schematic Diagram of Pest Risk Analysis.

Bangladesh till to date do not have any pest list of groundnut, so, to conduct PRA we first require an updated pest list of groundnut. Accordingly we conducted a survey program and take help from the Universities and Research Institutes, Extentionists, relevant stakeholders and from CABI, EPPO to make a pest list of groundnuts in Bangladesh. After completing the pest lists we have tried to asses the import risk of groundnut from the mentioned countries.

1.5.1 Methodology of Field Data Collection

In order to collect the information and present status of different insect pests, diseases and weeds in groundnut field and also infestation with insect pests in the storage and storage diseases in Bangladesh an extensive survey was conducted at 700 blocks under 70 upazilas of 28 major groundnut growing districts of Bangladesh. 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 groundnut in respected district. Moreover information on the area of groundnut 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 groundnut crop in the field and storage and control measures followed by them. Information was also collected from the Plant Quarantine Officer of various Land and Sea Ports in Bangladesh on interception of pests associated with imported groundnut. Primary data on incidence and severity of different insect pests, diseases and weeds were collected available in the field from the standing groundnut 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 groundnut crops

Sl. No.	District	Upazila
01.	Faridpur	1. Sadar
		2. Chorbhadrashan
		3. Sadurpur
		4. Bhanga
02.	Madaripur	5. Shibchar
		6. Rajoir
03.	Gopalgonj	7. Sadar
		8. Kotalipara
04.	Narail	9. Sadar
		10. Lohagora
05.	Comilla	11. Meghna
		12. Titas
		13. Homna

Sl. No.	District	Upazila
		14. Muradpur
06.	Norsingdi	15. Raipura
		16. Monohordi
07.	Kishoregonj	17. Astagram
		18. Nikhili
		19. Mithamon
08.	Sunamgonj	20. Sadar
		21. Bishambarpur
09.	Natore	22. Boraigram
		23. Sadar
10.	Noagaon	24. Atrai
		25. Manda
11.	Rangpur	26. Pirgonj
		27. Kaunia
		28. Gangachara
12.	Kurigram	29. Sadar
		30. Ulipur
		31. Roumari
		32. Nageshari
		33. Bhurangamari
13.	Sirajgonj	34. Chouhali
		35. Sadar
		36. Kazipur
14.	Pabna	37. Bera
		38. Suja Nagar
		39. Sadar
15.	Kustia	40. Doulatpur
		41. Kumarkhali
16.	Bhola	42. Lalmohan
		43. Charfashan
17.	Lalmonirhat	44. Aditmari
		45. Kaligonj
		46. Hatibandha
18.	Nilphamari	47. Domar
		48. Dimla
		49. Sadar
19.	Thakurgaon	50. Sadar
		51. Baliadanga
20.	Panchagor	52. Debigonj
		53. Boda
21.	Lakshmipur	54. Raipur

Sl. No.	District	Upazila
		55. Ramgoti
22.	Noakhali	56. Hatia
		57. Subarnachar
23.	Chittagonj	58. Sandip
		59. Mirersharai
24.	Khagrachari	60. Sadar
		61. Panchari
25.	Sherpur	62. Nokhla
		63. Sadar
26.	Jamalpur	64. Islampur
		65. Dewangonj
27.	Tangail	66. Bhuapur
		67. Sadar
28.	Manikgonj	68. Sadar
		69. Shibaloy
		70. Harirampur

1.5.1.1 Appointment and Training of Field Researchers

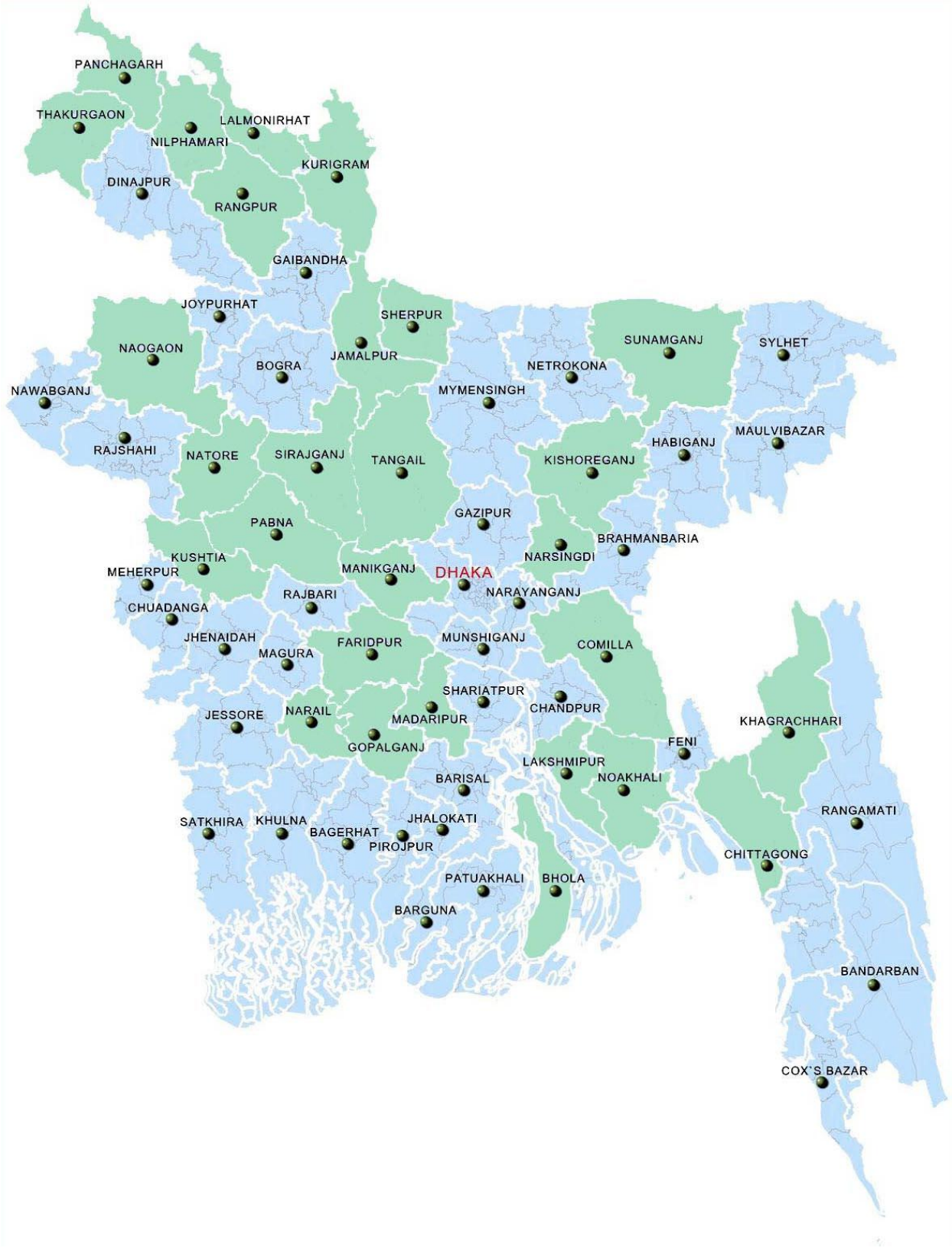
Agricultural graduates were appointed as field researchers. Theoretical and practical training on identification and data collecton of insect and mite pests, diseases and weeds of groundnut was given by specialist scientists of BARI. Questionnaires and field data collection Format were supplied to the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

1.5.1.2 Field Survey and Primary Data Collection

Seven teamsconsisting two members in each wereformed for field survey and collection of information based on questionnaire and format from the farmers and concerned officials of 28 districts (Figure 2). Each team was supplied with colored photographs of damage symptom for insect and mite pests, diseases and weeds for identification.

1.5.1.3 Secondary Data Collection

The secondary data on insect and mite pests, diseases and weeds of groundnut were collected from scientists of BARI and BINA, University teachers, DAE personnels, books, journals, published reports, CD of CABI and internet searching. These data were checked with primary data and the final list of insect and mite pests, diseases, weedsand other pestsof groundnut in field and storage was prepared.



Figrue 2. Study Area of GroundnutShowing in Bangladesh Map

1.5.1.4 Internet Searching

Information on insect and mite pests, diseases, weeds and other pests of groundnut crop in fieldand storage were collected worldwide through internet searching especially of China, India, Myanmar and Vietnam from where groundnut is imported to Bangladesh. Major groundnut growing areas of exporting countries to Bangladesh were identified and climate data of those areas were also collected so far available. Insect and mite 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 and mite pests, diseases and weeds of groundnut 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 and mite pests, diseases and weeds of groundnut in Bangladesh in comparison with four exporting countries.

1.5.2 Methodology of Risk Analysis

The process and methodology for undertaking import risk analyses need to collect the information on insectpests, 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 each of exporting countries hereinafter will be called as country of origin. Compare the lists critically to identify the potential destructive exotic pests.The diagram below illustrates the risk analysis process (Figure 3).

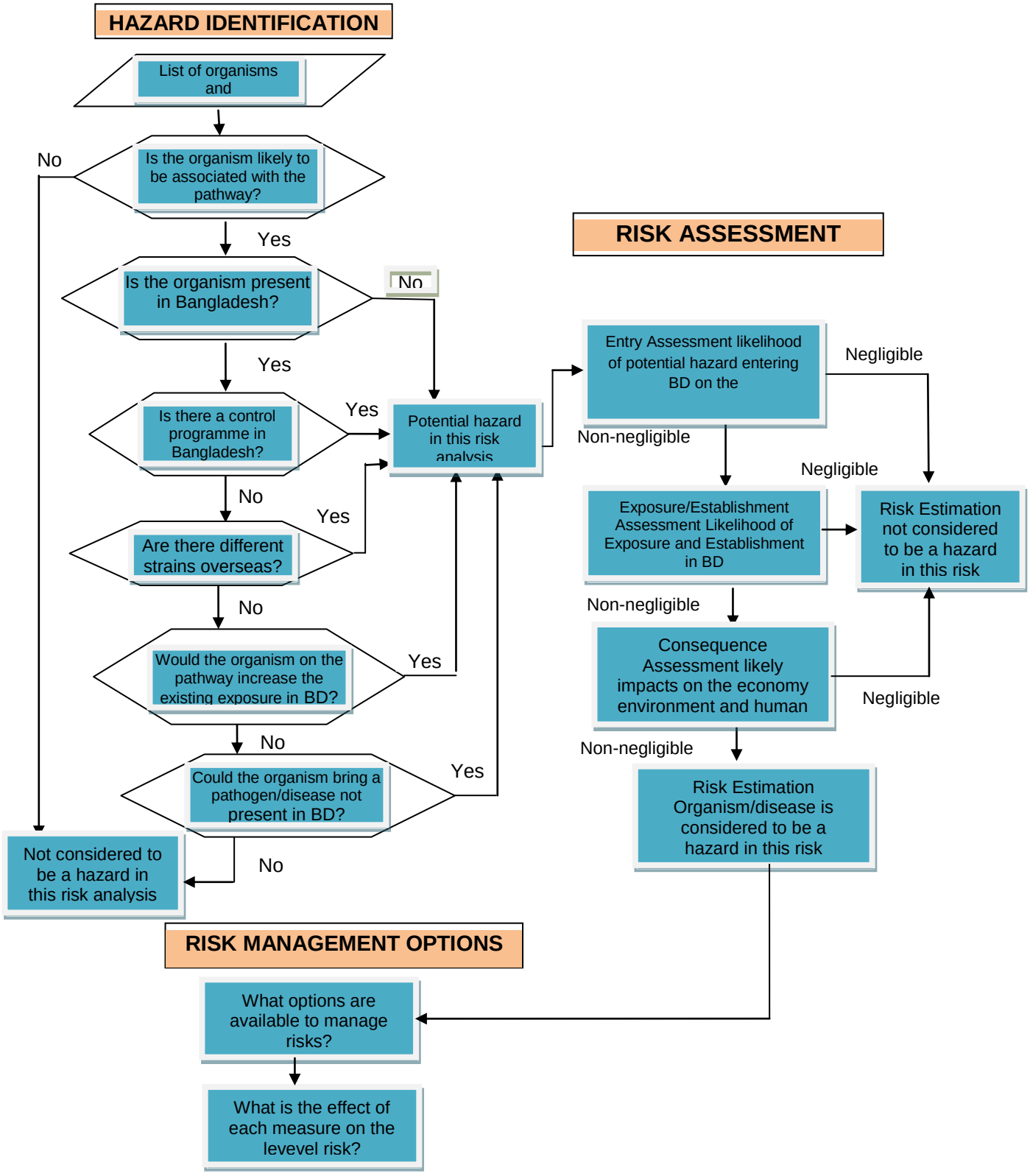


Figure 3. Diagram of the Risk Analysis Process. The three main aspects of analysis include: hazard identification, risk assessment, and risk management.

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 and mite pests, diseases (pathogen)or weeds which could be introduced into Bangladesh by risk goods, in this case selected groundnut is potentially capable of causing harm to groundnut 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.

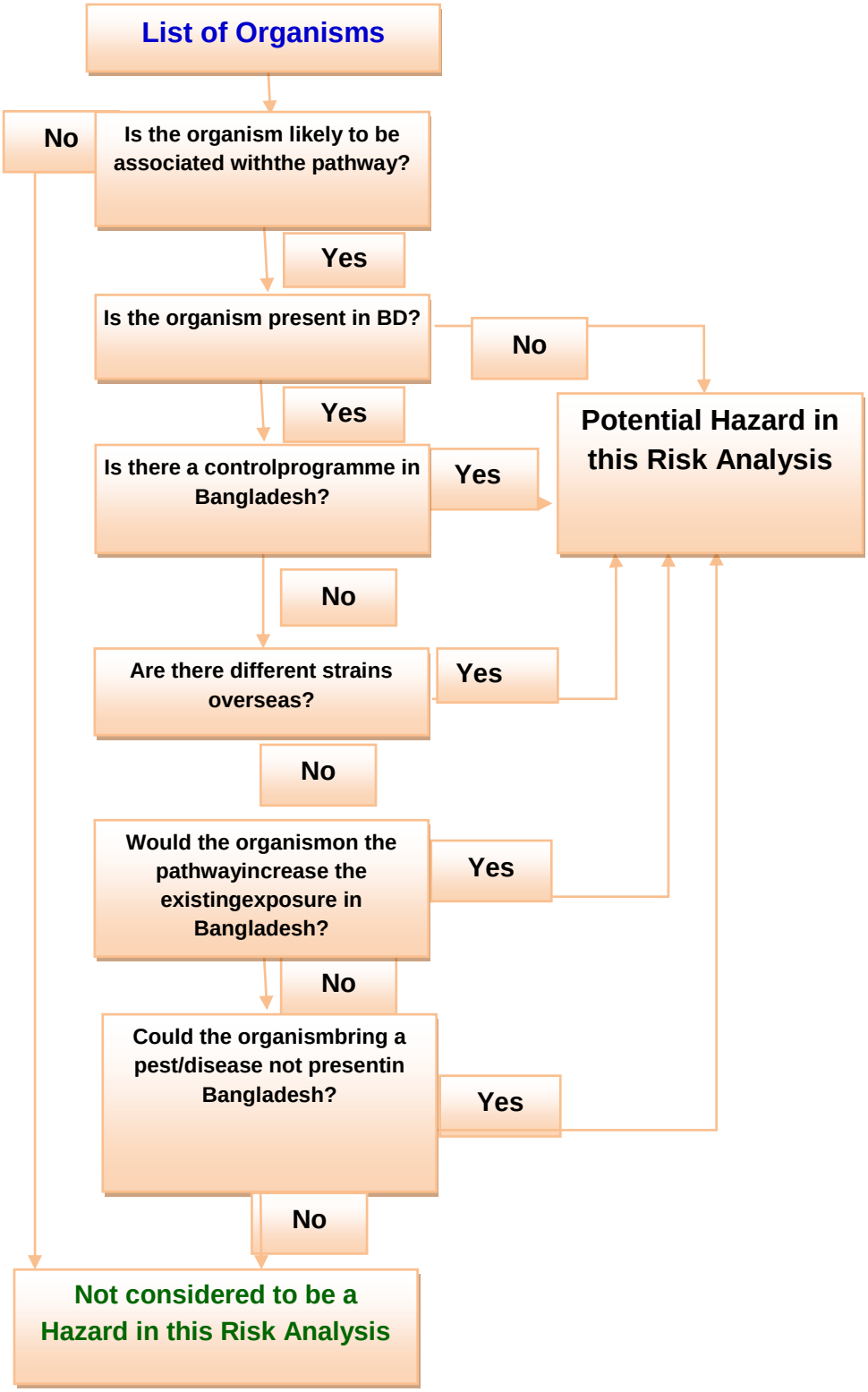


Figure 4. Diagrammatic Representation of Hazard Identification.

1.5.5 Risk Assessment of Potential Hazards

Risk assessment is the evaluation of the likelihood of entry, exposure and establishment of apotential hazard, and the environmental, economic, human and animal health consequencesof the entry within Bangladesh. The aim of risk assessment is to identify hazards whichpresent an unacceptable level of risk, for which risk management measures are required. Arisk assessment consists of four inter-related steps:

- Assessment of likelihood of entry
- Assessment of likelihood of exposure and establishment
- Assessment of consequences
- Risk estimation.

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

1.5.6 Methodology of Risk 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.

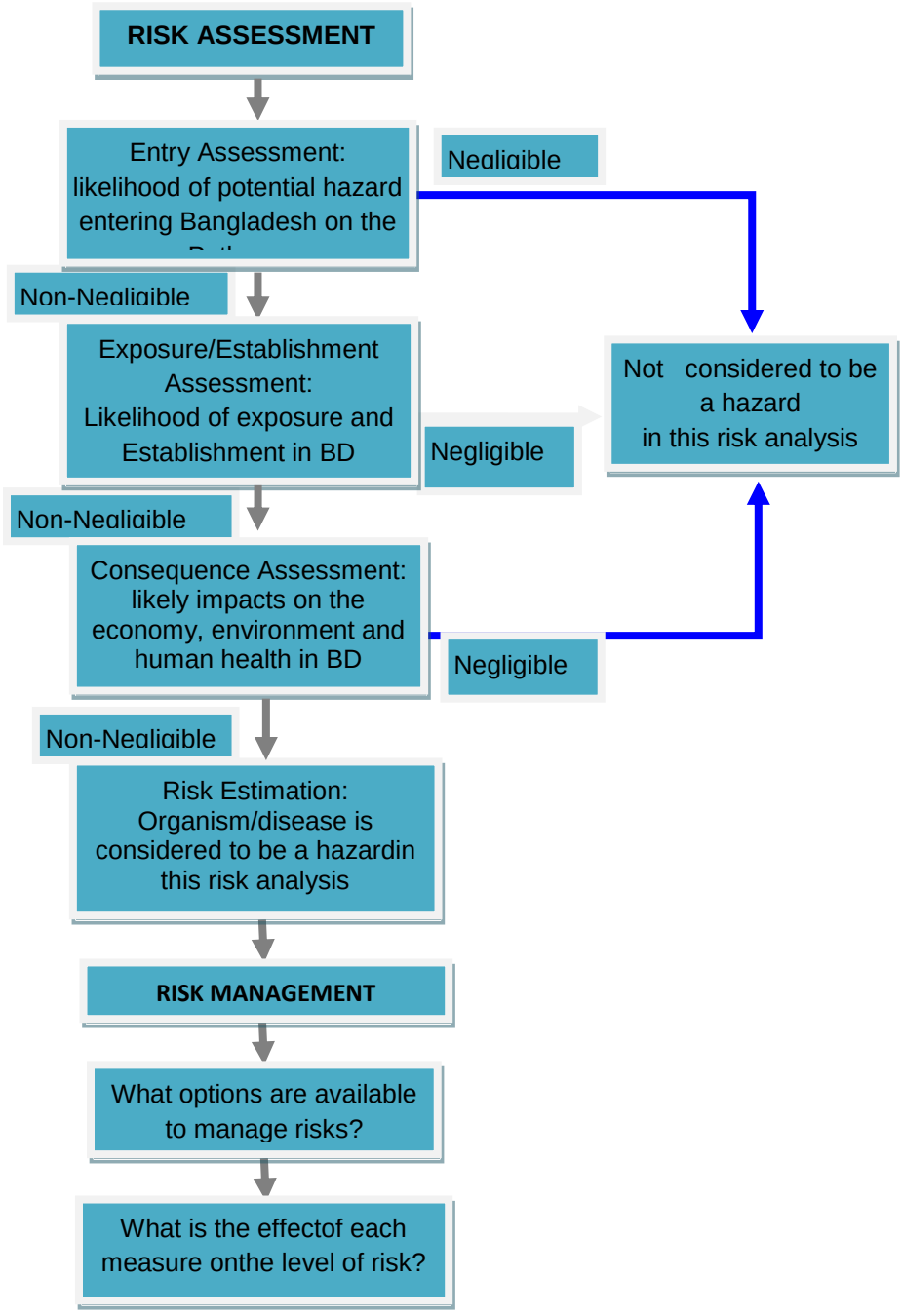


Figure 5. Diagrammatic Representation of the Process Followed for Risk Assessment and Management.

1.5.7 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.

1.5.8 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 framework in section 5.

1.5.9 Risk Evaluation

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

1.5.10 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 four established pathways (China, India, Myanmar and Vietnam) forgroundnut 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.

1.5.11 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

This chapter provides information on the commodity that is relevant to the analysis of biosecurity risks and common to all insect pests, diseases or weeds potentially associated with the commodity, groundnut in the present context. It also provides information of the commodity including history, morphological characteristics, climate requirement, cultivation and harvest and post harvest operations especially in the country of origin. Separate lists of insect pests, diseases and weeds are prepared for the selected exporting countries as well as for Bangladesh. After critical evaluation of the lists the quarantine pests for Bangladesh and their distribution among the exporting countries were identified. Information on groundnut production and climate in Bangladesh is also enumerated. Information on climate, geography and pest control strategies of the country of origin as well as in Bangladesh is collated and presented for assessing the likelihood of establishment and spread of potential hazard organism(s) when enter and exposed to Bangladesh environment.

2.2 Identification of Pathways

The pathways for conducting present PRA include groundnut (*Arachis hypogea)* imported from China, India, Myanmar and Vietnam.

2.2.1 Commodity Description- Groundnut

2.2.1.1 Introduction

In the present risk analysis the commodity is groundnut (*Arachis hypogaea* L.) imported from China, India, Myanmar and Vietnam is defined as the harvest of groundnutwith all vegetative parts removed and that have been cultivated, harvested, packed in the country of origin and transported to Bangladesh. Groundnut is also known as peanut is a legume crop grown mainly for its edible seeds. Peanuts play a significant role in the growth and development of the body. Peanuts, or commonly known as legumes, are packed with several health benefits. The nuts contain monounsaturated fats and other nutrients that are healthy for the functioning of the heart. Peanuts are also a rich source of antioxidants such as oleic acid responsible for the lowering of deaths from coronary heart diseases [4]. It contains antioxident properties and peanut oil is used for medical treatments and used in the kitchen [13]. It is widely grown in the tropics and subtropics, being important to both small and large commercial producers. It is classified as both a grain legume and, because of its high oil content, an oil crop. Groundnut is presently cultivated in over 80 countries from 40° N to 40° S in tropical and warm temperate regions of the world [25].

Ten leading groundnut producing countries namely China, India, Nigeria, United States, Sudan, Indonesia, Myanmar, Senegal, Argentina and Vietnam produced 13336860, 7156448, 2755649, 1837519, 1399500, 1274271, 841925, 694147, 463227 and 414968 metric tons respectively, during 2016 [4].

The productivity of groundnut varies from 3500 kg/ha in USA to 2500 kg/ha in South America, 1600 kg/ha in Asia and less than 800 kg/ha in Africa. This is due mainly to various abiotic and biotic constraints. The major abiotic stresses include temperature extremes, drought and soil factors like alkalinity or salinity. Poor soil fertility and nutrient deficiencies. The biotic factors include insect pests, diseases and weeds [29]. Groundnut pods develop under the ground. Due to this characteristic the botanist Linnaeus assigned the specific name hypogaea*,* which means "under the earth." Groundnut is used as food and food items in many different ways in different countries. As flour, boiled groundnut, dry roasted and cuisines are some worth mentioning use [16]. In Bangladesh groundnut is mostly used in bakery and also eating after in shell frying in hot sand. The plant is used as nutritious feed for cattle. The rhizobium bacteria developed on the roots harvest nitrogen from the environment which are added to the soil and improve soil fertility for the next crop.

Peanuts are particularly susceptible to contamination during growth and storage. Poor storage of peanuts can lead to an infection by the mold fungus *Aspergillus flavus*, releasing the toxic substance aflatoxin. The aflatoxin producing molds exist throughout the peanut growing areas and may produce aflatoxin in peanuts when conditions are favorable to fungal growth [17].

Groundnut oil is often used in cooking, because it has a mild flavor and a relatively high smoke point. Due to its high monounsaturated content, it is considered healthier than saturated oils, and is resistant to rancidity. Several types of peanut oil include: aromatic roasted peanut oil, refined peanut oil, extra virgin or cold-pressed peanut oil, and peanut extract are available. In the United States, refined peanut oil is exempt from allergen labeling laws [3].

2.2.1.2 History

Groundnut (*Arachis hypogaea*), also known as the peanut is a legume crop grown mainly for its edible seeds. It is widely grown in the tropics and subtropics, being important to both small and large commercial producers. It is classified as both a grain legume and, because of its high oil content, an oil crop. World annual production of shelled peanuts was 46 million tonnes in 2014. Groundnut pods develop under the ground. It is this characteristic that the botanist Linnaeus used to assign the specific name *hypogaea,* which means "under the earth." Cultivated peanut (*A. hypogaea*) arose from a hybrid between two wild species of peanut, thought to be *A. duranensis* and *A. ipaensis* [19, 23, 27]. The initial hybrid would have been sterile, but spontaneous chromosome doubling restored its fertility. Genetic analysis suggests the hybridization event probably occurred only once and gave rise to *A. monticola*, a wild form of peanut that occurs in a few restricted locations in northwestern Argentina, and by artificial selection to *A. hypogaea* [18, 19, 23, 27]. The process of domestication through artificial selection made *A. hypogaea* dramatically different from its wild relatives. The oldest known archeological remains of pods have been dated at about 7,600 years old. These may be pods from a wild species that was in cultivation, or *A. hypogaea* in the early phase of domestication [8]. However, a different opinion was that the earliest archeological records are from Peru, which dates back to 2000-3000 B.C. [10, 22]. Five major geographical groups of the cultivated groundnuts have distinguished in South America [22].The domesticated plants are more bushy and compact, and have a different pod structure and larger seeds. The initial domestication may have taken place in northwestern Argentina, or in southeastern Bolivia, where the peanut landraces with the most wild-like features are grown today [*20, 21].* Groundnuts are widely dispersed through South and Central America by the time Europeans reached the continent, probably by the Arawak Indians. The Peruvian runner type was taken to the Western Pacific, China, Southeast Asia Madagascar. The

Spanish probably introduced the Virginia type to Mexico, via The Philippines, in the sixteenth century. The Portuguese then took it to Africa, and later to India, via Brazil. Virginia type apparently reached the Southeast US with the slave trade [29].

In West Africa, it substantially replaced a crop plant from the same family, the Bambara groundnut, whose seed pods also develop underground. In Asia, it became an agricultural mainstay and this region is now the largest producer in the world [9]. At present groundnut is grown in almost all the tropical and subtropical countries of the world, and also in some warm temperate regions between 40ºN and 40ºS latitude [23]. Peanuts are widely produced in tropical and subtropical regions of the world. China accounts for 37% of world production, India for 16%, Nigeria for 8%, and the United States for 6%. Major exporters are India, which accounts for 31% of world exports, the United States for 21%, Argentina for 10%, and the Netherlands for 8% [15].

2.2.1.3 Groundnut in Bangladesh

The climate and soil conditions of Bangladesh are suitable for the production of a variety of oilseed species all the year round. It plays a vital role in Agricultural Sector of Bangladesh but can not meet the national demand. It has been shown that the production and yield of oilseed increase sharply during the period 1987-2010 though the area under cultivation decreased [6]. Groundnut is a legume as well as oilseed crop grown in Bangladesh mainly during Kharif-I. Among the oilseed crops it occupies third position in respect to area of production (Figure 6). This crop is grown in 47 districts of Bangladesh during 2015 [5]. However, the production varied in different years. At national level, the area and production of groundnut declined in the 1990s but in the late 2000s, groundnut production increased by 31% although area under groundnut was the same as in the late 1990s. Increase in groundnut yield (by 373 kg/ha or 32%) contributed towards increase in groundnut production in the late 2000s. In the late 2000s (TE2009/10), top five groundnut producing districts (Noakhali, Dhaka, Faridpur, Kishoreganj and Pabna) accounted for 59 percent of area and 55 percent of production. In the 2000s, Bangladesh achieved high annual growth (5.0% or more) in groundnut production at the national level and in nine districts (Faridpur, Tangail, Barisal, Jessore, Kushtia, Dinajpur, Pabna, Rangpur and Chittagong H.T.). On the other hand, variability in groundnut production in the 2000s increased insignificantly at the national level while three districts (Sylhet, Mymensingh and Tangail) experienced statistically significant increase in variability in groundnut production. Increase in variability in groundnut production was mainly due to the increased variability in area under groundnut indicating that the crop was expanded to less suitable areas [7].

In recent year, the Department of Agricultural Extension (DAE) and Ministry of Agriculture, Government of Bangladesh have considered groundnuts and oilseed as a high priority subsector and have taken a plan titled “Groundnuts and Oil crops Research and Development Vision: 2030” to increase the oilseed production[11]. During 2014-2015 oilseed crops in Bangladesh was grown in an area of 31766 ha and total production was 56713 mt with the yield of 1785 kg/ha [5]. During this year groundnut was grown in 47 districts of Bangladesh out of the 64 districts. Among the districts, Magura was the leading district in respect to area (1348.58 ha) and production (1086 ton) of this crop. This was followed by Faridpur (1080.6 ha and 594 ton), Gopalganj (945 ha and 634 ton) and Narail (586.6 ha and 349 ton) [5]. Figure 6 shows the comparative area under different oilseed crops in Bangladesh.

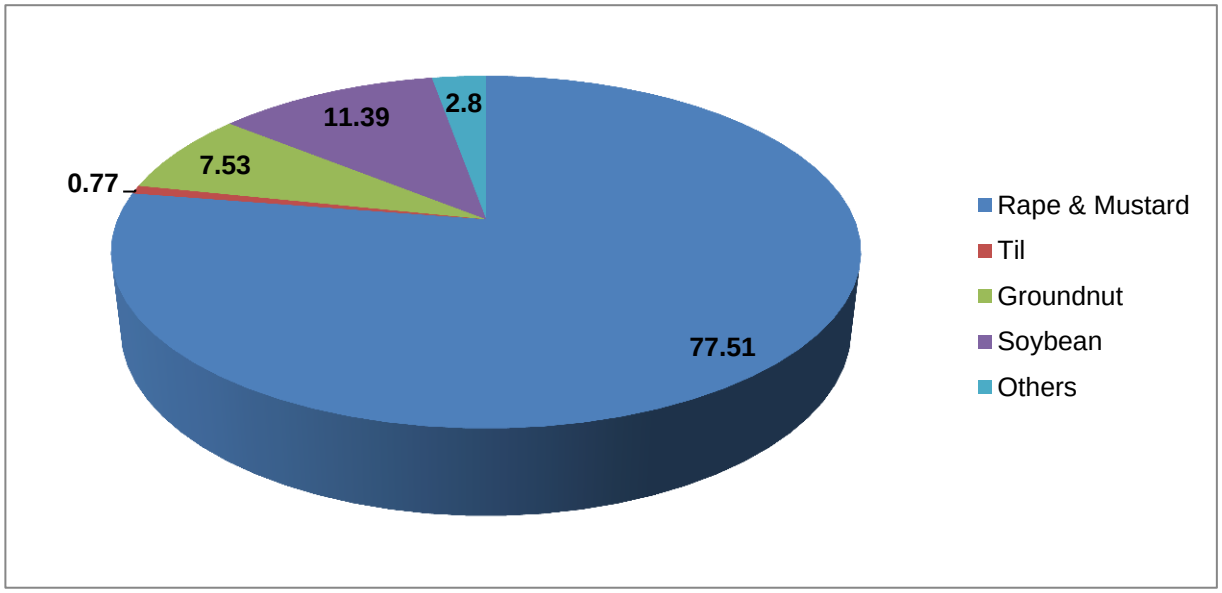


Figure 6.Share of Area under Different Species of Oilseed Crops in Bangladesh (BBS. 2016).

2.2.1.4 Taxonomy and Morphology of Commodity

Taxonomic position:

Kingdom: Plantae
(unranked): Angiosperms
(unranked): Eudicots
(unranked): Rosids
Order: Fabales
Family: Fabaceae
Subfamily: Faboideae
Tribe: Dalbergieae
Genus: *Arachis*
Species: *A. hypogaea* [16]

The groundnut belongs to genus *Arachis* of the family *Fabaceae*. *Arachis hypogaea* is by far the economically most important species in this genus and has two subspecies- *A. fastigiata* and *A. hypogaea*. Subspecies *A. fastigiata* types are more upright in their growth habit and have shorter crop cycles. Subspecies *A. hypogaea* types spread more on the ground and have longer crop cycles.

Peanut is an annual herbaceous plant growing 30 to 50 cm (1.0 to 1.6 ft) tall [27]. As a legume, it belongs to the botanical family Fabaceae (also known as Leguminosae, and commonly known as the bean or pea family). Like most other legumes, peanuts harbor symbiotic nitrogen-fixing bacteria in their root nodules. It has is a fairly developed root system and a tap root. Tap root appears on the second day after seed germination and has a massive root cap. It elongates rapidly and grows almost vertically. It may vary from a few millimeters in diameter in annual species to 10 cm in perennial species. The well developed tap root may penetrate to a depth of 130 cm but rarely goes

beyond 90 cm. The root system is normally concentrated at a depth of 5 to 35 cm and root spread is confined to a radius of 12 to 14 cm. The lateral roots are basically similar to tap roots but they lack the central pith and they multiply very quickly. The roots bear nodules reaching to about 0.40 cm in diameter and 800 to 4,000 in number. Sometimes number of nodules decline after 80 days of sowing [14, 15].

The young stem of groundnut is angular, usually pubescent and solid with a large pith. As the plant grows, the stems become hollow and tend to be cylindrical and shed hairs. The central stem is usually taller and has a few laterals, which form main basis for classification of different varieties and forms. The stem is covered with small hairs though the degree of hairiness varies in different types. Internodes are short and highly condensed at the base but are longer at the higher nodes [14, 15].

Groundnut leaves are pinnate with two pairs of leaflets borne on a slender and grooved petiole. There is a pair of stipules about 4 cm long with long alternate points which are fused with the petiole for about one half of their length. The leaflets are opposite, subsessile, obovate and situated closely towards the top of the petiole. The upper pair is larger than the lower one. The shape of leaflets varies from elliptic to ovate to oblong with the entire or ciliate margins, subcardate base and obtuse or shortly mucronate tip. The leaflets are borne on a slender, grooved and jointed rachis. Groundnut cultivars differ in leaf characteristics such as leaf colour (foliage colour), shape, hairiness and size. Stomata appear on both sides of the leaf [14, 15].

The inflorescence of the groundnut appears as a cluster of flowers (3-5 in number). The flowers are 1.0 to 1.5 cm (0.4 to 0.6 in) across, and yellowish orange with reddish veining produced in the axils of leaves on short reproductive branches [21] The flowers are complete, papilonate and sessile. Flowers are enclosed in between 2 bracts. The flower is sessile but appears stalked after the growth of a tubular hypanthium just before anthesis. The calyx has 5 lobes. The typical papilionoid corolla is inserted on the top of the hypanthium and surrounds the staminal column. The stamens are 10, monadelphous with the staminal column surrounding the ovary. The pistil consists of a single ovary surrounded by the base of the hypanthium. The stigma is club shaped or clavate, usually at anther level or protruding slightly above. Usually flowering takes place between 24 to 30 days after sowing. The flowering period normally lasts for 3-8 weeks in case of bunch type and 6-10 weeks in case of spreading. The plants are observed to flower till they reach maturity, however, it is influenced largely by the seasonal conditions prevailing during the flowering phase i.e. rain accelerates flowering while drought has its adverse effect on it. The flower opens between 6 to 8 a.m. and fertilization is completed before mid-day after which the flower droops, the corolla closes and the calyx-tube bends down by 4 pm and the flower withers within three days [15]. The ovary is located at the base of what appears to be the flower stem but is actually a highly elongated floral cup. After fertilization, a short stalk at the base of the ovary (termed a pedicel) elongates to form a thread-like structure known as a "peg". This peg grows down into the soil, and the tip, which contains the ovary, develops into a mature peanut pod [28]. Pods are 3 to 7 cm (1.2 to 2.8 in) long, normally containing one to four seeds [21].

