# Pest Risk Analysis (PRA) of Cotton in Bangladesh

## Strengthening Phytosanitary Capacity in Bangladesh Project

**Plant Quarantine Wing**
**Department of Agricultural Extension**
**Khamarbari, Farmgate, Dhaka-1215**

**June 2016**

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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 cotton in Bangladesh"** according to the provision of contract agreement signed between SPCB-DAE and Centre for Resource Development Studies Ltd. (CRDS) on10 December 2016. The PRA study is a four-month assignment commencing from 10 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 cotton and evaluate their risk, to identify endangered areas, and if appropriate, to identify risk management options. To carry out the PRA study, the consulting firm conducted field investigations in 44 upazilas under 22 major cucurbit growing districts of Bangladesh. The study covered the interview 4400 cotton growers; 22 FGDs each of which conducted in one district; information from DD of each districts, UAO and 10 SAAO of each upazila and CDB personnel and Cotton Researchers of each region; physical inspection and visits of the cotton fields under sampled districts. The consultants also reviewed secondary sources of information related to PRA of cotton.

The study findings revealed that the 29 species of insect and mite pests, 14 disease causing pathogen and 32 weeds likely to be associated with the cotton in Bangladesh. The study also demonstrated that a total number of 13 pest species of quarantine importance had been identified, of which 10 insect pests, one fungus, one virus, and one weed could be introduced into Bangladesh through importation of commercially produced cotton. The consultant team also conducted the risk assessment for each quarantine pest individually based on the consequences and potential of introduction of each quarantine pest and a risk rating was estimated for each. Based on the risk assessment and risk rating, six quarantine pests were identified as high risk, two pests as low risk and another five species were not present in the pathway of cotton imports. The findings also suggested the risk management options for the quarantine pests of cotton 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 26 June 2016. The concerned professionals of agricultural universities of Bangladesh, DAE (Department of Agricultural Extension), Cotton Development Board (CDB), 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, CDB, Agricultural Universities, research organizations and Cotton importer and exporters' associations for their assistance and cooperation extended in conducting the PRA study. Thanks are also due to all members of Technical Committees for cooperation. Special thanks to the Secretary, Additional Secretary, Additional Secretary (Extension), Director General of DAE, Director (Plant Quarantine Wing) and other high officials under the Ministry of Agriculture for providing us valuable advice and guidance. I hope that the report certainly would contribute to enhance the exports and imports of cotton.

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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 cotton in Bangladesh"** under Plant Quarantine Wing (PQW), Department of Agriculture Extension (DAE), Ministry of Agriculture (MOA), Government of the Peoples Republic of Bangladesh. The PRA study is a four-month assignment commencing from 10 December 2016 under the SPCB, DAE.

Consultancy services for "Conducting Pest Risk Analysis (PRA) of Cotton 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 cotton, 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 were prepared the Final Report of the PRA study based on comments and suggestions of the client and experts.

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# Acknowledgements

It is our great 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 cotton in Bangladesh"**. The Report has been prepared based on the past four months (Decmber 2016 to April 2016) activities of the survey study in 22 major cotton 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 principal author is Dr. Hamiz Uddin, Team Leader 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 authors are grateful to all persons involved in the PRA study. Our special gratitude to Md. Hamidur Rahman, Director General, DAE, Bangladesh, who provided his extended support and gave us an opportunity to meet Mr. Shomun saha, Director of Plant Quarantine Wing (PQW) of DAE. Special thanks to Dr. Mohammad Ali, Project Director, Strengthening Phytosanitary Capacity in Bangladesh (SPCB) Project; Mr. Md. Ahsan Ullah, Consultant (PRA); Mrs. Marina Jebunehar, Senior Monitoring and Evaluation Officer, SPCB for their valuable cooperation, guidance and suggestions to the study team in line with the activities performed during study and report preparation.

Our special grateful thanks are also given to Dr. Md. Farid Uddin, Executive Director and Dr. Md. Kamrul Islam, Program Director, Cotton Development Board, Bangladesh for their kind cooperation and suggestions during the study period. Active support of Managing Director and the Executive 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** |
| **CDB** | **Cotton Development Board** |
| **CIG** | **Common Interest Group** |
| **CLCuD** | **Cotton Leaf curl Virus Disease** |
| **CRDS** | **Center for Resource Development Studies Limited** |
| **CUO** | **Cotton Unit Officer** |
| **DAE** | **Department of Agricultural Extension** |
| **DD** | **Deputy Director** |
| **DDAE** | **Deputy Director Agricultural Extension** |
| **DPP** | **Development Project Proposal** |
| **ICM** | **Integrated Crop Management** |
| **IPM** | **Integrated Pest Management** |
| **ISPM** | **International Standard for Phytosanitary Measures** |
| **IPPC** | **International Plant Protection Convention** |
| **PC** | **Phytosanitary Certificate** |
| **PPW** | **Plant Quarantine Wing** |
| **PPW** | **Plant Quarantine Wing** |
| **PRA** | **Pest Risk Analysis** |
| **PSO** | **Principal Scientific Officer** |
| **RARS** | **Regional Agricultural Research Station** |
| **SAAO** | **Sub-Assistant Agriculture Officer** |
| **SPCB** | **Strengthening Phytosanitary Capacity in Bangladesh** |
| **TOR** | **Terms of Reference** |
| **UAO** | **Upazila Agriculture Officer** |

# Executive Summary

Bangladesh is importing cotton *(Gossypium hirsutum* L.) from China, Eqypt, India, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe for both lint and seed. Hybrid seed from China is also imported for large scale cultivation. No Pest Risk Analysis (PRA) for this commodity has so far been conducted in Bangladesh. The present PRA was initiated as per desire of the Govt. of Bangladesh because we are importing Cotton from different countries where some pests are present which are not present in Bangladesh and are likely to enter into Bangladesh by imports.

The Plant Quarantine Wing of Department of Agricultural Extension under the Ministry of Agriculture has developed a project on Strengthening Phytosanitary Capacity in Bangladesh (SPCB) and as a part of the project an activity entitled “Conducting Pest Risk Analysis (PRA) of Cotton in Bangladesh” is being implemented. One cosulting firm was selected for this assignment following open bidding process. Center for Resource Development Studies Limited (CRDS) was finally contracted for conducting Pest Risk Analysis (PRA) of Cotton in Bangladesh. The major objectives of the project included recording of major and minor insect pests, diseases and weeds of Cotton and listing of quarantine insect pests, diseases and weeds of Cotton. The study also included datail information on pests and pathogens, their entry, establishment and multiplication, climatic and other characters of both exporting and importing countries, etc. The project identified 22 major Cotton growing districts namely Jessore, Jhenaidah, Chuadanga, Meherpur, Magura, Kushtia, Pabna, Natore, Rajshahi, Chapainawabgonj, Noagaon, Serajgonj, Bogra, Rangpur, Dinajpur, Thakurgaon, Mymensingh, Tangail, Manikgonj, Banderban, Rangamati and Khagrachari as study areas. Two upazilas under each district were also identified for field survey and data collection on insect pests, diseases and weeds of Cotton. In each upazila 10 blocks and under each block, 10 farmers were selected for data collection.

Cotton is prone to different insect pests, diseases and weeds. In Bangladesh, in 2014-15 cropping season, Cotton was grown in an area of 42700 ha, the total production of Seed cotton was 69403 metric ton and the Lint production was 152536 bales and the productivity was 2.5 t/ha. The major varieties grown are CB-13 and CB-14. The major Cotton growing areas in Bangladesh are Rangpur, Rajshahi, Kushtia, Chuadanga, Jhenaidah and Jessore Regions. Cotton is also grown in three hill districts vise- Banderban, Rangamati and Khagrachari.

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 CDB, DAE, experts and professionals. Primary data were collected through field survey. Forthis 44 upazilas under 22 districts were selected and visited during January-February. The selected 22 districts were considered as the PRA area for Cotton. These areas might be endangered by the introduction of invasive alien pests. The PRA was conducted to identify the hazards for the PRA area.

In total 29 insects and pests were listed in Bangladesh among which 28 species are insect pests and one specimen is of mite pest. In addition,14 diseases and 32 weeds were identied. Among the insect and mite pests, 12 species were major and of the diseases four were major.