An intercalary meristem below the ovary is activated. The green ovary turns purplish from the tip downwards. The developing ovary pierces through the floral parts by the activity of the meristem to reveal an elongating peg or carpophore. The peg or gynophore is formed by the elongation of the basal portion of the ovary (which is called stipe) and bends down at such an angle to the stem as to reach the soil in the shortest distance. The growth of the peg is due to the positive geotropism. The pegs become visible in about 5-7 days of flowering and it takes 2 to 8 days in spreading type depending upon the soil moisture condition and the leaf axil from where the pegs develop. The

young pegs contain white deciduous hairs, which disappear after a few days. The peg bears the fertilized ovules at its tip. After some initial development, the ovary shows no apparent change until it is diageotropically positioned in the soil. It is then that the ovary starts developing into a fruit [3, 4]. Peanut pods develop underground, an unusual feature known as geocarpy [28].

The seeds of groundnut differ in size, shape and colour of the seed coat or testa. The testa is thin and papery. In general, 3 unicellular layers viz., the outer Seed size is an important economic character. Seed length ranges from 7 to 21 mm and diameter from 5 to 13 mm. Seed weight is also an important distinguishing character, which ranges from 0.17 to 1.24 g. Colour of seed coat or testa is an important criteria for classifying cultivated groundnuts and this may also influence the marketability of a cultivar. The colour characteristic is highly subjective and the different grades are difficult to describe on a uniform basis. However, this is an important diagnostic genetic character. Each seed consists of 2 cotyledons, upper stem axis and young leaf primordia (epicotyl) and lower stem axis (hypocotyl) and primary root. The embryo of the seed is straight rather than curved [15].

2.2.2 Climate Requirement

Peanut can be grown in both tropics and sub-tropics, It requires a long warm growing season and well distributed rainfall. The best suitable temperature 22-30C. Lower temp will reduce the crop yield and quality of the nuts. The crop requires warm and dry climate at the ripening stage [12].

Groudnuts require a high temperature and a frost-free period of about 160 days. They will not reach optimum maturity for a marketable yield to justify commercial production in areas with fewer heat units during the growing season. They are very sensitive to low temperatures and seeds should only be planted when the minimum temperature stabilizes above 18 °C. Germination is 95% at soil temperatures ranging from 18 °C to 30 °C. The suitable vegetative growth temperature ranges from 20 °C to 35 °C. However, at 33 °C this declines to 84%. A favorable temperature for flowering and pod formation is about 28 °C [2]. Climatic conditions such as temperature and rainfall significantly influence the groundnut production. Warm and moist conditions are very favorable than cool and wet climate, which results in slow germination and seedling emergence, increasing the risk of seed rot and seedling diseases. Temperature is a major environmental factor that determines the rate of crop development. Temperatures above 35°C inhibit the growth of groundnut. Optimum mean daily temperature to grow is 30°C and growth ceases at 15°C. For rapid emergence, soil temperature above 21°C is needed. The optimum temperature for the most rapid germination and seedling development is about 30°C [26].

A minimum 100 - day optimum temperature growing season is necessary for successful groundnut crop production. Adequate and well distributed rainfall during the growing season, especially during flowering, pegging and pod formation stages, is essential for maximum yield and quality of groundnut. Groundnut is grown in areas receiving 600 to 1500 mm of rainfall. However, the crop can be grown successfully with a rainfall of 1250 mm. The amount of rainfall required for pre-sowing operations is 100 mm, sowing 150 mm and at flowering and pod development 400-500 mm. Groundnut crop cannot stand frost for long time, severe drought and water stagnation[26].

2.2.3 Cultivation

Sandy-loam soil, rich in calcium and organic-mater, well-drained with a pH 5.0 to 7.0 is good for cultivation of groundnut. Seeds should shelled by hand maximum one week before sowing to avoid damage in the storage. Hand shelling is preferred for reducing seed damage. Seeds to be sown in a well prepared land at a distance of 30-60 cm between rows and 10-15 cm between plants plant to plant depending on the variety. Higher spacing is needed for spreading type varieties and 70-100 kg seed/ha is enough [1, 2, 12, 30].

Required fertilizers (Urea, TSP, Potash, Gypsum, and Boric acid) are to be added to the soil at final land preparation [1].

In bunch types, the row to row distance is kept 30-40 cm and in spreading type 45-60 cm. for this, 80-100 kg of seeds per hectare would be enough for bunch types and 60-80 kg for spreading types. Plant to plant distance would be 15 and 20 centimeters for bunch and spreading types respectively [1, 12, 30].

Sowing should be done about 5 centimeters deep behind the plough or with the help of dibbler or seed planter. On a large scale, seed planter can be used.Sowing period during Rabi is from mid-October to December, in kharif-1, June-August [1, 30].

Groundnuts should be weeded promptly especially during the early stages of growth upto 45 days of sowing. After seed sowing 20-40 days are the critical period for weed control. Earthing up should be done at the time of weeding to encourage pegging, or penetration of young nuts into the soil. It is recommended that farmers use hand weeding after the start of pegging to avoid disturbing the growing nuts or damaging the flowers. Clean weeding should take place up to 6 weeks after which only hand weeding should be done [1, 2, 30].

The crop requires adequate amounts of Calcium when pods are forming, otherwise the farmer ends up with empty pods. Nitrogen fertilizers are not needed since groundnuts are leguminous plants. If soils are acidic, you can apply lime to raise the raise the pH and supply calcium. If there is no rain during flowering or pod formation, irrigate if possible to ensure the yields do not drop.

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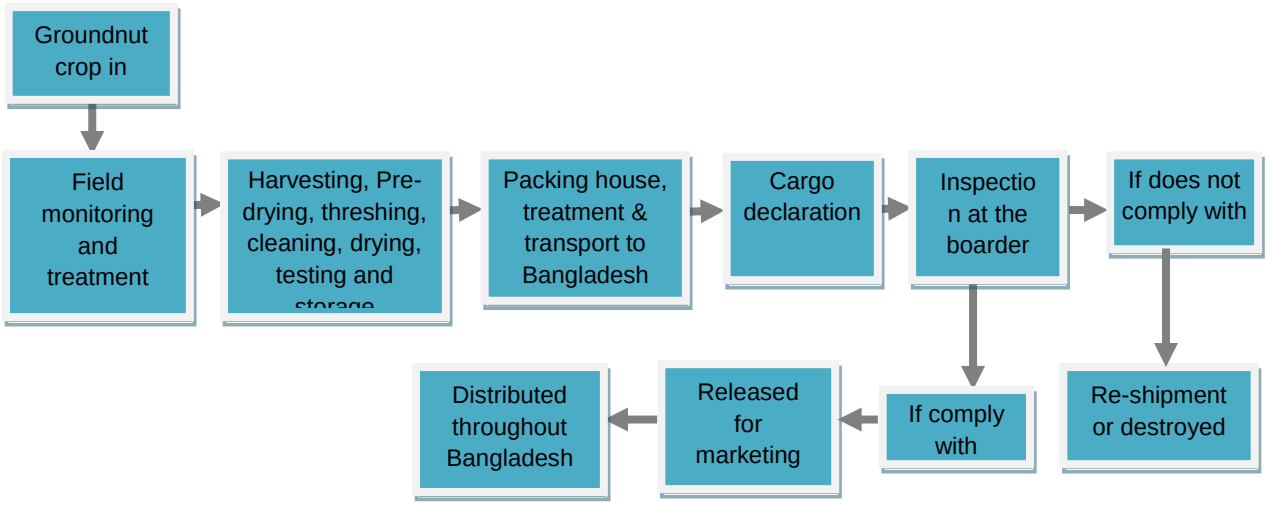
2.3 Description of Proposed Import Pathway

For the purpose of this risk analysis groundnut is imported from the countries such as China, India, Myanmar and Vietnam. To comply with existing Bangladesh import requirements for groundnut, 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. Groundnut from India and Myanmar would be transported to Bangladesh by road through Landports and from China and Vietnam 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 groundnut is shown in Figure 7.



Figrue 7. Diagrammatic Representation of the Import Pathways of Groundnut.

2.3.1 Steps in the Pathway

- Groundnut in China, India, Myanmar and Vietnam are being grown in the field usually as monocrop.
- Monitoring of the insect and mite pests, diseases, weeds or any other pests of groundnut is done and appropriate control measures are applied if pests are observed.
- Harvesting is carried out when pods have reached the appropriate maturity. Groundnut pod development takes place in the soil making itdifficult to correctly judge the maturity of the crop. A proper time to commence the harvest is when a good number of pods are fully developed and are fairly intact. This condition is normally achieved when the vine begins to turn yellow and leaf shedding starts. The actual maturity of the pod is determined when they attain normal size with prominent veins, the inside of the shell turns dark and the kernels reach maximum growth accompanied by good colouration of the seed coat. A fully mature pod can often be difficult to spilt open with the pressure of the fingers. Meanwhile an immature pod can be split easily revealing the white inside surface of the pod which appears also to be spongy in texture [4].Harvesting usually consists of a series of operations comprising digging, lifting, windrowing, stocking and threshing. Some of these tasks can be combined or eliminated depending on the system applied. Among the field operations concerned with groundnut cultivation, harvesting is the most laborious and costly endeavour. The actual method of harvest employed depends upon the type of groundnut grown. Harvesting may sometimes become a problem especially when the crop has passed the stage of full maturity and the soil has hardened. In certain areas, the vines are uprooted with country ploughs and the vines and pods are picked by manual labour.
- Stripping of pods is performed manually by the small farmers or by the strippers. There are two type of groundnut strippers, the drum type and comb type. The pegs become brittle within a week and pods are stripped by hand. In some areas in India the pods are first lifted out of the soil, dried in the field and then the pod ends of the plant are knocked against a crossbar to dislodge the pods. In this process some pods become damaged. This method of stripping is cheaper. A simple comb-type stripper and peddle-operated stripper are available and can be used for bunch types of groundnut.
- Threshing operations also very both within and among the developing countries. It varies from the age-old procedure of using sticks and racks to the modern power threshers. In India the smallholder and marginal farmers do manual threshing using sticks and rakes. Variations also exist in stripping pods from the plant. After harvest bunch type plants are stacked in heaps with the pod-end exposed. The best threshing is obtained with minimum loses at pod moisture content between 18 and20 percent [4].
- Curing and its interaction with the maturing process comprise the single most critical factor in establishing the basic flavour quality of groundnut after harvest. The terms curing and drying have been defined as two distinct phases marking the change in groundnut composition following harvest [2]. During the curing process, groundnuts are dried to an average moisture content of approximately 10 to 15 percent. This means that some kernels are drier, measuring as low as 10 percent while others contain more moisture.
- When groundnuts are harvested they contain wide range of foreign material. This impacts quality, beginning with airflow restrictions and uneven moisture distribution during curing. Foreign material at 5 percent and above results in a deduction in the value of farmer’s stock groundnut

brought to market. In general most of the threshers have blowers, which perform the cleaning operation by the process of winnowing. Foreign material and loose-shelled kernels (LSK), groundnut seed inadvertently shelled by harvesting and handling operations cause problems in storage and processing [3].

- Grading- The cultivated groundnut is defined as one of four types: i.) runner: runner have become the dominant type, because of their attractive size range which makes them useful for a variety of products; ii.) Virginia: Virginias have the largest kernels and account for most of the groundnuts roasted and eaten as in-shell. When shelled, the larger kernels are sold as saltedgroundnuts. They are also used in confectionery products; iii.) Spanish: Spanish type groundnuts have small kernels covered with a reddish-brown skin. They used predominately in groundnut candy, with significant quantities used for salted nuts and groundnut butter. They have a higher oil contents than others types; iv.) Valencia: Valencia's usually have three or more small kernels to a pod. They are very sweet groundnut and are usually roasted and sold in the shell. They are excellent for fresh use as boiled groundnuts. After drying, groundnut pods are graded at a prescribed moisture level in the kernels such as 9 percent. Undersized pods, chaff, inert matter, if any, is separated. The factors such as foreign material over 4 percent, moisture over 7 percent, damage over 1 percent, loose shelled kernel content, and split percent over 4 percent determines the value of the produce in the national and international markets. Seed size is another important characteristic that also determines both quality and value. The 100-seed weight may differ among genotypes from <30 g to >150 g. Size also varies within a genotype, and cultivars with more uniform seed size are desired for improved processing efficiency and marketing of groundnut products [4].
- Pods after grading to the requisite normal size are packed in gunny bags. Seed are seldom shelled and packed because in the kernel (seed) form they lose viability quickly than in-shell(pod) form. Therefore, seed is mainly sold in the form of pods and a small pack of thiram or captan is also kept in the gunny bag with the instruction to treat the seed (kernels) at the time of sowing. Packing for the milling or seed purpose in polyethylene bags is generally recommended, as it helps in maintaining the quality during storage. Similarly in several developing countries the roasted kernels are sold loose in the market, packaging of the confectionery groundnut in polyethylene bags may add to the value and quality of the product in the local markets. Other value-added product should also be sold with proper packaging to maintain the moisture content and the crunchy and crispy nature of groundnuts [4].
- Smallholder farmers store groundnut inshell, in earthen pots, mud bins, bamboo baskets or in other types of wicker receptacles. These containers are often plastered with mud and cow dung with little or no use of pesticides. For long-term storage the containers are sealed with mud after the addition of ashes, ground pepper, dried neem leaves or other local herbs to control storage pests. In Andhra Pradesh groundnuts are stored in big earthen pots and the mouth of the container is sealed with the sand or mud or cow dung. Daily storage of groundnuts in gunny bag is a common practice requiring utmost care to protect the produce from the pests. For consumption and seed purposes, groundnuts are stored for longer periods up to 8 to 10 months. Farmers generally have inadequate facilities and use their houses to keep bags of groundnuts over long periods of time [1,4].
- Marketing practices vary among the developing countries. Within 3 to 4 weeks after harvestime farmers take about 70 to 80 percent of their produce personally to the market to fulfil their cash

requirements. The marketable surplus of the small and marginal farmers is so small that they do not find it economically feasible to take it to wholesale markets, even though these distant markets often offer better prices. Rural markets often lack facilities and are generally strips of land serving as a meeting place between buyers and sellers. In India, marketing period for the rainy season crop commences in October and remains till February, with a peak between November and December. Within this period about 45 percent of the marketable surplus of groundnut arrives in the markets [4].

- 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 groundnuts from external attack by humidity, insects, sunlight, mould etc. Various types of packing are used for storage of groundnut such as jute bag, polythene bag, cotton bag, PP woven bag etc. [4].
- Groundnutis 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 groundnut to Bangladesh.
- Groundnut transport to Bangladesh by air or sea or land port. Groundnut from India and Myanmar 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 seed, any treatments completed, or other information required helping mitigate risks. Seeds 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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2.4 Background Information of Exporting Countries

Information of geography and climatic condition of four groundnut exporting countries namely China, India, Myanmar and Vietnam are briefly described here.

2.4.1 China

China is located inEastern Asia at 35^0 00 N, 105^0 00 E [16]. 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 [16].

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 [16].

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 [7].

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 [7].

2.4.2 India

In India, Groundnut is grown in rain-fed regions of the country so its production is highly vulnerable to rainfall deviation and display huse variation between the years. Over 89% of groundnut has been produced in five states namely Gujarat (50.77%), Andhra Pradesh (12.69%), Tamilnadu (9.91%), Rajasthan (9.39%) and Karnataka (6.81%) and rest of the production is from other states of the country during 2013-14. Therefore, geography and climate of these five major groundnut producing states are briefly described here.

2.4.2.1 Gujarat

The state Gujarat lies between 22.2587° N, 71.1924° E with an area of 196024 sq Kms. Gujarat is divided into 25 administrative districts and the total population is 55,696, 629. The capital of the state is Gandhinagar [5].

Gujarat is situated on the west coast of India. It is bounded in the west by the Arabian sea, in the north-west by Pakistan, in the north by Rajasthan, in the east by Madhya Pradesh and in the south and south-east by Maharashtra. The state of Gujarat occupies the northern extremity of the western sea-board of India. It has the longest coast line of 1290 kms. The state comprises of three geographical regions. The peninsula, traditionally known as Saurashtra, is essentially a hilly tract sprinkled with low mountains. Kutch on the north-east is barren and rocky and contains the famous Rann (desert) of Kutch, the big Rann in the north and the little Rann in the east. The mainland extending from the Rann of Kutch and the Aravalli Hills to the river Damanganga is on the whole a level plain of alluvial soil.

The Banas in the north, originating in the Siranva hill in Sirohi in Rajasthan, flows by the foothills of Abu and disappears in the desert. The Saraswati takes its birth at Koteshvar near Ambaji, flows by Siddhpur and Patan and merges into the desert. The Sabarmati, one of the biggest rivers of north Gujarat, originates from the Dhebar lake in Rajasthan and flows towards the Gulf of Cambay. The Hathmati, Vatrak, Mazam, Meshvo, Shedhi, Khari and the other rivulets also join it. The three virgin rivers of the north and the Sabarmati with its tributaries are the daughters of the Aravalli ranges, while the Mahi and Narmada with their families originate from Madhya Pradesh. The Narmada, one of the biggest and holiest river along with the only tributary, Karjan, meets the sea, about 16 kms. from Broach. The Tapi takes its birth in the Satpura ranges near Betwa and enters Gujarat at Kakarapar. It flows around Surat and Rander and falls into the sea. The Mindhola, Purna, Ambika, Vanki, Auranga, Vapi, Par, Kolak and Damanganga are the rivers of south Gujarat, which originates in the Sahyadri. Most of the rivers of Saurashtra and Kutch dries up in the summer. The rivers which originate in the central Saurashtra in the Chotila range flow to the south into the desert of Kutch. Only the Aji, Machhu and Brahmani are northward flowing rivers. The rivers originating in the Girnar and Gir namely, the Ojhat, Kamb, Surekh, Somal, Sangwada, Hirani, Kapila and Saraswati flow into the sea. The Saraswati and Vastu are sacred rivers. Though Kutch has many rivers, they are small and do not have much water. The Khari flowing by Bhuj meets the desert and Magh and Tara empty their waters in the Gulf of Cambay. The Rudramata has been bunded for irrigation, providing the only irrigation project in Kutch [5].

The climate of Gujarat is moist in the southern districts and dry in the northern region. The Arabian sea and the Gulf of Cambay reduce the temperature and makes the climate more pleasant. The year can be divided into four seasons which are the winter season from November to February, the summer season from March to May, the south-west monsoon season from June to September and the intervening month of October.

The winters are mild, pleasant, and dry with average daytime temperatures around 29 °C (84 °F) and nights around 12 °C (54 °F) with 100 percent sunny days and clear nights. The summers are extremely hot and dry with daytime temperatures around 49 °C (120 °F) and at night no lower than 30 °C (86 °F). In the weeks leading up to the arrival of the monsoon rains the temperatures are similar to above but with high humidity which makes the air feel hotter. Relief when the monsoon season starts around in mid June. The day temperatures are lowered to around 35 °C (95 °F) but humidity is very high and nights are around 27 °C (81 °F) [13].

The average rainfall in Gujarat varies from 33 to 152 cms. The southern region of the state has an average rainfall ranging from 76 to 152 cms, Dang district have the highest average of about 190 cms. The northern district have a rainfall ranging from 51 to 102 cms. The rainfall in the southern highlands of Saurashtra and the Gulf of Cambay is approximately 63 cms while the other parts of Saurashtra have a rainfall less than 63 cms. The semi-desert area of Kutch has a very low average rainfall. Certain areas in Ahmedabad, Mehsana, Banaskantha, Panchmahal, Surendranagar, Jamnagar and Kutch districts receives very less or no rains. As the Tropic of Cancer passes through the northern border of Gujarat, the state has an intensely hot or cold climate. But the Arabian sea and the Gulf of Cambay in the west and the forest covered hills in the east soften the rigors of climatic extremes [4].

2.4.2.2 Andhra Pradesh

It 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 (15).

2.4.2.3 Tamil Nadu

Tamil Nadu, the eleventh largest state in India covers an area of 130,058 square kilometres and lies between 11.1271° N, 78.6569° E. It is bordered by Kerala to the west, Karnataka to the northwest, Andhra Pradesh to the north, the Bay of Bengal to the east and the Indian Ocean to the south. Cape Comorin (Kanyakumari), the southernmost tip of the Indian Peninsula which is the meeting point of the Arabian Sea, the Bay of Bengal, and the Indian Ocean is located in Tamil Nadu.

The western, southern and the north-western parts are hilly and rich in vegetation. Tamil Nadu is the only state in India which has both the Western Ghat and the Eastern Ghat mountain ranges which both meet at the Nilgiri hills. The Western Ghats dominate the entire western border with Kerala, effectively blocking much of the rain bearing clouds of the South West Monsoon from entering the state. The eastern parts are fertile coastal plains. The northern parts are a mix of hills and plains. The central and the south-central regions are arid plains [19].

Tamil Nadu has both tropical and sub-tropical climate. The average temperature in different places range from 16.3 to 29.0 C. Tamil Nadu is heavily dependent on monsoon rains, and thereby is prone to droughts when the monsoons fail. The climate of the state ranges from dry sub-humid to semi-arid. The state has distinct periods of rainfall, which are the advancing monsoon period, South-westmonsoon (from June to September) with strong southwest winds, the North-eastmonsoon (from October to December), with dominant northeast winds, and the Dry season (from January to May). The normal annual rainfall of the state is about 945 mm (37.2 in), of which 48% is through the North East monsoon, and 32% through the South West monsoon. Since the state is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought [19].

There are three distinct seasons in Tamil Nadu, summer, winter and monsoon which are enumerated below:

Summer: The hot weather sets in and lasts until the middle of June. The highest temperature is often registered in May which is the hottest month in the state. The hot winds of the plains blow during April and May with an average velocity of 8–16 km/hour. These hot winds greatly affect human comfort during this season.

Winter: The cold weather commences early in October and comes to an end in the middle of January.The climate in the cold weather is pleasant. The days are bright and warm and the sun is not too hot.

As soon as the sun sets the temperature falls and the heat of the day yields place to a sharp bracing cold.

Monsoon: The state has three distinct periods of rainfall: advance rainfall ; rainfall from the tropical cyclones emerging in the neighbourhood of the Andaman islands during the Retreat of Monsoons(October-November); and the North East monsoon during the months of December, with dominant northeast monsoon winds from the western disturbances emerging over the Mediterranean Sea. The dry season is from February to July.

The normal annual rainfall of the state is about 945 mm (37.2 in) of which 48% is through the North East monsoon,and 32% through the South West monsoon. Since the state is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought. Tamil Nadu is classified into seven aggro-climatic zones: north-east, north-west, west,

southern, high rainfall, high altitude hilly,and Cauvery Delta (the most fertile agricultural zone). The table below shows the maximum and minimum temperatures that the state experiences in the plains and hills. Tamil Nadu has rain during the monsoon season due to the south west trade winds which blow towards the northern hemisphere. Tamil Nadu receives rainfall in the winter season due to north-east trade winds [14].

2.4.2.4 Rajasthan

It 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 [18].

2.4.2.5 Karntaka

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 [17]:

- Coastal Karnatakais 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 [17].

2.4.3 Myanmar

Geography and Climate

Myanmar is a republic in South-East Asia. The official name of Myanmar is the Union of Myanmar with a total area of 678,500 square kilometres (262,000 sq mi). It lies between latitudes 9° and 29°N, and longitudes 92° and 102°E [3]. The country is roughly diamond-shaped – with a long southeastern 'tail' – and extends 925km (575 miles) from east to west and 2,100km (1,300 miles) from north to south [12].

As of February 2011, Myanmar consisted of 14 states and regions, 67 districts, 330 townships, 64 sub-townships, 377 towns, 2,914 Wards, 14,220 village tracts and 68,290 villages [23].

Myanmar is bordered in the northwest by the Chittagong Division of Bangladesh and the Mizoram, Manipur, Nagaland and Arunachal Pradesh states of India. Its north and northeast border is with the Tibet Autonomous Region and Yunnan province for a Sino-Myanmar border total of 2,185 km (1,358 mi). It is bounded by Laos and Thailand to the southeast. Myanmar has 1,930 km (1,200 mi) of contiguous coastline along the Bay of Bengal and Andaman Sea to the southwest and the south, which forms one quarter of its total perimeter [22].

In the north, the Hengduan Mountains form the border with China. Hkakabo Razi, located in Kachin State, at an elevation of 5,881 metres (19,295 ft), is the highest point in Myanmar. Many mountain ranges, such as the Rakhaine Yoma, the Bago Yoma, the Shan Hills and the Tenasserim Hills exist within Myanmar, all of which run north-to-south from the Himalayas.The mountain chains divide Myanmar's three river systems, which are the Irrawaddy, Salween (Thanlwin), and the Sittaung rivers. The Irrawaddy River, Myanmar's longest river, nearly 2,170 kilometres (1,348 mi) long, flows into the Gulf of Martaban. North of the delta lies the Irrawaddy basin and the arid plains of central Myanmar, which are protected by a horseshoe of mountains. Fertile plains exist in the valleys between the mountain chains. The majority of Myanmar's population lives in the Irrawaddy valley, which is situated between the Rakhine Yoma and the Shan Plateau. Generally narrow and elongated in the interior, the central lowlands attain a width of about 320km (about 200 miles) across the Ayarwaddy-Sittaung delta. The delta plains, extremely fertile and economically the most important section of the country, cover an area of about 46,620 sq. km (18,000 sq. ml.). Both the Arakan (in the northwest) and the Tenasserim (in the southwest) coasts of myanmar are rocky and fringed with islands. The country has a number of excellent natural harbours. Intensive irrigated farming is practised throughout central Myanmar, and fruit, vegetables and citrus crops thrive on the Shan Plateau. Much of the land and mountains are covered by subtropical forest, although this coverage has been reduced by extensive logging particularly for teak.The vast deltas and flood plains of the Irrawaddy and Sittang Rivers form the heart of Myanmar provide its most productive

farmland. Bamboo grows extensively in many parts of the country. Myanmar used to be rich in rainforests, monsoon forests, and mangrove forests. Now, most of these woodlands are gone due to deforestation. The country's remaining forest cover, now less than 30 percent, is found mostly in the relatively inaccessible mountain areas of the north and northeast. The loss of forest cover in Myanmar not only has threatened animal and plant populations, but also has caused landslides, flooding, and drought [9, 12].

Steep, craggy limestone hills with many caves are found in the Shan Plateau and in the southeastern part of the country. Elsewhere in Myanmar there are foothill areas leading up to the mountain chains. The Shan plateau in the east with an average elevation of 1200 meters (3937 feet). The plateau borders to Northern Thailand and Laos. In Kachin State, the very north of Myanmar, May Kha and Malikha, the two rivers create the breathtaking view as the confluence flow into the Ayeyarwaddy River. The Ayeyarwaddy River valley lies across the country north to south. The Ayeyarwaddy River flows down south and forms the confluence with the Chindwin River which flows from the West Flank. The confluence is situated in the Central Basin of Myanmar. At the end, in the south, the Ayeyarwaddy changes into the tributaries of the Ayeyarwaddy delta in which lies the biggest city of Myanmar, Yangon. In the mid-eastern part of Myanmar, the Sittaung River starts flowing parallel to the Ayeyarwaddy River and ends up in the south by flowing into the Gulf of Mataban. The Thanlwin River crosses almost the entire length of Myanmar from the north to south. The Sanlwin River is rooted from China’s side and flows into Myanmar from the north to south. It flows along the Sittaung River more from the eastern side of the country and enters the Gulf of Mataban. Myanmar has very long coastal line so as to have many beaches [3].

Although Myanmar is located in the monsoon region of Asia, its climate is greatly modified by its geographic position and its relief. Much of the country lies between the Tropic of Cancer and the Equator. The climate of Myanmar is roughly divided into three seasons: Summer, Rainy Season, and Winter Season. From the end of February to the beginning of May are Summer months, with highest temperatures during March and April in Central Myanmar up to above 110F (43.3C) while in Northern Myanmar it is about 97F (36.1C) and on the Shan Plateau between 85F (29.4C) and 95F (35C). Winter which starts from November and lasts to the end of February with temperature in hilly areas of over 3000 feet drops below 32F (0C).The cold air masses of Central Asia bring snow to the northern mountains during the winter of the year, but this mountain wall prevents the cold air from moving farther south, so that Myanmar lies primarily under the influence of the monsoon winds. The north-south alignment of ranges and valleys creates a pattern of alternate zones of heavy and scanty precipitation during both the northeast and southwest monsoons. Most of the precipitation, however, comes from the southwest [3, 8, 21].

Humidity ranges from 66 percent to 83 percent. Most of the country's rainfall occurs during the monsoon. Rainy Season, from mid May to the end of October, with annual rain fall of less than 40 inches in Central Myanmar while the coastal regions of Rakhine and Tanintharyi get about 200 inches Annual rainfall in the delta region is approximately 2,500 mm (98.4 in), while average annual rainfall in the Dry Zone in central Myanmar is less than 1,000 mm (39.4 in). As a whole, the location and topography of the country generate a diversity of climatic conditions. Seasonal changes in the monsoon wind directions create summer, rainy and winter seasons. Extremes of temperature are rare. The direction of winds and depression bring rain, and although it is always heavy in the coastal areas during Monsoon season, it seldom creates hardships. The Government is giving priority to forest conservation and greening of nine arid districts in central Myanmar [3, 8, 23].

2.4.4 Vietnam

Geogreaphy and Climate

Vietnam is located on the eastern margin of the Indochinese peninsula and occupies about 331,211.6 square kilometers, of which about 25% was under cultivation in 1987. It borders the Gulf of Thailand, Gulf of Tonkin, and Pacific Sea, alongside China, Laos, and Cambodia. The S-shaped country has a north-to-south distance of 1,650 kilometers and is about 50 kilometers wide at the narrowest point. With a coastline of 3,260 kilometers, excluding islands, Vietnam claims 12 nautical miles (22.2 km; 13.8 mi) as the limit of its territorial waters, an additional 12 nautical miles (22.2 km; 13.8 mi) as a contiguous customs and security zone, and 200 nautical miles (370.4 km; 230.2 mi) as an exclusive economic zone.

The boundary with Laos, settled on both an ethnic and geographical basis, between the rulers of Vietnam and Laos in the mid-seventeenth century with the Annamite Range as a reference, was formally defined by a delimitation treaty signed in 1977 and ratified in 1986. The frontier with Cambodia, defined at the time of French annexation of the western part of the Mekong Delta in 1867, remained essentially unchanged, according to Hanoi, until some unresolved border issues were finally settled in the 1982-85 period. The land and sea boundary with China, delineated under the France-China treaties of 1887 and 1895, is "the frontier line" accepted by Hanoi that China agreed in 1957- 58 to respect. However, in February 1979, following China's limited invasion of Vietnam, Hanoi complained that from 1957 onward China had provoked numerous border incidents as part of its anti-Vietnam policy and expansionist designs in Southeast Asia. Among the territorial infringements cited was the Chinese occupation in January 1974 of the Paracel Islands, claimed by both countries in a dispute left unresolved in the 1980s.

Vietnam is a country of tropical lowlands, rolling green hills, and densely forested mountains. Low-level land covers about 20% of the country. The Red River delta is fronted by hills that rise gently into the high mountains of the northwest; the Annam Highlands cover much of the central landscape, and in the southern areas, the coastal lowlands and Mekong River Delta merge. A fertile and narrow coastal lowland extends south from the Red River Delta to the Mekong Delta. The Mekong Delta is a low-level plain, one inundated by hundreds of small rivers and canals. Thick jungles and mangrove swamps cover the far-southern areas of land. The Red River (Song Hong), and the Mekong are the most significant rivers; both have numerous tributaries, and the latter is certainly among the great rivers of the world. Vietnam's highest point is Fan Si Pan whose summit reaches 10,315 ft. (3,144 m); the lowest point is the South China Sea at 0m [11, 20].

The country is divided into the highlands and the Red River Delta in the north; and the Dãy Trường Sơn (Central mountains, or the Chaîne Annamitique, sometimes referred to simply as "the Chaine."), the coastal lowlands, and the Mekong Delta in the south. The Red River Delta (also known as the *Sông Hồng*), is a flat, triangular region of 15,000 square kilometers, is smaller but more intensely developed and more densely populated than the Mekong Delta. The ancestral home of the ethnic Vietnamese, the delta accounted for almost 70% of the agriculture and 80% of the industry of North Vietnam before 1975. The Red River, rising in China's Yunnan Province, is about 1,200 kilometers long. Its two main tributaries, the Sông Lô (also called the Lo River, the Riviere Claire, or the Clear River) and the Sông Đà (also called the Black River or Riviere Noire), contribute to its high water volume, which averages 4,300 cubic meters per second. The entire delta region, backed by the steep rises of the forested highlands, is no more than three meters above sea level, and much of it is one meter or less. The area is subject to frequent flooding; at some places the high-water mark of

floods is fourteen meters above the surrounding countryside. For centuries flood control has been an integral part of the delta's culture and economy. An extensive system of dikes and canals has been built to contain the Red River and to irrigate the rich rice-growing delta. Modeled on that of China's, this ancient system has sustained a highly concentrated population and has made double-cropping wet-rice cultivation possible throughout about half the region [10, 20].

The highlands and mountain plateaus in the north and northwest are inhabited mainly by tribal minority groups. The Dãy Trường Sơn (Annamite Range) originates in the Tibetan and Yunnan regions of southwest China and forms Vietnam's border with Laos. It terminates in the Mekong River Delta north of Hồ Chí Minh City (formerly Saigon).These central mountains, which have several high plateaus, are irregular in elevation and form. The northern section is narrow and very rugged; the country's highest peak, Fan Si Pan, rises to 3,142 meters in the extreme northwest. The southern portion has numerous spurs that divide the narrow coastal strip into a series of compartments. For centuries these topographical features not only rendered north-south communication difficult but also formed an effective natural barrier for the containment of the people living in the Mekong basin. The Mekong Delta, covering about 40,000 square kilometers, is a low-level plain not more than three meters above sea level at any point and criss-crossed by a maze of canals and rivers. So much sediment is carried by the Mekong's various branches and tributaries that the delta advances sixty to eighty meters into the sea every year. An official Vietnamese source estimates the amount of sediment deposited annually to be about 1 billion cubic meters, or nearly 13 times the amount deposited by the Red River. About 10,000 square kilometers of the delta are under rice cultivation, making the area one of the major rice-growing regions of the world. The southern tip, known as the Cà Mau Peninsula is covered by dense jungle and mangrove swamps.The Mekong, which is 4,220 kilometers long, is one of the 12 great rivers of the world. From its source in the Tibetan Plateau, it flows through the Tibetan and Yunnan regions of China, forms the boundary between Laos and Myanmar as well as between Laos and Thailand. At Phnom Penh it merges with the Tonlé Sap and divides into two branches - the Sông Hậu Giang (Hậu Giang river) (known as the Bassac River on the Cambodian side) and the Sông Tiền Giang (Tiền Giang river) - and continues through Cambodia and the Mekong basin before draining into the South China Sea through nine mouths known as the *Cửu Long* (nine dragons). The river is heavily silted and is navigable by seagoing craft of shallow draft as far as Kompong Cham in Cambodia. A tributary entering the river at Phnom Penh drains the Tonlé Sap, a shallow freshwater lake that acts as a natural reservoir to stabilize the flow of water through the lower Mekong. When the river is in flood stage, its silted delta outlets are unable to carry off the high volume of water. Floodwaters back up into the Tonlé Sap, causing the lake to inundate as much as 10,000 square kilometers. As the flood subsides, the flow of water reverses and proceeds from the lake to the sea. The effect is to reduce significantly the danger of devastating floods in the Mekong delta, where the river floods the surrounding fields each year to a level of one to two meters [10, 20].

Vietnam in the northern regions has a humid subtropical climate, with humidity averaging 84% throughout the year. However, because of differences in latitude and the marked variety of topographical relief, the climate tends to vary considerably from place to place. During the winter or dry season, extending roughly from November to April, the monsoon winds usually blow from the northeast along the China coast and across the Gulf of Tonkin, picking up considerable moisture; consequently the winter season in most parts of the country is dry only by comparison with the rainy or summer season. During the southwesterly summer monsoon, occurring from May to October, the heated air of the Gobi Desert rises, far to the north, inducing moist air to flow inland from the sea and

deposit heavy rainfall. The climate in the southern regions especially Ho Chi Minh City and surrounding Mekong Delta is predominantly Tropical savanna climate with high humidity and a distinct wet and dry season. Annual rainfall is substantial in all regions and torrential in some, ranging from 1,200 to 3,000 millimeters (47.2 to 118.1 in). Nearly 90% of the precipitation occurs during the summer. The average annual temperature is generally higher in the plains than in the mountains and plateaus. Temperatures range from a low of 5 °C (41 °F) in December and January, the coolest months, to more than 37 °C (98.6 °F) in August, the hottest month. Seasonal divisions are more clearly marked in the northern half than in the southern half of the country, where, except in some of the highlands, seasonal temperatures vary only a few degrees, usually in the 21–28 °C (69.8–82.4 °F) range. People from the North, the Central, and the South will experience different types of climate appropriately throughout the year. While the North has a cold winter because it is close to the Tropic of Cancer. The temperature can drop to 10 °C (50 °F). The Central of Vietnam experiences the hot and dry winter from mid January and mid August while the South's climate remaining hot and humid throughout the year. On rare occasions during winter, snow may fall in the highest elevations of northern Vietnam [20].

2.5 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, 6].

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, 6].

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, 6].

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2.6 International Transportation of Commodity

For the purpose of this risk analysis groundnut is presumed to be imported from anywhere in China, India, Myanmar and Vietnam. The commodity would be imported by sea, land and/or 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.

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 for consumption or used as seed.

Growers intend to export their groundnut 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. Groundnut for export will then be transported to packing housewhere necessary grading and cleaning will be done. It should beensured that pods/seeds 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 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 seed, any treatments completed, or other information required helping mitigate risks. 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, consignment is to be re-shipped or destroyed. Consignment met all the requirements will be released for disribution throughout the country

2.7 Hazard Identification

2.7.1 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 is potentially capable of causing unwanted harm, must be identified.

2.7.2 Potential Hazard Goups

Hazards are the unwanted insect and mite pests, diseases (pathogen) or weeds or any other pests of groundnut which could be introduced into Bangladesh and are potentially capable of causing harm to groundnut production, must be identified. This process begins with the collection of information on insect and mite pests, diseases (pathogen) or weed or any other pests of groundnut 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.

2.7.3 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 groundnut from the exporting counties, not a pest had been intercepted yet today on the groundnut imported into Bangladesh.

2.7.4 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.

2.7.4.1 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.

2.7.4.2 Symptomless Microorganisms

Pests such as microbes and fungi infect seeds 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 groundnuts rather than taking it to a diagnostic laboratory so there is little data on post entry appearance of “invisible organisms”.

2.8 Assumptions and Uncertainties

2.8.1 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.

2.8.2 Hazard Biology and Identification

The biology of insect and mite 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. *Scirototrhips dorsalis*vs *Caliotrhips indicus*, 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.

2.8.3 Assumption Regarding Transit Time of Groundnut

An assumption is made around the time the grains take to get from the field in China/Vietnam 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.

2.8.4 Assumption and Uncertainty around Disposal

It is assumed that a portion of seedthat might have infested or contaminated will be disposed off in a manner that exposes any potential hazard organisms on that seeds to suitable hosts. Disposal would include discarding seeds 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.

2.8.5 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.

This approach makes the following assumptions, that:

- The consignment is homogeneous (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 groundnuts. In the absence of efficacy data, assumptions are made on the basis of data for similar species or similar treatments.

2.9 Review of Management Options

2.9.1 Introduction

This chapter provides background information on possible measures to mitigate the biosecurity risk associated with importing groundnuts from China, India, Myanmar and Vietnam.

2.9.2 Production and Post-Harvest Measures

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

2.9.3 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 groundnut 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.

2.9.4 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 groundnut field. Any infected plant, leaves or plant parts should be cut or removed from the filed. Regular inspection and removal of infected plants, weeds

facilitate the health and growth by reducing the incidence of various fungal diseases and viral diseases, weeds and allowing in more sunlight.

2.9.5 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 the introduction of biocontrol agents for entomophagic fungi or parasitizing invertebrates.

2.9.6 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 seed, 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 identifygroundnut producing regions free of these pests. In general however, infestation pressure declines as one move into more northerly grain growing areas. If groundnut 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.

2.9.7 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 materiall. Many insect species find it much easier to become established in grain consignments containing admixture and damaged grains [5]. Grain moisture content should be less than 7%, which is independent of grade [9]. Stored grain pests are adversely affected by low moisture content. Complete removal of admixture of groundnuts from wheat reduces the risk of some species being imported to negligible levels.Sieving and grain cleaning will remove most snails and other incidental contaminants. Lower grades of groundnut 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.

2.9.8 Prevention of Infestation during Transportation, Storage and Handling

A number of species identified of quarantine concern, notably *Caryedon serratus*, *Sitophilus granaries*,*Plodia interpunctella* species, are not host specific and can be pests infesting residues present in groundnut handling systems [1, 4]. Such species can infest wheat 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 [3].

Ships used for the importation of groundnut 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 groundnut. This could include species which are not established in China or Vietnam including the Indian meal moth, *Plodia interpunctella*. Prior to loading groundnut, ships must be clean and free of infestation, at least to the standard expected of vessels which handle Bangladeshi 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 [3].

2.10 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.

2.10.1 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 [6]. 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 [6]

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

2.10.2 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.

2.10.2.1 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 [2, 11].

2.10.2.2 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 [4]

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 [4].

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 [10].

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 [8].

2.11 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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2.12 Review of earlier PRA

No PRA on groundnut crops has been done in Bangladesh earlier. Moreover PRA on groundnut in abroad is not found. However PRA on few insect pests, like thrips, granary weevil etc. attacking alternate hosts other than groundnut 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 groundnut in Bangladesh as well as exporting countries are discussed herein.

3.1 Insects, Mite, Diseases and Weeds of Groundnut in Bangladesh

3.1.1 Insect and Mite Pests of Groundnut in Bangladesh

Insect and mite pests of groundnut in Bangladesh are included in this section. Insect pests of groundnut recorded during field survey are shown in **Appendices IV & VII**.

In Bangladesh, 41 (forty one) species of pests (40 insects and 1 mite) are reported to attack groundnut. Of which 29 species (28 insects and one mite) cause infestation during production which are considered as field insect pests and 12 species attack in storage called storage insect pests (Table 4.).Among the field insect pests, six species namely common cutworm (*Spodoptera litura*), leaf roller (*Anarsia ephippias*), common hairy caterpillar (*Spilarctia obliqua*), groundnut leaf miner (*Stomopteryx nerteria*), jassid (*Empoasca terminalis*) and aphid (*Aphis craccivora*) were reported as major insect pests and rest of the pests were considered as minor ones. Five insect pests such as hairy caterpillar (*Spilarctia obliqua*), common cutworm (*Spodoptera litura*), jassid (*Empoasca terminalis*), leaf miner (*Stomopteryx nerteria*) and leaf roller (*Anersia ephippias*) were also reported as major insect pests [7].He also reported that minor insect pests like pod borer (*Helicoverpa armigera*), hairycaterpillar (*Spilosoma nydia*) hairy caterpillar (*Pericallia ricini*), semilooper (*Plusia orichalcea*), aphid (*Aphis craccivora*), greengrasshopper (*Atractomorpha crenulata*), green stink bug (*Nezara viridula*), thrips (*Scirtothrips dorsalis*), groundnut moth (*Scopula emissaria*), termite (*Microtermes obesi*) and white grub (*Oxycetuia versicolor*) become occasionally important and cause serious damage tothe groundnut crop. Several researchers reported eleven insect pests of groundnut viz., *S. obliqua*, *S. litura*, *O. versicolor*, *E. sordidus*, *S. nydia*, *A. ephipias*, *S. nerteria*, *S. emissaria*, *A. psittacina*, *Plusia* sp., and *H. indicus* in field [1, 6, 14, 17, 21, 23]. Among the recorded 12 species of insect pests attacking groundnut crop, hairy caterpillar (*S. obliqua*), leaf roller (*A. ephippias*), and leaf miner (*S. nerteria*) were recorded as major pests [23]. Field survey report of in the northern Bangladesh revealed 25 species of insect pests at different stages of groundnut of these, 8 species were considered as serious pests [22]. Moreover, twenty five species insect pests attacking groundnut were reported from Gazipur [8]. Two spotted mite (*Tetranychus urticae*) causes less damage to groundnut in field which is considered as minor pest.

Among the storage insect pests of groundnut, pod sucking bug (*Elasmolemus sordidus*), saw-toothed grain beetle (*Oryzaephilus surinamensis*), red flour beetle (*Tribolium castaneum*) and rice moth (*Corcyra cephalonica*) are major pests in Bangladesh (Table 4). Other pests attack groundnut but their incidence are low due to presence alternate hosts. Although khapra beetle was reported in Bangladesh on other hosts [5, 15] it was not reported as groundnut pest by researchers and did not observe during survey period. Moreover no scientists, DAE personnel and farmers mention khapra beetle infestation on groundnut. Pod sucking bug (*Elasmolemus sordidus*) is mainly storage pests of groundnut and it startsinfestation from the field when harvested crops are heaped on the threshing floor [7]. Most of the minor pests of groundnut in storage have the potentiality to become major pest in favourable environment. Photographs of some important field and storage insect pests of groundnut in Bangladesh are shown in Figure 10 and Figure 11, respectively.

Table 4. List of insect pests of groundnut in field and storage, damaging stage(s), infested plant parts and pests status in Bangladesh

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
Field insect pests						
01.	Termite	*Microtermes obesi* Holmgren	Isoptera: Termitidae	Nymph and adult cut and feed root	Minor	7, 22
02.		*Odontotermes obesus* (Rambur)	Isoptera: Termitidae	Nymph and adult cut and feed root	Minor	7, 9
03.	Black cutworm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Larvae cut and feed stem	Minor	4, 7,9,21
04.	Common cutworm	*Spodoptera litura* Fabricius	Lepidoptera: Noctuidae	Larvae feed on leaves, tender shoot and flower	**Major**	1, 6,7,14,21
05.	Defoliator	*Spodoptera exigua* (Hübner)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	7, 9, 4, 12
06.	Leaf roller	*Anarsia ephippias* Meyrick	Lepidoptera: Noctuidae	Larvae web leaves and eat shoot	**Major**	1, 4, 6,7,8, 14,22, 23, 29
07.	Semilooper.	*Thysanoplusia / Plusia orichalcea* (Fabricius)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	4, 7, 14, 22, 29
08.	Pod borer	*Helicoverpa armigera*(Hübner)	Lepidoptera: Noctuidae	Larvae bore stem and pod	Minor	7,9, 14,
09.	Groundnut moth	*Scopula emissaria*(Walker)	Lepidoptera: Geometridae	Larvae roll and feed on leaves	Minor	6, 7, 14,29
10.	Common hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera: Arctiidae	Larvae feed leaves	**Major**	6, 7,23
11.	Hairy caterpillar	*Spilosoma nydia* Butler	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	6,7, 14 29
12.	Hairy caterpillar	*Pericallia ricini* Fabricius	Lepidoptera: Lymentridae	Larvae feed leaves	Minor	7,9
13.	Groundnut leaf miner/ shoot miner	*Aproarema modicella* Deventer/ *Aproaerema nerteria*Meyrick/ *Stomopteryx nerteria*Meyrick	Lepidoptera: Gelechiidae	Larvae roll and feed on leaves	**Major**	1, 6, 7,14 22, 29
14.	Jassid	*Empoasca terminalis* Distant	Homoptera: Cicadellidae	Nymph and adult suck sap	**Major**	7, 22
15.		*Empoasca kerri* Purthi			Minor	19

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
16.	White leaf hopper	*Cofana spectra* (Distant)	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	7, 9, 12
17.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Nymph and adult suck sap	**Major**	1, 4, 6,7, 8,14, 17, 22
18.	Green stink bug	*Nezara viridula* Linnaeus	Hemiptera: Pentatomidae	Nymph and adult suck sap	Minor	4, 7, 27
19.	Green grasshopper	*Atractomorpha crenulata* Fabricius	Orthoptera: Acrididae	Nymph and adult feed on leaves	Minor	4,7
20.	Leaf beetle	*Monolepta signata* Olivier	Coleoptera: Chrysomelidae	Adult feed on leaves	Minor	7, 9
21.	White grub	*Holotrichia serrata* (Fabricius)	Coleoptera: Scarabaeidae	Larvae cut and feed on root	Minor	6, 7, 14, 17, 22
22.	Black weevil	*Cyrtozemia cognata* Marshall	Coleoptera: Curculionidae	Adult feed on leaves	Minor	7,9
23.	Ant	*Camponotus* spp.	Hymenoptera: Formicidae	Nymph and adult feed root and stem	Minor	7
24.	Ear wig	*Euborellia stali* D	Dermaptera: Forficulidae	Nymph and adult eat root, stem and pod	Minor	7, 9
25.	Chili thrips	*Scirtothrips dorsalis* Hood	Thysanoptera: Thripidae	Adult and nymph feed on young leaves	Minor	7, 13,15
26.	Flower thrips	*Megalurothrips distalis (*Karny)		Adult and nymph feed flower	Minor	7,9
27.	Cotton thrips	*Frankliniella schultzei* (Trybom)		Adult feeds flowers, nymph feeds leaf buds	Minor	7, 10, 25
28.	Stem borer	*Sphenoptera perotetti*	Coleoptera: Buprestidae	Larvae bore stem	Minor	7
29.	Two spotted spider mite	*Tetranychus urticae Koch*	Acarina: Tetranychidae	Nymph and adult suck sap	Minor	20
Storage insect pests						
30.	Pod sucking bug	*Elasmolemus sordidus* (Fabricius)	Hemiptera: Lygaeidae	Nymph and adult suck oil from kernel starting from field	**Major**	6,7, 14,22

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
31.	Khapra beetle	*Trogoderma granarium* Everts	Coleoptera: Dermestidae	Larvae and adult feed kernel	Minor	5, 15
32.	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Larvae and adult feed kernel	**Major**	7
33.	Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	**Major**	9 , 26
34.	Confused flour beetle	*Tribolium confusum* Jacquelin du Val	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	Minor	2
35.	Longheaded flour beetle	*Latheticus oryzae* Waterhouse	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	Minor	4
36.	Cigarette beetle	*Lasioderma serricorne* (Fabricius)	Coleoptera: Anobiidae	Larvae and adult feed kernel	Minor	3
37.	Drugstore beetle	*Stegobium paniceum* (Linnaeus)	Coleoptera: Anobiidae	Larvae and adult feed kernel	Minor	28
38.	Flat grain beetle	*Cryptolestes pusillus* (Schoenherr)	Coleoptera: Laemophloeidae	Larvae and adult feed kernel	Minor	18
39.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Larvae and adult feed kernel	Minor	9, 24
40.	Rice moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Crambidae	Larvae feeds kernel	**Major**	11
41.	Almond moth	*Ephestia cautella* (Walker)	Lepidoptera: Crambidae	Larvae feeds kernel	Minor	30

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Larvae of leaf miner

Larvae of common cutworm

Aphid infested shoot

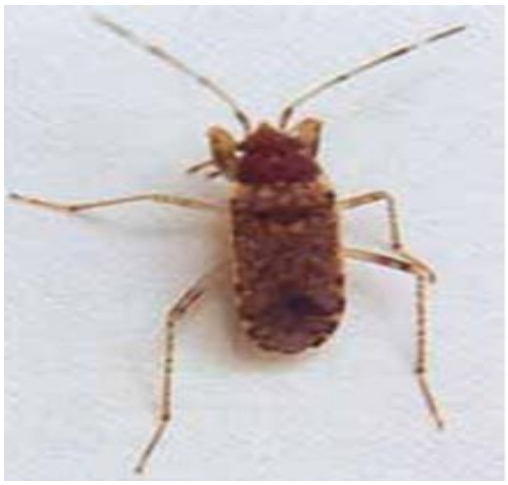
Aphid infested leaves

Mealybug infested shootE.

White grub larva infested groundnut pod

Figure 10. Some Important Field Insect Pests of Groundnut in Bangladesh.

Pod sucking bug infested groundnut seeds



Adult pod sucking bug

Red flour infested groundnut seeds

Adult red flour beetles

Rice moth larvae infested groundnut seeds

Adult rice moth

Figure 11. Some Important Storage Insect Pests of Groundnut in Bangladesh.

3.1.2 Diseases of Groundnut in Bangladesh

Diseases of groundnut, so far recorded in Bangladesh has been compiled and presented in Table 5. A total of 28 diseases are recorded, among which 18 are caused by fungal pathogen, 3 by virus and 7 by nematodes. Among the disease five fungal disease namely late leaf spot, rust, foot & root rot, stem rot and collar rot/crown rot are the major concern for groundnut production in Bangladesh. Photographs of some important diseases are shown in Figure 12. Among the disease organisms, *Aspergillus flavus* and*Aspergillus niger* cause rotting of seeds in storage.

Table 5. List of Groundnut Diseases Reported in Bangladesh

Sl.No.	Disease	Causal organism	Status	Plant parts infected	References
01	Early Leaf spot	*Cercospora arachidicola*	Minor	Leaf	1, 4, 7, 11
02	Late Leaf spot	*Phaeoisariopsispersonata/ Cercosporidium personatum*	**Major**	Leaf	1, 4, 7, 11
03	Rust	*Puccinia arachidis* Speg.	**Major**	Leaf, other aerial parts except flower	1, 3, 7
04	Foot & root rot	*Sclerotium rolfsii* Sacc.	**Major**	Stem base, root, pod	1
05	Stem rot	*Sclerotium rolfsii* Sacc.	**Major**	Stem	7, 11
06	Leaf blight	*Alternaria* sp.	Minor	Leaf	1, 11
07	Wilt	*Sclerotium rolfsii, Fusarium* sp.	Minor	Stem base, root, pod	1, 4, 11
08	Stem blight/Stem spot	*Macrophomina phaseolina*	Minor	Stem	4, 11
09	Anthracnose	*Colletotrichum acutatum Colletotrichum dematium Colletotrichum orbiculare*	Minor	Leaf, branch, stem	10
10	Bud rot	*Fusarium semitectum*	Minor	Bud	1
11	Collar rot/ Crown rot	*Aspergillus niger* Tiegh.	**Major**	Stem base, root, pod	2, 4, 7
12	Leaf spot	*Phyllosticta* sp.	Minor	Leaf	1, 11
13	Leaf spot/ seedling rot	*Rhizoctonia solani*	Minor	Leaf, seed, seedling base	5, 7
14	Sclerotinia blight	*Sclerotinia sclerotiorum*	Minor	Branches, stems at soil surface	7
15	Dry root	*Rhizoctonia solani*	Minor	Root	4
16	Cylindrocladium black rot	*Cylindrocladium crotalariae* (Loos) Ben & Sobers	Minor	Stem, branch, pod, root	10
17	Seed rot & germination failure	*Aspergillus flavus*	Minor	Pod, peg, seed	4, 7

Sl.No.	Disease	Causal organism	Status	Plant parts infected	References
18	Damping-off	*Fusarium* sp., *Pythium* sp., *Rhizoctonia solani*	Minor	Seedling base	
19	Stunt	*Peanut stunt virus*	Minor	Entire plant	9
20	Spotted wilt	*Tomato spotted wilt virus*	Minor	Entire plant	9
21	Mosaic	*Peanut mosaic virus*	Minor	leaf	4, 9
22	Root knot	*Meloidogyne* spp.	Major	Peg, root, pod	6
23	Root lesion	*Aphelenchoides* sp.	Minor	Peg, root	8
24		*Belonolaimus longicaudtus*	Minor	Peg, root	8
25		*Criconemoides rusticum*	Minor	Peg, root	8
26		*Pratylenchus coffeae*	Minor	Peg, root	8
27		*Trichodorus christiei*	Minor	Peg, root	8
28		*Xiphinema diversicaudatum*	Minor	Peg, root	8

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Late leaf spot (*Cercosporidium personatum*)

Stem rot (*Sclerotium rolfsii*)

Rust (*Puccinia arachidis*)

Figure 12. Some Important Diseases of Groundnut in Bangladesh.

3.1.3 Weeds of Groundnut

Altogether 29 weed species representing 13 families are, so far, recorded in groundnut field in Bangladesh. The highest number of species (six) was found under the grass family Poaceae followed by Amaranthaceae with five species. Two species were found under each of the families Commelinaceae, Convolvulaceae, Euphorbiaceae, Fabaceae and Solanaceae. Only one species was found under each of the rest six families viz. Asteraceae, Chenopodiaceae, Compositae, Cyperaceae, Lamiaceae and Papaveraceae. Out of 29 weed species nine was major, which distributed under seven families such as Amaranthaceae, Poaceae, Cyperaceae, chenopodiaceae, compositae, Lamiaceae and Solanaceae. The major species were *Alternanthera sessilis, Amaranthus spinosus, Cynodon dactylon, Cyperus rotundus, Chenopodium album, Gnaphalium luteo-album, Leucas aspera, Paspalum distichum* and *Physalis heterophylla* (Table 6). *Chenopodium album* was major only in rabi season. Photographs of some important weeds of groundnut are shown in Figure 13.

Table 6. List of Common Weeds of Groundnut in Bangladesh with Scientific Name and Pest Status

Sl. No.	Common name	Scientific name	Family	Status	References
01	Chanchi	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	**Major**	3
02	Katanote	*Amaranthus spinosus* L.	Amaranthaceae	**Major**	4
03	Shaknotey	*Amaranthus viridis* L.	Amaranthaceae	Minor	5
04	Mexican poppy	Agremone mexicana	Papaveraceae	Major	2
05	Kanaibashi	*Commelina benghalensis* L	Commelinaceae	Minor	3
06	Kanainala	*Cyanotis axillaris*	Commelinaceae	Minor	3
07	Boroapang	*Cyathula prostrata*	Amaranthaceae	Minor	5
08	Durba	*Cynodon dactylon* (L.) Pers.	Poaceae	**Major**	3, 4
10	Mutha	*Cyperus rotundus* L.	Cyperaceae	**Major**	3, 4
11	Bathua	*Chenopodium album L.*	Chenopodiaceae	**Major**[1]	3, 4
12	Bindi	*Convolvulus arvensis* L.	Convolvulaceae	Minor	4
13	Kakpaya	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Minor	3
14	Digera	*Digera muricata* (L.) Mart.	Amaranthaceae	Minor	5
15	Khude shama	*Echinochloa colonum* (L.) Link	Poaceae	Minor	3
16	Shyama	*Echinochloa cruss-galli*	Poaceae	Minor	3
17	Baro dudhia	*Euphorbia hirta* L.	Euphorbiaceae	Minor	3
18		*Euphorbia microphylla* Lam.	Euphorbiaceae	Minor	3
19	Shwetomuli	*Gnaphalium luteo-album L.*	Compositae	**Major**	3
20	Kolmi sak	*Ipomea aquatica* Forsskål,	Convolvulaceae	Minor	3
21	Arail	Leersia hexandra Swartz	Poaceae	Minor	3
22	Shetodron	*Leucas aspera* (Wild.) Link	Lamiaceae	**Major**	4, 5
23	Perthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Minor	5
24	Knot grass	*Paspalum distichum L.*	Poaceae	**Major**	3
25	Foska begun	*Physalis heterophylla L.*	Solanaceae	**Major**	3, 4
26	Kash	*Saccharum spontaneum* L.	Poaceae	Minor	1
27	Tita begun	*Solanum torvum Sw.*	Solanaceae	Minor	3
28	Bon mashur	*Vicia sativa* L.	Fabaceae	Minor	3, 4
29	Mashurchana	*Vicia hirsute* (L.) S.F. Grav	Fabaceae	Minor	4

[1]Major in winter

Note: Some weed species reported in one or another exporting country are not reported to occur in groundnut field in Bangladesh but these are present in Bangladesh. Therefore, not included in the list of quarantine pests for Bangladesh. The weed species are:

Acalypha australis; Acalypha indica' Ageratum conyzoides (g);Abutilon indicum (h); Borreria articularis (d);Brachiaria eruciformis (a); Celosia argentea , Cyperus irria, *Digitaria marginata synonym of Digitaria ciliaris; D sanguinalis* (n); *Dichanthium annulatum* (f); *Eleusine indica; Digitaria sanguinalis; Portulaca oleracea; Setaria viridis;* Imperata cylindrical; *Solanum nigrum* (i); *Dinebra*

retroflexa (c);Cyperus defformis (e); Portulaca oleracea (j);*Commelina diffusa* (k);*Trianthema portulacastrum*(m);*Eragrostis tenella*(o) *Asteracantha longifolia* (b);*Lantana camara* (l).

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Mutha (*Cyperus rotundus*)

Durba (*Cynodon dactylon*)

Chanchi (*Alternanthera sessilis*)

Foska begun (*Physalis heterophylla*)

Bathua (*Chenopodium album*)

Kakpaya (*Dactyloctenium aegyptium)*

Figure 13.Some important weeds of groundnut in Bangladesh.

3.2 Insects, Mites, Diseases and Weeds of Groundnut in Selected Exporting Countries

Bangladesh imports groundnut from China, India, Myanmar and Vietnam. Insect pests, diseases and weeds of the groundnut in exporting countries are discussed herein.

3.2.1 Insect and mite pests of groundnut in exporting countries

3.2.1.1 Insect and mite pests of groundnut in China

Thirty six pest species (35 insects and one mite) have been reported to attack groundnut in China. Of which 20 species (19 insects and one mite) cause infestation in field during production of groundnut and 16 species attack in storage (Table 7). Among the field insect pests, six species namely common cutworm (*Spodoptera litura*), common hairy caterpillar (*Spilarctia obliqua*), groundnut leaf miner (*Aproarema modicella*)) and aphid (*Aphis craccivora*) have been reported as major insect pests and rest of them are considered as minor ones. Two spotted mite (*Tetranychus urticae*) causes less damage to groundnut in field which is considered as minor pest. Out of 16 storage insect pests, saw-toothed grain beetle (*Oryzaephilus surinamensis*), red flour beetle (*Tribolium castaneum*) and rice moth (*Corcyra cephalonica*) have been reported as major pests and the rest of the insect pests are reported as minor pest. Most of the minor pests of groundnut in storage have the potentiality to become major pest in favourable environment.

Table 7. List of insect pests of groundnut in field and storage, damaging stage(s), infested plant parts and pests status in China

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
Field Insect Pests						
01.	Black cutworm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Larvae cut and feed stem	Minor	2, 8
02.	Common cutworm	*Spodoptera litura*Fabricius	Lepidoptera: Noctuidae	Larvae feed on leaves, tender shoot and flower	**Major**	12
03.	Defoliator	*Spodoptera exigua* (Hübner)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	2, 9
04.	Semilooper.	*Thysanoplusia / Plusia orichalcea* (Fabricius)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	14
05.	Pod borer	*Helicoverpa armigera* (Hübner)	Lepidoptera: Noctuidae	Larvae bore stem and pod	Minor	12, 15
06.	Bihar hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera: Arctiidae	Larvae feed leaves	**Major**	2, 3
07.	Hairy caterpillar	*Spilosoma nydia* Butler	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	22
08.	Red hairy caterpillar	*Amsacta albistriga* (Walker)	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	3
09.	Red tiger moth	*Amsacta lactinea* (Cramer)	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	3
10.	Hairy caterpillar	*Amsacta moorei*Butler	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	23
11.	Groundnut leaf miner/ shoot miner	*Aproarema modicella* Deventer/ *Aproaerema nerteria* Meyrick/ *Stomopteryx nerteria*Meyrick	Lepidoptera: Gelechiidae	Larvae roll and feed on leaves	**Major**	3, 21
12.	White leaf hopper	*Cofana spectra* (Distant)	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	9
13.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Nymph and adult suck sap	**Major**	10

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
14.	Green stink bug	*Nezara viridula* Linnaeus	Hemiptera: Pentatomidae	Nymph and adult suck sap	Minor	4
15.	Cotton mealybug	*Phenacoccus solenopsis* Tinsley	Homoptera: Pseudococcidae	Nymph and adult suck sap	Minor	6, 13
16.	Leaf beetle	*Monolepta signata* Olivier	Coleoptera: Chrysomelidae	Adult feed on leaves	Minor	2
17.	Ant	*Camponotus* spp.	Hymenoptera: Formicidae	Nymph and adult feed root and stem	Minor	3
18.	Chili thrips	*Scirtothrips dorsalis* Hood	Thysanoptera: Thripidae	Larvae and adult suck sap	Minor	12
19.	Flower thrips	*Megalurothrips distalis (*Karny)		Larvae and adult eat flower	Minor	2,20
20.	Two spotted spider mite	*Tetranychus urticae Koch*	Acarina: Tetranychidae	Nymph and adult suck sap	Minor	15
Storage Insect Pests						
21.	Khapra beetle	*Trogoderma granarium* Everts	Coleoptera: Dermestidae	Larvae and adult feed on kernel	Minor	2
22.	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Larvae and adult feed on kernel	**Major**	7
23.	Merchant grain beetle	*Oryzaephilus mercator* (Fauvel)	Coleoptera: Silvanidae	Larvae and adult feed on kernel	Minor	2
24.	Lesser mealworm	*Alphitobius diaperinus* (Panzer)	Coleoptera: Tenebrionidae	Larvae and adult feed on kernel	Minor	2
25.	Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera: Tenebrionidae	Larvae and adult feed on kernel	**Major**	2, 18
26.	Longheaded flour beetle	*Latheticus oryzae* Waterhouse	Coleoptera: Tenebrionidae	Larvae and adult feed on kernel	Minor	2
27.	Coffee bean beetle	*Araecerus fasciculatus* (DeGeer)	Coleoptera: Anthribidae	Larvae and adult feed on kernel	Minor	17

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
28.	Cigarette beetle	*Lasioderma serricorne* (Fabricius)	Coleoptera: Anobiidae	Larvae and adult feed on kernel	Minor	2
29.	Corn sap beetle	*Carpophilus dimidiatus* (Fabricius)	Coleoptera: Nitidulidae	Larvae and adult feed on kernel	Minor	1
30.	Checkered beetle	*Necrobia rufi pes* (De Geer)	Coleoptera: Cleridae	Larvae and adult feed on kernel	Minor	2
31.	Drugstore beetle	*Stegobium paniceum* (Linnaeus)	Coleoptera: Anobiidae	Larvae and adult feed on kernel	Minor	16
32.	Cadelle	*Tenebroides mauritanicus* Linnaeus	Coleoptera: Trogositidae	Larvae and adult feed on kernel	Minor	2
33.	Flat grain beetle	*Cryptolestes pusillus* (Schoenherr)	Coleoptera: Laemophloeidae	Larvae and adult feed on kernel	Minor	11
34.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera:Curculionidae	Larvae and adult feed on kernel	Minor	2
35.	Almond moth	*Ephestia cautella* (Walker)	Lepidoptera: Pyralidae	Larvae feedskernel	Minor	19
36.	Rice moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Pyralidae	Larvae feedskernel	**Major**	5

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3.2.1.2 Insect and Mite Pests of Groundnut in India

In India, 53 species of pests (52 insects and 1 mite) have been reported as groundnut pests of which 32 species (31 insects and 1 mite) attack in field and 21 species cause infestation in storage (Table 8). Among the field insect pests, termite (*Microtermes obesi*and *Odontotermes obesus*), common cutworm (*Spodoptera litura*), pod borer (*Helicoverpa armigera*), common hairy caterpillar (*Spilarctia obliqua*), red hairy caterpillar (*Amsacta albistriga*), groundnut leaf miner (*Aproarema modicella*), jassid (*Empoasca kerri*), aphid (*Aphis craccivora*), cotton mealybug (*Phenacoccus solenopsis*), white grub (*Holotrichia serrata* and *Holotrichia consanguinea*), chili thrips (*Scirtothrips dorsalis*), cotton thrips (*Frankliniella schultzei*), onion thrips (*Caliothrips indicus*) have been reported as major pests by several authors [21, 26, 33] and other species are reported as minor pests. Two spotted mite (*Tetranychus urticae*) causes less damage to groundnut in field which is considered as minor pest.

Pod sucking bug (*Elasmolomus sordidus*), groundnut bruchid (*Caryedon serratus*), Saw-toothed grain beetle (*Oryzaephilus surinamensis*), red flour beetle (*Tribolium castaneum*) and rice moth (*Corcyra cephalonica*) have been reported as major storage insect pests and the rest of the storage insect pests were minor importance. Most of the storage insect pests attack several grains and stored products. Pod sucking bug (*Elasmolemus sordidus*) mainly storage pests of groundnut but it starts infestation from the field when harvested crops are heaped on the threshing floor [26, 33].

Aphid (*Aphis craccivora*), bruchid (*Caryedon serratus*), jassid (*Empoasca kerri*), leaf miner (*Aproarema modicella*), termite (*Odontotermes* spp.), thrips ((*Scirtothrips dorsalis*), common cutworm (*Spodoptera litura*) and white grub (*Holotrichia serrata* and *Holotrichia consanguinea*) are reported as major insect pests of national significance [33]. Most of the minor pests of groundnut in storage have the potentiality to become major pest in favourable environment.