The available insect and mite pests, diseases and weeds of Cotton in eight exporting countries were prepared. Comparing with record it is evident that 10 insect species prevalent in exporting countries are absent in Bangladesh and these are Cotton mealybug, Mexican mealybug, Cotton yellow scale, Tarnished plant bug, Cotton boll weevil, Cotton shoot weevil, Cotton stem weevil, Cotton grey weevil, Leaf miner and Flower bud maggot. Inrespect of diseases, two diseases namely Verticillium wilt and Cotton leaf curl disease are absent in Bangladesh. One specimen of weed speceies (Pathenium) is considered as a quarantine weed. All of these 10 insect pests, two diseases and one weed were considered in the risk analysis and were identified as potential hazard for Bangladesh. Risk assessment considering entry, exposure, establishment potential of each of these organisms in Bangladesh showed medium to high potentiality and negative consequences on economy, environment or health and non-negligible risk prompted discussion and review of management options for these species. Similar assessment and analysis were also done for diseases and weed species.

The report included the pest risk management of quarantine pests of Cotton with specific approaches and methods in detail. It is now, necessary to follow the recommended quarantine practices while importing Cotton.

## 1.0 Introduction

In Bangladesh Cotton *(Gossypium hirsutum* L.) is the most important fiber crop. The crop is grown mainly in northern and western regions of the country. The crop has also been introduced in hilly regions. The total area under Cotton was 42700 ha while the total production of Seed cotton was 69,403 metric ton and Lint production was 1,52,536 bales in 2014-2015. The total requirement of the country is around 45-50 lac Bales. In others words, only 4% of the requirement is met from the local production. The rest is imported from several countries; some of them are Uzbekistan, India, Turkey, Pakistan, China, Egypt, etc. In addition Seeds of different varieties from those countries were also imported as research material. The Hybrid Seed is also imported from China for cultivation.

Cotton is vulnerable to different insect pests and diseases which cause damage to the crop leading to severe yield loss. Fourteen Diseases have been recorded in Bangladesh and they are caused by different groups of causal agents like fungi, bacteria and nematodes. Among the diseases, four are major. A total of 29 insect pests and mites are so far recorded to affect Cotton crop in the field. Among the insect pests, thirteen are major. The world record on insect pests and diseases indicated that there are many highly devastating insect pests and diseases are present in other countries but these are not recorded in Bangladesh. As major part of Seed and Lint are imported from other countries, it is felt necessary to identify the Quarantine insect pests and diseases of cotton and to perform the task of Pests Risk Analysis (PRA) in Bangladesh.

To limit, minimize or prevent the international movement of devastating pests and disease organisms of plants, IPPC has taken some measures to be adopted by the member countries that include preparation of pest list for each crop and conduct PRA to identify the potential hazard for each crop of a country. Proper implementation of these will minimize the risk of introduction of unwanted pests, help stabilizing the yield and remove unnecessary barrier on international trade. Being a signatory of IPPC, Bangladesh has started to implement the specified measures. The present activities are taken up to perform PRA for Cotton to develop and implement sound national and international policies to prevent or restrict the entry of the organisms having potential threat to Cotton cultivation in Bangladesh.

## 2.0 Methodology for Data Collection

To collect the information and present status of different insect pests, diseases and weeds in Cotton field and also infestation with insect pests and diseases in the storage an extensive survey was conducted at 440 blocks under 44 upazilas of 22 major Cotton growing districts of the countries. Field activities included interview with Sub-Assistant Agriculture Officer (SAAO), Upazila Agriculture Officer (UAO) and the Deputy Director (DD), Department of Agricultural Extension (DAE) and also concerned scientists and Extensions officers of Cotton Development Board (CDB) using structured questionnaire to record the present status of insect pests and diseases on Cotton crop. Additional information on the area of Cotton cultivation and production in the selected districts were collected from the DDAE 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 Cotton crop in the field and storage and control measures followed by them. Primary data were collected from the standing Cotton crop of the selected farmers from each upazila and the incidence and severity of different insect pests and diseases available in the field were recorded. A list of selected districts and upazilas are provided in Table 1.

For conducting Pest Risk Analysis (PRA) all the Formats and Questionnaires used are included in the Appendices XII, XIII, XIV, XV and XVI.

**Table 1: List of Districts and Upazilas selected for PRA Studies of Cotton.**

| Sl. No. | District | Upazila |
|---|---|---|
| 1. | Jessore | 1. Monirampur |
| | | 2. Chougacha |
| 2. | Jhenaidah | 3. Moheshpur |
| | | 4. Shoilokupa |
| 3. | Chuadanga | 5. Jiban Nagar |
| | | 6. Chuadanga Sadar |
| 4. | Meherpur | 7. Mujib Nagar |
| | | 8. Gangni |
| 5. | Magura | 9. Sreepur |
| | | 10. Magura Sadar |
| 6. | Kushtia | 11. Doulatpur |
| | | 12. Mirpur |
| 7. | Pabna | 13. Pabna Sadar |
| | | 14. Atghoria |
| 8. | Natore | 15. Baraigram |
| | | 16. Bagatipara |
| 9. | Rajshahi | 17. Bagha |
| | | 18. Charghat |
| 10. | Chapainawabgonj | 19. Nachole |
| | | 20. Gomastapur |
| 11. | Noagaon | 21. Neamatpur |
| | | 22. Porsha |
| 12. | Serajgonj | 23. Kamarkhand |
| | | 24. Serajgonj Sadar |
| 13. | Bogra | 25. Gabtoli |
| | | 26. Shibgonj |

| Sl. No. | District | Upazila |
|---|---|---|
| 14. | Rangpur | 27. Rangpur Sadar |
| | | 28. Taragonj |
| 15. | Dinajpur | 29. Birol |
| | | 30. Birgonj |
| 16. | Thakurgaon | 31. Pirgonj |
| | | 32. Ranisankail |
| 17. | Mymensingh | 33. Fulbaria |
| | | 34. Muktagacha |
| 18. | Tangail | 35. Ghatail |
| | | 36. Nagarpur |
| 19. | Manikgonj | 37. Saturia |
| | | 38. Manikgonj Sadar |
| 20. | Bandarban | 39. Bandarban Sadar |
| | | 40. Ruma |
| 21. | Rangamati | 41. Naniarchar |
| | | 42. Baghaichari |
| 22. | Khagrachari | 43. Dhighinala |
| | | 44. Matiranga |

**Appointment and Training of Field Researchers**

Field Researchers having Bachelor degree in agriculture were appointed and proper training was imparted on identification of insect pests and diseases and weeds of Cotton have been imparted. Necessary Questionnaire and Formats were supplied to collect the appropriate information from the Farmers, SAAO, UAO, DD, Researchers and CDB Extension personnel.

**Field Survey and Primary Data Collection**

Five teams having two members in each team were made for field survey and collection necessary information based on Questionnaire and formats from the farmers and concerned officials of 22 districts (Figure 1). Each team was supplied with colored pictures of damage symptoms for diseases and insect pests.

**Secondary Data Collection**

The secondary data on insect pests and diseases of Cotton were collected from CDB and DAE, published reports and internet. These data were checked with primary data and the final list of insect pests and diseases were prepared.