Table 8.List of Insect Pests of Groundnut in Field and Storage, Damaging Stage(S), Infested Plant Parts and Pests Status in India

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
Field Insect Pests						
01.	Termite	*Microtermes obesi* Holmgren	Isoptera: Termitidae	Nymph and adult cut and feed root	**Major**	21,26, 33
02.		*Odontotermes obesus* (Rambur)	Isoptera: Termitidae	Nymph and adult cut and feed root		
03.	Black cutworm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Larvae cut and feed stem	Minor	7, 27
04.	Common cutworm/ Army worm	*Spodoptera litura*Fabricius	Lepidoptera: Noctuidae	Larvae feed on leaves, tender shoot and flower	**Major**	2, 21, 26, 33
05.	Defoliator	*Spodoptera exigua* (Hübner)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	12
06.	Leaf roller	*Anarsia ephippias* Meyrick	Lepidoptera: Noctuidae	Larvae web leaves and eat shoot	Minor	7
07.	Semilooper	*Thysanoplusia / Plusia orichalcea* (Fabricius)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	14, 35
08.	Gram pod borer	*Helicoverpa armigera* (Hübner)	Lepidoptera: Noctuidae	Larvae bore stem and pod	**Major**	2, 21, 26, 33
09.	Common hairy caterpillar	*Spilarctia obliqua*Walker	Lepidoptera: Arctiidae	Larvae feed leaves	**Major**	2, 33
10.	Red hairy caterpillar	*Amsacta albistriga* Walker	Lepidoptera: Arctiidae	Larvae feed leaves	**Major**	2, 26, 33
11.	Tiger moth	*Amsacta moorei* Butler	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	30, 33
12.	Red tiger moth	*Amsacta lactinea*Cramer	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	7
13.	Hairy caterpillar	*Pericallia ricini* Fabricius	Lepidoptera: Lymentridae	Larvae feed leaves	Minor	7

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
14.	Groundnut leaf miner/ shoot miner	*Aproarema modicella* Deventer/ *Aproaerema nerteria*Meyrick/ *Stomopteryx nerteria*Meyrick	Lepidoptera: Gelechiidae	Larvae roll and feed on leaves	**Major**	2, 3, 21, 26, 33
15.	Jassid	*Empoasca terminalis*Distant	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	3
16.		*Empoasca kerri* Purthi			**Major**	2, 21, 26, 33
17.	White leaf hopper	*Cofana spectra* (Distant)	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	2, 13
18.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Nymph and adult suck sap	**Major**	2, 13, 21, 26, 33
19.	Green stink bug	*Nezara viridula*Linnaeus	Hemiptera: Pentatomidae	Nymph and adult suck sap	Minor	8
20.	Cotton mealybug	*Phenacoccus solenopsis*Tinsley	Homoptera: Pseudococcidae	Nymph and adult suck sap	**Major**	26
21.	Green grasshopper	*Atractomorpha crenulata F*abricius	Orthoptera: Acrididae	Nymph and adult feed on leaves	Minor	7
22.	Leaf beetle	*Monolepta signata*Olivier	Coleoptera: Chrysomelidae	Adult feed on leaves	Minor	7
23.	White grub	*Lachnosterna serrata* (*Holotrichia serrata*)(Fabricius)	Coleoptera: Scarabaeidae	Larvae cut and feed on root	**Major**	26, 33
24.		*Holotrichia consanguinea* Blanchard				21, 26, 33
25.	Black weevil	*Cyrtozemia cognata* Marshall	Coleoptera: Curculionidae	Adult feed on leaves	Minor	7
26.	Ant	*Camponotus* spp.	Hymenoptera: Formicidae	Nymph and adult feed root and stem	Minor	7
27.	Chili thrips	*Scirtothrips dorsalis*Hood	Thysanoptera: Thripidae	Adult and nymph feed on young leaves	**Major**	2, 15,21, 26, 33
28.	Cotton thrips	*Frankliniella schultzei* (Trybom)		Adult feeds flowers, nymph feeds leaf buds	**Major**	9,25, 26
29.	Onion thrips	*Caliothrips indicus*Bagnall		Adult and nymph feed on lower leaves	**Major**	26

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
30.	Flower thrips	*Megalurothrips distalis (*Karny)		Adult and nymph feed flower	Minor	5, 7
31.	Stem borer	*Sphenoptera perotetti*Glammer	Coleoptera: Buprestidae	Larvae bore stem	Minor	17
32.	Two spotted spider mite	*Tetranychus urticae Koch*	Acarina: Tetranychidae	Nymph and adult suck sap	Minor	19
StorageInsect Pests						
33.	Pod sucking bug	*Elasmolomus sordidus* (Fabricius)	Hemiptera: Lygaeidae	Nymph and adult suck oil from kernel starting from field	**Major**	29
34.	Groundnut bruchid	*Caryedon serratus* (Olivier)	Coleoptera: Bruchidae	Larvae attack unshelled nut and feed on kernel	**Major**	1, 21, 26,29, 33
35.	Khapra beetle	*Trogoderma granarium* Everts	Coleoptera: Dermestidae	Larvae and adult feed kernel	Minor	4, 15
36.	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Larvae and adult feed kernel	**Major**	11
37.	Merchant grain beetle	*Oryzaephilus mercator* (Fauvel)	Coleoptera: Silvanidae	Larvae and adult feed kernel	Minor	7
38.	Lesser mealworm	*Alphitobius diaperinus* (Panzer)	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	Minor	1
39.	Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera: Tenebrionidae	Larvae and adult feed grains	**Major**	7, 23, 29
40.	Confused flour beetle	*Tribolium confusum* Jacquelin du Val	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	Minor	22, 31
41.	Longheaded flour beetle	*Latheticus oryzae* Waterhouse	Coleoptera: Tenebrionidae	Larvae and adult feed kernel	Minor	1, 7
42.	Coffee bean beetle	*Araecerus fasciculatus* (De Geer)	Coleoptera: Anthribidae	Larvae and adult feed kernel	Minor	7, 24
43.	Cigarette beetle	*Lasioderma serricorne* (Fabricius)	Coleoptera: Anobiidae	Larvae and adult feed kernel	Minor	16

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
44.	Corn sap beetle	*Carpophilus dimidiatus* (Fabricius)	Coleoptera: Nitidulidae	Larvae and adult feed kernel	Minor	1
45.	Checkered beetle	*Necrobia rufipes* (De Geer)	Coleoptera: Cleridae	Larvae and adult feed kernel	Minor	7
46.	Drugstore beetle	*Stegobium paniceum* (Linnaeus)	Coleoptera: Anobiidae	Larvae and adult feed kernel	Minor	20, 34
47.	Cadelle	*Tenebroides mauritanicus* Linnaeus	Coleoptera: Trogositidae	Larvae and adult feed kernel	Minor	8
48.	Flat grain beetle	*Cryptolestes pusillus* (Schoenherr)	Coleoptera: Laemophloeidae	Larvae and adult feed kernel	Minor	6, 32
49.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Larvae and adult feed kernel	Minor	7
50.	Granary weevil	*Sitophilus granarius* Linnaeus	Coleoptera: Curculionidae	Larvae and adult feed kernel	Minor	7
51.	Almond moth	*Ephestia cautella* (Walker)	Lepidoptera: Crambidae	Larvae feeds kernel	Minor	11
52.	Indian meal moth	*Plodia interpunctella* (Hubner)	Lepidoptera: Crambidae	Larvae feeds kernel	Minor	28
53.	Rice moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Crambidae	Larvae feedskernel	**Major**	10, 18,29

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3.2.1.3 Insect Pests of Groundnut in Myanmar

Thirty four species of insect pests are reported in Myanmar of which 19 species attack in field and 15 species attack in storage (Table 9). Among the storage insect pests, termite (*Odontotermes* sp.), common cutworm (*Spodoptera litura*), leaf miner (*Aproarema modicella*), pod borer (*Helicoverpa armigera*), aphid (*Aphis craccivora*) andjassid (*Empoasca* sp.) are reported as major pests and rest of the insect pests is considered as minor pest [16]. Out of 15 storage insect pests, pod sucking bug (*Elasmolomus sordidus*), groundnut bruchid (*Caryedon serratus*) saw-toothed grain beetle (*Oryzaephilus surinamensis*), red flour beetle (*Tribolium castaneum*) and rice moth (*Corcyra cephalonica*) are reported as major insect pests in storage. Most of the minor pests of groundnut in storage have the potentiality to become major pest in favourable environment.

Table 9.List of Insect Pests of Groundnut in Field and Storage, Damaging Stage(S), Infested Plant Parts and Pests Status in Myanmar

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
Field Insect Pests						
01.	Termite	*Microtermes obesi* Holmgren	Isoptera: Termitidae	Nymph and adult cut and feed root	Minor	2,14
02.		*Odontotermes obesus* (Rambur)	Isoptera: Termitidae	Nymph and adult cut and feed root	**Major**	
03.	Black cutworm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Larvae cut and feed stem	Minor	14, 17
04.	Common cutworm	*Spodoptera litura*Fabricius	Lepidoptera: Noctuidae	Larvae feed on leaves, tender shoot and flower	**Major**	14
05.	Defoliator/ army worm	*Spodoptera exigua* (Hübner)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	7, 17
06.	Semilooper.	*Thysanoplusia / Plusia orichalcea* (Fabricius)	Lepidoptera: Noctuidae	Larvae feed on leaves	Minor	2,14
07.	Pod borer	*Helicoverpa armigera*(Hübner)	Lepidoptera: Noctuidae	Larvae bore stem and pod	**Major**	14
08.	Bihar hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	2
09.	Red hairy caterpillar	*Amsacta albistriga* (Walker)	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	14,17
10.	Red tiger moth	*Amsacta lactinea* (Cramer)		Larvae feed leaves	Minor	14, 17

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
11.	Groundnut leaf miner/ shoot miner	*Aproarema modicella* Deventer/ *Aproaerema nerteria* Meyrick/ *Stomopteryx nerteria* Meyrick	Lepidoptera: Gelechiidae	Larvae roll and feed on leaves	**Major**	2, 14,17
12.	Tussock moth/ Groundnut hairy caterpillar	*Orgyia turbata* Butler	Lepidoptera: Lymantriidae	Larvae feed on leaves	Minor	2, 17
13.	Jassid	*Empoasca* sp.	Homoptera: Cicadellidae	Nymph and adult suck sap	**Major**	14
14.	White leaf hopper	*Cofana spectra*(Distant)	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	7, 18
15.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Nymph and adult suck sap	**Major**	8, 14, 17
16.	Green stink bug	*Nezara viridula* Linnaeus	Hemiptera: Pentatomidae	Nymph and adult suck sap	Minor	4,17
17.	Green grasshopper	*Atractomorpha crenulata* Fabricius	Orthoptera: Acrididae	Nymph and adult feed on leaves	Minor	14
18.	Chili thrips	*Scirtothrips dorsalis* Hood	Thysanoptera: Thripidae	Larvae and adult suck sap	Minor	2, 9,14, 17
19.	Groundnut thrips	*Callothrips indicus* (Bagnall)		Larvae and adult suck sap	Minor	14
Storage Insect Pests						
20	Pod sucking bug	*Elasmolomus sordidus* (Fabricius)	Hemiptera: Lygaeidae	Nymph and adult suck oil from kernel starting from field	**Major**	14
21.	Groundnut bruchid	*Caryedon serratus* (Olivier)	Coleoptera: Bruchidae	Larvae attack unshelled nut and feed on kernel	**Major**	15
22.	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Larva and adult feed kernel	**Major**	6, 16
23.	Merchant grain beetle	*Oryzaephilus mercator* (Fauvel)	Coleoptera: Silvanidae	Larva and adult feed kernel	Minor	6

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
24.	Lesser mealworm	*Alphitobius diaperinus* (Panzer)	Coleoptera: Tenebrionidae	Larva and adult feed kernel	Minor	1
25.	Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera: Tenebrionidae	Larva and adult feed kernel	**Major**	3, 10
26.	Longheaded flour beetle	*Latheticus oryzae* Waterhouse	Coleoptera: Tenebrionidae	Larva and adult feed kernel	Minor	1
27.	Coffee bean beetle	*Araecerus fasciculatus* (DeGeer)	Coleoptera: Anthribidae	Larva and adult feed kernel	Minor	13
28.	Cigarette beetle	*Lasioderma serricorne* (Fabricius)	Coleoptera: Anobiidae	Larva and adult feed kernel	Minor	1
29.	Corn sap beetle	*Carpophilus dimidiatus* (Fabricius)	Coleoptera: Nitidulidae	Larva and adult feed kernel	Minor	1
30.	Cadelle	*Tenebroides mauritanicus* Linnaeus	Coleoptera: Trogositidae	Larva and adult feed kernel	Minor	1
31.	Flat grain beetle	*Cryptolestes pusillus* (Schoenherr)	Coleoptera: Laemophloeidae	Larva and adult feed kernel	Minor	12
32.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Larva and adult feed kernel	Minor	3
33.	Almond moth	*Ephestia cautella* (Walker)	Lepidoptera: Crambidae	Larvae feed kernel	Minor	15
34.	Rice moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Crambidae	Larvae feed kernel	**Major**	5,11

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3.2.1.4 Insect and Mite Pests of Groundnut in Vietnam

Twenty threespecies of pests (22 insects and one mite) were reported to attack groundnut in Vietnam of which 15 species (14 insects and 1 mite) cause infestation in field and 8 species attack in storage (Table 10). Among the insect pests, common cutworm/armyworm (*Spodoptera litura*), defoliator/ beet armyworm (*Spodoptera exigua*),pod borer (*Helicoverpa armigera*) and green stink bug (*Nezara viridula*) were reported as major pests which caused considerable loss every year and the rest of the insect pests are of minor importance [15]. Minor pests cause less damage or presence in Vietnam with low incidence. Two spotted mite (*Tetranychus urticae*) causes less damage to groundnut in field which is considered as minor pest. Among the 8 storage insect pests red flour beetle (*Tribolium castaneum*) is major pest and other seven species are minor pests of groundnut in storage. Most of the minor pests of groundnut in storage have the potentiality to become major pest in favourable environment.

Table 10. List of Insect Pests of Groundnut In Field And Storage, Damaging Stage(S), Infested Plant Parts and Pests Status In Vietnam

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
Field Insect Pests						
01.	Black cutworm	*Agrotis ipsilon* (Hufnagel)	Lepidoptera: Noctuidae	Larvae cut and feed stem	Minor	1, 16
02.	Common cutworm/ Armyworm	*Spodoptera litura* Fabricius	Lepidoptera: Noctuidae	Larvae feed on leaves, tender shoot and flower	**Major**	16
03.	Defoliator/ Beet armyworm	*Spodoptera exigua* (Hübner)	Lepidoptera: Noctuidae	Larvae feed on leaves	**Major**	7,16
04.	Pod borer	*Helicoverpa armigera* (Hübner)	Lepidoptera: Noctuidae	Larvae bore stem and pod	**Major**	16
05.	Hairy caterpillar	*Spilosoma nydia* Butler	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	17
06.	Red tiger moth	*Amsacta lactinea* (Cramer)	Lepidoptera: Arctiidae	Larvae feed leaves	Minor	16
07.	Tussock moth/ Groundnut hairy caterpillar	*Orgyia turbata* Butler	Lepidoptera: Lymantriidae	Larvae feed on leaves	Minor	16
08.	Groundnut leaf miner/ leaf webber	*Aproarema modicella* Deventer/ *Aproaerema nerteria* Meyrick/ *Stomopteryx nerteria* Meyrick	Lepidoptera: Gelechiidae	Larvae roll and feed on leaves	Minor	14
09.	Jassid	*Empoasca* sp.	Homoptera:	Nymph and adult suck	Minor	16

Sl. No.	Common name	Scientific name	Order: Family	Infested plant parts	Status	Reference
			Cicadellidae	sap		
10.	White leaf hopper	*Cofana spectra* (Distant)	Homoptera: Cicadellidae	Nymph and adult suck sap	Minor	18
11.	Aphid	*Aphis craccivora* Koch	Homoptera: Aphididae	Nymph and adult suck sap	Minor	1, 8, 16
12.	Green stink bug	*Nezara viridula* Linnaeus	Hemiptera: Pentatomidae	Nymph and adult suck sap	Major	4, 16
13.	Cotton mealybug	*Phenacoccus solenopsis* Tinsley	Homoptera: Pseudococcidae	Nymph and adult suck sap	Minor	6, 13
14.	Leaf beetle	*Monolepta signata* Olivier	Coleoptera: Chrysomelidae	Adult feed on leaves	Minor	16
15.	Two spotted spider mite	*Tetranychus urticae Koch*	Acarina: Tetranychidae	Nymph and adult suck sap	Minor	11, 16
Storage Insect Pests						
16.	Saw-toothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Larva and adult feed kernel	Minor	16
17.	Red flour beetle	*Tribolium castaneum* (Herbst)	Coleoptera: Tenebrionidae	Larva and adult feed kernel	**Major**	3, 10
18.	Confused flour beetle	*Tribolium confusum* Jacquelin du Val	Coleoptera: Tenebrionidae	Larva and adult feed kernel	Minor	9
19.	Coffee bean beetle	*Araecerus fasciculatus* (De Geer)	Coleoptera: Anthribidae	Larva and adult feed kernel	Minor	12
20.	Flat grain beetle	*Cryptolestes pusillus* (Schoenherr)	Coleoptera: Laemophloeidae	Larva and adult feed kernel	Minor	15
21.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Larva and adult feed kernel	Minor	3
22.	Almond moth	*Ephestia cautella* (Walker)	Lepidoptera: Crambidae	Larva feeds kernel	Minor	3
23.	Rice moth	*Corcyra cephalonica* (Stainton)	Lepidoptera: Crambidae	Larva feeds kernel	Minor	2, 5

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3.2.2 Diseases of Groundnut in Selected Exporting Countries

Through extensive searches of Books, Journals and internet resources records of diseases on groundnut in four exporting countries viz., China, India, Myanmar and Vietnam were collated and presented in Tables11. Information provided in the tables include name of disease, causal organism, status, plant parts affected and sources.

It appears from table 11that in China groundnut is affected by all the four groups of organisms viz., fungus, bacterium, virus and nematode. Our search revealed 14 diseases inflicting groundnut crop in China. Among these 9 diseases are caused by fungal pathogens, one by bacterium, three by viruses and one by nematode. The status of seven diseases was major. Out of seven major diseases five are caused by fungal pathogens. The only bacterial disease showed minor status. Out of five virus diseases peanut stunt was occasionally major and the only nematode disease was major (Table 11). Seed-borne diseases are Sclerotinia blight, pod rot and peanut mild mottle disease.

In India, total number of disease records was 24, of which 15, 1, 5, and 3 are incited by fungi, bacterium, virus, mycoplasma and nematode pathogens. Altogether 13 diseases were of major concern for groundnut production. Among the major diseases seven were fungal, three viral and three were nematode diseases. Among the fungal diseases Afla-root or yellow mold caused by *Asperg*illus flavus, crown rot (*Aspergillus niger*), crown/collar rot (*Sclerotium rolfsii*), seed rot (*Fusarium oxysporum*), seed and seedling rot (*Rhizopus spp.*) and black rot (*Cylindrocladium crotalariae*) and among the viruses peanut mottle virus and peanut stripe virus are seed-borne (Table 12).

Ten diseases were found to occur on groundnut in Myanmar. Among the diseases eight are caused by fungi, one by bacterium and one by virus. Out of 10 diseases four were of major concern.

All the four major diseases are caused by fungal pathogen. The major diseases were early leaf spot, late leaf spot, collar rot and rust. *Aspergillus flavus* and peanut stripe virus are known to be seed-borne (Table 13).

In Vietnam 15 diseases were found to occur on groundnut caused by fungal, bacterial and viral agents. Out of 15 diseases 12 are caused by fungi, one by bacterium and two by viruses. The major fungal diseases were late leaf spot, collar rot and rust. Early leaf spot disease is generally minor but occasionally become major. The only bacterial disease caused by *Ralstonia solanacearum* was also major. Both the virus disease appeared as minor. *Aspergillus niger, Aspergillus flavus* and peanut stripe virus are known to be seed-borne (Table 14).

Table 11. List of Groundnut Diseases in China

Sl.No.	Disease	Pathogen	Status	Plant parts affected	Reference
01	Early leaf spot	*Cercospora arachidicola* S. Hori	**Major**	Leaf	3
02	Late leaf spot	*Cercosporidium personatum* *Phaeoisariopsis personata* (Berk & M.A. Curtis) Arx	**Major**	Leaf	16, 21
03	Rust	*Puccinia arachidis* Speg.	**Major**	Leaf, other aerial parts except	4

Sl.No.	Disease	Pathogen	Status	Plant parts affected	Reference
				flower	
04	Phyllosticta leaf spot	*Phyllosticta arachidis-hypogaea* Vasant Rao	Minor	Leaf	5
05	Root rot	*Aspergillus niger* Tiegh.	Minor	Stem base, root	18
06	Sclerotinia blight	*Sclerotinia sclerotiorum* (Lib.) de Bary *Sclerotinia minor* Jagger	**Major**	Leaf, branch, peg, pod, seed	13
07	Brown root rot	*Fusarium oxysporum,* *F. solani*	**Major**	Root	7
08	Pod rot	*Pythium, Rhizoctonia, Fusarium* spp.*, Macrophomina phaseoli*	Minor	Pod, seed	17
09	Yellow mold	*Aspergillus flavus* Link. Ex. Fries.	Minor	Root, shell, seed	24
10	Bacterial wilt	*Ralstonia solanesearum* (Smith) Smith	Minor	Root, stem, branch	12, 13
11	Peanut stripe	*Peanut stripe virus* (PStV)	Minor	Leaf	19, 20,
12	Cucumber mosaic	*Cucumber mosaic virus*	Minor	Leaf	20
13	Peanut stunt	*Peanut stunt virus* (PSV)	Occasionally **major**	Entire plant	14, 20
14	Root knot nematodes	*Meloidogyne hapla* Chitwood	**Major**	Peg, root, pod	14

Table 12. List of Diseases of Groundnut in India

Sl.No.	Disease	Pathogen	Status	Plant parts affected	References
01	Early leaf spot	*Cercospora arachidicola* S. Hori	**Major**	Leaf	9
02	Late leaf spot	*Cercosporidium personatum* Berk. & M.A. Curtis	**Major**	Leaf	9
03	Rust	*Puccinia arachidis* Speg.	**Major**	Leaf, other aerial parts except flower	1
04	Afla root/ Yellow mould	*Aspergillus flavus*Link. Ex. Fries.	**Major**	Root, shell, seed	1
05	Crown rot	*Aspergillus niger* Tiegh.	**Major**	Crown, germinating seed	9
06	Dry root rot	*Macrophomina phaseolina (Rhizoctonia bataticola)*	Minor	Root	1

Sl.No.	Disease	Pathogen	Status	Plant parts affected	References
07	Crown rot/Collar rot /Stem rot	*Sclerotium rolfsii* Sacc.	**Major**	Stem base, root, pod, seed	9, 11
08	Alternaria leaf spot	*Alternaria alternata*(Fries) Keisler	Becoming increasingly important	Leaf	1, 11
09	Phyllosticta leaf spot	*Phyllosticta arachidis-hypogaea* Vasant Rao	Minor	Leaf	11
10	Alternaria leaf disease	*Alternaria arachidis* and *A. tenuissima*	Minor	leaf	1, 11
11	Anthracnose	*Colletotrichum arachidis* Swada, *C. capsici* *C. dematium* (Pers.) Grove, *C. mangenoti* chevaugeon	Minor	Leaf, stipules, stem	1, 11
12	Seed rot	*Fusarium oxysporum, F. solani*	Minor	Pod, Seed	1
13	Rhizopus seed and seedling rot	*Rhizopus arrhizus, R. oryzae, R. stolonifer*	Minor	Pod, Seed	1
14	Collar rot	*Lasiodiplodia theobromae* (Pat.) Grifon & Maubl.	**Major**	Stem base, shell, seed	1, 14
15	Cylindrocladium black rot	*Cylindrocladium crotalariae* (Loos) Ben & Sobers	Minor	Stem, branch, root, pod,seed	1, 11
16	Bacterial wilt	*Pseudomonas solanesearum* (Smith) Smith	Minor	Root, stem base, branch	11
17	Peanut bud necrosis	*Peanut bud necrosis virus*	**Major**	Terminal buds	1, 11, 15
18	Peanut clump	*Indian Peanut clump virus* (IPCV)	**Major**	Entire aerial parts	11, 15
19	Peanut mottle	*Peanut mottle virus* (PeMoV)	**Major**	Leaf, pod, seed	11, 15
20	Peanut stripe	*Peanut stripe virus (PStV)*	Minor	Entire plant seed	11
21	Peanut stunt	*Peanut stunt virus (PSV)*	Minor	Entire plant	11
22	Root lesion	*Pratylenchus brachyurus* (Godfrey) Filipjev & Sch.	**Major**	Peg, root, pod	14
23	Root knot nematodes	*Meloidogyne arenaria* (Neal) Chitwood, M. javanica *M. hapla* Chitwood	**Major**	Peg, root, pod	10, 14
24	Kalahasti malady	*Tylenchorhynchus brevilineatus* Williams	**Major**	Peg, root, pod	6

Table 13.List of groundnut diseases in Myanmar

Sl. No.	Disease	Pathogen	Status	Plant Parts affected	References
01	Early leaf spot	*Cercospora arachidicola* S. Hori	**Major**	Leaf	23
02	Late leaf spot	*Phaeoisariopsis personata* Berk. & M.A. Curtis	**Major**	Leaf	22
03	Collar rot	*Aspergillu niger* Tiegh.	**Major**	Stem base, root, pod	2
04	Yellow mold	*Aspergillus flavus* Link. Ex. Fries.	Minor	Root, pod, seed	5
05	Root rot	*Sclerotium rolfsii* Sacc.	Minor	Root	2, 23
06	Rust	*Puccina arachidis speg.*	**Major**	Leaf, other aerial parts except flower	4
07	Charcoal rot	*Macrophomina phaseolina*	Minor	Entire plant	2
08	Dry root rot	*Rhizoctonia solani*	Minor	Root	23
09	Bacterial wilt	*Ralstonia solanacearum*	Minor	Root, stem base, branch	2
10	Groundnut stripe	Peanut stripe virus	Minor	Entire plant seed	2

Table 14. List of groundnut diseases in Vietnam

Sl. No.	Disease	Pathogen	Status	Plant Parts infected	References
01	Early leaf spot	*Cercospora arachidicola* S. Hori	Occassionally **major**	Leaf	8
02	Late leaf spot	*Phaeoisariopsis personata* (Berk & M.A. Curtis) Arx	**Major**	Leaf	8
03	Collar rot	*Aspergillu niger* Tiegh.	**Major**	Stem base, root, pod	8
04	Rust	*Puccina arachidis speg.*	**Major**	All aerial parts except flower	4, 8
05	Leaf blight	*Rhizoctonia solani*	Minor	Leaf	8
06	Root rot	*Sclerotium rolfsii*	Minor	Root	8
07	Alternaria Leaf Spot	*Alternaria alternata* (Fries) Keissler	Minor	Leaf	8
08	Phyllosticta leaf spot	*Phyllostictus arachicis-hypogea Vasant Rao*	Minor	Leaf	8
09	Charcoal rot	*Macrophomina phaseolina*	Minor	Entire plants	8
10	Dry root rot	*Rhizoctonia solani*	Minor	Root	8

Sl. No.	Disease	Pathogen	Status	Plant Parts infected	References
11	Damping-off	*Pythium sp., Fusarium sp.*	Minor	Young seedling base	8
12	Yellow mold	*Aspergillus flavus* Link. Ex. Fries.	Minor	Root, pod, seed	8
13	Bacterial wilt	*Ralstonia solanacearum* (Smith) Smith	**Major**	Root, stem base, branch	8
14	Groundnut stripe	Peanut stripe virus	Minor	Leaf, seed	8
15	Bud necrosis	*Peanut bud necrosis virus*	Minor	Terminal Bud	8

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3.2.3 Weeds of Groundnut in Four Selected Exporting countries

Association of weed species with groundnut crop in four selected groundnut exporting countries were collected and tabulated. Information provided in the tables include common name of the weed, scientific name, family, status of individual and references.

In China information on 19 weed species representing 9 families and their status were shown in table 15. Out of 19 species eight were major, The major weeds were distributed under seven families of which family Poaceae had the highest number of major weeds. The major weeds were Amaranthus spinosus (Amaranthaceae), *Acanthospermum hispidum*(Asteraceae), *Cyperus rotundus*(Cyperaceae), *Boerhavia diffusa* (Nyctaginaceae), *Digitaria sanguinalis, Eleusine indica, Setaria viridis* (Poaceae) and *Portulaca oleracea*(Portulacaceae).

In India as high as 38 weed species were recorded in groundnut fields at different regions. The weed species represented 17 families (Table 16). The most predominant family was Poaceae under which

14 different weed species were found. This was followed by family Amaranthaceae and Asteraceae each having four species. Among the 39 weed species 14 species are major concern for the growers. The major weeds representing the families, in order of prevalence were Poaceae (*Dactyloctenium aegyptium,* Digitaria sanguinalis, *Echinochloa colonum*and *Paspalum repens),* Amaranthaceae (*Amaranthus spinosus*, *Amaranthus viridis and Celosia argentea*), Euphorbiaceae (*Acalypha indica andEuphorbia hirta*), Each of the rest five families had only one species.

In Myanmar 17 weed species representing eight families reported to occur in groundnut crop field are shown in Table 17.Six weed species were found under the Poaceae, three under Euphorbiaceae, two under Amaranthaceae and two under Malvaceae family. Each of the rest four families had only one species. Out of 17 weed species seven were of major importance. These were *Achanthospermum hispidum, Trianthema portulacastrum, Euphorbia hirta, Abutilon indicum, Cynodon dactylon, Digitaria sanguinalis*and *Portulaca oleracea* (Table 17).

Groundnut field weeds recorded in Vietnam are shown in Table 18. Altogether 16 weed species representing nine families were recorded. Poaceae was the most predominant family included five species, which was followed by Amaranthaceae and Cyperaceae under each had two species. Only one species represented each of the six families such as Asteraceae, Aizoaceae, Commelinaceae, Euphorbiaceae, Malvaceae and Portulacaceae. In Vietnam eight species were found as major problem for groundnut (Table 18).

Table 15. List of Groundnut Weeds in China

Sl.No.	Common name	Scientific name	Family	Status	References
01	redroot pigweed	*Amaranthus retroflexus* L.	Amaranthaceae	Minor	5
02	Katanotey	*Amaranthus spinosus* L.	Amaranthaceae	**Major**	24
03	Goat's head	*Acanthospermum hispidum* DC.	Asteraceae	**Major**	25
04	Asiatic dayflower	*Commelina communis* Benth., non L Syn. *C. diffusa* Burm. f.	Commelinaceae	Minor	23
05	purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	**Major**	1
06	rice flatsedge	*Cyperus iria* L.	Cyperaceae	Minor	1
07	Asian copperleaf	*Acalypha australis* L.	Euphorbiaceae	Minor	23
08	Indian nettle	Acalypha indica L	Euphorbiaceae	Minor	2
09	Red spiderling	*Boerhavia diffusa* L.	Nyctaginaceae	**Major**	8
10	Crabgrass	*Digitaria sanguinalis* (L.) Scop.	Poaceae	**Major**	23, 27
11	Barnyard grass	Echinochloa crus-galli (L.) P.Beauv	Poaceae	Minor	1
12	Goose grass	*Eleusine indica* (L.) Gaertn.	Poaceae	**Major**	23
13	Green foxtail	*Setaria viridis* (L.) Beauv.	Poaceae	**Major**	23
14	Bermuda grass	Cynodon dactylon (L.) Pers.	Poaceae	Minor	1
15	Cogon grass	Imperata cylindrica	Poaceae	Minor	1

Sl.No.	Common name	Scientific name	Family	Status	References
		(Linnaeus) Raeuschel			
16	Australian fingergrass	Chloris truncate R.Br.	Poaceae	Minor	1
17	Common purslane	*Portulaca oleracea* L.	Portulacaceae	**Major**	23
18	Purslane	Portulaca oleracea L.	Portulacaceae	Minor	1
19	Black nightshade	Solanum nigrum .	Solanaceae	Minor	1

Table 16. Common Weed Infestation in Groundnut Field in India

Sl. No.	Common name	Scientific name	Family	Status	Reference
01	Katanotey	*Amaranthus spinosus* L.	Amaranthaceae	**Major**	14
02	Pigweed	*Amaranthus viridis* L.	Amaranthaceae	**Major**	13, 14, 17
03	White cock's comb	*Celosia argentea* L.	Amaranthaceae	**Major**	22
04	Wild carrot	*Daucus carota* L.	Apiaceae	Minor	6
05	Billy goat weed	Ageratum conyzoides L.	Asteraceae	Minor	6
06	Goat's head	*Acanthospermum hispidum* DC.	Asteraceae	Minor	6
07	Blackjack	*Bidens pilosa* L.	Asteraceae	Minor	21
08	Parthenium weed	*Parthenium hysterophorus* L.	Asteraceae	Minor	14
09	Horse purslane	*Trianthema portulacastrum* L.	Aizoaceae	**Major**	14, 16, 22
10	Lams' Quarter	Chenopodium album L.	Chenopodiaceae	Minor	3, 13
11	Nettle leaf goosefoot	Chenopodium murale L.	Chenopodiaceae	Minor	3, 13
12	Wandering Jew	*Commelina benghalensis* L.	Commelinaceae	Minor	6
13	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Minor	3, 14, 19
14	Small flower Nut sedge	*C. difformis* L.	Cyperaceae	**Major**	13, 22
15	Indian nettle	Acalypha indica L	Euphorbiaceae	**Major**	14
16	wild poinsettia	*Euphorbia geniculata* Ort.	Euphorbiaceae	Minor	14
17	Spurge	*Euphorbia hirta* L.	Euphorbiaceae	**Major**	13, 14, 22
18	Threeflower beggarweed	*Desmodium triflorum* (L.) DC.	Fabaceae	Minor	6
19	Sida	*Sida acuta* L.	Malvaceae	Minor	4, 14
20	Red spiderling	*Boerhavia diffusa* L.	Nyctaginaceae	Minor	17
21	Mexican poppy	*Argemone Mexicana* L.	Papaveraceae	**Major**	22
22	Corn spurge	*Phyllanthus niruri* L.	Phyllanthaceae	Minor	13, 14
23	Sweet	*Brachiaria eruciformis*(Smith)	Poaceae	Minor	14

Sl. No.	Common name	Scientific name	Family	Status	Reference
	signalgrass	Grisebach, Fl. Ross.			
24	Bermuda grass	*Cynodon dactylon* (L.) Pers.	Poaceae	Minor	3, 14
25	Crow foot grass	*Dactyloctenium aegyptium*(L.) Willd.	Poaceae	**Major**	3, 13, 14, 22
26	Kleberg's bluestem	*Dichanthium annulatum* (Forssk.) Stapf	Poaceae	Minor	14
27	southern crabgrass	*Digitaria marginata* (Link.) Henrard	Poaceae	Minor	14
28	Crab grass	Digitaria sanguinalis	Poaceae	**Major**	13, 14, 22
29	Viper grass	*Dinebra retroflexa* (Vahl) Panz.	Poaceae	Minor	14
30	Jangle rice	*Echinochloa colonum* (L.) Link	Poaceae	**Major**	13,14, 22
31	Barnyard grass	*Echinochloa crusgalli* (L.)Beauv	Poaceae	Minor	13
32	Goose grass	*Eleusine indica* (L.) Gaertner	Poaceae	Minor	14
33	Love grass	*Eragrostis tenella* (L.) P.Beauv.ex Roem.& Schult.	Poaceae	Minor	13
34	Knot grass	*Paspalum distichum* L.	Poaceae	Minor	13
35	Knotgrass	*P. repens* L.	Poaceae	**Major**	14
36	Purslane	*Portulaca oleracea*	Portulacaceae	**Major**	22
37	Button plant	*Borreria articularis*(L. f.) F. N. Will.	Rubiaceae	**Major**	22
38	Lantana	*Lantana camara* L.	Verbenaceae	Minor	9, 20

Table 17. Common Weed Infestation in Groundnut Field in Myanmar

Sl. No.	Common name	Scientific name	Family	Status	References
01	Katanotey	*Amaranthus spinosus* L.	Amaranthaceae	Minor	26
02	Celosia	*Celosia argentea* L.	Amaranthaceae	Minor	26
03	Goat's head	*Achanthospermum hispidum* DC.	Asteraceae	**Major**	18
04	Horse purslane	*Trianthema portulacastrum* L.	Aizoaceae	**Major**	18
05	Indian nettle	Acalypha indica L	Euphorbiaceae	Minor	2
06	wild poinsettia	*Euphorbia geniculata* Ort.	Euphorbiaceae	Minor	26
07	Spurge	*Euphorbia hirta* L.	Euphorbiaceae	**Major**	26
08	Indian mallow	*Abutilon indicum*(L.) Sweet	Malvaceae	**Major**	26
09	Sida	*Sida acuta* L.	Malvaceae	Minor	26
10	Bermuda grass	*Cynodon dactylon* L.	Poaceae	**Major**	11
11	Crow foot grass	*Dactyloctenium aegyptium* (L.) P. Beauv.	Poaceae	Major	11

Sl. No.	Common name	Scientific name	Family	Status	References
12	Crab grass	*Digitaria sanguinalis*(L.) Scop.	Poaceae	**Major**	26
13	Janglerice	*Echinochloa colona* (L.) Link	Poaceae	Minor	26
14	Goose grass	*Eleusine indica* (L.) Gaertner	Poaceae	Minor	11
15	Knot grass	*Paspalum distichum* L.	Poaceae	Minor	26
16	Purslane	*Portulaca oleracea* L.	Portulacaceae	**Major**	26
17	Lantana	*Lantana camara* L.	Verbenaceae	Minor	26

Table 18. Common Weed Infestation in Groundnut Field in Vietnam

Sl. No.	Common name	Scientific name	Family	Status	References
01	White cock's comb	*Celosia argentea* L.	Amaranthaceae	Minor	18
02	Katanotey	Amaranthus spinosus	Amaranthaceae	**Major**	26
03	Pigweed	Amaranthus viridis L.	Amaranthaceae	**Major**	11
04	Billy goat weed	*Ageratum conyzoides* L.	Asteraceae	**Major**	11
05	Horse purslane	*Trianthema portulacastrum* L.	Aizoaceae	**Major**	18
06	Wandering Jew	*Commelina benghalensis* L.	Commelinaceae	Minor	26
07	Small flower Nut sedge	*C. difformis* L.	Cyperaceae	**Major**	10
08	Purple nutsedge	*Cyperus rotundus* L.	Cyperaceae	Minor	11
09	wild poinsettia	*Euphorbia geniculata* Ort.	Euphorbiaceae	Minor	26
10	Indian mallow	*Abutilon indicum*	Malvaceae	Minor	26
11	Bermuda grass	*Cynodon dactylon* L.	Poaceae	**Major**	11
12	Crow foot grass	*Dactyloctenium aegyptium* (L.) P. Beauv.	Poaceae	Minor	12
13	Southern crabgrass	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	Minor	11
14	Janglerice	*Echinochloa colona* (L.) Link	Poaceae	**Major**	26
15	Goose grass	*Eleusine indica* L.	Poaceae	**Major**	11
16	Knotgrass	*Portulaca oleracia L*.	Portulacaceae	Minor	15

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4.0 QUARANTINE PESTS OF GROUNDNUT FOR BANGLADESH

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

4.1 Quarantine Insect Pests of Groundnut

Thirteen species of insect pests have been identified as quarantine insect pests of groundnut for Bangladesh (Table 19). Of which six species namely *Amsacta albistriga*, *Amsacta moorei*, *Amsacta lactinea*, *Orgyia turbata*, *Phenacoccus solenopsis* and *Caliothrips indicus*attack groundnut in field during production. Seven species such as groundnut bruchid (*Caryedon* serratus), merchant grain beetle (*Oryzaephilus Mercator*),lesser mealworm(*Alphitobius diaperinus*),coffee bean beetle (*Araecerus fasciculatus*),cadelle beetle (*Tenebroides mauritanicus*),granary weevil(*Sitophilus granarius*)and Indian meal moth (*Plodia interpunctella*) attack stored groundnut.All the field and storage quarantine pests are polyphagous and reported to attack many alternate hosts.Most of the storage pests have the potentiality to cause considerable damage of stored groundnut in favourable environment.Out of 13 quarantine species, 8 species are present in China, 12 species in India, 9 species in Myanmar and 3 species are present in Vietnam (Table 19).

Table 19.List of Quarantine Insect Pest of Groundnut In Exporting Countries and Plant Parts Likely to Carry the Pests

Sl. No.	Name of the insect pests	Scientific name (Order: Family	Name of the countries from where groundnut imported in Bangladesh				Plant parts are likely to carry the pests
			China	India	Myanmar	Vietnam	
01.	Red hairy caterpillar	*Amsacta albistriga* Walker Lepidoptera: Arctiidae	**Present** [5]	**Present** [2, 15,19]	**Present** [13, 20]	**Absent**	Eggs and larvae carried with leaves, branch carry externally
02.	Tiger moth	*Amsacta moorei* Butler Lepidoptera: Arctiidae	**Present** [21]	**Present** [18, 19]	**Absent**	**Absent**	Eggs and larvae carried with leaves, branch carry externally
03.	Red tiger moth	*Amsacta lactinea* Cramer Lepidoptera: Arctiidae	**Present** [5]	**Present** [5]	**Present** [13]	**Present** [20]	Eggs and larvae carried with leaves, branch carry externally
04.	Tussock moth	*Orgyia turbata* Butler Lepidoptera: Lymantriidae	**Absent**	**Absent**	**Present** [20]	**Present** [20]	Eggs and larvae carried with leaves, branchcarry externally
05.	Cotton mealybug	*Phenacoccus solenopsis* Tinsley Homoptera: Pseudococcidae	**Present** [6, 9]	**Present** [15]	**Absent**	**Absent**	Infested leaves, stems flowers, fruits, roots carry nymphs and adults externally
06.	Groundnut thrips	*Caliothrips indicus* Bagnall Thysanoptera: Thripidae	**Absent**	**Present** [15]	**Present** [13]	**Absent**	Egg, arvae, pupa, adult carry with plant parts and soil
07.	Groundnut bruchid	*Caryedon serratus* (Olivier) Coleoptera: Bruchidae	**Absent**	**Present** [1, 10, 15, 17, 19]	**Present** [17]	**Absent**	Pods, seeds and stored productscarry egg, larvae, pupa and adult
08.	Merchant grain beetle	*Oryzaephilus mercator* (Fauvel) Coleoptera: Tenebrionidae	**Present** [3]	**Present** [5]	**Present** [7]	**Absent**	Seeds and stored products carry egg, larva, pupa and adult
09.	Lesser mealworm	*Alphitobius diaperinus* (Panzer) Coleoptera: Tenebrionidae	**Present** [3]	**Present** [1]	**Present** [1]	**Absent**	Seeds and stored products carry egg,

Sl. No.	Name of the insect pests	Scientific name (Order: Family	Name of the countries from where groundnut imported in Bangladesh				Plant parts are likely to carry the pests
			China	India	Myanmar	Vietnam	
							larva, pupa and adult
10.	Coffee bean beetle	*Araecerus fasciculatus* (De Geer) Coleoptera: Anthribidae	**Present** [12]	**Present** [5,14]	**Present** [11]	Present [11]	Seeds and stored products carry egg, larva, pupa and adult
11.	Cadelle beetle	*Tenebroides mauritanicus* Linnaeus Coleoptera: Trogositidae	**Present** [5]	**Present** [5]	**Present** [1]	**Absent**	Seeds and stored products carry egg, larva, pupa and adult
12.	Granary weevil	*Sitophilus granarius* Linnaeus Coleoptera: Curculionidae	**Absent**	**Present** [5]	**Absent**	**Absent**	Seeds and stored products carry egg, larva, pupa and adult
13.	Indian meal moth	*Plodia interpunctella* (Hubner) Lepidoptera: Crambidae	**Absent**	**Present** [16]	**Absent**	**Absent**	Seeds and stored products carry egg, larva, pupa and adult

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4.2 Quarantine Diseases of Groundnut

After comparing the diseases of groundnut occur in Bangladesh to those in China, India, Myanmar and Vietnam 5 diseases have been identified as quarantine object for Bangladesh. *Aspergillus flavus* is a cosmopolitan fungus present almost everywhere including Bangladesh. As such this organism is not a quarantine pest for Bangladesh. However, this fungus produces afla-toxin, which is harmful for man and animal. Therefore, afla-toxin contaminated seed is considered as quarantine object for Bangladesh. Besides, 4 diseases absent in Bangladesh are peanut bud necrosis, peanut stripe, Indian peanut clump, and peanut mottle. Out of the 5 diseases one is caused by fungal pathogens and 4 by viruses (Table 20).

Table 20. Distribution of Quarantine Diseases for Bangladesh in Four Exporting Countries

Sl. No.	Disease	Pathogen	Distribution among groundnut exporting countries	Plant parts likely carry the pathogen
01.	Yellow mold	*Aspergillus flavus*Link. Ex. Fries.	China, India, Myanmar, Vietnam	Shell, seed
02.	Peanut bud necrosis	*Peanut bud necrosis virus*	China, India, Vietnam	Terminal buds
03.	Peanut stripe	*Peanut stripe virus* (PStV)	China, Myanmar, Vietnam	Leaf and seed
04.	Indian Peanut clump	*Indian Peanut clump virus* (IPCV)	India	Entire aerial parts
05.	Peanut mottle	*Peanut mottle virus* (PeMoV)	India	Entire aerial parts

4.3 Quarantine Weeds of Groundnut

Three weed species, such as *Amaranthus retroflexus*, *Boerhavia diffusa* and*Euphorbia geniculata*wereidentified as quarantine weeds for Bangladesh. Distribution of this threre quarantine weeds in four groundnut exporting countries is shown in Table 21. It reveals from the table that only one weed species (*Euphorbia geniculata)* was present in three countries such as India, Myanmar and Vietnam. *Amaranthus retroflexus* were present only in China and *Boerhavia diffusa* in China and India. Table also revealed that out of three weed species two were present in India, two in China, and one in Myanmar and Vietnam. All three three weed species may be associated with groundnut as seed contaminant (Table 21).

Table 21. Distribution of Quarantine Weeds for Bangladesh in Four Exporting Countries

Sl.No.	Weed Species	Family	Distribution among groundnut exporting countries	Plant parts likely carry the pathogen
01.	*Amaranthus retroflexus* L.	Amaranthaceae	China	Seed contaminated with groundnut
02.	*Boerhavia diffusa* L.	Nyctaginaceae	China, India	Seed contaminated with groundnut
03.	*Euphorbia geniculata* Ort.	Euphorbiaceae	India, Myanmar, Vietnam	Seed contaminated with groundnut

5.0 PEST RISK ASSESSMENT

5.1 Insect Pests

5.1.1 Red hairy caterpillar (*Amsacta albistriga*)

5.1.1.1 Hazard Identification

Common name: Red hairy caterpillar

Scientific name: *Amsacta albistriga* Walker 1864 [3]

Synonyms: Hairy caterpillar, other scientific names-*Creatonotos albistriga* Walker, *Aloa albistriga* Walker [2].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Arctiidae
Genus: *Amsacta*
Species: *Amsacta albistriga*

Bangladesh status:is not known to be present in Bangladesh [1,2]

EPPO code: AMSAAL (*Amsacta albistriga*) [2].

5.1.1.2 Biology

Adult moth is having white coloured wings with red margin on forewings and black spots on hindwings. Larvae are black with bright red coloured with long hairs. Spilosoma obliqua: Medium sized brown moth with a red abdomen. Wings pinkish with numerous black spots. The eggs are laid in cluster on the underside of leaves and larvae are covered with long yellowish to black hairs. Young larvae feed gregariously mostly on the under surface of the leaves. Larvae are voracious defoliator destroys many crops. They migrate in groups from field to field feeding voraciously on the crops that come across on their way giving them grazed appearance often whole crop is defoliated. Drying up of infected leaves is the main symptom [3].The adults emerge from the soil at the onset of the southwest monsoon (usually in June).Females lay 800-1000 eggs in clusters of 50-100 on groundnut and other host plants. The larvae are initially light brown, but turn reddish as they grow. Their 'hairiness' makes them conspicuous, especially the larger ones.They devastate groundnut foliage and then migrate to the next groundnut field. There is confusion about how many generations the pest completes per annum in different geographical regions, though it is now known that the pest has two generations per annum in Southern Karnataka [4].

5.1.1.3 Hosts

Major hosts -Sorghum(*Sorghum bicolor*), maize (*Zea mays*); minor hosts -*Arachis hypogaea* (groundnut) [2].In endemic areas, groundnut and other crops such as sesamum, sunflower, redgram etc. suffer heavy defoliation from large populations of red hairy caterpillar.

5.1.1.4 Geographic Distribution

China and India [2].

The red headed hairy caterpillar (RHC), *A. albistriga* (Walker) (Lepidoptera: Arctiidae) is one of the major pests causing severe damage to the crop in South India [6]. *A. albistriga* has been a major pest in red loamy soils in the districts of Raichur, Bellary, Gulbarga, Belgaum, Bijapur, Chitradurga, Chikkamagalur and Kolar [7, 8]. Recently, the outbreak was also reported from some parts of Bidar and Bellary districts.

5.1.1.5 Hazard Identification Conclusion

Considering the fact that *A. albistriga*–

- is not known to be present in Bangladesh [1, 2].
- is potentially economic important to Bangladesh. It is a minor pest of groundnut, sorghum, and maize in China, India from where groundnut is imported [2] but major pest of South India [5].
- is not likely to become established in Bangladesh through importation of groundnut pods or seeds because *A. albistriga*is not known to carry with groundnut pods or seeds trade and transport [2].

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

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5.1.2 Tiger moth (*Amsacta moorei*)

5.1.2.1 Hazard Identification

Common name: Tiger moth

Scientific name: *Amsacta moorei* Butler1876

Synonyms: Other scientific names-*Creatonotus moorei* (Butler), *Amsacta moorei sara* (Swinhoe)

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Arctiidae
Genus: *Amsacta*
Species: *Amsacta moorei*

Bangladesh status:is not known to be present in Bangladesh[3, 4]

EPPO code: AMSAMO (*Amsacta moorei*)[4]

5.1.2.2 Biology

Several authors have made observations on the biology and ecology of *A. moorei* in India [2,5,7,10,11, 12,13, 14]. Adult emergence starts with the first monsoon showers during the end of June. The moths invariably emerge during the night and early hours of the day and mate 10-36 hours after emergence. They are poor fliers and when disturbed invariably curl their bodies, raise wings upwards, try to cling to the surface and release a jet of dirty-white or light brown fluid from the posterior end. Females are easily differentiated from males by their larger size, tubular body with a large slit like gonopore and by being more sluggish. The copulation generally starts after 8.00 p.m. and the copulatory period lasts 6.5-9.5 hours. Moths almost invariably mate once and start laying eggs 0.5-4 hours after the end of copulation.

Eggs are laid in irregular batches of 40-600 eggs. Females do not require any food for laying fertile eggs and oviposition continues for 2-5 days. The maximum number of eggs is generally laid on the second day of oviposition and about 90% are deposited by the third day. A female lays 500-1900 eggs during her life span. The eggs are laid in rows of 6-22 eggs which hatch in 3-4 days with a hatching percentage of 95-100%. The pre-oviposition, oviposition and post-oviposition periods are about 1.6 (range 1-2), 2.5 (1-6) and 2.0 (1-5) days, respectively.

The newly hatched larvae feed on egg chorion and are able to survive without food for 13-15 hours. They hatch out together and feed first on the leaf they are on and those close by. They either eat the entire leaf or nibble the epidermis on both sides, giving the leaves a peculiar whitish and spotted appearance. After 3-4 days, the larvae spread a little resulting in a group of plants having several leaves without chlorophyll. The late instars begin to spread throughout the field and feed solitarily on the foliage causing heavy defoliation.

Damage by larvae differs from crop to crop. The young or germinating plants of certain crops (for example, clusterbean) are completely killed where the larvae prefer to feed on the soft stem rather

than on leaves as compared to other crops such as pearl millet (*Pennisetum glaucum*) which mostly survive damage. Late-instar larvae, when disturbed, curl-up for a while and often release a greenish fluid from their mouths. Cannibalism among the mature larvae is occasionally observed under laboratory rearing conditions. The larvae pass through 5-7 instars and become full-grown in 15-25 days. They stop feeding a few hours to a few (1-3) days before pupation but keep on moving quite fast, probably in search of a suitable site for pupation. During this period, most of the larvae lose their original colour and turn golden or orange red and slightly decrease in size. In outbreak years, armies of caterpillars moving from one field to another are a common sight.

Before pupation, the larva makes a small pit on the ground and entangles sand grains around this pit in its saliva and covers the pit with this mass. As the larva tunnels down deeper, more and more of such mass is produced and pushed upwards, filling the tunnel with a loose mass of sand grains and silken threads.

Most larvae pupate in the soil at varying depths. However, a few pupate on the soil surface mainly under plant debris. About 65% of larvae pupate deeper than 10 cm and some reach 28 cm or deeper. After reaching the required depth, the larva sheds its hair, prepares a cocoon with the help of shed hair and silken threads, and pupates inside.

The pupal period varies: 10-20 days in the multivoltine race and from 9 to over 10 months in the univoltine race. It lengthens or shortens according to the late or early arrival of the monsoon in the latter race. In a population, there is a 1:3 ratio of univoltine to multivoltine individuals.

Moth emergence is often irregular and is governed by the rainfall pattern. In years of good and frequent/intermittent rains, the majority (>80%) of the moths emerge within a short period of about 7-10 days. By contrast, when rains are scattered, moth emergence is spread over several weeks. Under laboratory conditions, moth emergence from the larvae pupating in sand in jars starts when the relative humidity in the environment reaches 80% RH or more. Similarly, under field conditions moths start emerging when, after the rains, the relative humidity exceeds 70% RH coupled with the lowering of mean temperature to around 30°C [13].

Moth emergence is inversely related to the depth of pupation. In the same season almost all moths emerge from pupae at shallow (0-5 cm) depths, whereas no moth emerges from those at more than 25 cm depth. Moths from the latter emerge the following year after the first monsoon showers. Thus, generally about three-quarters of the moth population of a generation emerges during the same year while the remaining portion is carried to the next year. However, this ratio may vary depending upon the rainfall pattern and the proportion of the population pupating at different depths. For initiation of moth emergence a minimum of 70-80% RH is necessary. However, subsequent moth emergence could take place even at a lower relative humidity, but not below 50% RH. A peak of emergence of moths appears after almost every time it rains or relative humidity reaches above 60% RH together with the favourable temperature. From July to September, there are 2-3 generations under laboratory conditions, and although second-generation moths emerge in the field during most years, the build-up of the larval population from second-generation moths is not in sufficient numbers to cause any significant damage to the crops.

The moths are strongly attracted to artificial light. However, freshly emerged females are not attracted to light until they have, at least partially, oviposited in the field. Even after oviposition, they move towards the light source slowly, taking short flights of a few metres. Significantly more males are attracted to light than females. In a night, about 50% of the moth population is attracted within

the first 2 hours (8.00-10.00 p.m.) after dusk. Moth attraction to light declines sharply after midnight, reaching a minimum between 2 a.m. and 4 a.m. and then increasing slightly.

5.1.2.3 Hosts

Major hosts:*Arachis hypogaea* (groundnut), *Cajanus cajan* (pigeon pea), *Citrullus lanatus* (watermelon), *Crotalaria juncea* (sunn hemp), *Cyamopsis tetragonoloba* (guar), *Glycine max* (soyabean), *Pennisetum glaucum* (pearl millet), *Ricinus communis* (castor bean), *Sesamum indicum* (sesame), *Vigna aconitifolia* (moth beans), *Vigna mungo* (black gram), *Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea) [4].

Minor hosts: *Boehmeria nivea* (ramie), *Carthamus tinctorius* (safflower), *Eleusine coracana* (finger millet), *Gossypium*spp. (Cotton), *Sorghum bicolor* (sorghum), *Zea mays* (maize)[4].

Furthermore, a number of weeds serve as good alternate hosts in supporting the population build-up of this pest [4].

5.1.2.4 Geographic Distribution

A. moorei is typically a pest of arid sandy zones where rainfall is scanty and irrigation facilities are poor. This species is predominant in the Indian sub-continent though it has also been reported from Senegal and China. In India, it is widely distributed in the north where its incidence has been reported to vary from localized to widespread [4].

Asia: China[16], India[8, 10, 15] Pakistan[6], Sri-Lanka[1]; **Africa:** Senegal [9].

5.1.2.5 Hazard Identification Conclusion

Considering the fact that *A. moorei* –

- is not known to be present in Bangladesh [3, 4].
- is potentially economic important to Bangladesh. It is a major pest of groundnut in arid sandy zones where rainfall is scanty and irrigation facilities are poor from where groundnut pods or seeds are not imported in Bangladesh [3].
- is not likely to become established in Bangladesh through importation of groundnut because *A.lactinea*is not known to carry with groundnut pod or seed trade and transport [4].

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

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5.1.3 Red tiger moth (*Amsacta lactinea*)

5.1.3.1 Hazard Identification

Common name: Red tiger moth

Scientific name: *Amsacta lactinea*Cramer 1777 [3]

Synonyms: Black hariy caterpillar**,** ragi hairy caterpillar [5];other scientific name -*Estigmene lactinea* Cramer.

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Arctiidae
Genus: *Amsacta*
Species: *Amsacta lactinea*

Bangladesh status: is not known to be present in Bangladesh [2, 3, 4]

EPPO code: Not mentioned

5.1.3.2 Biology

Females of a similar species, *A. moorei,* may lay 500-1900 eggs during their life spans [4]. After eclosion, early instar larvae feed gregariously. Later instars spread throughout the field. Adults of *A. moorei* are poor fliers, but they are strongly attracted to artificial light-especially males [4]. Rearingin the laboratory on maizerevealed that the incubation period ranged from 3 to 4 days, the total larval period from 24.8±1.3 to 31±1 days, and the total life cycle ranged from 35.8±2.3 days in the 1st generation (beginning of July to end of August) to 252±4 days in the 3rd generation (mid-October to end of June) [7]. Hence, *A. lactinea* may have several generations per year. This pest has a high reproductive potential, but its dispersal could be considered low.

5.1.3.3 Hosts

Larvae destroy many crops like sorghum, castor, maize, groundnut [CABI 2007] etc. They migrate in groups from field to field feeding voraciously on the crops that come across on their way giving them grazed appearance [5].

5.1.3.4 Geographic Distribution

China [3], India [3], Indonesia[6], Korea Republic [1], Laos[6], Malaysia[6], Myanmar [6], Thailand [6], Vietnam [6].*A. lactinea* is distributed over several subtropical and tropical countries including China, India, Korea, Laos, Malaysia, Myanmar, Taiwan, Thailand, Vietnam [4].

5.1.3.5 Hazard Identification Conclusion

Considering the fact that *A.lactinea* –

- is not known to be present in Bangladesh [2, 3].
- is potentially economic important to Bangladesh. It is a minor pest of groundnut, sorghum, and maize in China, India, Myanmar, and Vietnam from where groundnut is imported [3].
- is not likely to become established in Bangladesh through importation of groundnut pod or seeds because *A.lactinea*is not known to carry with groundnut pod or seed trade and transport [3].

*A. lactinea*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 Tussock moth (*Orgyia turbata*)

5.1.4.1 Hazard Identification

Common name: Tussock moth

Scientific name: *Orgyia turbata* Butler 1879 [7]

Synonyms: Other scientific name- *Notolophus turbatus* Butler [4]

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Lymantriidae
Genus: *Orgyia*
Species: *Orgyia turbata*

Bangladesh status:is not known to be present in Bangladesh [4]

EPPO code: Not mentioned

5.1.4.2 Biology

No information on biology of *O. turbata* has been found. However, the Biology of its related species *O. antiqua* is similar to *O. turbata*.Several hundred eggs are laid on the outside of the female's empty cocoon, usually attached to a host plant or something close by (e.g. fence, wall) [5]. The species overwinters in the egg stage. Each brownish egg is rounded, somewhat flattened top and bottom. A small darker depression is seen in the upperside [8].

The larvae hatch early in the spring, as soon as foliage starts to appear [8]. They are easily recognized by their horn-like tufts of hair-like setae. Four toothbrush-like tufts occur along the back, and hair pencils project from the sides at the front and at the back. The body is dark grey to black, and red tubercules are along the sides and back.

They have defensive glands at the back, and wipe their setae against them to charge them with toxins. They grow to about 30–40 mm, females being considerably larger than males [8]. In the UK, caterpillars can be found between May and early September [5].

The pupa forms in a crevice (e.g. in tree bark or fence) inside a silk cocoon. It is glossy black and hairy [8].The male flies in a zigzag pattern-often high up in search of females-and is active during the day or at night. Males occasionally come to light [5]. In New Brunswick, adult males are attracted to pheromone traps set in commercial forests for white-marked tussock moth (*O. leucostigma*).

The female is flightless, spending her brief life attached to her cocoon. The female attracts other males via release of a pheromone, the males find the female via the concentration gradient of the released pheromone. The female mates and lays her grey-yellow eggs in large numbers on her fine-meshed cocoon.

The adult moths do not feed, so only live a short time. The two (sometimes three) generations fly from May till October; in North America, only one generation occurs in a year [8]. In the UK, one protracted generation, from July to October in the south, and from September to October in the north, is believed to happen [5, 8].The males are diurnal, flying during the day, but are occasionally attracted to light [8].

5.1.4.3 Hosts

Groundnut (*Arachis hypogaea*), coconut (*Cocos nucifera*), durian (*Durio zibethinus*), tobacco (*Nicotiana tabacum*), cocoa (*Theobroma cacao*) and cowpea (*Vigna unguiculata*) [4].

5.1.4.4 Geographic Distribution

Malaysia [6], Myanmar [1, 6], Thailand [1, 3**,** 6], Vietnam [6].

5.1.4.5 Hazard Identification Conclusion21

Considering the fact that *O. turbata*–

- is not known to be present in Bangladesh [2, 4].
- is potentially economic important to Bangladesh. It is a minor pest of groundnut, tobacco, cowpea and coconut in China, Myanmar, and Vietnam from where groundnut is imported [4].
- is not likely to become established in Bangladesh through importation of groundnut pod or seeds because *O. turbata*is not known to carry with groundnut pod or seed trade and transport [4].

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

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5.1.5 Groundnut mealybug (*Phenacoccus solenopsis*)

5.1.5.1 Hazard Identification

Common name: Groundnut mealybug

Scientific name: *Phenacoccus solenopsis* Tinsley 1898

Synonyms: Solenopsis mealybug, soil mealybug, Chinese hibiscus mealybug; other scientific names - *Phenacoccus cevalliae* Cockerell 1902, *Phenacoccus gossypiphilous* Abbas et al. 2005[1]

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Family: Pseudococcidae
Genus: *Phenacoccus*
Species: *Phenacoccus solenopsis*

Bangladesh status: is not known to be present in Bangladesh [5]

EPPO code: (PHENSO *Phenacoccus solenopsis*) [7, 8].This pest has been included in EPPO alert list [5].

5.1.5.2 Biology

Females of this ovoviviparous, bisexual species have been reported as capable of producing from 150 to 600 eggs, protected within a waxy ovisac. Upon hatching, females undergo three immature stages prior to reaching adulthood, whereas males undergo first, second, pre-pupa and pupa stages prior to adulthood. The period of development from crawler to adult stage is approximately 25-30 days, depending upon the weather and temperature. This species is capable of producing multiple generations annually [11].

5.1.5.3 Hosts

This species has been documented infesting 202 plant species representing 55 families with a distribution in Africa, Asia, North America and South America and Oceanic regions including the Caribbean nations. In a field survey, it was identified from 154 plant species, the majority of which belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae [4]. Significant economic damage was determined to occur on cotton [*Gossypium* spp.], brinjal [*Solanum melongena*], okra [*Abelmoschus esculentus*], tomato [*Solanum lycopersicum*], sesame [*Sesamum indicum*], sunflower [*Helianthus annuus*] and China rose [*Hibiscus rosa-sinensis*] [4, 9, 15]. It has been reported from groundnut in India [13].

5.1.5.4 Geographic Distribution

P. solenopsis is a native to USA [12] and introduced to many Asian countries. It is highly invasive species [6, 8].The occurrence of *P*. *solenopsis* is widespread with the species damaging plants in a variety of habitats ranging from dry arid areas to tropical regions.

Asia: Cambodia, China [6, 8, 17], India [4, 5, 13], Indonesia, Iran, Iraq, Japan, Pakistan [1, 2], Sri Lanka (localized), Taiwan (localized),Thailand (localized) [6, 8], Turkey [7], Vietnam [14]; **Europe:**Cyprus, Netharlands[4, 5]; **Africa:** Bennin, Cameroon, Egypt [2], Ghana, Mali, Mauritius, Nigeria, Senegal; **Central America and Caribbean**: Belize, Cuba, Dominican Republic, Jamaica, Nicaragua. Panama [6, 8].**North America:** Canada (present but few occurrences), Mexico (present but few occurrences), it is native pest of USA; **Oceania:** Australia (restricted distribution) [6, 8].

5.1.5.5 Hazard Identification Conclusion

Considering the facts that *P. solenopsis* –

- is not known to be present in Bangladesh [6, 8];
- is potentially economic important to Bangldesh because it is an important pest of many crops in Egypt, South Africa, Asia (China, India, Pakistan, Vietnam, Iran, Iraq and other Asian countries), Africa (Egypt and other countries) [6, 8]. It is a major pest of groundnut in India [13] from where groundnut is imported to Bangladesh.
- can become established in Bangladesh through imports of groundnut or other plant parts It has capability to cause direct economic and ecological damage to many valuable cultivated crops.

P. solenopsis is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.1.5.6 Risk Assessment

5.1.5.6.1 Entry Assessment

Nymphs and adults of*P.solenopsis*are transported with flowers, leaves, stems, inflorescences, shoots, trunks. It can be transported with cargo and aircraft for long distance [5]. It has been introduced in many new countries with plant trades recently [6, 8]. It may frequenty transported with various ornamental plants. So, the probability of entry into Bangladesh with imprtation of groundut is medium.

5.1.5.6.2 Exposure Assessment

*P. solenopsis*is highly polyphagous pest having wide host range under different families.Afterentering into Bangladesh, may be carried to different places of the country. During loading and unloading at different locations, nymphs and adults of mealybug may be exposed to the environment and attack different host plants. Therefore, the probability of exposure of *P. solenopsis*in Bangladesh environment is high.

5.1.5.6.3 Establishment Assessment

P. solenopsis has many host species in Bangladesh other than cotton. It can attack many vegetables and ornamental hosts which are available in most of the places in Bangladesh. This mealybug species has the ability to increase rapidly in population size and spread to cover vast areas where host plants occur, in a relatively short period of time. It has been reported from over 200 hosts [5]. Morover, environmental conditions are also favourable for its growth, development and reproduction. Therefore, the probability of establishment of the insect pest in *P. solenopsis* is high.

5.1.5.6.4 Determination of Likelihood of the Pest Establishment 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–It is a native pest of USA and established many Asian countries in recent years [6, 8]. The occurrence of *P*. *solenopsis* is widespread with the species damaging plants in a variety of habitats ranging from dry arid areas to tropical regions. • **The pathway appears good for this pest to enter Bangladesh and establish, and**YES- Nymphs and adults of *P. solenopsis* are transported with flowers, leaves, stems, inflorescences, shoots, trunks and groundnut pods or seeds. It can be transported with cargo and aircraft for long distance [5]. It has been introduced in many new countries with plant trades recently [6, 8]. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established**. YES–Many of its major hosts are common in Bangladesh and climate is also similar to places where it is 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, and • 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

The solenopsis mealybug is an important plant pest worldwide. Mealybug feeding may cause the leaves to turn yellow and results in defoliation, reduced plant growth or plant death. The presence of the solenopsis mealybug has the potential to inflict significant damage to field crops (i.e. cotton [*Gossypium* spp.] and tobacco [*Nicotiana* spp.]) in all growing regions. This mealybug caused serious damage to cotton in Pakistan in 2005 and India. Also, it is a pest of commercial crops including a variety of vegetables, grapes [*Vitis vinifera*], jute [*Corchorus* spp.], mesta [*Hibiscus cannabinus*] and tobacco.*P. solenopsis* has the capability to cause direct economic and ecological damage to native fauna and flora with heavy infestations reducing plant vigour and causing plant death. Once the species has established on a host plant within a region, it has the capability of rapid growth resulting in significant damage to the crop [5]. It was recorded 17 provinces and 11 regions in China where this invasive species could spread and cause significant economic and environmental

damage. Based on the international pest risk analysis for *P*. *solenopsis*, Wang et al. (2009) classified this mealybug as a high risk invasive species to China [16].

5.1.5.7.2 Environmental

As a result of *P*. *solenopsis* dispersal, reproductive and survival capacity, this invasive pest has the potential to damage or kill native plant species that could result in their displacement by other more aggressive species.Application of chemical insecticides for its management may cause health and environmental hazards.

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 is a serious pest of an important crop for Bangladesh?** YES- *P*. *solenopsis* is a serious pest of cotton which as an important crop in Bangaldesh. This mealybug caused serious damage to cotton in Pakistan in 2005 and India [5, 6]. • **Is this a serious pest of several important crops for Bangladesh?** YES-This is a serious pest of several important crops (tomato, brinjal, okra, sesame) for Bangladesh. This species has been documented infesting 202 plant species representing 55 families with a distribution in Africa, Asia, North America and South America and Oceanic regions including the Caribbean nations. The majority of host plants belong to the families Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. Significant economic damage was determined to occur on cotton [*Gossypium* spp.], brinjal [*Solanum melongena*], okra [*Abelmoschus esculentus*], tomato [*Solanum lycopersicum*], sesame [*Sesamum indicum*], sunflower [*Helianthus annuus*] and China rose [*Hibiscus rosa-sinensis*] [3, 6, 10].	**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

Considereing all these *P. solenopsis*has been classified as a **potential risk organism** for Bangladesh and **risk management** is justified.

5.1.5.9 Possible risk management and phytosanitary measures

- Planting material of host-plant species of *P*. *solenopsis* should be inspected in the growing season previous to shipment and be found free of infestation [5].
- Avoid importation of groundnut seeds, pods or other host plants from countries where *P*. *solenopsis* occurs.
- It is relatively easy to detect the *P*. *solenopsis* by inspection, so the basic requirement is that imported consignments of plants for planting should be free from the pest [5]. Any shipments of fresh plant material from an infested country should be examined thoroughly to detect *P*. *solenopsis* after the consignment has arrived in Bangladesh [5].

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5.1.6 Groundnut thrips (*Caliothrips indicus*)

5.1.6.1 Hazard Identification

Common name: Onion thrips **Scientific name:** *Caliothrips indicus*Bagnall 1913

Synonyms: Black thrips [5], sesbania thrips [8];other scientific names- *Hercothrips indicus* Bagnall, *Heliothrips indicus*.

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Thysanoptera
Family: Thripidae
Genus: *Caliothrips*
Species: *Caliothrips indicus*

Bangladesh status: is not known to be present in Bangladesh [4, 5].*Caliothrips indicus*was not found during official surveys performed at 70 upazila in Bangladesh. It has been included CPPC A1 list.

EPPO code: CALHIN (*Caliothrips indicus*) [5, 6]

5.1.6.2 Biology

Biology of four common thrips pests *Frankliniella schultzei* (Trybom), *Scirtothrips dorsalis* Hood, *Megalurothrips usitatus* (Bagnall) and *Caliothrips indicus* (Bagnall) almost similar.Duration of egg incubation period for *F. schultzei* and *S. dorsalis* was 6-8 days, of larval instars 6-7 days and prepupal and pupal stages 2-4 days. For *C. indicus*, the duration of egg instar was slightly longer, 7-10 days, and was similar to *F. schultzei* and *S. dorsalis* for other development stages. *C. indicus* produced many more progeny than the other two species [2]**.** *C. indicus* causes stippling on older leaves.

S. dorsalis goes through five developmental phases: egg, two active larval instars that feed, followed by 2 relatively inactive pupal instars and winged, feeding adults. Eggs are inserted into young and soft tissues of leaves, stems and fruit. The first and second larval stages are found on the green plant parts from which the second stage larvae seek out some sheltered place (leaf litter or crevices of bark) and then pass through two resting stages called propupa and pupa, respectively. Rarely, these occur beneath the calyces of fruits. Winged adults, male and female, are found normally on the green plant parts, where they feed. Eggs are bean-shaped, minute (less than 0.2 mm). The two feeding larval stages are yellow to orange, cigar-shaped and just visible to the naked eye. The pest has no diapause.

Caliothrips indicus is one of the serious pests of groundnut in Saurashtra region of Gujarat India causing extensive losses. Seven years (1999 to 2005) field studies report indicated that *its* population was present through out the year on groundnut and fluctuated from season to season. However, the intensity was greater during summer followed by rabi and kharif. Further correlation studies between weather parameters and *C. indicus* population revealed that, maximum and minimum temperature showed significant positive correlation morning and evening relative humidity showed significant negative correlation during rabi. In summer, morning and evening relative

humidity showed significant negative correlation during kharif, only morning relative humidity showed significant negative correlation while the remaining parameters fail to show any significant correlation with the thrips population [8]. This species is a pest on soybeans, peas, clover and other legumes, sometimes causing considerable yield reduction through feeding damage to leavesin India.

5.1.6.3 Hosts

Major hosts: Onions, garlic, leek, etc., (*Allium*), groundnut (*Arachis hypogaea*) Fabaceae (leguminous plants), soyabean (*Glycine max*) [5].

Minor/ alternate hosts: Grasspea (*Lathyrus sativus*), sesame (*Sesamum indicum*), aubergine (*Solanum melongena*), sorghum (*Sorghum bicolor*), moth beans(*Vigna aconitifolia*), black gram (*Vigna mungo*), mung bean (*Vigna radiata*) [1,5].

C. indicus was found as a serious pest of some economic crops, especially legumes, during summer in the Punjab. Its host range included a total of 29 cultivated and wild plant species belonging to 11 different families, with the Leguminosae predominating. Seventeen of these hosts are reported for the first time [2]. It is a major pest of groundnut in India [7, 8, 11].

5.1.6.4 Geographic Distribution

India [6, 7,8,10, 11], Thailand [13].It is widespread in India [7, 8, 11] and reported as a pest of groundnut in Thailand.