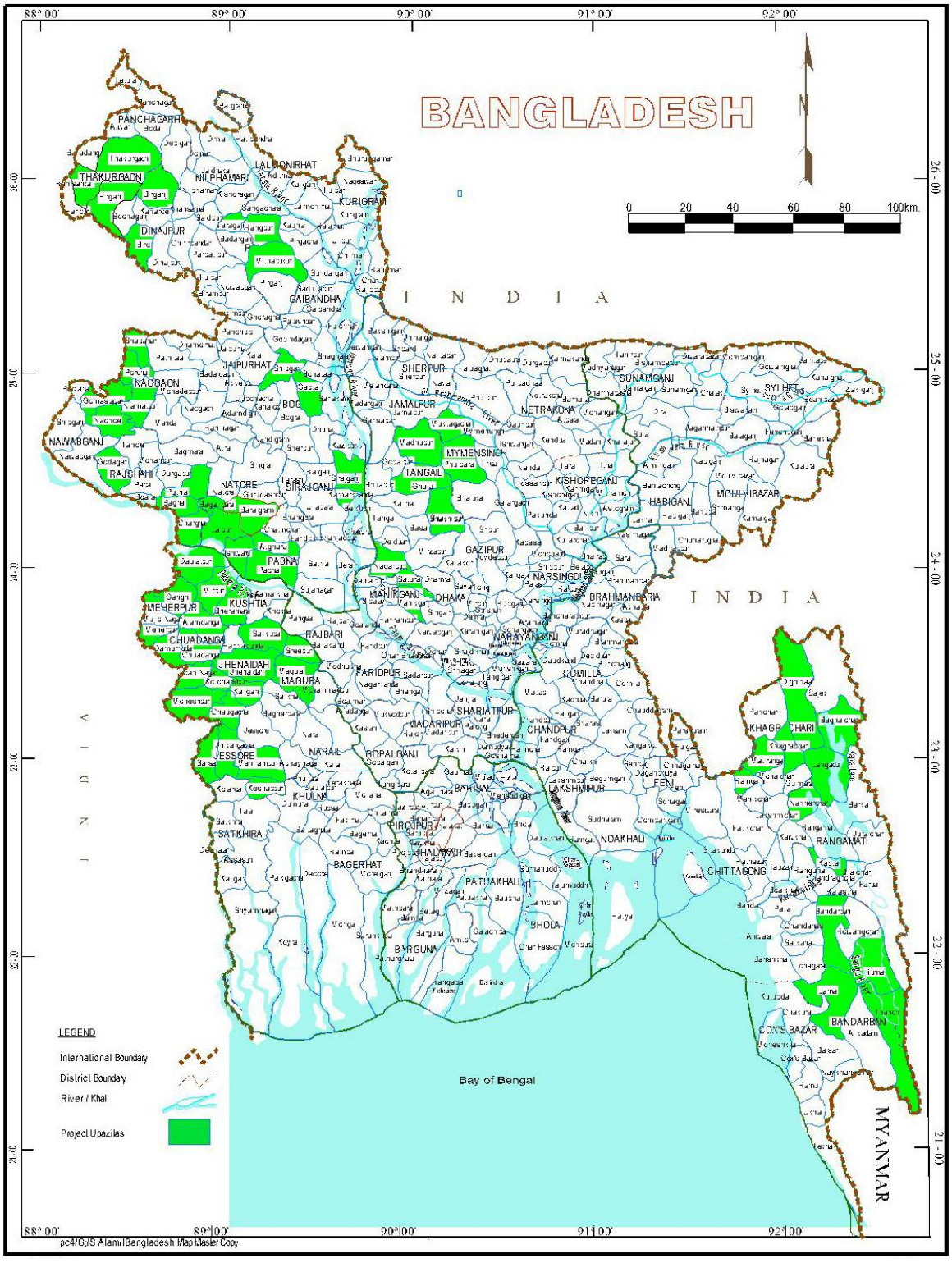
**Internet Searching**

The internet searching was done to collect information on insect pests and diseases of Cotton worldwide, especially in the countries from where Cotton is imported to Bangladesh. Major Cotton growing areas of Cotton exporting countries to Bangladesh were identified and climate data of those areas were also collected, so far available. Insect pests and disease control measures taken in the field, pre-shipment phytosanitary measures and other handling procedures followed in the exporting countries were also recorded. Collected information was analyzed to identify the quarantine pests and diseases.

**Interpretation of Results**

The collected data on insect pests and diseases of Cotton from different locations were analyzed and interpreted with the aim to finding out variations in respect of incidence and status of each pest against the location. The most vulnerable stage of plant growth for insect pests and disease attack was also determined based on both primary and secondary data. Finally, a check list was prepared based on locally available insect pests and diseases of Cotton in Bangladesh in comparison with other countries of export and import importance of respective crop.

**Figure-1: Study Area showing in Bangladesh Map**



# 3.0 Insect Pests, Diseases and Weeds of Cotton in Bangladesh

The insect pests, diseases and weeds of Cotton in Bangladesh were studied by field survey, published reports of Cotton Development Board (CDB), other concerned organizations, scientific personnel and internet searching. Summary list of insect pests, diseases and weeds recorded in Cotton field discussed herein.

## 3.1 Insect Pests of Cotton

The list of recorded insect pests of cotton, feeding habit and their pests status in Bangladesh is shown in Table 2. Twenty nine species of pests were recorded in Bangladesh of which 28 species were insect pests and one species was mite pest. Among the insect pests, thirteen species were major, which caused considerable damage of cotton in field every year. The rest of the insect pests were minor. Ten species of sucking insect pests namely cotton jassid, aphid, white fly, spiraling white fly, mealybug, red cotton bug, green stink bug and two species of dusky cotton bug under Order Homoptera and Hemiptera were recorded which suck the cell sap from different parts of the plant. Cotton jassid and whitefly transmit virus diseases and act as vector. Mealybug, jassid, red cotton bug and green stink bug also inject toxin to the plants during sucking sap. Moreover, red cotton bugs stain the lint by their excreta. Dusky cotton bug sucks sap from seeds (*Oxycarenus laetus* Kirby [1] and *Oxycarenus hyalipennis* (Costa) [6]) has been reported in Bangladesh. Two species of termites feed on root of the crops but they were minor pest. Five species of leaf feeding Lepidopteran insect pests were recorded whose larvae feed on leaves and sometimes defoliate the plants. Four species of bollworm under Lepidoptera Order were reported in Bangladsh. Among them *Helicoverpa armigera* [5, 6], *Pectinophora gossypiella*[1,5,7] and*Earias vittella* [1,5] are widespread in Bangladesh but *Earias insulana* is present [1].Among the different mealybug species, pink mealybug, *Phenacoccus hirsutus* Green [2, 3, 5] and *Ferrisiana virgata* (Cockerell) [1] are also reported from Bangladesh. But dusky cotton bug and mealybug are not found during the survey period. One mite pest (red spider mite) was recorded which sucks the cell sap from underside of leaves [7, 8].

**Table 2: List of insect and pests of cotton in Bangladesh with their common name, scientific name, their mode of infestation and pest status**

| Sl. No. | Common name | Scientific name | Order : Family | Infested plant parts | Pest status |
|---|---|---|---|---|---|
| 01. | Grasshopper | *Oxya chinensis* (Thunberg) | Orthoptera: Acrididae | Feed on foliage | Minor |
| 02. | Field cricket | *Brachytrupes portentosus* (Lichtenstein) | Orthoptera: Gryllidae | Cut the seedlings | Minor |
| 03. | Termite | *Odontotermes obesus* (Rambur) | Isoptera: Termitidae | Feed on cotton roots | Minor |
| 04. | | *Microtermes obesi* Holmgren | | | |
| 05. | Indian cotton jassid | *Amrasca biguttula biguttula* Ishida | Homoptera: Cicadellidae | Suck cell sap from foliage and virus vector | Major |
| 06. | Cotton aphid | *Aphis gossypii* Glover | Homoptera:Aphididae | Suck cell sap from different parts of plant and secrete honeydew | Major |
| 07. | Cotton whitefly | *Bemisia tabaci* (Gennadius) | Homoptera: Aleyroridae | Suck cell sap form foliage and virus vector | Major |
| 08. | Spiraling white fly | *Aleurodicus dispersus Russell* | Homoptera: Aleyroridae | Suck cell sap form leaves | Minor |
| 09. | Pink mealybug | *Phenacoccus hirsutus Green* | Homoptera: Pseudococcidae | Suck cell sap form foliage and inject toxin with saliva | Minor |
| 10. | Tailed mealybug | *Ferrisiana virgata* (Cockerell) | Homoptera: Pseudococcidae | Suck cell sap form foliage and inject toxin with saliva | Minor |
| 11. | Red cotton bug | *Dysdercus cingulatus* (Fabricius) | Hemiptera: Pyrrhocoridae | Suck cell sap form cotton boll inject toxin and stain lint | Major |
| 12. | Green stink bug | *Nezara viridula* (Linnaeus) | Hemiptera: Pentatomidae | Suck cell sap form foliage and inject toxic saliva | Minor |
| 13. | Dusky cotton bug/ Cotton seed bug | *Oxycarenus hyalipennis* (Costa) | Hemiptera: Oxycarenidae | Suck the sap from seeds, stain lint | Minor |
| 14. | | *Oxycarenus laetus Kirby* | | | |
| 15. | Cotton thrips | *Thrips tabaci Linndeman* | Thysanoptera: Thripidae | Infest leaves and flowers | Major |
| 16. | Black cutworm | *Agrotis ipsilon* (Hufnagel) | Lepidoptera: Pyralidae | Cut the base of seedlings | Minor |
| 17. | Leaf roller | *Sylepta derogata* (Fabricius) | Lepidoptera: Crambidae | Larvae roll and feed on leaves | Major |
| 18. | Cotton semilooper | *Tarache notabilis* (Walker) | Lepidoptera: Noctuidae | Larvae feed on leaves | Major |

| Sl. No. | Common name | Scientific name | Order : Family | Infested plant parts | Pest status |
|---|---|---|---|---|---|
| 19. | Green semilooper | *Anomis flava* (Fabricius) | Lepidoptera: Noctuidae | Larvae feed on leaves, tender shoots, flowers, bolls | Minor |
| 20. | Hairy caterpillar | *Spilarctia obliqua* Walker | Lepidoptera: Arctiidae | Larvae feed on leaves, defoliator | Minor |
| 21. | Armyworm | *Spodoptera litura* (Fabricius) | Lepidoptera: Noctuidae | Larvae feed on leaves between veins and veinlets | Major |
| 22 | Spotted bollworm | *Earias insulana (*Boisduval) | Lepidoptera: Noctuidae | Larvae bore stem and bolls | Major |
| 23. | | *Earias vittella* (Fabricius) | | | |
| 24. | American bollworm | *Helicoverpa armigera (*Hubner) | Lepidoptera: Noctuidae | Larvae bore bolls | Major |
| 26. | Pink bollworm | *Pectinophora gossypiella* (Saunders) | Lepidoptera: Gelechidae | Larvae bore flowers and bolls | Major |
| 27. | Blister beetle | *Mylabris pustulata* Thunberg | Coleoptera: Meloidae | Adult feed on flowers | Minor |
| 28. | Cotton flea beetle | *Phyllotreta* spp. | Colepoptera: Chrysomelidae | Adult feed on leaves | Minor |
| 29. | Red spider mite | *Tetranychus urticae* Koch | Acari: Tetranychidae | Feed on underside of leaves | Major |

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

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**Figure 2: Photographs of some important insect pests of cotton in Bangladesh**

**A.** Nymph and adult of jassid

**B.** Jassid infested cotton leaf

**C.** Aphid infested twig

**D.** Cotton semilooper

**E.** Mealybug infested branch

**F.** Mealybug infested stalk of boll

**G.** Cotton whitefly at the ventral surface of leaves

**H.** Spiraling whitefly of cotton

**I.** Adult and nymph of red cotton bug

**J.** Cotton bug infested boll

**K.** Leaf roller infested leaf

**L.** Leaf roller larvae

**M.** Bollworm larvae and infested boll

**N.** Blister beetle

## 3.2 Diseases of Cotton

In Bangladesh, so far a total of 14 diseases of cotton were recorded [1, 2, 3, 4, 5]. Among these, 12 diseases are caused by fungal pathogens, one by bacteria and one by nematode (Table 3). Among the 14 diseases four diseases namely, seedling blight, wilt, bacterial blight or Angular leaf spot and Boll rot are presently considered as major. Seedling blight is actually a disease complex caused by a number of soil-borne pathogens namely, *Sclerotium rolfsii*, *Fusarium* spp., *Macrophomina phaseolina*, *etc*. These disease causing organisms can attack the seed before or at germination. They also can attack the young seedling before or after emergence. It causes poor plants stand in the field. When the death of plant is significant re-planting is needed. This not only adds to cost of production but also reduces the yield of cotton due to delay planting. Wilt caused by *Fusarium oxysporum* f.sp. *vasinfectum and* bacterial blight can also cause a great loss. Boll rots cause heavy losses to cotton producers during wet growing season.Humid conditions after rain and speedy wind favor the spread and severity of boll rot. Sometimes, different boll worms also play a role, to transmit disease, from infected to healthy bolls. Fungi causing boll rots are also cause seed infection. Occurrence of rust disease in Bangladesh is rare and the causal agent has not yet been identified. Fungi involved in causing leaf diseases namely, anthracnose, cercospora leaf spot, alternaria leaf spot, Rhizoctonia leaf spot, areolate mildew and leaf blight caused by *Colletotrichum gossypii, Cercospora gossypii/gossypina, Alternaria macrospora, Rhizoctonia solani, Ramularia areola* and *Sphaeropsis* sp are of minor importance. The only nematode disease reported is root-knot, which is also a minor disease. Seven different fungi viz., *Alternaria macrospora, Aspergillus niger, Chaetarium globosus*, *Colletotrichum gossypii*, *Curvularia lunata, Furarium* spp. and *Macrophomina phaseolina* were found to be associated with the seed of cotton. Among these *A. macrospora* and *C. gossypii* are causing leaf spots and *M. phaseolina* is associated with seedling blight.Photgraphs of some important disease symptoms are shown in Figure 3.

**Table 3: List of diseases of cotton in Bangladesh with their common name, causal organisms and pest status**

| Sl. No. | Name of the Disease | Causal Organisms | Pest Status |
|---|---|---|---|
| 01. | Seedling blight | *Sclerotium rolfsii, Fusarium spp., Macrophomina phaseolina, Pythium sp.* | Major |
| 02. | Wilt | *Fusarium oxysporum f. sp. vasinfectum* | Major |
| 03. | Boll rot | *Diplodia gossypina, Fusarium* spp., *Colletotrichum* spp. | Major |
| 04. | Root rot | *Rhizoctonia solani* *Sclerotium rolfsii* | Minor |
| 05. | Anthracnose | *Colletotrichum gossypii* | Minor |
| 06. | Cercospora leaf spot | *Cercospora gossypii* | Minor |
| 07. | Alternaria leaf spot | *Alternaria macrospora* | Minor |
| 08. | Rhizoctonia leaf spot | *Rhizoctonia solani* | Minor |
| 09. | Areolate mildew | *Ramularia areola* | Minor |
| 10. | Powdery mildew | *Leveillula taurica* | Minor |
| 11. | Leaf blight | *Sphaeropsis* sp | Minor |
| 12. | Tropical Rust | *Phakopsora gossypii* | Rare |
| 13. | Angular leaf spot/ Bacterial blight | *Xanthomonas campestris* pv. *malvacearum* | Major |
| 14. | Root knot | *Meloidogyne* spp. | Minor |

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**Figure 3: Photographs of some important diseases of cotton in Bangladesh**

**A.** Cercospora leaf spot disease

**B.**Bacterial leaf blight

**C.** Boll rot disease

**D.** Fusarium wilt disease

### 3.3 Weeds of Cotton

A total of 32 weeds were identified in cotton fields in the Bangladesh. The botanical name, common name, and status of weeds are present in the Table 4.

**Table 4: List of weeds of cotton in Bangladesh with their botanical name, common name and pest status**

| Sl. No. | Botanical Name | Common Name(s) | Pest Status |
|---|---|---|---|
| 01. | *Alternanthera sessilis* (L.) | Sessile Joyweed, Dwarf Copperleaf | Major |
| 02. | *Amaranthus blitoides* S. Wats. | Spreading amaranth,Prostrate pigweed | Minor |
| 03. | *Amaranthus viridis* L. | Pig weed, Calalu, Slender amaranth | Minor |
| 04. | *Amaranthus spinosus* L. | Spiny pig weed | Minor |
| 05. | *Anagallis arvensis* L. | Pimpernel, scarlet pimpernel, sheperd's weather-glass | Minor |
| 06. | *Blumea lacera* L. | Kakronda | Minor |
| 07. | *Cardaria draba* (L.) | Heart- podded, hoary cress, thanet cress, white top, white weed, perennial peppergrass | Major |
| 08. | *Chenopodium album* L. | Lamb's-quarters | Major |
| 09. | *Cynodon dactylon* (L.) | Bermudagrass | Major |
| 10. | *Cyperus rotundus* .L. | Nut grass | Major |
| 11. | *Digitaria ischaemum* (Schreb.) | Smooth crabgrass<br>Small crabgrass | Major |
| 12. | *Digitaria sanguinalis* (L.) | Summer grass/ Crabgrass/<br>Hairy crabgrass | Major |
| 13. | *Echinochloa colona (*L.) | Barnyardgrass | Major |
| 14. | *Echinochloa crus-galli (L.)* | Barnyard grass | Major |
| 15. | *Eclipta alba (L.)* | False Daisy | Minor |
| 16. | *Elusine indica* (L.) | Goose grass | Major |
| 17. | *Enhydra fluctuans* Lour. | Water Cress<br>Marsh Herb | Major |
| 18. | *Fimbristylis miliacea* (L.) | Hoorahgrass | Minor |
| 19. | *Leucas aspera* Willd. | Thumbe | Major |
| 20. | *Nicotiana plumbaginifolia* Vivi. | Curled-leaved tobacco | Major |
| 21. | *Oxalis europaea* Jord. | Sour grass | Minor |
| 22. | *Parthenium hysterophorus* L. | Parthenium weed Carrot grass, bitter weed, star weed, white top, congress weed | Minor |
| 23. | *Physalis heterophylla* L. | Clammy | Minor |
| 24. | *Polygonum hydropiper* L. | water-pepper | Minor |
| 25. | *Polygonum plebeium* R. Br. | Small knotweed | Minor |