5.1.6.5 Hazard Identification Conclusion

Considering the facts that *C. indicus*–

- is not known to be present in Bangladesh [4, 5];
- is potentially economic important to Bangldesh because it is an important pest of groundnut in India [6, 7, 8, 10, 11], from where groundnut is imported to Bangladesh.
- can become established in Bangladesh through imports of groundnut or other plant parts. It has capability to cause direct economic damage to many valuable cultivated crops other than groundnut [5].

*C. indicus*is a **quarantine pest** for Bangladesh and considered to be a **potential hazard organism** in this risk analysis.

5.1.6.6 Risk Assessment

5.1.6.6.1 Entry Assessment

Adult thrips can fly and ensure natural spread within crops. *C. indicus* can be transported over long distance by the horticultural trade with fruits and vegetables, cut flowers, plants for planting of host plants, soil, from countries where *C. indicus* occurs.*C. indicus* inserted eggs intoyoung and soft tissues of leaves, stems and fruit. The first and second larval stages are found onthe green plant parts from which the second stage larvae seek out some sheltered place (leaf litteror crevices of bark) and then pass through two resting stages called propupa and pupa, respectively. Rarely, these occur beneath the calyces of fruits.Winged adults, male and female, arefound normally on the green plant parts, where they feed. Moreover, the lower leaves of the plant are preferred for feeding. Thus the probability of entry with importation of groundnut pods or seeds from India is low.

5.1.6.6.2 Exposure Assessment

*C. indicus*is a polyphagous pest which can attack onions, garlic, leek, etc., (*Allium*), groundnut (*Arachis hypogaea*), Fabaceae (leguminous plants), soyabean (*Glycine max*) [CABI 2007].Its host range included a total of 29 cultivated and wild plant species belonging to 11 different families, with the Leguminosae predominating [1].During loading and unloading at different locations, larvae and adults of thrips may be exposed to the environment and attack different host plants. Therefore, the probability of exposure of *C. indicus*in Bangladesh environment is high.

5.1.6.6.3 Establishment Assessment

Hosts of *C. indicus* are fairly common in Bangladesh and transported within the PRA area. Thus, because of the difficulties to detect the pest at low infestation levels and the wide host range, spread by movement of plant material can be extensive. Climate is also similar to places where it is established. The probability of establishment in Bangladesh is high.

5.1.6.6.4 Determination of Likelihood of the Pest Establishment 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 –*C. indicus* is a major pest of groundnut in India [6, 7, 8, 10, 11] and is also reported from Thailand. It has not established in other courntries. • **The pathway appears good for this pest to enter Bangladesh and establish, and**NO– Importation of groundnut pods or seeds is not likely a good pathway of transprotation of thrips • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established**. YES –Many hosts are widely distributed and commonly transported within the PRA area. Thus, because of the difficulties to detect the pest at low infestation levels and the wide host range, spread by movement of plant material can be extensive. Climate is also similar to places where it is 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, and • 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

The feeding of this species results in spots or stippling on the upper surface of the older leaves. The lower leaves of the plant are preferred for feeding. The injury results in white spots and patches intermingled with black excreta on the leaf surface. It transmits tomato spotted wilt virus in groundnut [12]. It has been reported as serious pests of groundnut in Saurashtra region of Gujarat India causing extensive losses [8].

5.1.6.7.2 Environmental

No direct impact on environment of this pest has been reported. Application of chemical insecticides for its management may cause health and environmental hazards.

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 is a serious pest of an important crop for Bangladesh?** YES- *C. indicus*is a serious pest of groundnut which as an important crop in Bangaldesh. [5, 6]. • **Is this a serious pest of several important crops for Bangladesh?** YES-This is also serious pest of several important crops like onions, garlic, soybean 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

5.1.6.8 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

Establishment Potential	Consequence Potential	Risk Rating
Moderate	Moderate	Moderate
Moderate	Low	Low
Low	Moderate	Low
Low	Low	Low

CALCULATED RISK RATING – Moderate

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

5.1.6.9 Possible Risk Management and Phytosanitary Measures

- Planting material of host-plant species of *C. indicus*should be inspected in the growing season previous to shipment and be found free of infestation [5, 6].
- All plant parts, debris should be free from groundnut pods or seeds.
- Groundnut will be imported from the pest free areas.

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5.1.7 Groundnut bruchid (*Caryedon serratus*)

5.1.7.1 Hazard Identification

Common name: groundnut bruchid

Scientific name: *Caryedon serratus* (Olivier 1790)

Synonyms:tamarind weevil, groundnut borer, seed beetle [4], peanut beetle, ground seed beetle; other scientific names- *Caryedon gonagra* (Fabricius), *Caryedon fuscus* (Goeze), *Caryedon languidus* Gyllenhal, *Pachymerus sibutensis* Pic, *Careydon sibutensis* (Pic), *Caryedon acaciae* auct., *Pachymerus gonager* (Fabricius), *Bruchus serratus* Olivier, *Caryedon gonager* (Fabricius), *Caryoborus gonagra* (Fabricius), *Pachymerus gonagra* (Fabricius), *Caryoborus gonager* (Fabricius), *Caryoborus serratus* (Olivier), *Pachymerus serratus* Olivier [4].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Bruchidae
Genus: *Caryedon*
Species: *Caryedon serratus*

Bangladesh status: is not known to be present in Bangladesh [4].

EPPO code: CARESE (Caryedon serratus) [4, 10].

5.1.7.2 Biology

The females lay several hundred eggs, more in shelled groundnut than in tamarind and unshelled groundnuts, gluing them to the surface of the shells or kernels. The newly hatched larva burrows straight through the eggshell and pod wall, and eats the kernel, feeding only within a single seed. Development requires about 10 weeks at 25°C [3].

C. serratus eggs are glued on to groundnut pods or kernels, and infestation can take place as soon as the groundnuts are harvested and left to dry. The larvae bore into the groundnut shells and feed on the seed. They are probably the only insect pests able to penetrate the intact shell. They usually leave the pod to pupate. Each larva spins a paper-like pupal cocoon which it usually attaches to the outside of a pod. Severe infestations are usually restricted to the outer layer of a bulk of groundnuts. The optimum conditions for development are 30-33°C and 70-90% RH, under which conditions the development period is 41-42 days. Breeding can take place between 23 and 35°C [7].It was also reported that *Caryedon serratus* had four larval stages and the duration of total life cycle ofrom egg laying to adult emergence was found to be 46 days under 30±2^{0}C temperature and 70% RH [8].

A single gravid female lays 20- 30 creamy white eggs (1 mm long), which are glued to the surface of groundnut shell or kernels. The incubation period varies from 4 to 6 days. The newly hatched larva burrows straight through the eggshell and pod wall, and starts eating the kernel. No damage can be seen at this stage unless one searches carefully. The fi rst sign of attack is the appearance of ‘windows’ (approximately 3 mm in diameter) made on the pod wall by the grub to allow the adult to

leave the pod. Each larva feeds solely within a single kernel. Larval development is completed in 40 to 45 days, and the pupal stage lasts for about 15 days. Sometimes, the grown-up larvae leave the pod and pupate at the bottom of the sacks. By this stage, the groundnut seeds are badly damaged and are unfit for human consumption, seed use or oil expulsion. Under optimum conditions (30-33°C and 70-90% relative humidity), the life cycle of *C. serratus* is completed in about 60 days [16].

5.1.7.3 Hosts

C. serratus is an important pest of groundnuts (especially when stored in their shells) and palm kernels, cocoa beans and cotton seed cake (as stored products). It is also a pest of tamarind pods. It breeds on several species of wild tree legumes, especially Cassia, *Acacia* (A. spirocarpa and A. tortilis), *Bauhinia* and *Piliostigma* spp. [4]. It is the major pests of peanuts (*Arachis hypogaea* Linnaeus), Tamarind (*Tamarindus indica* Linnaeus) and *Acacia* spp.

Major hosts: *Arachis hypogaea* (groundnut), tamarind (*Tamarindus indica* Linnaeus) stored products (dried stored products) [4].

Minor hosts: *Acacia nilotica* (Acacia) [9], *Elaeis guineensis* (African oil palm), *Gossypium* (cotton), *Phaseolus* (beans), *Theobroma cacao* (cocoa), *Pennisetum glaucum* (pearl millet) [4].

5.1.7.4 Geographic Distribution

C. serratus is of Asian origin, but has become distributed to many tropical and subtropical regions of the world [20]. Although it is especially prevalent in the warm and hot parts of Asia, North-Eastern and West Africa, the West Indies, Hawaii, and parts of South and Central America as far north as Mexico, it is a serious pest of stored groundnuts only in West Africa [4].*C. serratus*is a serious pest of India and Vietnam banned importation of groundnut frof India due to presence of this obnoxious pest [2].

Europe: France [4]; **Asia:** India [1, 4, 13, 14, 16], Myanmar [16], [Pakistan [12], Thailand [16], widespread in Israel [1]; **Africa:** Widespread in Gambia, Ghana, Nigeria, Senegal Tanzania [1,4]; **Central America:**Barbados, Haiti, Jamica [4]; **North America:** widespread in Mexico [1], USA [4]; **South America:**South America (as a whole) and Venezuela [4]; Oceania: Australia [6].

5.1.7.5 Hazard Identification Conclusion

Considering the fact that *C. serratus* –

- is not known to be present in Bangladesh [4];
- is potentially economic importance to Bangladesh because and it is an important pest of groundnut, tamarind other stored products India[1, 4, 13, 14, 16] and Myanmar [16]from where groundnut is imported to Bangladesh.
- is likely to have spread through international trade of groundnut [20] and would be able to establish and cause unwanted consequences in Bangladesh. *C. serratus* is of Asian origin, but has become distributed to many tropical and subtropical regions of the world [20].

*C. serratus*is 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

C. serratus is of Asian origin, but has become distributed to many tropical and subtropical regions of the world [20]. Itis a post-harvest pest although its infestation started on mature Acacia pod when it remained on the tree [21]. Egg, larva, pupa and adult are transported with groundnut pods, seeds, acacia and tamarind pods, and other stored products. Plant parts are not known to carry the pests in transport or trade but adult cannot fly. Thus probability of entry of *C.serratus* with groundnut pods and seeds through this pathway is high.

5.1.7.6.2 Exposure Assessment

C. serratus is a polyphagous and primary insect pest of groundnut and tamarind and secondary pests of *Acacia nilotica* [4]. Groundnut is an important crop in Bangladesh but acacia and tamarind are not available. There will be less chance of finding its potential hosts in Bangladesh. The dispersal of any stage of*C.serratus*during transport, storage and marketing may not create high risk for its exposure to potential hosts. So probability of exposure is moderate.

5.1.7.6.3 Establishment Assessment

C. serratus is a primary insect pest of groundnut which is an important crop in Bangladesh but stored groundnut is not available all over Bangladesh. Other hosts are also not enough for its establishment. But the optimum conditions for development of this bruchid are 30-33°C and 70-90% RH [7] which prvail in Bangladesh during February-November. Although it is a pest of Asian origin, it has distributed and established many African countries [20]. Thus the probability of establishment is high.

5.1.7.6.4 Determination of likelihood of the pest establishment 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 - *C. serratus*is a pest of Asian originbut has become distributed and established many tropical and subtropical regions of the world [20]. It is widespread in many countries of Africa [1, 4] • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES - Egg, larva, pupa and adult are transported with groundnut pods, seeds, acacia and tamarind pods, and other stored products. Thus importation of inested material will introduce this obnoxious insect pest in Bangladesh that may establish this pest.	**High**

Description	The Establishment Potential is:
• **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.** YES - Its major host is groundutnut which is common in Bangladesh [4] but other hosts are not available. Climate of Bangla is favourable for its development and also similar to places it has been established.	
• Not as above or below	Moderate
• This pest has not established in new countries in recent years, and • The pathway does not appears good for this pest to enter 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

*C. serratus*is an important post-harvest pest of groundnut (especially when stored in their shells) and palm kernels, cocoa beans and cotton seed cake (as stored products). It is also a pest of tamarind pods. The pest damages peanuts as well as tamarinds. The larvae of *C. serratus* bore into the seeds via small holes and feed on the embryo and the endosperm, leaving all infested seeds non-viable. Infested seeds are failed to germination.In Senegal, losses in groundnut due to the pest reached 83% after a four month storage period [19].

Infestations cause reductions in food value, in the quality of the oil and in reduced seed germination. Such damage is particularly significant when the peanuts are destined for confectionery purposes. The heat and moisture generated by the insects increases mold growth and the development of aflatoxins in groundnuts [15].Larval boring through the groundnut hulls favours attack by secondary pests and the spread of *Aspergillus flavus*, an aflatoxin-producing mould [18].

C. serratus was a serious pest of stored seeds of*Acacia nilotica*inSudan. The mean infestation rate was significantly higher in pods on the forest floor than in pods from the standing trees. In Wad Dabkara forest, the mean infestation rate was 10.7% and 11.1% in pods from the standing trees in gerf and maya site types, respectively, whereas the mean infestation rate was 17.2% and 16.7% in pods on the forest floor in gerf and maya, respectively. In Wad El Guzuoli forest, the mean infestation rate was 10.8% and 12.5% in pods from the standing trees in gerf and maya, respectively, whereas the mean infestation rate was 16.6% and 17.6% in pods on the forest floor in gerf and maya, respectively.Higher seed infestation rates of 87.8%, 87.6% and 90% were observed on seeds stored in Sennar, Singa and Wad Medani, respectively and all infested seeds failed to germinate compared with uninfested seeds [9].

Extensive pre-season survey of groundnut post-harvest process and storage premises in Zambia suggested that primary infestation from the field was critical in establishment of bruchid in the stores, and that the groundnuts lifted early and dried for longer period than usual in the field (a common practice for confectionery varieties) received consistently higher insect infestation [5].

5.1.7.7.2 Environmental

No direct impact on environment of this pest has been reported. It causes about 17.2% pod infestation in forest and 90% in storage on acacia which may reduce population of this plant. Moreover application of chemical insecticides for its management may cause health and environmental hazards [9].

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?** YES- This is serious pest groundnut [4] which is an important crop in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** NO – Its alternate hosts tamarind, acacia pods and other stored products [9] 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.	Low

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

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**
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 *C. serratus*has been classified as a **risk organism** for Bangladesh and **risk management** is justified.

5.1.7.9 Possible Risk Management and Phytosanitary Measures

- After harvest drying the crop as quickly as possible and placing it in sacks or other containers where insect penetration will be prevented [4].
- Cleaning grain stores, keeping them airtight, maintaining temperatures below 20°C and hermetically sealed packaging can conserve seed viability. Storing groundnuts in jute bags greatly restricts the movement of adults into and out of bags.
- 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 [11] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.. Effective control of eggs, larvae, and adults of *Caryedon serratus* Olivier was achieved with methyl bromide vacuum fumigation @ 16 g/m^3 for 4 h exposure [17]. When treating groundnuts in shell the phosphine dosage needs to be higher than normal due to excessive absorption [4].
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.The presence of larval emergence holes and of cocoons outside the pods attests to the pest's presence. The damage to seeds can be seen when infested pods are opened.

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5.1.7 Merchant grain beetle (*Oryzaephilus mercator*)

5.1.8.1 Hazard Identification

Common name: Merchant grain beetle

Scientific name: *Oryzaephilus mercator* (Fauvel 1889)

Synonyms: other scientific names- *Silvanus mercator* Fauvel, *Silvanus gossypii* [3]

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Silvanidae
Genus: *Oryzaephilus*
Species: *Oryzaephilus mercator*

Bangladesh status: is not known to be present in Bangladesh [3]

EPPO code: ORYZME (*Oryzaephilus mercator*) [3, 5]

5.1.8.2 Biology

The life history of *O. surinamensis* and *O. mercator* has been reported in 1956 by [9]. Eggs are laid loosely on foodstuffs at a peak rate of 6-10 per day in *O. surinamensis*, and 3 per day in *O. mercator.* Up to 375 eggs are laid by an *O. surinamensis* female and up to 200 by an *O. mercator* female. The larvae feed within the mass of produce. When attacking cereal grain, they enter damaged and broken kernels to feed, especially on the germ. The larvae also attack the germ in whole cereal grains, thereby altering the nutritional content and reducing the percentage germination. Adults and larvae are able to enter small cracks, so they can often attack packaged food or nuts in shell. On copra, the larvae tend to feed close beneath the outer skin.

The larvae moult 2-4 times depending on conditions. On a diet of wheatfeed, the life cycle of *Oryzaephilus* spp. varies from about 20 days to more than 80 days at temperatures of 17.5-37.5°C and 10-90% RH. Optimum conditions for development are 30-35°C and 70-90% RH for *O. surinamensis*, and 30-33°C and 70% RH for *O. mercator*. *O. surinamensis* is more tolerant of extremes in temperature and humidity than *O. mercator*. For example, *O. surinamensis* can survive temperatures of 20-37°C at 0% RH, whereas *O. mercator* can only survive at 25-32.5°C at this humidity. Adult *O. surinamensis* have been reported to survive sub-zero temperatures for up to 4 days; under these and less extreme conditions (temperatures down to 5°C), *O. mercator* did not survive. In temperate areas, *O. surinamensis* can survive winters in unheated stores.

Adult *Oryzaephilus* spp. are winged but rarely fly. They tend to wander from the stored food into crevices, ducts and roofing spaces, from which they are difficult to eradicate; they can often be found beneath the bark of trees near to stores. *Oryzaephilus* spp. have not been recorded on grain in the field before harvest.

5.1.8.3 Hosts

O. surinamensis is a common secondary pest of cereals and cereal products; *O. mercator* is more common on oilseeds, though it is also sometimes found on cereals. Both species may be found on copra, spices, nuts and dried fruit. *O. surinamensis* is prevalent on white milled rice; *O. mercator* is common on brown rice and rice bran [3]. It is a post-harvest pest which attacks seeds.

Major hosts: *Arachis hypogaea* (groundnut), *Cocos nucifera* (coconut).

Minor hosts: *Ceratonia siliqua* (locust bean), *Myristica fragrans* (nutmeg), *Oryza sativa* (rice), stored products (dried stored products), *Theobroma cacao* (cocoa). Other hosts are *Citrullus lanatus* (watermelon), *Cucumis melo* (melon), fruits , *Helianthus annuus* (sunflower), *Irvingia gabonensis* (wild mango), *Mangifera indica* (mango), *Phoenix dactylifera* (date-palm), *Pistacia vera* (pistachio), *Secale cereale* (rye), *Triticum aestivum* (wheat) [3].

5.1.8.4 Geographic Distribution

O. surinamensis is cosmopolitan; *Oryzaephilus mercator* is mostly found in warmer, temperate and tropical regions.

Europe: Belgium [3], Cyprus [3], Former Yugoslavia [10], Poland [4], Portugal [4], United Kingdom [4]; **Asia:** China [3], India [3], Malaysia [4],Myanmar [4], Saudi Arabia [4], Singapore [2] and Thailand [1, 4]; **Africa:**Central African Republic, Gambia, Kenya, Mozambique, Nigeria[4], Somalia [3],South Africa [7],Tanzania[11], Zimbabwe [4];**Central America & Caribbean:**Antigua and Barbuda, Jamaica, Trinidad and Tobago [4]; **North America:**Canada, USA [4]; **South America:** Brazil, Peru[4].

5.1.8.5 Hazard Identification Conclusion

Considering the fact that *O. mercator* –

- is not known to be present in Bangladesh [3];
- is potentially economic importance to Bangladesh because and it is an important pest of groundnut, dried fruits and other stored products in China, India, and Myanmar from where groundnut and other stored products are imported to Bangladesh.
- is likely to have spread through international trade of groundnut, dried fruits and other stored products [3,4] and would be able to establish and cause unwanted consequences in Bangladesh.

*O. mercator*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

O. surinamensis is cosmopolitan; *Oryzaephilus mercator* is mostly found in warmer, temperate and tropical regions. Egg, larva, pupa and adult can easily be transported with groundnut [3].Adult *Oryzaephilus* spp. are winged but rarely fly. So the probability of entry with imported grain is high.

5.1.8.6.2 Exposure Assessment

O. surinamensis is a common secondary pest of cereals and cereal products; *O. mercator* is more common on oilseeds, though it is also sometimes found on cereals. Both species may be found on

copra, spices, nuts and dried fruit. *O. surinamensis* is prevalent on white milled rice; *O. mercator* is common on brown rice and rice bran [3].There would be no shortage of potential hosts in Bangladesh throughout the year. So dispersal of any stage of*O.mercator*may expose to its potential hosts that will enhance its establishment in Bangladesh. Thus the probability of exposure of *O. mercator* is high.

5.1.8.6.3 Establishment Assessment

*O. mercator*is a polyphagous stored grain pest whidh feeds on oilseeds, dried food and other stored materials. Optimum conditions for its development are 30-33°C and 70% RH for *O. Mercator* which prevaisl in Bangladesh. Moreover, they tend to wander from the stored food into crevices, ducts and roofing spaces, from which they are difficult to eradicate; they can often be found beneath the bark of trees near to stores.Thus the probability of establishment of *O. mercator* is high.

5.1.8.6.4 Determination of likelihood of the pest establishment 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-*Oryzaephilus mercator* is mostly found in warmer, temperate and tropical regions. They can hide easily in crevices, ducts and roofing spaces, from which they are difficult to eradicate.This pest has been established in many countries [3]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?**YES*,* Egg, larva, pupa and adult can easily be transported with groundnut [3]. Thus the pathway is good for this pest to enter into Bangladesh and establish. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.**YES Its major hosts, groundnut and other cereals are common in Bangladesh and climate is also favourable for its development [3].	**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

5.1.8.7 Consequence Assessment

5.1.8.7.1 Economic

*Oryzaephilu*s spp. areexternal feeders of seeds and are not associated with any substantial weight loss in stored food products; The larvae feed within the mass of produce. When attacking cereal grain, they enter damaged and broken kernels to feed, especially on the germ. The larvae also attack the germ in whole cereal grains, thereby altering the nutritional content and reducing the percentage germination.However, infestations by these pests can lead to substantial contamination with frass and dead bodies. Thus quality deterioration is an important issue [3].

Adult beetles of *O. surinamensis* and *O. mercator* can be seen moving rapidly over stored food. The immature stages are inconspicuous.

5.1.8.7.2 Environmental

No direct impact on environment of this pest has been reported. Moreover application of chemical insecticides for its management may cause health and environmental hazards.

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 a major pest of groundnut [3] which is an important crop in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES - This is a serious pest of cerals and dried stroed products [3] which are also important stored material 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

5.1.8.8 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

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 – HIGH

Considering all these *O. mercator*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 store hygiene plays an important role in limiting infestation by *Oryzaephilus* spp.
- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled.
- Infestations may also be limited by the storage of good quality grains such as whole cereals with fewer broken grains and dockage, and milled rice with a high milling degree (at least 95%) and few broken grains [3].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6].
- Inspection will be undertaken in Bangladesh after the consignment has arrived. Pitfall traps are unsuitable for the detection of *O. surinamensis* and *O. mercator* as these insects are able to climb on clean glass. They do enter refuge traps, such as strips of corrugated cardboard, or bag traps containing a suitable food bait [8].

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5.1.9 Lesser mealworm (*Alphitobius diaperinus*)

5.1.9.1 Hazard Identification

Common name: Lesser mealworm

Scientific name: *Alphitobius diaperinus* (Panzer 1797)

Synonyms: litter beetle;other scientific names- *Tenebrio diaperinus* Panzer sensu, *Alphitobius ovatus* (Herbst, 1783), *Alphitobius piceus* (Olivier, 1792) [4],*Phaleria diaperinus* Latreille 1804,*Alphitobius mauritanicus* Stephens 1832, *Heterophaga opatroides* Dejean 1833, *Alphitobius diaperinus* Wollaston 1854[7].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family:Tenebrionidae
Genus: *Alphitobius*
Species: *Alphitobius diaperinus*

Bangladesh status: is not known to be present in Bangladesh [4].

EPPO code: ALPHDI (*Alphitobius diaperinus*)[4, 8].

5.1.9.2 Biology

A. diaperinus and *A. laevigatus* will feed on grain, cereal products and animal feeds, especially if they are damp and slightly mouldy. Optimum conditions for development for *A. diaperinus* are about 33°C and 95% RH [29, 31]. *A. laevigatus* can complete its life cycle in about 30 days at 35°C and 70% RH, provided some drinking water is provided [15].

After mating, a female beetle has the potential to lay over 2,000 eggs (with an average closer to 200 to 400). Adults lay their eggs in cracks and crevices in the poultry house, in manure or litter, in grain

hulls, and under feed and water lines. Adults can live three to twelve months, with females continuing to produce eggs most of their life at one to five day intervals.

Larvae hatch in four to seven days and complete development to the adult stage in 40 to 100 days, depending on temperature and food quality. Several studies have been conducted on *A. diaperinus* development on varied diets, at varying ambient temperatures and microhabitats, and among other poultry house inhabiting species [5, 6, 14, 19, 20, 21, 22, 23, 26, 30]. Larvae consume spilled feed, manure, and in some cases dead or sick birds and cracked eggs.There are approximately six to 11 larval instars, and environmental conditions required for optimum development are 30° to 33°C with approximately 90% relative humidity.They are very active and quickly burrow into the litter when disturbed. Adults are long lived, normally persisting for more than a year, and under experimental conditions have survived for more than two years [10].

5.1.9.3 Hosts

Both *A. diaperinus* and *A. laevigatus* are associated with a wide range of stored commodities, especially if they have suffered some mould damage. Cereal grains, oilseed cake, illipe nuts (*Shorea* spp.), groundnuts and copra cake are all primary hosts of *A. diaperinus* and *A. laevigatus*.

Major hosts:*Arachis hypogaea* (groundnut), *Oryza sativa* (rice), stored products (dried stored products) [4].*Alphitobius diaperinus* is usually found infesting flour, meal, and other grain products, especially in poorly maintained grain processing plants [25]. It has been associated with wheat, barley, rice, oatmeal, soybeans, cowpeas, and peanuts. It has also been reported from linseed, cottonseed, oilseed products, tobacco, skims, and drugs [14].

A. diaperinus is commonly found in deep-litter poultry houses where it feeds on rotting animal waste, poultry food and dung.

5.1.9.4 Geographic Distribution

A. diaperinus and *A. laevigatus* are cosmopolitan and are found in temperate, sub-tropical and tropical regions around the world, although *A. laevigatus* appears to be more commonly encountered in the tropics.

Europe: Widespread in United Kingdom [1], Austria, Former USSR, IreLand, Poland [4]; **Asia:** Widespread in India, Myanmar, Malayasia, Singapore, Thailand [1] and SriLanka [12]; **Africa:** Present in Africa as whole [4] and widespread in Malawi and Mali [12]; **Central America & Caribbean:** Widespread in Jamaica [17]; North America: Present in Mexico, USA [4]; South America: Widespread in Brazil [12]; **Oceania:** Widespread in Solomon Islands[12] and present in Australia, Fiji [4].

5.1.9.5 Hazard Identification Conclusion

Considering the fact that *A. diaperinus*–

- is not known to be present in Bangladesh [4];
- is potentially economic importance to Bangladesh and it is an important pest of groundnut, dried fruits and other stored products in India and Myanmar from where groundnut and other stored products are imported to Bangladesh.
- is likely to have spread through international trade of groundnut, and other stored products [3,4] and would be able to establish and cause unwanted consequences in Bangladesh.

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

5.1.9.6 Risk Assessment

5.1.9.6.1 Entry Assessment

Egg, larva, pupa and adult of*A.diaperinus* are transported with infested commodities in internation trade. Adults are long lived, normally persisting for more than a year and under experimental conditions have survived for more than two years [10]. Adults can live three to twelve months, with females continuing to produce eggs most of their life at one to five day intervals. Larvae are very active and quickly burrow into the litter when disturbed [14, 19, 20], So, importation of groundnut and other stored products from India and Myanmar may introduce this pest in Bangladesh. Therefore, the probability of entry of *A. diaperinus* in Bangladesh is high.

5.1.9.6.2 Exposure Assessment

Both *A. diaperinus* and *A. laevigatus* are associated with a wide range of stored commodities, especially if they have suffered some mould damage. Cereal grains, oilseed cake, illipe nuts (Shorea spp.), groundnuts and copra cake are all primary hosts of *A. diaperinus* and *A. laevigatus*.*Arachis hypogaea* (groundnut), *Oryza sativa* (rice), stored products (dried stored products) [4]. *Alphitobius diaperinus* is usually found infesting flour, meal, and other grain products, especially in poorly maintained grain processing plants [25]. It has been associated with wheat, barley, rice, oatmeal, soybeans, cowpeas, and peanuts. It has also been reported from linseed, cottonseed, oilseed products, tobacco, skims, and drugs [14].There would be no shortage of potential hosts in Bangladesh throughout the year. So dispersal of any stage of*A.diaperinus*may expose to its potential hosts that will enhance its establishment in Bangladesh. Thus, the probability of exposure of *A. diaperinus* is high.

5.1.9.6.3 Establishment Assessment

A. diaperinus and *A. laevigatus* are cosmopolitan and are found in temperate, sub-tropical and tropical regions around the world. It is widespread in many countries of the world [CABI 2007]. Optimum conditions for development for *A. diaperinus* are about 33°C and 95% RH[29, 31].*A. laevigatus* can complete its life cycle in about 30 days at 35°C and 70% RH, provided some drinking water is provided [15]. So, the probability of establishment of *A. diaperinus* is high.

5.1.9.6.4 Determination of likelihood of the pest establishment 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- *A. diaperinus* is widedspread in many countires of the world [1]. *A. diaperinus* is cosmopolitan and found in temperate, sub-tropical and tropical regions around the world.	**High**

Description	The Establishment Potential is:
• **Does the pathway appear good for this pest to enter Bangladesh and establish?** YES- Egg, larva, pupa and adult can easily be transported with groundnut [4].Adults are long lived, normally persisting for more than a year and under experimental conditions have survived for more than two years [10]. Adults can live three to twelve months, with females continuing to produce eggs most of their life at one to five day intervals. Larvae are very active and quickly burrow into the litter when disturbed [14, 19, 20]. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.** YES - Cereal grains, oilseed cake, illipe nuts (*Shorea* spp.), groundnuts and copra cake are all primary hosts of *A. diaperinus* and *A. laevigatus*.It has been associated with wheat, barley, rice, oatmeal, soybeans, cowpeas, and peanuts. It has also been reported from linseed, cottonseed, oilseed products, tobacco, skims, and drugs [14].	
• 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

5.1.9.7 Consequence Assessment

5.1.9.7.1 Economic

The lesser mealworm, *Alphitobius diaperinus* (Panzer), is a cosmopolitan general stored products pest of particular importance as a vector and competent reservoir of several poultry pathogens and parasites. Although *A. diaperinus* is not considered of major economic importance to whole grains, it does occur commonly on products already damaged by other biological agents, especially molds [7]. In good storage conditions *A. diaperinus* and *A. laevigatus* are minor pests. Their presence usually indicates moisture problems within the commodity or a general lack of attention to the disposal of damp residues.

However, it is of considerable importance in the poultry business as an avian disease vector, and there are human health risks associated with exposure to *A. diaperinu*s. Poor community relations can also develop with, costly litigation when adults fly mass to the artificial lights at private residences from beetle-infested manure [13].

Lesser mealworms can also cause poultry house structural damage. When searching for suitable pupation sites, larvae will chew holes in styrofoam, fiberglass, and polystyrene insulation panels in the walls of poultry houses. The resulting damage can cause increased heating bills and additional

building repair costs when the infested area is replaced. Energy costs in beetle-damaged broiler houses are reported to be 67% higher than in houses without beetle damage [11].

5.1.9.7.2 Environmental

Adults can become a nuisance when they move en masse toward artificial lights generated by residences near fields where beetle-infested manure has been spread [3]. Poor community relations can also develop with, costly litigation when adults fly mass to the artificial lights at private residences from beetle-infested manure [13].

5.1.9.7.3 Health

Another area of concern regarding *A. diaperinus* is associated health problems in humans. Tenebrionid beetles, including *A. diaperinus*, produce highly reactive benzoquinones as defense against predation [27]. Quinones can be hazardous to human health and cause health risks when exposed to the insect for extended periods. Reported health related ailments caused by *A. diaperinus* include symptoms of asthma, headaches, dermatitis, allergic angiodema, rhinitis, erythema (reddening), and formation of papules [10, 24, 28]. Exposure to quinone vapors can also result in conjunctivitis and corneal ulceration [10, 24].Quinones produced by tenebrionids are also suspected carcinogens; thus, quinone producing insects also represent a health hazard at all levels of food production and distribution [16, 18].

5.1.9.7.4 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- *A. diaperinus* and *A. laevigatus* are associated with a wide range of stored commodities, especially if they have suffered some mould damage. Cereal grains, oilseed cake, illipe nuts (*Shorea* spp.), groundnuts and copra cake are all primary hosts of *A. diaperinus* [4]. • **Is this a serious pest of several important crops for Bangladesh?** YES - Cereal grains, oilseed cake, illipe nuts (Shorea spp.), groundnuts and copra cake are all primary hosts of *A. diaperinus* and *A. laevigatus*. *A. diaperinus*, produce highly reactive benzoquinones as defense against predation [27]. Quinones can be hazardous to human health and cause health risks when exposed to the insect for extended periods. Quinones produced by tenebrionids are also suspected carcinogens.	**High**
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.	Low

5.1.9.8 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

Considering all these *A. diaperinus* hasbeen classified as a **risk organism** for Bangladesh and **risk management** is justified.

5.1.9.9 Possible Risk Management and Phytosanitary Measures

- Good store hygiene plays an important role in limiting infestation by *A. diaperinus*. In good storage conditions *A. diaperinus* and *A. laevigatus* are minor pests [4].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [9] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.10 Coffee bean weevil (*Araecerus fasciculatus*)

5.1.10.1 Hazard Identification

Common name: Coffee bean weevil

Scientific name: *Araecerus fasciculatus* De Geer, 1775 [5].

Synonyms: cocoa weevil, areca nut weevil, coffee weevil,nutmeg weevil; other scientific names- *Curculio fasciculatus* De Geer, *Araecerus coffeae* (Fabricius), *Anthribus coffeae* Fabriciuis, *Amblycerus japonicus* Thunberg [5].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Anthribidae
Genus: *Araecerus*
Species: *Araecerus fasciculatus*

Bangladesh status: is not known to be present in Bangladesh [5].

EPPO code: ARAEFA (*Araecerus fasciculatus*) [5, 9].

5.1.10.2 Biology

Adult *A. fasciculatus* feed externally on commodities and may live up to 17 weeks at optimal humidity (80% RH). At lower humidities, adult life span may be considerably shorter, especially on cocoa beans. Each female lays approximately 50 eggs on or near the commodity. Incubation time of the egg is from 5-9 days at optimal humidity.

Newly-hatched larvae bore into the commodity and develop internally. Larvae havefour instars but occasionally may have three or five. The body is covered with fine hairs. [15]. Larval development time varies considerably depending upon commodity type, the moisture content of the commodity and relative humidity. On maize, larval development time at optimal conditions (27°C, 100% RH) was 29 days but increased to 56 days when humidity was lowered to 60%. In general, larvae cannot survive relative humidities below 60%. The moisture content of the commodity also affects larval development and survival. A. fasciculatus females preferentially attack cocoa beans at moisture contents between 17 and 20%, but will attack beans with moisture content as low as 12%. In contrast, *A. fasciculatus* will significantly attack coffee beans at moisture contents over 12-13% but larvae cannot survive on beans with moisture content below 8%. Generally, larval development time in favourable field conditions will range from 46-66 days.

Larvae pupate in the commodity and pupae are exarate in form. The combined prepupal and pupal stages last up to 8 days depending upon humidity. Upon eclosing, adults chew their way out of the commodity. Little research has been done on flight and dispersal of *A. fasciculatus*; but the primary means of dispersal is probably through transportation and distribution of infested commodities [5].

5.1.10.3 Hosts

A. fasciculatus is primarily a pest of stored commodities, although it may attack coffee berries while still on the plant. *A. fasciculatus* has a wide host range. Its ability to attack a broad spectrum of commodities is improved by high moisture content of the food or high relative humidity of the environment. *A. fasciculatus* is of primary importance on coffee beans, cocoa, and cassava. Properly stored coffee beans and cocoa suffer much less damage than badly stored commodities, but *A. fasciculatus* acts as a contaminant even in a properly stored commodity. *A. fasciculatus* can do severe damage to stored cassava [1, 19].

*A. fasciculatus*damages fruits/pods, roots, seeds and stems at flowering stage, fruiting stage and post-harvest storage [5].

Its major host species are *Allium sativum* (garlic), *Arachis hypogaea* (groundnut), *Areca catechu* (betelnut palm), *Bertholletia excelsa* (Brazil nut), *Citrus*, *Citrus sinensis* (navel orange), *Cocos nucifera* (coconut), Coffea (coffee), *Dioscorea* (yam), *Elaeis guineensis* (African oil palm), *Helianthus annuus* (sunflower), *Ipomoea batatas* (sweet potato), *Leucaena leucocephala* (leucaena), Macadamia , *Manihot esculenta* (cassava), Musa (banana), *Myristica fragrans* (nutmeg), *Persea americana* (avocado), *Phaseolus* (beans), *Saccharum officinarum* (sugarcane), *Solanum tuberosum* (potato), *Sorghum bicolor* (sorghum), stored products (dried stored products), *Theobroma cacao* (cocoa), *Voandzeia subterranea* (bambara groundnut), wheat flour, *Zea mays* (maize) [5].

5.1.10.4 Geographic Distribution

The coffee bean weevil probably **originated in India**, but is now a cosmopolitan pest in most tropical and subtropical regions.The distribution of *A. fasciculatus* is concentrated in tropical and sub-tropical areas.

The status of *A. fasciculatus* in Canada [3] cited in previous editions of the Compendium has been changed from 'present' to 'absent, intercepted only' as this record is based on an interception of the pest on a commodity of coffee beans from Indonesia in 1975.

The status for *A. fasciculatus* in New Zealand has also been changed from 'present' to 'absent, intercepted only' as all records of the pest are for interceptions [11, 21].

Europe: France Italy, United Kingdom [18] and Germany [22]; **Asia:** Widedspread in India [8, 18, 20], Indonesia [2, 18, 25], Malayasia [7,], Singapore [25], and present in China [16], Japan [18], Korea Republic [2, 27], Laos [12], Myanamar [13], SriLanka [18], Thailand [2, 25], Vietnam [12]; **Africa:**Present in Congo [18], Egypt [14], Ghana, Kenya, Nigeria, Senegal, Tanzania, Togo, Uganda [18]; **Central America & Caribbean:** Burmuda[18], Costa Rica [17], Cuba [4], El Salvador [26],Trinidad and Tobago [23]; **North America:** Mexico [6] USA[18, 24]; **South America:** Widespread in Brazil [18], Colombia [18], present in other countries; **Oceania:** Australia [28], Fiji [18], Guam [29], New Caledonia [18], Tonga [2].

5.1.10.5 Hazard Identification Conclusion

Considering the fact that *A. fasciculatus* –

- is not known to be present in Bangladesh [5];
- is potentially economic importance to Bangladesh and it is an important pest of groundnut, garlic, citrus, coconut, maize sorghum and other stored products in China, India, Myanmar and Vietnam from where groundnut and other stored products are imported to Bangladesh.

- is likely to have spread through international trade of infested commodity [5] and would be able to establish and cause unwanted consequences in Bangladesh.

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

5.1.10.6 Risk Assessment

5.1.10.6.1 Entry Assessment

Egg, larva, pupa and adult can easily be transported with groundnut, garlic, maize and other stroed products. Adult *A. fasciculatus* feed externally on commodities and may live up to 17 weeks at optimal humidity (80% RH). Newly-hatched larvae bore into the commodity and develop internally [5]. Thus it may enter into Bangladesh with infested commodities. So probability of entry with imported grounut and other stored material is high.

5.1.10.6.2 Exposure Assessment

A. fasciculatus has a wide host range. Its ability to attack a broad spectrum of commodities is improved by high moisture content of the food or high relative humidity of the environment [5].There would be no shortage of potential hosts in Bangladesh and will be available throughout the year. So dispersal of any stage of *A.fasciculatus* during transport, storage and marketing may expose to its potential hosts that will help its establishment in Bangladesh. So probability of exposure is high.

5.1.10.6.3 Establishment Assessment

*A. fasciculatus*is a polyphagous pest and its hosts are available in Bangladesh throughout the year. The coffee bean weevil probably originated in India, but is now a cosmopolitan pest in most tropical and subtropical regions.The distribution of *A. fasciculatus* is concentrated in tropical and sub-tropical areas.Thus the probability of establishment of *S. granarius* in Bangladesh is high.

5.1.10.6.4 Determination of likelihood of the pest establishment 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 - The coffee bean weevil probably originated in India and is now a cosmopolitan pest in most tropical and subtropical regions.The distribution of *A. fasciculatus* is concentrated in tropical and sub-tropical areas [5]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?** YES- Adult *A. fasciculatus* feed externally on commodities and may live up to 17 weeks at optimal humidity (80% RH). Newly-hatched larvae bore into the commodity and develop internally [5]. Egg, larva, pupa and adult can easily be transported with groundnut and other stroed products. • **Its host(s) is fairly common in Bangladesh and the climate is**	**High**

Description	The Establishment Potential is:
similar to places it is established. YES - Its hosts, groundnut, garlic, maize and other cereals are common in Bangladesh and as it is a pest of tropical and subtropical regions, climate is also favourable for its development [5].	
• 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

5.1.10.7 Consequence Assessment

5.1.10.7.1 Economic

A. fasciculatus is of primary importance in tropical and subtropical areas of Central and South America, Africa and Asia where coffee beans or cocoa are grown. The economic impact of *A. fasciculatus* is particularly severe on coffee berries/beans and cocoa beans where conditions are favourable for the insect (i.e. where the commodity has a high moisture content or relative humidities are in excess of 70-80%). Properly stored coffee beans and cocoa suffer much less damage than badly stored commodities but *A. fasciculatus* still has an economic impact as a contaminant. A. fasciculatus can also do severe damage to stored cassava [1, 19]. *A. fasciculatus* is primarily a pest of stored commodities, although it may attack coffee berries while still on the plant. *A. fasciculatus* is of primary importance on coffee beans, cocoa, and cassava.

5.1.10.7.2 Environmental

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

5.1.10.7.3 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- *A. fasciculatus* is a serious pest of stored groundnut and garlic which are important crops in Bangladesh. But it is the major pests of coffee beans, cocoa, and cassava which are not important crops in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES - *A. fasciculatus*maybe improtant pest of maizeand other stroed products which are also important stored	**High**

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

5.1.10.8 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 *A. fasciculatus*has been classified as a **risk organism** for Bangladesh and **risk management** is justified.

5.1.10.9 Possible Risk Management and Phytosanitary Measures

- Good store hygiene plays an important role in limiting infestation by *A. fasciculatus*. Cleaning of handling or processing equipment, storage areas, etc. is very important [5].
- Moisture contents of 8% and less usually eliminate all problems for allstored materials.
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [10] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.1.11 Cadelle (Tenebroides mauritanicus)

5.1.11.1 Hazard identification

Common name: Cadelle

Scientific name: *Tenebroides mauritanicus* Linnaeus 1758

Synonyms: Cadelle beetle; other scientific names -*Tenebrio mauritanicus* Linnaeus, *Trogosita mauritanica* Linnaeus [2].

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Trogositidae
Genus: *Tenebroides*
Species: *Tenebroides mauritanicus*

Bangladesh status: is not known to be present in Bangladesh [2]

EPPO code: TEBRMA (*Tenebroides mauritanicus*) [2,3]

5.1.11.2 Biology

The physical limits for the development of *T. mauritanicus* appear not to have been studied under controlled conditions but it is claimed that development can be completed in about 8 weeks under optimal conditions [7]. It is known that both adults and larvae can survive very cold situations [5]. The adults may live for 1-3 years.

5.1.11.3 Hosts

T. mauritanicus is well known as a minor pest of stored products and as a predator of other insects. It has been found in association with a wide range of stored commodities, including cereals (maize, milled rice, paddy rice, wheat, sorghum, oats) and cereal products, carob (*Ceratonia siliqua*), spices, cocoa beans, groundnuts, cotton seed and cotton seed cake [2].

Major hosts: *Avena sativa* (oats), *Oryza sativa* (rice), Poaceae (grasses), *Sorghum bicolor* (sorghum), stored products (dried stored products), *Triticum* (wheat), *Triticum aestivum* (wheat), *Zea mays* (maize).

Minor hosts: *Arachis hypogaea* (groundnut), *Ceratonia siliqua* (locust bean), *Gossypium* (cotton), *Theobroma cacao* (cocoa) [2].

5.1.11.4 Geographic Distribution

T. mauritanicus is found throughout the temperate, sub-tropical and tropical regions of the world.This species from Mali, Malawi, Mexico, Sri Lanka, Yemen, Ecuador, Philippines and the Solomon Islands [6]. Records for imports into the UK indicate *T. mauritanicus* infestations in Kenya, Mozambique, Tanzania, Nigeria, Sierra Leone, Italy, Myanmar, Thailand and Malaysia [1]. It is well known in the USA and Canada [7]. It is also reported from Australia, **China, India,** Brazil and many other countries [2].

5.1.11.5 Hazard Identification Conclusion

Considering the fact that *T. mauritanicus*–

- is not known to be present in Bangladesh [2];
- is not potentially economic importance to Bangladesh and it is a minor pest of groundnut, dried fruits, rice, wheat and other stored products in China and India [2]from where groundnut and other stored products are imported to Bangladesh.
- is likely to have spread through international trade of groundnut, dried fruits and other stored products [2, 3] and would be able to establish and cause unwanted consequences in Bangladesh.

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

5.1.11.6 Risk Assessment

5.1.11.6.1 Entry Assessment

Egg, larva, pupa and adult can easily be transported with groundnut, rice, wheat, maize and other stroed products.Moreover, it is a minor pest of groundnut. Thus it may enter into Bangladesh with infested materials. So probability of entry with imprted grounut is medium.

5.1.11.6.2 Exposure Assessment

It has been found in association with a wide range of stored commodities, including cereals (maize, milled rice, paddy rice, wheat, sorghum, oats) and cereal products, carob (*Ceratonia siliqua*), spices, cocoa beans, groundnuts, cotton seed and cotton seed cake [2, 3].There would be no shortage of potential hosts in Bangladesh and will be available throughout the year. So dispersal of any stage of *T. mauritanicus* during transport, storage and marketing may expose to its potential hosts that will help its establishment in Bangladesh. So probability of exposure is high.

5.1.11.6.3 Establishment Assessment

T. mauritanicus is a polyphagous pest and its hosts are available in Bangladesh throughout the year. Morover, it is found throughout the temperate, sub-tropical and tropical regions of the world Thus the probability of establishment of *S. granarius* in Bangladesh is high.

5.1.11.6.4 Determination of likelihood of the pest establishment 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- *T. mauritanicus*is mostly temperate, sub-tropical and tropical regions of the world. It has reported from many countries of the world [2, 3]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?** YES - Egg, larva, pupa and adult can easily be transported with groundnut and other stroed products [2]. • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.** YES- Its major hosts, rice, wheat and other cereals are common in Bangladeshand climate is also favourable for its development [2].	**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

5.1.11.7 Consequence Assessment

5.1.11.7.1 Economic

T. mauritanicus is of very limited significance as a storage pest. When infesting grain the larvae feed preferentially on the embryo and the last instar larvae are known to bore into any soft wood material found in the store to create a pupation chamber. However, the loss due to the small amount of damage done is probably offset by the gain from predation on other storage pests. Both larvae and adult are external feeder [2].

5.1.11.7.2 Environmental

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

5.1.11.7.3 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 - This is a minor pest of groundnut [2, 3] which is an important crop in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** NO - This is also minor pest of rice, wheat and other cerals and dried stroed products [2] which are also important stored material for Bangladesh.*T. mauritanicus* is of very limited significance as a storage pest.	High
• Not as above or below	Moderate
• This is not likely to be an important pest of common crops grown in Bangladesh.YES- *T. mauritanicus* is a minor pest of rice, wheat and other cereals and stored products [2]. Both larvae and adult are external feeder; the loss due to the small amount of damage done is probably offset by the gain from predation on other storage pests	**Low**

5.1.11.8 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 *T. mauritanicus*has been classified as a risk organism for Bangladesh and risk management is justified.

5.1.11.9 Possible Risk Management and Phytosanitary Measures

- Good store hygiene plays an important role in limiting infestation by *T. mauritanicus*.
- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled [2].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- 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.
- Inspection will be undertaken in Bangladesh after the consignment has arrived.Adults and larvae of *T. mauritanicus* may be found moving through stored food. The adults are particularly conspicuous because of their relatively large body size.

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5.1.12 Granary weevil (*Sitophilus granarius*)

5.1.12.1 Hazard identification

Common name: Granary weevil

Scientific name: *Sitophilus granarius* Linnaeus, 1785

Synonyms: Grain weevil,*Calandra granaria* Linnaeus, *Calendra granaria* (Linnaeus), *Curculio granarius* Linnaeus [2]. *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:is not known to be present in Bangladesh [1]

EPPO code: CALAGR (*Sitophilus granarius*) [1, 5].

5.1.12.2 Biology

The biology and behaviour of *S. granarius* is similar to the tropical species *S. oryzae* and *S. zeamais*, except that it cannot fly [10]. 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 [12].

Optimum conditions for development are similar to other tropical species of *Sitophilus*, about 30°C and 70% RH [12], but in tropical areas it is apparently not able to compete with *S. oryzae* and *S. zeamais* [2]. 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 [9]. Being flightless, *S. granarius* cannot usually infest crops in the field before harvest.

5.1.12.3 Hosts

S. granarius is a frequent pest of wheat and barley. It can attack other cereals such as maize, sorghum and rice, but it does not compete well with the other two *Sitophilus* species on these grains.It attacks seeds at post-harvest, pre-emergence and seedling stage of various host grains.

Major hosts:*Hordeum vulgare* (barley), stored products (dried stored products), *Triticum* (wheat), *Triticum aestivum* (wheat)

Minor hosts:*Arachis hypogaea* (groundnut), *Avena sativa* (oats), *Cicer arietinum* (chickpea), *Helianthus annuus* (sunflower), *Oryza sativa* (rice), *Panicum* (millets), *Pennisetum* (feather grass), *Secale cereale* (rye), *Sorghum bicolor* (sorghum), *Triticale*, *Vicia faba* (broad bean), Zea mays (maize) [1, 2].

5.1.12.4 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 [2]. 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 [3]. It is also reported from Yemen [8], India [1, 2] and Turkey [1,2].

Egg, larva and pupa can easily be transported with groundnut 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 [2].

5.1.12.5 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, groundnut, chickpea, faba bean in India, from where groundnut is imported to Bangladesh.
- is likely to have spread with groundnut seed through international trade and will be able to establish and cause unwanted consequences in Bangladesh although it is a pest temperate regions [2].
- 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.

5.1.12.6 Risk Assessment

5.1.12.6.1 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 [2]. Thus probability of entry of *S. granarius* through this pathwayis high.

5.1.12.6.2 Exposure Assessment

S. granarius is a polyphagous and primary insect pest which infests different stored grains such as wheat, rice, maize, groundnut, chickpea, etc. [2] 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.

5.1.12.6.3 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* [2]. Hosts are available in Bangladesh throughout the year. Thus the probability of establishment of *S. granarius* is medeium.

5.1.12.6.4 Determination of likelihood of the pest establishment 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- 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* [2]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?** YES- Egg, larva, pupa and adult can easily be transported with groundnut [2]. So the pathway is good for entry of this pest. • **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 [2] and climate is also favourable for its development [13] although it is a serious pest of temperate regions [2].	High
• Not as above or below	**Moderate**
• This pest has not established in new countries in recent years, and **YES-** The pest has established in many countries [1]. • 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, 2] and climate also favourable [13].	Low

5.1.12.7 Consequence Assessment

5.1.12.7.1 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 [1,2]. 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.

5.1.12.7.2 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.

5.1.12.7.3 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, 2] which is an important crop in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES - This is a serious pest of rice, maize, chickpea, groundnut [1, 2] which are 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.	Low

5.1.12.8 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 *S. granarius*hasbeen classified as a risk organism for Bangladesh and risk management is justified.

5.1.12.9 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, 2].
- 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 [6] 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 [11].
- 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 [7].
- 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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5.1.13 Indian meal moth (*Plodia interpunctella*)

5.1.13.1 Hazard identification

Common name: Indian meal moth

Scientific name: *Plodia interpunctella* (Hübner 1813)

Synonyms: mealworm moth, cloaked-not-horn moth, horn compressed vegetable moth; other scientific names-*Ephestia interpunctella* Hübner, *Tinea interpunctella* Hübner [5]

Taxonomic tree

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Lepidoptera
Family: Crambidae
Genus: *Plodia*
Species: *Plodia interpunctella*

Bangladesh status: is not known to be present in Bangladesh [5]

EPPO code: PLODIN (*Plodia interpunctella*) [5, 6]

5.1.13.2 Biology

P. interpunctella is a surface feeder, restricted to the top 20 cm, in grain bins and elevators. Grains on the surface are often held together by a mat of silken webbing containing frass and larval skins. The larvae move through the commodity leaving a trail of webbing and excreta. White, silken cocoons containing the pupae can be seen on the sides of infested bags.

P. interpunctella feeds and multiplies continuously in heated premises. It overwinters in the larval stage or in diapause during low winter temperatures and resumes its life cycle in the spring if weather conditions are favourable. There are typically one or two generations per year in temperate climates, but there can be up to eight generations per year [19]. Females mate very soon after adult eclosion.

Some aspects of the sexual behaviour of *P. interpunctella* have been investigated by [20] including the role of ultrasound in courtship behaviour and the role of other signals in pair forming. The factors

which influence oviposition choice and competition patterns have been studied by [2, 15]. After copulation, females may lay up to 400 eggs. The eggs are sticky and adhere to food and storage structures. At 30°C and 70% RH, the eggs hatch in about 4 days.

The larvae undergo four to seven moults and are ready to pupate after approximately 16 days when fed on an optimal diet of wheat feed under a controlled photoperiod of 16 h light and 8 h dark. The mature larvae are very active and often migrate from the food to find a pupation site. They pupate in a thin cocoon. Fully-grown larvae of some strains of *P. interpunctella* are able to undergo a diapause. This may be caused by short photoperiods (not applicable to tropical areas), low temperature [16] or overcrowding [18].

At 30°C and 70% RH, the adults emerge after 7 days. Under these conditions, and with the food and photoperiod described above, complete development takes on average 27 days [4]. The development period increases to 52 days at 20°C and 70% RH and development is not possible at or below 15°C. Longer development periods have been recorded on natural foods or with other photoperiods [1].The critical photoperiod for 50% diapause is between 14 and 16 h at 20°C, 12 and 14 h at 25°C, and 6 and 8 h at 30°C [10].

Development and life table statistics for *P. interpunctella* on brown rice were determined at 17, 20, 25, 28 and 32°C. The development period and lifespan of the adult moth decreased as the temperature increased, ranging from 150 to 38 days, and from 19 to 7 days, at 17 and 32°C, respectively. The emergence rate increased with increasing temperature, from 13% at 17°C to 49% at 32°C. The hatching rate peaked (74%) at 25°C. The number of eggs laid per female at 17-25°C was not related to temperature, and ranged from 133 to 154, however, it decreased at 32°C suggesting a close relationship with hatching ability. Reproduction rate was highest at 28°C.

P. interpunctella was reared on whole buckwheat with pericarp, decorticated buckwheat, wheat cv. Centauro, wholemeal wheat flour and whole buckwheat flour[12]. The first adults were found after 28 days on wheat and after 56 days on buckwheat with pericarp. The shortest mean period of development occurred on wheat (34 days) and the longest was on buckwheat with pericarp at 81 days.

A life cycle can be completed in 27 to 305 days. A single female can lay up to 400 eggs after mating. The mating and laying of eggs occurs about three days after adult emergence. The eggs can be laid singly or in clusters, and are generally oviposited directly on the larval food source. The eggs hatch in seven to eight days at 20°C and three to four days at 30°C. Upon hatching, the larvae begin to disperse and within a few hours can establish themselves in a food source. The larvae can complete their development in six to eight weeks at temperatures from 18 to 35°C. The number of larval instars varies from five to seven (depending on the food source and the temperature). The pupal stage can last from 15 to 20 days at 20°C and seven to eight days at 30°C [8].

5.1.13.3 Hosts

P. interpunctella attacks stored grains (in which it eats the embryo), milled cereal products, nuts, spices, peas, beans, lentils, chocolate and other commodities.

Major hosts: *Arachis hypogaea* (groundnut), *Oryza sativa* (rice), *Prunus* (stone fruit), stored products (dried stored products), *Triticum aestivum* (wheat), and *Zea mays* (maize).

Minor hosts: *Avena sativa* (oats), Corylus), *Helianthus annuus* (sunflower), *Hordeum vulgare* (barley), *Juglans regia* (walnut), *Pistacia vera* (pistachio), *Prunus dulcis* (almond), *Sorghum bicolor* (sorghum), *Theobroma cacao* (cocoa), wheat flour [5].

5.1.13.4 Geographic Distribution

P. interpunctella is common in warm climates. In hot tropical climates, it is often more prevalent in cooler areas, such as highland regions. In cool temperate countries, *P. interpunctella* can survive in heated buildings.
Asia: India [17], widespread in Japan [21], Korea Republic [11] and Yemen [9]; **Europe:** Widespread in France, Germany, Italy, Sicily, Switzerland and UK [5]; **Africa:** Widespread in Egypt [1], Lesotho and Malawi [5, 9]; **North America:** Widespread in Mexico [9] and USA [22]; **Oceania:** Australia [3]

5.1.13.5 Hazard Identification Conclusion

Considering the fact that *P. interpunctella*–

- is not known to be present in Bangladesh;
- is potentially economic importance to Bangladesh because it is an important pest of groundnut, rice, stored cereals and other stored products in India [5, 16], from where groundnut is imported to Bangladesh.
- is likely to have spread with groundnut seed through international trade and will be able to establish and cause unwanted consequences in Bangladesh [5].
- It has capability to cause direct economic and ecological damage to many valuable stored products.

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

5.1.13.6 Risk Assessment

5.1.13.6.1 Entry Assessment

Long distance movement of adult is not possible because males exhibited flight or wing fanning responses up to 4 m [13]. Egg, larva, pupa and adult are easily transported with infested grains. The presence of *P. interpunctella* in infested commodities is readily detected by observing larval webbing intermixed with frass, cocoons, adults and larvae.Egg, larva, pupa and adult of *P. interpunctella*can easily enter into Bangladesh with imported groundnut from India [5]. Thus the rating of entry potential is high.

5.1.13.6.2 Exposure Assessment

P. interpunctella attacks stored grains like rice, wheat, groundnut, maize, milled cereal products, nuts, spices, peas, beans, lentils, chocolate and other commodities [5] 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*P.interpunctella*during transport, storage and marketing may expose to its potential hosts that will help its establishment in Bangladesh. So probability of exposure of *P. interpunctella*is high.

5.1.13.6.3 Establishment Assessment

*P. interpunctella*is a polyphagous stored grain pest which feeds many important stored gains in Bangladesh. Optimum conditions for its development are 30°C and 70% RH [4] which prevais in Bangladesh. Morover, it overwinters in the larval stage or in diapause during low winter temperatures and resumes its life cycle in the spring if weather conditions are favourable[19].Thus the probability of establishment of *P. interpunctella*is high.

5.1.13.6.4 Determination of likelihood of the pest establishment 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- *P. interpunctella* is common in warm climates. It is widespread in many countries of the world [5]. Morover, it overwinters in the larval stage or in diapause during low winter temperatures and resumes its life cycle in the spring if weather conditions are favourable [19]. • **Does the pathway appear good for this pest to enter Bangladesh and establish?** YES- Egg, larva, pupa and adult can easily be transported with groundnut [5] and cereal grains • **Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.** YES- Its major hosts, rice, wheat, groundnut, maize and other cereals are common in Bangladesh [5] and climate is also favourable for its development [4].	**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

5.1.13.7 Consequence Assessment

5.1.13.7.1 Economic

Larvae of the Indian meal moth feed upon grains, grain products, dried fruits, nuts, cereals, and a variety of processed food products. The Indian meal moth is also a common pantry pest. Direct damage to grain is the result of larvae feeding on the seed germ. In grain to be sold for human or animal consumption, meal moth feeding reduces the dry weight. At the same time, grain weight may

actually increase because of water absorption; with an increase in water content mold can become a problem. The biggest reduction in value is the result of contamination by larvae that leave droppings and silken webs in the grain. The presence of live insects and insect parts can result in dockage of the grain when sold.

In many countries *P. intepunctella* can cause serious infestations of stored products in large warehouses, grain elevators and food factories. In the USA it is one of the most common and important pests of stored maize and groundnuts. In Russia it is a secondary pest of cereal products, also causing damage to dried fruit and stored medicinal herbs [5].

The infestation of stored groundnuts by *P. interpunctella*, especially in southern USA, may cause considerable losses if unchecked. Attacks by *P. interpunctella* on processed foods, such as dried fruit, nuts and chocolate, frequently result in consumer rejection.

5.1.13.7.2 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 chemical insecticides and fumigants which are hazardous for human health and environment.

5.1.13.7.3 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
• **Is this a serious pest of an important crop in Bangladesh?** YES- This is serious pest rice [1, 2] which is an important crop in Bangladesh. • **Is this a serious pest of several important crops for Bangladesh?** YES - This is a serious pest of wheat, groundnut maize, chickpea [1, 2] which are important food grains 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

5.1.13.8 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

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

5.1.13.9 Possible Risk Management and Phytosanitary Measures

- Good storage hygiene plays an important role in limiting infestation by *P. interpunctella*. The removal of infested residues from the previous season's harvest is essential [5].
- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled.
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [7] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains. Warm air disinfection of stored cereals gave good control of *P. interpunctella*. After 3 h at 55°C, mortality was 100% for insect storage pests including *P. interpunctella*[14].
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

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5.2 DISEASE

Fungus

5.2.1 Yellow mold

5.2.1.1 Hazard Identification

Disease: Yellow mold/Afla-toxin

Pathogen: *Aspergillus flavus* Link. Ex. Fries.

Taxonomic Tree

Kingdom: Fungi

Division: Ascomycota

Class: Eurotiomycetes

Order: Eurotiales

Family: Trichocomaceae

Genus: *Aspergillus*

Species: *Aspergillus flavus* Link.

Bangladesh status: Present

5.2.1.2 Biology

Aspergillus flavus is a cosmopolitan facultative pathogen. This fungus is present normally in air, soil and water and is associated with living or dead plants and animals throughout the world and causes disease on many important agriculture crops including groundnut.Yellow mold is considered as a quarantine pests for Bangladesh due to the production of aflatoxin by the pathogen. In strict sense the quarantine object is the aflatoxin. Aflatoxin contamination is a serious quality problem in groundnut. *Aspergillus flavus* causes yellow mold in peanuts either before or after harvest. Infection can be occur in the field, preharvest, postharvest, during storage, and during transit and causes aflatoxin production in the kernals. It is common for the pathogen to originate while host crops are still in the field; however, symptoms and signs of the pathogen are often unseen. The disease is favored by late season moisture stress to the crop for more than 20 days. Mean soil temperatures of 28-31°C in the pod zone. Growth cracks, mechanical injury or insect damage or nematode damage to the pod aggravates the infection in the soil. Favorable factors for postharvest infection are harvesting over-mature crop, mechanical damage during harvesting and stacking after harvest under high humidity conditions. Infection may also occur while in the storage when immature or small pods are stored and also when damaged by insects [5].

Yellow mold first appears on groundnut cotyledons after the emergence of seedlings. Necrotic spots become covered with masses of yellow-green spore heads of the *A. flavus* group of fungi. Fungus toxins are translocated throughout the seedling in the transpiration stream. Infected plants generally become stunted with symptoms of vein clearing chlorosis on the leaflets. Such seedlings lack a secondary root system, a condition known as "aflaroot." Yellow-green Aspergillus colonies develop on over mature and damaged seeds and pods [12].

Soil and air temperature between 22 and 35^{o}C seem to encourage aflatoxin production. Kernel moisture in a range around 15 to 30% for more than 7-14 days encourage aflatoxin production. These conditions can occur pre-harvest when end-of-season drought leads to crop water stress, or post-harvest when wet weather affects windrowing and/or when pods are inadequately dried. Poor post-harvest drying methods can result in uneven drying, which can lead to increased aflatoxin contamination in storage [1].

5.2.1.3 Host

Aspergillus flavus has a broad host range as an opportunistic pathogen/saprobe. In the field, A. flavus is predominantly a problem in the oilseed crops, maize, peanuts, cotton seed and tree nuts. Under improper storage conditions, *A. flavus* is capable of growing and forming aflatoxin in almost any crop seed [8].

5.2.1.4 Geographic Distribution

This fungus is present in almost all countries including China [14], India [7], Myanmar [6] and Vietnam (10).

5.2.1.5 Hazard Identification Conclusion

Considering the facts that:

- *Aspergillus flavus* is known to be present in Bangladesh;
- It is also present in China, India, Myanmar and Vietnam.
- *Aspergillus flavus* is known to produce aflatoxin in groundnut, which is hazardous for health. Imported groundnuts are mostly used for direct consumption.
- Therefore *A. flavua* (aflatoxin)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

Aspergillus flavus is reported to be a seed-borne pathogen. It produced aflatoxin in the seed. Seed infection sometimes remains symptomless. The toxin remains in the seed and therefore, there is high probability of entering this toxin through this pathway.

5.2.1.6.2 Exposure Assessment

In Bangladesh most of the groundnut seeds after import distributed throughout the country and exposed to the peoples who procure these for consumed. Exposure of the pathogen is not important in this particular context because it is widely present in Bangladesh. There is high probability of exposure of contaminated seed to the people.

5.2.1.6.3 Establishment Assessment

The quarantine object is the toxin so there is no question of establishment. The pathogen *A. flavus* is already established in many countries including Bangladesh. Moreover, this is a facultative pathogen and it can easily survive of dead plant tissue.

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 (This pest is already established in most of the groundnut producing countries [13]. • The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, peanut seed is the means of dispersal of this pest/toxin* [10]. • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***Yes*** The fungus is host specific and lentil is the only known host (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

5.2.1.7 Consequence Assessment

5.2.1.7.1 Economic Impact

Aspergillus falvus has a very wide host range including groundnut and causes economical damage to the crops including field crops, horticultural crops and fruits [2]. Aflatoxin contamination of agricultural commodities poses considerable risk to human and livestock health and has significant economic implication for the agricultural industry worldwide [11]. In the USA, it was reported that income losses due to aflatoxin contamination cost an average of more than US$100 million per year to US producers [4]. According to Cardwell *et al*., aflatoxin contamination of agricultural crops, such as groundnut and cereals, causes annual losses of more than $750 million in Africa (3]

5.2.1.7.2 Social Impact

Depending on the levels, the toxins can severely affect the liver and they are a known human carcinogen (i.e. causes cancer). In many developing countries aflatoxin is a major health risk to humans and animals due to the high levels of contaminated product consumed. A study, in collaboration with WHO, it is estimated that aflatoxin causes between 5 to 30 percent of all liver cancer cases in the world. Highest incidence of 40 percent is in Africa. The study estimates that there are between 25,200 to 155,000 global aflatoxin induced liver cancer cases per year [9].

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 **(No) However, the toxin is a serious concern for Bangladesh [9]**	**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

5.2.1.8.1 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 avoiding maize or other host-groundnut sequence for export purpose.
- Regular field inspection by competent authority to record the presence of the disease.
- Seeds 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/toxin.
- Proper seed cleaning to remove other plant parts.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *A. flavus/* toxin.
- Test for the presence of aflatoxin should be conducted at the port of entry.

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VIRUS

5.2.2 Groundnut bud necrosis disease

5.2.2.1 Hazard Identification

Disease: Groundnut bud necrosis disease

Pathogen: *Peanut bud necrosis virus* (PBNV)

Taxonomic Tree

Group: Group V ((−)ssRNA)

Order: *Unassigned*

Family: *Bunyaviridae*

Genus: *Tospovirus*

Species*:* Peanut bud necrosis virus

Bangladesh status: Not present in Bangladesh

5.2.2.2 Biology

Peanut bud necrosis disease (PBND) is an important disease of peanut in south and southeast Asia. It is caused by Peanut bud necrosis virus (PBNV). The disease was first reported in India in 1949, and it became economically important during the late 1960s when incidences of up to 100% were recorded in many peanut-growing regions of the country. The virus is not seed-borne. It is vectored by *Thrips palmi* Karny in a propagative manner. The primary symptom of PBND on peanut is a mild chlorotic mottle or specks on young, quadrifoliate leaves, which develop into chlorotic and necrotic rings and streaks. Necrosis from the leaf extends to the petiole and terminal bud and results in necrosis of the terminal bud. Secondary symptoms include stunting, auxiliary shoot proliferation, and malformation of leaflets. The virus can cause severe crop losses, when the plants are infected before they are a month old. Seeds from such plants are small, shriveled, mottled, and discolored. Plants infected at a later stage produce normal-sized seeds, but testa on such seeds are often mottled and cracked [6]. The population of vectors increases rapidly from January-March and August-September Kharif and hence the crop suffers a heavy loss in both the seasons. A prolonged dry spell favours the multiplication of thrips and spread of the virus [8].

Studies with three Thrips species viz., *Thrips palmi, Frankliniella schultzei* and *Scirtothrips dorsalis* showed that only *T. palmi* transmitted PVNB. *Thrips palmi* as larvaeacquired the virus by a >5-minute feeding on the infected host and transmitted the virus to healthy plants at adult stage. To acquire the virus adults need an inoculation feeding of > 1 hour. Once acquired the virus it can transmit throughout their life [10].

5.2.2.3 Host

PBNV has a wide host range infecting Groundnut, potato, tomato, chilli, carrot, brinjal, peas, onion, cowpea, blackgram and green gram, sunflower, cotton, ornamental crops like zinniz, cosmos, wild species/sub-species of Vigna such as *V. umbellata*, *V. glabrescens*, *V. hainiana*, V. *mungo* var.*mungo*, V. *radiate* var. radiata and V. *radiata* var. sublobata and weeds such as Ageratum

conyzoides, Cassia tora, Acanthospermum hispidum, Desmodium triflorum, and Lagasca mollis[3, 4, 7, 9].

5.2.2.4 Geographic Distribution

India, Nepal, Srilanka, China, Taiwan, Indonesia, Thailand and Vietnam [1, 2, 5, 8]. The disease is wide spread in India.

5.2.2.5 Hazard Identification Conclusion

Considering the facts that:

- *Peanut bud necrosis virus* is not known to be present in Bangladesh;
- It is present in many countries in the world including China, India and Vietnam
- PBNV is not seed-borne and transmitted through different *Thrips palmi*, which persist throughout the life of the vector insect.

Therefore PBNV isas a hazardon this commodity.

5.2.2.6 Risk Assessment

5.2.2.6.1 Entry assessment

Peanut bud Necrosis virus is not a seed-borne virus but is transmitted by Thrips vactor. Although once acquired, the insect can transmit the virus throughout its life, there is no possibility of association of live Thrips with groundnut pod or seed. Therefore, there is no probability of entering this organism through this pathway. Hence further assessment has not been done.

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VIRUS

5.2.3 Stripe disease

5.2.3.1 Hazard Identification

Disease: Peanut stripe

Pathogen: Peanut stripe virus

Taxonomic Tree

Virus Group: Virus

Family: Potyviridae

Genus: Potyvirus

Bangladesh status: Not present in Bangladesh

5.2.3.2 Biology

Symptoms on groundnut plants vary, depending on virus isolate and groundnut cultivar. For most isolates, the initial symptoms appear as chlorotic flecks or rings on young quadrifoliates. The plants are slightly stunted. Subsequently, the older leaves show symptoms which are more specific to the isolate: mild mottle, blotch, stripe, chlorotic ring mottle, chlorotic line pattern, oak leaf pattern or necrosis [11]. The symptoms normally persist throughout plant development. Among seven isolates found in South-East Asia, the 'blotch' and 'mild mottle' isolates are predominant, but have little effect on plant growth. The 'stripe' [V-shaped or herringbone pattern] and 'necrotic' isolates, which are seen less often, can severely stunt the plants if they infect them early. The other isolates are considered minor and are found only occasionally. PStV is primarily seed-borne and the secondary spread of the virus in done by two species of aphid- Aphis craccivora and *Muzus persicae* [3, 4, 9].