| Sl. No. | Botanical Name | Common Name(s) | Pest Status |
|---|---|---|---|
| 26. | *Rumex maritimus* L. | Golden dock | Major |
| 27. | *Setaria glauca* (L.) | Yellow foxtail | Minor |
| 28. | *Setaria viridis* (L.) | Green foxtail | Minor |
| 29. | *Solanum torvum* Swartz. | Turkey Berry | Major |
| 30. | *Sonchus oleraceus* L. | Common sow thistle | Major |
| 31. | *Thlaspi arvense* L. | Pennycress, field pennycress, bastardcress, fan weed, stink weed | Major |
| 32. | *Xanthium strumarium* L. | Rough cocklebur | Major |

**Figure 4: Photographs of some important weeds of cotton fields in Bangladesh**

**A.** Durba

**B.** Mutha

**C.** Bontamak

**D.** Shak Notey

**E.** Lajjaboti

**F.** Foska begun

**G.** Ghagra

**H.** Bishkatali

**I.** Bonpalong

**J.** Bathua

**K.** Chapra

**L.** Tita begun

# 4 Insect and Mite Pests, Diseases and Weeds of Cotton in Eight Exporting Countries and Identification of Quarantine Pests

## 4.1 Insect and Mite Pests of Cotton

Thirty nine species of pests were recorded of which 38 species were insect pest and one specimen was a mite pest (Table 5). These insect pests feed on leaves, shoots and roots of cotton, suck the cell sap from different parts of the plant, bore the bolls and flowers, and cut the base of seedling. Some insect pests inject toxic substance during sucking and transmit diseases. Among the insect pests, 21 species were major and 18 species were minor. Mite pests suck the cell sap from underside of cotton leaves.

**Table 5: List of insect and mite pests, their mode of infestation, infested plant parts and pest status**

| Sl. No. | Common name | Scientific name | Order : Family | Infested Plant Parts | Pest Status | Present in Bangladesh |
|---|---|---|---|---|---|---|
| 01. | Grasshopper | *Oxya chinensis* (Thunberg) | Orthoptera: Acrididae | Feed on foliage | Minor | Yes |
| 02. | Field cricket | *Brachytrupes portentosus* (Lichtenstein) | Orthoptera: Gryllidae | Cut the base of cotton seedlings | Minor | Yes |
| 03. | Termite | *Odontotermes obesus* (Rambur) | Isoptera: Termitidae | Feed on cotton roots | Minor | Yes |
| 04. | | *Microtermes obesi* Holmgren | | | | |
| 05. | Indian cotton jassid | *Amrasca biguttula biguttula Ishida* | Homoptera: Cicadellidae | Suck cell sap from foliage and virus vector | Major | Yes |
| 06. | Cotton aphid | *Aphis gossypii* Glover | Homoptera:Aphididae | Suck cell sap from different parts of plant and secrete honeydew | Major | Yes |
| 07 | Cotton whitefly | *Bemisia tabaci (*Gennadius) | Homoptera: Aleyroridae | Suck cell sap form foliage and virus vector | Major | Yes |
| 08. | Spiraling whitefly | *Aleurodicus dispersus* Russell | Homoptera: Aleyroridae | Suck cell sap form leaves | Minor | Yes |
| 09. | Cotton mealybug | *Phenacoccus solenopsis* Tinsley | Homoptera: Pseudococcidae | Suck cell sap form foliage and inject saliva | Major | No |
| 10. | Tailed mealybug | *Ferrisiana virgata* (Cockerell) | Homoptera: Pseudococcidae | | Minor | Yes |

| Sl. No. | Common name | Scientific name | Order : Family | Infested Plant Parts | Pest Status | Present in Bangladesh |
|---|---|---|---|---|---|---|
| 11. | Pink mealybug | *Macollenicoccus hirsutus* (Green) | Homoptera: Pseudococcidae | | Major | Yes |
| 12. | Mexican mealybug | *Phenacoccus gossypii* Townsend and Cockerell | Homoptera: Pseudococcidae | | Minor | No |
| 13. | Cotton yellow scale | *Cerococcus indicus* (Maskell) | Homoptera: Cerococcidae | Suck sap from foliage | Minor | No |
| 14. | Red cotton bug | *Dysdercus cingulatus* (Fabricius) | Hemiptera: Pyrrhocoridae | Suck cell sap form leaves and cotton boll inject saliva, stain lint | Major | Yes |
| 15. | Green stink bug | *Nezara viridula* (Linnaeus) | Hemiptera: Pentatomidae | Suck cell sap form foliage and inject toxic saliva | Minor | Yes |
| 16. | Dusky cotton bug | *Oxycarenus hyalipennis* (Costa) | Hemiptera: Oxycarenidae | Suck the sap from seeds, stain lint | Major | Yes |
| 17. | | *Oxycarenus laetus* Kirby | | | Major | Yes |
| 18. | Tarnished plant bug/Cotton lygus | *Lygus lineolaris* Palisot de Beauvois | Hemiptera: Miridae | Suck sap from buds and developing fruits | Major | No |
| 19. | Cotton thrips | *Thrips tabaci* Linndeman | Thysanoptera: Thripidae | Infest leaves, flowers | Major | Yes |
| 20. | Black cutworm | *Agrotis ipsilon* (Hufnagel) | Lepidoptera: Pyralidae | Cut the seedlings | Minor | Yes |
| 21. | Leaf roller | *Sylepta derogata* (Fabricius) | Lepidoptera: Crambidae | Larvae roll and feed on leaves | Major | Yes |
| 22. | Cotton semilooper | *Anomis flava* (Fabricius) | Lepidoptera: Noctuidae | Larvae feed on leaves | Major | Yes |
| 23. | Green semilooper | *Tarache notabilis* (Walker) | Lepidoptera: Noctuidae | Larvae feed on leaves | Major | Yes |
| 24. | Hairy caterpillar | *Spilarctia obliqua* Walker | Lepidoptera: Arctiidae | Larvae feed on leaves | Minor | Yes |
| 25. | Armyworm | *Spodoptera litura* (Fabricius) | Lepidoptera: Noctuidae | Larvae feed on leaves between veins and veinlets | Major | Yes |
| 26. | Spotted bollworm | *Earias vittella* (Fabricius) | Lepidoptera: Noctuidae | Larvae bore stem and bolls | Major | Yes |
| 27. | | *Earias insulana (*Boisduval) | | | Major | Yes |
| 28. | American bollworm | *Helicoverpa armigera (*Hubner) | Lepidoptera: Noctuidae | Larvae bore bolls | Major | Yes |
| 29. | Pink bollworm | *Pectinophora gossypiella* (Saunders) | Lepidoptera: Gelechidae | Larvae bore flowers and bolls | Major | Yes |

| Sl. No. | Common name | Scientific name | Order : Family | Infested Plant Parts | Pest Status | Present in Bangladesh |
|---|---|---|---|---|---|---|
| 30. | Cotton leaf miner | *Acrocercops bifasciata* Walsingham | Lepidoptera: Gracillariidae | Larvae mine the leaves | Minor | Yes |
| 31. | Blister beetle | *Mylabris pustulata* (Thunberg) | Coleoptera: Meloidae | Adult feed on flowers | Minor | Yes |
| 32. | Cotton flea beetle | *Phyllotreta* spp. | Colepoptera: Chrysomelidae | Adult feed on leaves | Minor | Yes |
| 33. | Cotton boll weevil | *Anthonomus grandis* Boheman | Coleoptera: Curculionidae | Bore bolls | Major | No |
| 34. | Cotton shoot weevil | *Alcidodes affaber* Aurivillus | Coleoptera: Curculionidae | Grub feeds on tissue of node axle | Minor | No |
| 35. | Cotton stem weevil | *Pempherulus affinis* (Faust) | Coleoptera: Curculionidae | Grubs tunnel the stem | Minor | No |
| 36. | Cotton grey weevil | *Myllocerus undecimpustulatus* Faust | Coleoptera: Curculionidae | Grubs feed on roots and adults feed on leaves, buds, flowers and bolls | Minor | No |
| 37. | Leaf miner | *Liriomyza trifolii* Burgess in Comstock | Diptera: Agromyzidae | Larvae mine leaves | Major | No |
| 38. | Flower bud maggot of Cotton | *Dasineura gossypii* Fletcher | Diptera: Ceceidomyidae | Maggot damage flower buds | Minor | No |
| 39. | Red spider mite | *Tetranychus urticae* Koch | Acari: Tetranychidae | Feed on underside of leaves | Major | Yes |

[1, 4, 5, 7,10, 11,13]

### 4.1.1 Quarantine Insect Pests of Cotton for Bangladesh

Ten species of insect pests are absent in Bangladesh and they are considered as quarantine pests of cotton for Bangladesh. Among them, three species viz., *Phenacoccus gossypii*, *Lygus lineolaris* and *Anthonomus grandis* are present in North and Central America (Table 6). On the other hand seven species of insect pests such as *Phenacoccus solenopsis, Cerococcus indicus, Alcidodes affaber, Pempherulus affinis*, *Myllocerus undecimpustulatus, Liriomyza trifolii and Dasineura gossypii* are present in China, India, Pakistan, Turkey, Egypt and other Asian countries (Table 6). However, these insects are not present in Bangladesh. As cotton seed and lint are imported from China, India, Egypt, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe, so the consideration of these is important for taking quarantine measure.

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**Table 6: List of quarantine insect pests of cotton for Bangladesh, available at cotton exporting countries and plant parts that likely carry the pest**

| Sl. No. | Name of Pests | Scientific Name | Available at Cotton Exporting Countries | Plant parts that likely carry the pest | References |
|---|---|---|---|---|---|
| **01.** | Cotton mealybug | *Phenacoccus solenopsis* | China, India, Pakistan, Turkey, Egypt, USA | Infested leaves, stems flowers, fruits, roots carry nymphs and adults externally | 4, 8 |
| **02.** | Mexican mealybug | *Phenacoccus gossypii* | USA, Mexico | Infested leaves, stems flowers, fruits, roots carry nymphs and adults externally | 3, 8 |
| **03.** | Cotton yellow scale | *Cerococcus indicus* | China, India, Pakistan, Myanmar, Malaysia | Nymphs and adults carry externally with infested plant parts | 9, 16 |
| **04.** | Tarnished plant bug | *Lygus lineolaris* | USA, Mexico, Burmuda but not in Asia or Africa | Carry externally with infested boll | 7 |
| **05.** | Cotton boll weevil | *Anthonomus grandis* | USA, Mexico, Central and South America | Carry externally with infested bolls | 3 |
| **06.** | Cotton shoot weevil | *Alcidodes affaber* | India | Carry internally with infested shoot | 3 |
| **07.** | Cotton stem weevil | *Pempherulus affinis* | India, Myanmar, Thailand, Philippines | Carry internally with infested stem | 12 |
| **08.** | Cotton grey weevil | *Myllocerus undecimpustulatus* | India, Indonesia, Pakistan | Carry with soil | 3, 14 |
| **09.** | Serpentine leaf miner | *Liriomyza trifolii* | China, India, Egypt, Turkey, USA, Uzbekistan, Zimbabwe | Egg and larva are borne internally with leaves | 2, 8 |
| **10.** | Flower bud maggot | *Dasineura gossypii* | India | Carry internally with infested stem or flower | 15 |

The details of these insect pests have been discussed in section 9, Potential Hazard Organisms Risk Analyses (9.1 - 9.10).

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## 4.2 Diseases of Cotton

A total of 16 diseases were found to occur in eight cotton exporting countries viz., China, Egypt, India, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe (Table 7). Among the diseases nine diseases were considered as major and rests were minor.

**Table 7: Diseases of cotton in eight exporting countries**

| Sl. No. | Name of the Disease | Causal Organisms | Present Status | References |
|---|---|---|---|---|
| 01 | Root rot | *Rhizoctonia bataticola* and *Rhizoctonia solani* *Sclerotium rolfsii* | Major | 2, 3, 8, 13, 15 |
| 02 | Alternaria leaf spot | *Alternaria macrospora* | Major | 3, 6, 8, 11, 16, |
| 03 | Areolate mildew/ Grey mildew | *Ramularia areola* | Major | 3, 5, 12,13, 16 |
| 04 | Powdery mildew | *Leveillula taurica* | Major | 2, 3, 9, |
| 05 | Verticillium wilt | *Verticillium dahliae* | Major | 2, 3, 4, 8, 14 |
| 06 | Fusarium wilt | *Fusarium oxysporum f. sp. vasinfectum* | Major | 2, 3, 6, 8, 10, 15, |
| 07 | Damping-off/Seedling blight | *Fusarium spp., Macrophomina phaseolina, Pythium sp.* | Major | 1, 4 |
| 08 | Boll rot | *Fusarium moniliforme, Colletotrichum capsici, Aspergillus flavus, A. niger, Rhizopus nigricans, Nematospora nagpuri* and *Botryodiplodia* sp. | Minor | 2, 3, 5, 8, 14, 15 |
| 09 | Anthracnose | *Colletotrichum gossypii* | Minor | 3, 8, 9, 15 |
| 10 | Cercospora leaf spot | *Cercospora gossypina* | Minor | 3, 8, 15 |
| 11 | Rhizoctonia leaf spot | *Rhizoctonia solani* | Minor | 3, 8 |
| 12 | Leaf blight | *Sphaeropsis* sp | Minor | 3 |
| 13 | Tropical Rust | *Phakopsora gossypii* | Minor | 3, 7, |
| 14 | Angular leaf spot/ Bacterial blight | *Xanthomonas axonopodis* pv. *malvacearum* | Major | 2, 3, 8, 9, 13, 15. |
| 15 | Leaf Curl | *Cotton leaf curl virus* | Major | 3, 5, 8, 13, 14, 16 |
| 16 | Root knot | *Meloidogyne* spp. | Minor | 3 |

The details of these diseases have been discussed in section 9, Potential Hazard Organisms Risk Analyses (9.11 - 9.12).

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### 4.2.1 Quarantine Diseases of Cotton for Bangladesh

Analysis of the disease situation in eight countries namely China, Egypt, India, Pakistan, Turkey USA, Uzbekistan and Zimbabwe from where Bangladesh is importing cotton lint and/or seed and the occurrence of diseases of cotton in Bangladesh revealed that two major diseases viz., Verticillium wilt (*Verticillium dahliae*) and Leaf curl disease (Leaf curl virus) are not present in Bangladesh. The former one is a fungal and the later one is a virus disease. *Verticillium dahliae* the incitant of wilt disease of cotton is not present in Bangladesh but present in China, India, Pakistan, Turkey, USA, Uzbekistanand Zimbabwe, however absent in Egypt [1, 2, 6, 7, 10, 11, 12]. Verticillium Wilt is the extremely harmful disease of cotton as it may affect more than 60% of plants [5].This is a soil-borne disease and survive in soil as microsclerotia for over 10 years [2, 4], but it may also cause seed infection in cotton [9] and tuber infection in potato [4]. Therefore longdistance dissemination of the pathogen occurs via infected cotton seed or seed tubers. So, there is probability of its entry through cotton seed [9] or infected plant part or infected seed tubers of potato but not with lint.Moreover, more than 300 woody and herbaceous plantspecies are known to be susceptible to this fungal pathogen including some fruits [6, 7], there is probability of its entry also through saplings if imported from these countries. Cotton Leaf curl virus disease (CLCV) is caused by a virus which is transmitted through vector insect whitefly (*Bemisia tabaci*) in a circulative and persistent manner, and so once acquired, can be carried and transmitted for the life of the vector [8]. The viruses are transovarially (passed through the egg) or sexually transmitted. The viruses of the CLCV complex are not seed transmitted. Early season transmission of this virus caused more severe damage to the crop even 100% compared to late transmission. In Africa, Asia, and the Americas, early season infection of cotton by whitefly-transmitted viruses has resulted in a total loss of the crop. Considering these facts, it may be concluded that the there is no possibility of entry of this virus through cotton lint or seed but it may enter through the insect or infected eggs. Therefore, these two diseases were identified as quarantine diseases for Bangladesh (Table 8).