5.2.3.3 Host

Arachis hypogaea (groundnut), *Calopogonium caeruleum* (jicama), *Centrosema pubescens* (Centro), *Crotalaria pallida* (smooth crotalaria), *Desmodium* (tick clovers), *Glycine max* (soyabean), *Indigofera* (indigo), *Lupinus albus* (white lupine), *Medicago sativa* (lucerne), *Pueraria phaseoloides* (tropical kudzu), *Senna obtusifolia* (sicklepod), *Senna occidentalis* (coffee senna), *Senna tora* (sicklepod), *Sesamum indicum* (sesame), *Stylosanthes* (pencil-flower), *Vigna radiata* (mung bean), *Vigna unguiculata* (cowpea) [6].

5.2.3.4 Geographic Distribution

Asia: China, India, Indonesia, Iran, Japan, Korea, Republic of Malaysia, Myanmar, Philippines, Thailand, Vietnam.

Africa: Sudan, South Africa

North America: USA [2, 3, 7, 8]

5.2.3.5 Hazard Identification Conclusion

Considering the facts that:

- PStV is not reported to be present in Bangladesh
- The virus is present in all the selected four peanut exporting countries.
- PStV is primarily seed-transmitted, secondary spread is done by aphids.
- This virus is identified as a potential hazard for Bangladesh

5.2.3.6 Risk Assessment

5.2.3.6.1 Entry Assessment

Peanut stripe virus is a seed-borne and seed-transmitted virus in groundnut. Among other countries this disease on groundnut is reported to occur in China and India from where Bangladesh is imported groundnut. Therefore, there is high probability of entering the virus in Bangladesh with this commodity.

5.2.3.6.2 Exposure Assessment

After entry the commodity is distributed to different parts of the country both urban and rural areas in different types of vehicles. Ground for consumption purpose normally cleaned before processing and the half-filled grains are discarded and thrown anywhere and exposed to the environment. Germplasm is carrying the virus are exposed to the environment while sowing. Therefore probability of exposure of PStV is high.

5.2.3.6.3 Establishment Assessment

Groundnut is grown in Bangladesh in both rabi and Kharif season. Besides groundnut PStV has many other hosts hosts, some of which are available in Bangladesh. The secondary transmitter aohids are also present in Bangladesh. Therefore, once exposed there will be no problem of this virus for its establishment in in PRA area.

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 (**YES** [4].	

Description	**The Establishment Potential is:**
• The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, peanut seed is the source for this virus*[5, 9]. • 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

5.2.3.7 Consequence Assessment

5.2.3.7.1 Economic Impact

In Northern China, where more than 65% of the nation's groundnuts are produced, an incidence of over 50% has been reported [12]. In Gujarat, India, the disease was only found in trace amounts during 1988, but in 1992, up to 40% of groundnut plants were infected in most fields surveyed [10]. In South-East Asia, high incidences of up to 38% have been reported in Indonesia (7] and the Philippines [1] The yield loss is depending on the test conditions, groundnut cultivar, plant age at the time of infection, and the virus isolate used. In the USA, when plants were inoculated at 5 weeks old and kept in the greenhouse, yield loss was about 20%.The yield reduction was only 5% when the experiment was done under the screened-cage test [5). In China, the average loss was ca. 44% in the two most commonly grown cultivars assessed under field conditions [12].

5.2.3.7.2 Social Impact

Yield reduction influences market price of the product and hence it will bring a negative social impact. It also causes considerable negative national impact worldwide by damaging the worldwide groundnut improvement programme. It has reduced the domestic and international exchange of groundnut germplasms, delayed the release of new cultivars and destroyed many breeding materials in experimental plantings [13].

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 **(Yes)**	**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

5.2.3.8.1 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

5.2.3.9 Phytosanitary Measures

- Planting of certified/healthy/treated seed in the country of origin.
- Regular field inspection by competent authority to record the presence of the disease.
- No distribution of seed from PStV-infested areas.

- Sowing near leguminous crops or other potential hosts of PStV should be avoided.
- Seed health test should be conducted previous to shipment to confirm that the lot is free from infection.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from *A. PStV*.
- Test for the presence of PStV should be conducted at the port of entry.

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Virus

5.2.4 Peanut Clump disease

5.2.4.1 Hazard Identification

Disease: Peanut clump disease

Pathogen: *Indian Peanut clump virus* (IPCV)

Taxonomic Tree

Group: Group IV ((+)ssRNA)

Family: Virgaviridae

Genus: Pecluvirus

Species: Peanut clump virus

Bangladesh Status: Absent in Bangladesh

5.2.4.2 Biology

The peanut clump disease appears in patches in the field and reappears in the same position in progressively enlarged patches, in succeeding years. The patchy appearance of the disease and its occurrence year after year in almost the same area of a field are due to the soil-borne nature of the vector, the obligate fungal parasite (*Polymyxa graminis*), and its survival as highly resistant resting spores. Typical symptoms are severe stunting of the plant apparent first on newly emerged leaves of two- to three-week-old seedlings. The newly emerged leaves show mottling and chlorotic rings. Later, the infected leaves turn dark green with faint mottling. Infected plants ultimately appear bushy and have small, dark green leaves and usually produce several flowers on erect petioles. The number and size of pods are reduced, resulting in small seeds. Root systems of infected plants get reduced in size and become dark. Their epidermal layer peels off easily [7, 8].

The IPCV is transmitted through seeds up to 11 % in groundnut therefore is of particular importance for long distance disease transmission through seed or germplasm [11, 12]. Natural virus transmission is highly favored by the temperature (23–30 C) during rainy season [4]. Seed transmission in the field-infected groundnut plants ranged from 3.5 to 17 %, depending on the genotype. The transmission frequency was 48–55 % in seed collected from plants infected through seed [11]. The disease is also a sap transmissible.

5.2.4.3 Host

The host range of IPCV includes many monocot and dicot plants which showed the highest incidence of weed species tested. The major hosts are wheat, barley, Avena fatua , Cynodon dactylon , Digitaria ciliaris , Chenopodium murale , Cyperus rotundus , Sorghum halepense , S. bicolor , S. sudanensis , Dactyloctenium aegyptium , Cenchrus ciliaris , Eleusine coracana , Eragrostis ciliaris , E. tremula , E. unioloides , Pennisetum glaucum , Setaria italica , Triticum aestivum , Chenopodium album , Celosia argentea , Oldenlandia corymbosa, Eleusine coracana , groundnut, maize, rice, sorghum, and finger millet [1, 3, 4, 9, 13].

5.2.4.4 Geographical Distribution

Asia: **India**, Pakistan [2, 6],

Africa: Benin [2, 6], Burkina Faso [6, 13], Chad, Congo, Côte d'Ivoire, Gabon and Mali [2, 6], Niger [6, 13], Senegal [5]) and Sudan [6].

5.2.4.5 Hazard Identification Conclusion

Considering the facts that:

- *Indian peanut clump virus* (IPCV) is not known to be present in Bangladesh;
- Among the four selected countries it is present only in India.
- IPCV is transmitted by an obligate soil-borne fungal parasite, Polymyxa graminis. It is also seed transmitted in groundnut.
- IPCV *is* considered to be a potential hazard for Bangladesh.

5.2.4.6 Risk Assessment

5.2.4.6.1 Entry Assessment

IPCV is seed borne in groundnut it is also transmitted by a soil-borne fungus. The rate of seed transmission is quite high (around 50%). The virus could survive in the seed for long time. This disease is present in India especially in the major groundnut growing areas. Therefore, there is high probability of entering this virus long with the infected imported from India.

5.2.4.6.2 Exposure Assessment

After entry into Bangladesh groundnut either for food or as planting material are transported to different parts of the country. During handling and transport operations of the infected grain might fall to the ground and seeds will be sown to the soil. Thus the probability of exposure of the virus to the environment is high.

5.2.4.6.3 Establishment Assessment

As the seed transmission rate of the virus is very high, up to 55% in groundnut 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 a soil-borne root inhabiting fungus. It is not known if the fungus is present in Bangladesh soil. Some of which is present in Bangladesh. Under such circumstances in the PRA area the probability of establishment of this disease in moderate.

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**)	High

Description	**The Establishment Potential is:**
• The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes**, infected groundnut seed are the means of dispersal of this pest[11, 12). • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES*** Seed transmission is favored by temperature at 23-30C and rainfall [4] which are prevail during groundnut cultivation in Bangladesh.	
• Not as above or below	**Moderate**
• This pest has **not** established in new countries in recent years, and • The pathway does **not** appears good for this pest to enter 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

Most of the infected plants failed to produce pods, and even in cases of late infection, losses upto 60 per cent are recorded [7].

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

5.2.4.8.1 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 IPCV infection
- Use of disease resistant varieties.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from IPCV
- Seed health test should be conducted at the port of entry.

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VIRUS

5.2.5 Peanut mottle

5.2.5.1 Hazard Identification

Disease: Peanut mottle

Pathogen: *Peanut mottle virus* (PeMoV)

Taxonomic Tree

Family: Potyviridae

Genus: Potyvirus

Species: Peanut mottle virus

Bangladesh status: Not present in Bangladesh

5.2.5.2 Biology

PeMoV is a plant pathogenic virus of the family Potyviridae , genus Potyvirus . PeMoV is a flexuous, non-enveloped, filamentous virus with particles ranging from 723 to 763 nm in length and 12 nm in diameter [9]. In infected plant cells, the virus makes characteristic Potyvirus cylindrical inclusions that are visible in the light microscope with proper staining. Newly formed leaves show mild mottling and vein clearing, whereas older leaves show upward curling and interveinal depression with dark-green islands. Infected plants are not severely stunted, and older plants seldom show typical disease symptoms. Some pods from plants infected with PeMoV may be smaller than normal and have irregular, green to brown patches. Seeds from such pods are discolored. Infected groundnuts are considered to be the primary sources of PeMoV [10], and other nearby leguminous crops become infected from this crop. The virus is seed transmitted in a range from 0.1 to 3.5 % depending on the type of cultivar [2] transmitted by different species of aphids, *Aphis craccivora, Myzus persicae, A. gossypii, Hyperomyzus lactucae, Rhopalosiphum padi* and *R. maidis* in a non-persistent manner (stylet-borne). Transmission through seed appears to be the most important source of PeMoV for groundnut. Most commercial peanut seed lots have a low frequency (<15.0 %) of seed infection. However, a frequency as low as 0.1 % will provide about two infected seedlings per 100 m2 in a field. Aphids are efficient vectors of PeMoV and will transmit the virus rapidly to nearby plants (7).

5.2.5.3 Host

PeMoV occurs in several important legume crops, including groundnut, bambara groundnut and soybean, and weeds. The PeMoV occurs in nature on several important legume crops. The virus has been isolated from Pisum sativum, Glycine max and forage legumes and a few weed hosts like *Cassia obtusifolia, C. leptocarpa, C. occidentalis*, and *Desmodium canum* in nature]11].

5.2.5.4 Geographical Distribution

In India PeMoV is reported to occur mainly in Andhra Pradesh, Maharashtra, and Gujarat [1]. This disease is also reported from Australia [3], East Africa (5), Iran [4]nd United States [6, 8].

5.2.5.5 Hazard Identification Conclusion

Considering the facts that:

- *Peanut mottle virus* is not known to be present in Bangladesh.
- It is present in India among the four selected groundnut exporting countries. PeMoV is also present in some other countries.
- PeMoV is primarily a seed-borne and seed-transmitted virus. Therefore PeMoV *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

Bangladesh imports groundnut mainly from India where the disease is wide spread. Being a seed-borne and seed-transmitted virus, there is every chance that PeMoV is associated with groundnut consignment. Therefore, the probability of entry of PeMoV through this pathway is high.

5.2.5.6.2 Exposure Assessment

After releasing the consignment from the port of entry groundnut either for food or as planting material are transported to different parts of the country. During handling and transport operations of the infected grain might fall to the ground and seeds will be sown to the soil. Thus the probability of exposure of the virus to the environment is high.

5.2.5.6.3 Establishment Assessment

Like other seed-borne organism the PeMoV remains protected within the seed and remains viable as long as the seed is viable. Therefore, from infected seed the virus will be transmitted to the plant and cause seed infection to the infected plants. Secondary spread is caused by aphid vector which are already present in the PRA area. It has been shown experimentally that from a seed lot having 0.1% seed infection will give rise to two infected plants/m2. Under such circumstances in the PRA area the probability of establishment of this disease in 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**, infected groundnut seed are the means of dispersal of this pest[2, 10]. • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established. ***YES*** Climate is not a decisive	High

Description	The Establishment Potential is:
factor for seed transmission and establishment.As the virus is embryo-borne it will go to the plant system [1]	
• 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

The disease can cause up to 30 % loss in yield [7].

5.2.5.7.2 Environmental Impact

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

5.2.5.7.3 Social Impact

As the disease causes high yield reduction the total production would be reduced tremendously that will affect the food security as well as reduce the income of the growers.

5.2.5.7.4 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**	**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

5.2.5.8.1 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 PeMoV infection
- Use of disease resistant varieties.
- Declaration is needed in the phytosanitary Certificate that the consignment is free from PeMoV
- Seed health test should be conducted at the port of entry.

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6.3 WEED

5.3.1 Amaranthus retroflexus

5.3.1.1 Hazard Identification

Name of weed: *Amaranthus retroflexus* L.

Common Name: redroot pigweed

English name: common amaranth

Taxonomic Tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Caryophyllales
Family: Amaranthaceae
Genus: Amaranthus
Species: Amaranthus retroflexus

Bangladesh status: Not present in Bangladesh

5.3.1.2 Biology

A. retroflexus is a monoecious, erect, finely hairy, freely-branching, herbaceous annual growing to 2 m tall; taproot pink or red, depth varies with soil profile; leaves alternate, egg-shaped or rhombic-ovate, cuneate at base, up to 10 cm long, margins somewhat wavy, veins prominent on underside, apex may be sharp, petiole shorter or longer than leaf; flowers numerous, small, borne in dense blunt spikes 1 to 5 cm long, densely crowded onto terminal panicle 5 to 20 cm long but may be smaller on upper axils; three spiny-tipped, rigid, awl-shaped bracteoles surround the flower, exceeding the perianth, length 4 to 8 mm, persistent; tepals five, much longer than fruit, usually definitely recurved at tips, obovate or highly spatulate, one pistil and five stamens; style branches erect or a bit recurved; fruit a utricle, membranous, flattened, 1.5 to 2 mm long, dehiscing by a transverse line at the middle, wrinkled upper part falling away; seed oval to egg-shaped, somewhat flattened, notched at the narrow end, 1 to 1.2 mm long, shiny black or dark red-brown. It tolerates soil pH from 4.2 to 9.1 [3], but is less common on acid soils. It is common in cultivated fields, gardens, waste places, roadsides, river banks, and other open, disturbed habitats where annual weeds predominate. It is seldom found in closed or shaded communities [10]. A. retroflexus is an annual which reproduces solely by seed. It is a prolific seed producer, with single vigorous plants capable of producing between 230,000 and 500,000 seeds [8]. Seed production declines beneath crop canopies where light is limited [5]. Germination requirements and dormancy patterns are highly variable depending on distribution and local climatic and ecological conditions and, as such, generalizations should be treated with caution. Recent research suggests that germination is stimulated by light and high temperatures [4, 6]. The seeds are small and most germinate near to the soil surface, with optimum emergence from about 1 cm depth [7, 11]. Seeds of this weed can remain

viable in the soil for many years [10], but another report stated that a 90% decline in viability after seed burial for 18 months [2]. Seeds are dispersed by wind, animals and as contaminants of crop seeds or farm machinery. A. retroflexus has the C4 pathway of photosynthesis, typical 'Kranz' leaf anatomy, a low carbon dioxide compensation point and high water use efficiency [9, 10].

5.3.1.3 Host

Onion, **groundnut,** oats, beetroot, rape, peppers, citrus, coffee, carrot, strawberry, soybean, cotton, sunflower, barley, flax, tobacco, pea, beans, millet, rice, rye, potato, sorghum, grapevine, maize [1].

5.3.1.4 Geographic Distribution

Among the selected four countries it is present in China and India. It also present in many countries in Africa, South America, North America,Central America and Caribbean, Europe and Oceania [1].

5.3.1.5 Hazard Identification Conclusion

Considering the facts that-

- *Amaranthus retroflexus*is not known to be present in Bangladesh;
- It is present in many countries in the world including China and India
- *A. retroflexus* is growing in groundnut field and the seed may be associated with groundnut
- Therefore *A. retroflexus* 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

Amaranthus retroflexus is grown along with groundnut crop in the field. This weed is produce huge number of seeds. During harvesting there is chance to contaminate groundnut pod or seed with weed seed. So there is medium probability of entering this organism through this pathway from China or India.

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 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. Germination requirements are highly variable depending on distribution and local climatic and ecological conditions. However, recent studies suggest that germination is stimulated by light and high temperatures. Therefore the probability establishment of this weed in the PRA area is high.

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 [**NO]** • The pathway appears good for this pest to enter Bangladesh and establish, and [**Yes**, It may enter into Bangladesh as contaminant with groundnut seed]). • 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

Yield reduction under *A. retroflexus* interference was found 4.1 and 63.9% at 0.2 and 4.7 plants m-1 crop row, respectively.Thus if introduce this weed will cause significant damage to the crops in Bangladesh.

5.3.1.7.2 Environmental Impact

No information is available

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 [Yes]	**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

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

Establishment Potential	X	Consequence Potential	=	Risk

TableCalculation 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

- Seeds for growing the crop for export purpose should be free from *A. retroflexus* seed.
- Prevent seed production for several consecutive years.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of *A. retroflexus* seed.
- Declare in Phytosanitary certificate that the consignment is free from *A. retroflexus* seed.
- Test the sample at the port of entry for the presence of *A. retroflexus* seed from India and China origin,

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WEEDS

5.3.2 Hogweed

5.3.2.1 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

5.3.2.2 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].

5.3.2.3 Host

Groundnut, Cowpea, 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].

5.3.2.4 Geographical Distribution

Boerhavia diffusa has been reported to be present in China and India among the selected groundnut 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].

5.3.2.5 Hazard Indentification Conclusion

Considering the facts that:

- *Boerhavia diffusa* L. is not known to be present in Bangladesh;
- is present in China and India;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of groundnut or other host species as contaminant; and thus

Boerhavia diffusa is considered to be a potential hazard organism in this risk analysis.

5.3.2.6 Risk Assessment

5.3.2.6.1 Entry Assessment

The weed is reported from Australia, China, India and Nepal from where Bangladesh imports groundnut. There is possibility of mixing weed seed with groundnut seed during harvesting. The probability of entry into Bangladesh along with this commodity is considered as low.

5.3.2.6.2 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.

5.3.2.6.3 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.

5.3.2.6.4 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**,]). • 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

5.3.2.7 Consequence Assessment

5.3.2.7.1 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].

5.3.2.7.2 Environmental Impact

Boerhavia diffusa is a first growing weed. It can reduced native biodiversity, cause modification of successional patterns and negatively impacts agriculture

5.3.2.7.3 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	**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

- 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 China or India origin.

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WEEDS

5.3.3 Wild poinsettia

5.3.3.1 Hazard Identification

Scientific name of weed: *Euphorbia heterophylla*L.

Common name: Wild poinsettia

Other Scientific names

- Euphorbia geniculata Ort. (1797)
- Euphorbia prunifolia Jacq.
- Euphorbia taiwaniana
- Euphorbia zonosperma Müll
- Poinsettia geniculata (Ort.) Klotzsch & Garcke
- Poinsettia heterophylla (L.) Klotzsch & Garcke

Taxonomic Tree:

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Euphorbiales
Family: Euphorbiaceae
Genus: Euphorbia
Species: Euphorbia heterophylla

Bangladesh status: Not present in Bangladesh

5.3.3.2 Biology

Euphorbia heterophylla is herbaceous, erect and 20-200 cm in height (depending on growing conditions). The most common size is 40-60 cm tall. Milky latex is present when most parts of the plant are broken. The stem is branched and cylindrical, with nodes at regular intervals. The surface is smooth and reddish-green. Obovate to lanceolate leaves are formed along the stem, with secondary branches sprouting from axillary buds. Basal leaves are long-petiolate and alternate. Upper leaves are sessile and opposite or verticillate, forming a cluster of bracts, often with a pale patch at the base, subtending the terminal inflorescence. The latter consists of a dense cluster of small, short-stalked cyathia. Each cyathium comprises a cup-shaped involucre with inconspicuous male flowers producing a single stamen only, and a female flower, without sepals or petals, producing a 3-lobed, yellowish-green fruit [3].

Seeds are 2.5-3 mm wide and 2.5 mm long, oblong to oboval and dark brown to black. The surface is pitted with transverse ridges. The seedling have elliptical-short smooth petiolated cotyledonous leaves, green or reddish-green. First true leaves are opposite obovate to lanceolate with an acute apex and are shiny green [6].

Light and alternate temperatures (25/3°C) stimulate germination (6). Each fruit bears three seeds which are expelled when the fruit is ripe.

An alternating temperature regime of 25 and 35°C was optimal for germination and no effect of light was noted at these temperatures. However, light increased germination at constant temperatures of 25 and 35°C, and decreased germination at alternating temperatures of 10 and 35°C. Storage of E. heterophylla seeds at 36°C for 2-12 weeks caused a significant decrease in dormancy as compared to corresponding storage at 5°C. Seed moisture levels below 7.7% did not affect viability at 5 or 25°C after a storage period of 3-9 months. Seed viability decreased rapidly when seeds were stored for 3 months at 25°C with a moisture content of 10.8%, or at 5 or 25°C with a moisture content of 18.6%. Seeds buried in the autumn at a depth of 5 cm germinated in the field 9 months later. Field germination decreased as sowing depth increased [1]. The seed has the ability of the weed to germinate from considerable depths in soil [7].

5.3.3.3 Host

Groundnut, onion, Soybean, cotton, sugarcane, tomato, cowpea, maize [3].

5.3.3.4 Geographical Distribution

Among the four selected groundnut exporting countries to Bangladesh, the weed is present in India, Myanmar and Vietnam. It has also been reported to present in many countries in Asia, Africa, North America, Central America and Caribbean, South America, Europe and Oceania. *Euphorbia heterophylla* has restricted distribution in India and Vietnam [3, 4].

5.3.3.5 Hazard Identification Conclusion

Considering the facts that-

- *Euphorbia heterophylla* is not known to be present in Bangladesh;
- is present in India, Myanmar and Vietnam
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of groundnut or other host species as contaminant; and thus

Euphorbia heterophylla 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 India, Myanmar and Vietnam from where Bangladesh imports groundnuts. As the weed produce profuse seed there is possibility of mixing weed seed with groundnut seed. The probability of entry into Bangladesh through this pathway is considered as medium.

5.3.3.6.2 Exposure Assessment

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It also get exposed when contaminated seed are sown. The probability of exposure to the nature is high.

5.3.3.6.3 Establishment Assessment

The environmental condition in Bangladesh is suitable for the growth of *E. heterophylla.* The released weed seeds under favorable condition germinate and grow to produce plant and 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.

5.3.3.6.4 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) 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

5.3.3.7 Consequence Assessment

5.3.3.7.1 Economic Impact

Crops in which it is reported as a major weed include cocoa, coffee, cotton, cowpeas, maize, papaya, groundnut, sorghum, soyabean, sugarcane, tea and upland rice [5]. Season-long E. heterophylla interference reduced the yield of groundnut up to 54% in Georgia [2].

5.3.3.7.2 Environmental Impact

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

- Groundnut seeds used for growing the crop for export purpose should free from *E. heterophylla* seed.
- Preferably grow the crop for export purpose in areas free from *E.heterophylla* weed.
- Top cutting of the weed before seed setting.
- Test the samples for the presence of the seed of *E.heterophylla*.
- Declare in Phytosanitary certificate that the consignment is free from *E.heterophylla* seed.
- Test the sample at the port of entry for the presence of *E.heterophylla* seed

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6.0 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 groundnut from China, India, Myanmar and Vietnam or any other countries of groundnut 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

6.1.1.2 Use of Pest Resistant Varieties

The use of resistant varieties is a common and effective component in reducing pest risk. Cultavation of resistant varieties can reduce thrips damage in groundnut [14].

6.1.1.3 Chemical Spray Program

Pre-harvest chemical sprays may be used to control pests within production fields, for example, the use of chemical insecticies to control the mealybug and thrips of groundnut.

6.1.1.4 Crop Rotation

Groundnut crop rotation with other crops, such as sorghum, maize, cotton, pigeon peaand castor is beneficial in several ways: i.) more effective use of residual soil fertility; ii.) improved efficiency in controlling certain weeds; and iii.) reduction in soil borne disease and nematode problems [7].

6.1.1.5 Control of Insects

Sucking and chewing insects may transmit many diseases. For example the virus disease was found to transmit by thrips in groundnut. 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.

6.1.1.6 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 groundnut production. Laboratory testing should be done periodically. Quarantine restrictions may be used to limit spread of insects, mites, diseases and weeds detected.

6.1.2 Post-Harvest Management Options

6.1.1.7 Sanitization of Equipment and Storage Material

All machinery, transport and storage surfaces that the groundnut 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.

6.1.1.8 Disposal of Infected Pods/Seeds

All insect infested or diseases infected pods or seeds of groundnut should be discarded away from production site.

6.1.1.9 Cleaning and Grading

Groundnut should be cleaned properly and Plant parts must be removed from seed. Broken seeds should be separated which enhance pest's infestation especially red flour beetle and other secondary pests.Foreign material and loose-shelled kernels (LSK), groundnut seed inadvertently shelled by harvesting and handling operations cause problems in storage and processing [3].

6.1.1.10 Drying

After threshing the moisture content of the grains remains generally higher than the desired for safe storage of grains. 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 seed for safe storage and further processing. Ensuring seed is well dried at intake is very important. Moisture content of seed must be reduced to 7% [13].

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 [1].

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. Drying groundnut pods at 40-45^{0}C temperature for 2-3 days after harvest prevent bruchid infestation [13].

6.1.3.3 Accept only Certified Groundnut Seeds for Crop Production

This measure is highly effective in mitigating pest risk, because it ensures the absence of specific pests, particularly pathogens, or a defined low prevalence of pests at planting. The main components of seed certification include: sampling and testing of production areas to ensure free from viruses; approval of land and seed to be multiplied; inspection of crops for variety purity and crop health; inspection of cucurbit fruit samples; and sealing and labeling of certified seed. Cucurbit seeds to be imported from the exporting countries should be sourced from an officially recognized seed certification system.

6.1.3.4 Shipments Traceable to Place of Origin in Exporting Countries

A requirement that groundnut is packed in containers with identification labels indicating the place of origin, variety and grade is necessary to ensure traceability to each production site.

6.1.3.5 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 groundnut with high risk potential are found during inspection, the phytosanitary procedures should be maintained.

Consignments of groundnuts 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 [5] that groundnut should come from an area where bruchid do not occur and where routine intensive control measures are applied.

Groundnut 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 [6].

6.1.3.6 Requirement of Phytosanitary Certification from Country Of Origin

The phytopathological service of the country of origin should ensure that groundnut of the consignment was 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.

6.1.3.7 Port-of-Entry Inspection and Treatment

Upon arrival in Bangladesh, each consignment of groundnut 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 Specificquarantine Insect Pests, Diseases and Weeds of Groundnut

Insect and mite pests, diseases organisms and weeds are transported with groundnut. Thus risk management is essential. Manament practices for quarantine pests associated with groundnut trade and transportation are discussed herein.

6.2.1 Risk Management for Insect Pests

Among the thirteen quarantine insect pests identified in the present analysis, nine was found to have significant risk to enter into the PRA area through the present pathway. So, risk management options of these nine insect pests have been discussed herein.

6.2.1.1 *Phenacoccus solenopsis*

- Planting material of host-plant species of *P*. *solenopsis* should be inspected in the growing season previous to shipment and be found free of infestation [3].

- Avoid importation of groundnut seeds, pods or other host plants from countries where *P*. *solenopsis* occurs.
- It is relatively easy to detect the *P*. *solenopsis* by inspection, so the basic requirement is that imported consignments of plants for planting should be free from the pest. Any shipments of fresh plant material from an infested country should be examined thoroughly to detect *P*. *solenopsis* after the consignment has arrived in Bangladesh [3].

6.2.1.2 *Caliothrips indicus*

- Planting material of host-plant species of *C. indicus*should be inspected in the growing season previous to shipment and be found free of infestation [1]. .
- All plant parts, debris should be free from groundnut pods or seeds.
- Groundnut will be imported from the pest free areas.

6.2.1.3 *Caryedon serratus*

- After harvest drying the crop as quickly as possible and placing it in sacks or other containers where insect penetration will be prevented [1].
- In case of *C. serratus,* avoid drying groundnuts near Tamarind, Acacia and Pongamia trees to prevent primary infestation from alternate hosts [13].
- Ensuring grain is well dried at intake is very important. Moisture content of 7% is desirable [Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].
- Cleaning grain stores, keeping them airtight, maintaining temperatures below 20°C and hermetically sealed packaging can conserve seed viability. Storing groundnuts in jute bags greatly restricts the movement of adults into and out of bags.
- 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 [6] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains. . Effective control of eggs, larvae, and adults of *Caryedon serratus* Olivier was achieved with methyl bromide vacuum fumigation @16 g/m3 for 4 h exposure [12]. When treating groundnuts in shell the phosphine dosage needs to be higher than normal due to excessive absorption [1].
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived. The presence of larval emergence holes and of cocoons outside the pods attests to the pest's presence. The damage to seeds can be seen when infested pods are opened.

6.2.1.4 *Oryzaephilus mercator*

- Good store hygiene plays an important role in limiting infestation by *Oryzaephilus* spp.

- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled.
- Ensuring grain is well dried at intake is very important. Moisture content of 7% is desirable [Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].
- Infestations may also be limited by the storage of good quality grains such as whole cereals with fewer broken grains and dockage, and milled rice with a high milling degree (at least 95%) and few broken grains [1].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6].
- Inspection will be undertaken in Bangladesh after the consignment has arrived. Pitfall traps are unsuitable for the detection of *O. surinamensis* and *O. mercator* as these insects are able to climb on clean glass. They do enter refuge traps, such as strips of corrugated cardboard, or bag traps containing a suitable food bait [9].

6.2.1.5 *Alphitobius diaperinus*

- Good store hygiene plays an important role in limiting infestation by *A. diaperinus*. In good storage conditions *A. diaperinus* and *A. laevigatus* are minor pests [1].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.6 *Araecerus fasciculatus*

- Good store hygiene plays an important role in limiting infestation by *A. fasciculatus*. Cleaning of handling or processing equipment, storage areas, etc. is very important [1].
- Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.1.7 *Tenebroides mauritanicus*

- Good store hygiene plays an important role in limiting infestation by *T. mauritanicus*.
- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled [1].

- Ensuring grain is well dried at intake is very important. Moisture content of 7% is desirable [Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.
- Inspection will be undertaken in Bangladesh after the consignment has arrived. Adults and larvae of *T. mauritanicus* may be found moving through stored food. The adults are particularly conspicuous because of their relatively large body size.

6.2.1.8 *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 7% is desirable [Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].
- 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 [6] 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 [8].
- 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.

6.2.1.9 *Plodia interpunctella*

- Good storage hygiene plays an important role in limiting infestation by *P. interpunctella*. The removal of infested residues from the previous season's harvest is essential [1].
- The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores such as ensuring that all spillages are removed and all cracks and crevices filled.
- Phytosanitary certificate from the country of origin is essential stating the shipment is free of khapra beetle.
- Ensuring grain is well dried at intake is very important. Moisture content of 7% is desirable [Moisture contents of 7% and less usually eliminate all problems for all stored materials [13].

- Fumigation with aluminium phosphide tablets @ 3 g PH_3 per m^3 above 25^0C for 7 days [6] or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains. Warm air disinfection of stored cereals gave good control of *P. interpunctella*. After 3 h at 55°C, mortality was 100% for insect storage pests including *P. interpunctella* [11].
- Inspection will be undertaken in Bangladesh after the consignment has arrived.

6.2.2 Risk Management for Disease Organisms

Five diseases of groundnut have been identified as quarantine disease for Bangladesh. Out of these four diseases namely yellow mold, stripe disease, peanut clump disease and peanut mottle posses risk for Bangladesh and management options of these four diseases are presented here.

6.2.2.1 *Aspergillus flavus*

- Since the fungus is a weak parasite, agronomic practices which favour rapid germination and vigorous growth of seedling will reduce the chance of *A. flavus* infection.
- Seed treatment with carbendazim @ 2g/kg seed or Captafol @ 3 g/kg seed or thiram @ 3-5 g/kg seed has given good results [19].
- Import toxin free seed
- Must accompany phytosanitary having declaration that the consignment is free from aflatoxin.

6.2.2.2 Stripe disease (PStV)

- Use of virus free seed
- Peanut seed production should be done in the wet season when aphid populations are low and PStV incidence is negligible [27, 29].
- Growing groundnuts for seed at a distance from commercial groundnut fields. In the USA, 100 m is regarded as a safe distance [17], whereas in China, it is 200 m [31,32] recommended at least 5 km away.
- In seed production fields, roguing diseased plants when they are noticed..
- If farmers use seed from the previous season's crop, they should be encouraged to be more selective in harvesting their groundnuts for seed stock. Because symptoms of PStV persist in old plants, they should collect seed from the normal-looking plants only.
- Meristem tip culture has been used to obtain virus-free plants of valuable peanut interspecific hybrids.
- Use of resistant variety but not yet available [25]. However, varieties with moderate resistance to PStV have been found more recently in China and Indonesia.
- Import seed free from peanut stripe (PStV) disease
- Must accompany phytosanitary having declaration that the consignment is free from PStV.

6.2.2.3 Peanut clump disease (IPCV)

- Pre-export field inspection and serological test for the presence of the virus in the seed
- Rejection of the infected seeds
- Must accompany phytosanitary having declaration that the consignment is free from IPCV.

6.2.2.4 Peanut mottle disease (PeMoV)

- Pre-export field inspection and serological test for the presence of the virus in the seed
- Rejection of the infected seeds
- Must accompany phytosanitary having declaration that the consignment is free from IPCV.

6.2.3 Risk Management for Weeds

Three weed species namely*Amaranthus retroflexus* L, *Boerhavia diffusa* L. and *Euphorbia geniculata* Ort.were identified as quarantine pest for Bangladesh and all the three possess the potential risk for Bangladesh. Therefore management options of these weed species are presented here.

6.2.3.1 *Amaranthus retroflexus*

- Hand weeding, mechanical weeding at seedling stage
- Soil solarization with plastic covering [22].
- Retroflexus is readily controlled by most herbicides which inhibit photosynthesis, such as atrazine, simazine, metribuzin, linuron and bromoxynil. It is also highly susceptible to the synthetic auxin herbicides, such as 2,4-D or dicamba, and sulfonylurea and imidizolinone herbicides, such as imazethapyr, thifensulfuron-methyl, rimsulfuron and nicosulfuron. Most other herbicides for control of broad-leaved weeds also provide good control including acifluorfen, fomesafen and pendimethalin [15, 16, 21, 28].
- Regulatory control to prevent introduction from outside
- Use of seed for planting free from weed seed

6.2.3.2 *Boerhavia diffusa*

- Seedlings are relatively susceptible to 2,4-D and some control of established plants can also be expected [20]. 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 [23] and atrazine in fodder maize [26].
- Hand weeding of *B. diffusa* resulted in a yield increase [24].
- Regulatory control to prevent introduction from outside
- Use of seed for planting free from weed seed

6.2.3.3 *Euphorbia geniculata*

- Compounds giving some useful control included fluridone, oxadiazon, cyanazine, 2,4-DB, bentazon and acifluorfen. Oxadiazon gives less reliable control than metribuzin, but may be useful on soils where metribuzin cannot be used.
- Regulatory control to prevent introduction from outside
- Use of seed for planting free from weed seed

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