The distribution of two quarantine diseases for Bangladesh among eight cotton exporting countries is shown in Table 8. Our search results indicated that among the diseases, wilt caused by *Verticillium dahliae* Kleb. and Leaf curl disease caused by cotton leaf curl virus are present in all the selected cotton exporting countries except Egypt.

**Table 8: Distribution of quarantine diseases for Bangladesh in exporting countries**

| Sl. No. | Name of Disease | Causal Agent | Distribution to Cotton Importing Countries |
|---|---|---|---|
| 01. | Wilt | *Verticillium dahliae* | China, India, Pakistan, Turkey, USA, Uzbekistan, Zimbabwe |
| 02. | Cotton leaf curl | *Cotton leaf curl virus* | China, India, Pakistan, Turkey, USA, Uzbekistan, Zimbabwe |

The details of these disease organisms have been discussed in section 9, Potential Hazard Organisms Risk Analyses (9.11 & 9.12).

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### 4.3 Weeds of Cotton

A total of 32 weeds were identified in eight exporting countries. The botanical name, common name, host range, and status of weeds are present in Table 9.

**Table 9: List of weeds of cotton with botanical name, common name, host range, status**

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| 01. | *Alternanthera sessilis* (L.) | Sessile Joyweed, Dwarf Copperleaf | Avena sativa**,** *Arachis hypogaea, Cicer arietinum, Cucurbita pepo,* ***Gossypium hirsutum****, Helianthus annuus, Lens culinaris, Hordeum vulgare, Malus domestica, Oryza sativa, Phaseolus vulgaris, Saccharum officinarum, Secale cereale, Solanum tuberosum, Sorghum bicolor, Sorghum vulgare,Triticum aestivum, Zea mays,* | Major | Yes |
| 02. | *Amaranthus blitoides* S. Wats. | Spreading amaranth, Prostrate pigweed | *Glycine max, Gossypium hirsutum*, *Heliathus annuus, Lycopersicon esculentum, Medicago sativa, Olea europaea sub. Sp. Europaea, Phaseolus vulgaris, Pisum sativum, Triticum aestivum, Zea mays* | Minor | Yes |
| 03. | *Amaranthus viridis* L. | Pig weed, Calalu, Slender amaranth | *Arachis hypogaea, Brassica napus, Capsicum annuum, Glycine max,* ***Gossypium*** **spp**., *Lycopersicon esculentum, Pennisetum glaucum, Ricinus communis, Saccharum officinarum,Solanum melongena, Solanum tuberosum*, *Sorghum bicolor, Triticum aestivum, Zia mays*, | Minor | Yes |
| 04. | *Amaranthus spinosus* L. | Spiny pig weed | *Arachis hypogaea, Brassica napus, Capsicum annuum,* Glycine max, ***Gossypiumhirsutum***, *Lycopersicon esculentum, Oryza sativa, Pennisetum glaucum, Ricinus communis , Saccharum officinarum, Solanum melongena, Solanum tuberosum, Sorghum bicolor, Triticum aestivum, Zia mays*. | Minor | Yes |
| 05. | *Anagallis arvensis* L. | Pimpernel, scarlet pimpernel, sheperd's weather-glass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium hirsutum***, *Helianthus annuus, Lycopersicon esculentum, Nicotiana tabacum, Phaseolus vulgaris, Solanum melongena, Solanum tuberosum, Sorghum vulgaris, Triticum aestivum****, Zia mays* | Minor | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| 06. | *Blumea lacera* L. | Kakronda | *Avena sativa, Beta vulgaris, Citrus spp., Fragaria ananassa,* ***Gossypium hirsutum,*** *Helianthus annus, Hordeum vulgaris, Lens culinaris, Medicago sativa, Nicotiana tabacum, Quercus spp., Secale cereale*, *Solanum tuberosum, Triticum aestivum, Vitis vinifera, Zea mays* | Minor | Yes |
| 07. | *Cardaria draba* (L.) Desv. | Heart- podded, hoary cress, thanet cress, white top, white weed, perennial peppergrass, | *Avena sativa, Beta vulgaris, Citrus spp., Fragaria ananassa, Gossypium hirsutum, Helianthus annus, Hordeum vulgaris, Lens culinaris, Medicago sativa, Nicotiana tabacum, Pyrus communis, Quercus spp., Secale cereale*, *Solanum tuberosum, Triticum aestivum, Vitis vinifera, Zea mays* | Major | Yes |
| 08. | *Chenopodium album* L. | Lamb's-quarters | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Phaseolus vulgaris, Solanum melongena, Solanum tuberosum, Sorghum vulgaris, Triticum aestivum****,*** *Zia mays* | Major | Yes |
| 09. | *Cynodon dactylon* (L.) | Bermudagrass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Ricinum communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum,* | Major | Yes |
| 10. | *Cyperus rotundus* .L. | Nut grass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Ricinum communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum, Sorghum bicolor, Sorghum vulgare, Triticum aestivum****,*** *Zia mays* | Major | Yes |
| 11 | *Digitaria ischaemum* (Schreb.) Small crabgrass | Smooth crabgrass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine* | Major | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| | | | *max,* ***Gossypium*** **spp**., *Helianthus annuus, Hordeum vulgaris, Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinum communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum.* | | |
| 12. | *Digitaria sanguinalis*(L.) Scop. | Summer grass/ Crabgrass/ Hairy crabgrass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Hordeum vulgaris,Ipomoea batatas,Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinum communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum.* | Major | Yes |
| 13. | *Echinochloa colona (*L.) | Barnyardgrass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Hordeum vulgaris, Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinum communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum.* | Major | Yes |
| 14. | *Echinochloa crus-galli* (L.) | Barnyard grass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp.,***Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinus communis, Saccharum officinarum.* | Major | Yes |
| 15. | *Eclipta alba* (L.) | False Daisy | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lens culinaris, Nicotiana tabacum, Oryza sativa, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinus communis, Solanum melongena, Solanum tuberosum.* | Minor | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| 16. | *Elusine indica* (L.) | Goose grass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium* spp**., *Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lens culinaris, Nicotiana tabacum, Oryza sativa, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinus communis, Saccharum officinarum, Solanum melongena, Solanum tuberosum.* | Major | Yes |
| 17. | *Enhydra fluctuans* Lour. | Water Cress Marsh Herb | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium* spp**., *Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lactuca sativa*, *Lens culinaris, Nicotiana tabacum, Oryza sativa, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinus communis, Solanum melongena, Solanum tuberosum.* | Major | Yes |
| 18. | *Fimbristylis miliacea* (L.) | Hoorahgrass | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium* spp.,***Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lactuca sativa*, *Lens culinaris, Lycopersicon esculentum, Nicotiana tabacum, Oryza sativa, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Ricinus communis, Solanum melongena, Solanum tuberosum.* | Minor | Yes |
| 19. | *Leucas aspera* Willd. | Thumbe | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Capsicum annuum, C. frutescens, Corchorus* spp., *Daucus carota, Glycine max,* ***Gossypium* spp**., *Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas, *Lactuca sativa*, *Lens culinaris, Nicotiana tabacum, Oryza sativa, Pennisetum glaucum Phaseolus vulgaris, Pisum sativum, Raphanus sativus Ricinus communis, Solanum melongena, Solanum tuberosum, Sorghum bicolor.* | Major | Yes |
| 20. | *Nicotiana plumbaginifolia* Vivi. | Curled-leaved tobacco | *Allium cepa, Arachis hypogaea****,*** *Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Corchorus* spp*., Coriandrum sativum,Cucumis sativus, Cuminum cyminum, Glycine max,* ***Gossypium*** | Major | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| | | | ***hirsutum***, *Helianthus annuus, Hordeum vulgaris,Ipomoea batatas*, *Lactuca sativa*, *Lens culinaris, Lycopersicon esculentum,Nicotiana tabacum.* | | |
| 21. | *Oxalis europaea* Jord. | Sour grass | *Arachis hypogaea, Capsicum annuum, C. frutescens, Corchorus* spp., *Glycine max,* ***Gossypium* spp**., *Helianthus annuus, Hordeum vulgaris,Ipomoea batatas*, *Lactuca sativa*, *Lens culinaris, Nicotiana tabacum, Oryza sativa, Pennisetum glaucu,m Phaseolus vulgaris, Pisum sativum, Raphanus sativus Ricinus communis, Solanum melongena, Solanum tuberosum, Sorghum bicolor, Sorghum vulgare, Triticum aestivum, Zia mays* | Minor | Yes |
| 22. | *Parthenium hysterophorus* L. | Parthenium weed, Carrot grass, bitter weed, star weed, white top, congress weed | *Arachis hypogaea, Avena sativa, Brassica napus, Capsicum annuum, Citrullus vulgaris, Corchorus spp., Glycine max,* ***Gossypium spp.****, Helianthus annuus,* Lactuca sativa*, Lens culinaris,*Linum usitatissimum,*Lolium perenne, Lycopersicon esculentum, Oryza sativa, Pennisetum glaucum, Phaseolus spp., Pisum sativum, Ricinus communis, Solanum melongena, Solanum tuberosum.* | Minor | Restricted distribution |
| 23. | *Physalis heterophylla* L. | Clammy | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica campestris, Brassica napus, Capsicum annuum, Glycine max,* ***Gossypium* spp**., *Helianthus annuus, Lactuca sativa*, *Lens culinaris, Linum usitatissimum, Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pisum sativum, Solanum melongena, Solanum tuberosum.* | Minor | Yes |
| 24. | *Polygonum hydropiper* L. | water-pepper | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium hirsutum****, Helianthus annuus, Hordeum vulgaris, Ipomoea batatas*, *Lens culinaris Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pennisetum glaucum Pinus taeda, Populus spp..* | Minor | Yes |
| 25. | *Polygonum plebeium* R. Br. | Small knotweed | *Allium cepa, Beta vulgaris, Brassica rapa,* ***Gossypium hirsutum,*** *Helianthus annuus, Hordeum vulgaris, Medicago* | Minor | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| | | | *sativa, Nicotiana tabacum, Populus spp., Raphanus sativus, Ricinus communis, Triticum aestivum, Zea mays* | | |
| 26. | *Rumex maritimus* L. | Golden dock | *Allium cepa, Arachis hypogaea, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium hirsutum****, Helianthus annuus, Hordeum vulgaris, Lathyrus sylvestris*,*Lens culinaris, Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pennisetum glaucum Pinus taeda, Populus spp.* | Major | Yes |
| 27. | *Setaria glauca* (L.) | Yellow foxtail | *Allium cepa, Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium herbaceum*****,** *Gossypium hirsutum, Helianthus annuus, Hordeum vulgaris, Lathyrus sativus*, *Lathyrus sylvestris*, *Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pennisetum glaucum.* | Minor | Yes |
| 28. | *Setaria viridis* (L.) | Green foxtail | *Allium cepa, Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Glycine max,* ***Gossypium herbaceum*****,** *Gossypium hirsutum, Helianthus annuus, Hordeum vulgaris, Lathyrus sativus*, *Lathyrus sylvestris*, *Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pennisetum glaucum.* | Minor | Yes |
| 29. | *Solanum torvum* Swartz. | Turkey Berry | *Allium cepa, Arachis hypogaea, Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Citrus sinensis, Glycine max, Gossypium herbaceum,****Gossypium hirsutum****, Helianthus annuus, Hordeum vulgaris, Lathyrus sativus*, *Lathyrus sylvestris*,*Lens culinaris, Lycopersicon esculentum, Medicago sativa, Nicotiana tabacum, Phaseolus vulgaris, Pennisetum glaucum.* | Major | Yes |
| 30. | *Sonchus oleraceus* L. | Common sow thistle | *Allium cepa, Arachis hypogaea, Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Capsicum annuum, C. frutescens, Citrus sinensis, Glycine max, Gossypium herbaceum****, Gossypium hirsutum****, Helianthus annuus, Hordeum vulgaris, Ipomea batatas, Lathyrus sativus*, *Lathyrus sylvestris*,*Lens culinaris, Lycopersicon esculentum, Medicago* | Major | Yes |

| Sl. No. | Botanical Name | Common Name(s) | Host Range | Status | Present in Bangladesh |
|---|---|---|---|---|---|
| | | | *sativa, Nicotiana tabacum, Phaseolus vulgaris.* | | |
| 31. | *Thlaspi arvense* L. | Pennycress, field pennycress, bastardcress, fan weed, stink weed | *Allium cepa, A. porrum, Asparagus officinalis, Avena sativa, Beta vulgaris, Brassica napus var. napus, Carthamus tinctorius, Cicer arietinum, Daucus carota, Glycine max,* ***Gossypium*** **spp.,***Helianthus annuus, Hordeum vulgaris, Lens culinaris, Linum usitatissimum, Medicago sativa, Oryza sativa, Phaseolus* spp., *Pisym sativum, Solanum tuberosum, Triticum aestivum, Visia fabam Zea mays* | Major | Yes |
| 32. | *Xanthium strumarium* L. | Rough cocklebur | *Allium cepa, Asparagus officinalis, Avena sativa, Beta vulgaris, Brassica napus, Brassica rapa, Carthamus tinctorius, Cicer arietinum, Daucus carota, Glycine max,* ***Gossypium*** **spp**., *Helianthus annuus, Hordeum vulgaris,* Ipomoea batatas*, Lycopersicon esculentum, Oryza sativa, Phaseolus vulgaris, Ricinus communis, Saccharum officinalis, Solanum tuberosum, Triticum aestivum, Zia mays.* | Major | Yes |

### 4.3.1 Quarantine Weeds of Cotton for Bangladesh

Among the weeds, *Parthenium hysterophorus* L. is present in Bangladesh, only northern part of the Jamuna River (Rajshahi, Natore, Chapainababgonj, Jessore, Kustia, Pabna, Sirajgonj districts). Thus, it is considered as quarantine weeds for Bangladesh. Common name, botanical name and distributions of quarantine weed for Bangladesh have been shown in Table 10.

**Table 10: Available of quarantine weed for Bangladesh in eight exporting countries**

| Sl. No. | Common Name | Botanical Name | Available at Cotton Importing Countries |
|---|---|---|---|
| 01. | Parthenium | *Parthenium hysterophorus*L. | China [1,2], India [2,3], Pakistan [2,5], USA [2] and Zimbabwe [2,4] |

The details of this weed have been discussed in Section 9, Potential Hazard Organisms Risk Analyses (9.13).

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# 5.0 Risk Analysis for Cotton in Bangladesh

## 5.1 Background

Bangladesh has been importing cotton lint and seed from China, India, Egypt, Pakistan, Turkey, USA, Uzbekistan, and Zimbabwe. 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 wheat pests is required. Hence the present activities were taken up. Here pests are referred to insect pests, diseases and weed of cotton and the PRA areas are the selected 22 districts as shown in Table 1.

## 5.2 Scope of the Risk Analysis

The scope of this risk analysis is to determine the presence of insect pests, diseases and weed of cotton in Bangladesh and to ascertain the potential hazard organisms or diseases associated with cotton seed/lint imported from the countries mentioned above. Cotton seed as germplasm or advanced lines are imported from abroad for development of varieties. Recently, hybrid cotton seeds are being imported from China. Risk in this context is defined as the likelihood of the entry of the hazards with the pathway or commodity, probability of establishment and the likely magnitude of the consequences of the hazards on economic, environment or health. In the present context cotton means the seed or lint of cotton without attached stems or leaves. The framework of pest risk analysis in the present activities include three stages of pest risk analysis viz., initiation, pest risk assessment and pest risk management.The standard focuses on the initiation stage. Generic issues of information gathering, documentation, risk communication, uncertainty and consistency are addressed.

## 5.3 Risk Analysis Process and Methodology

The process and methodology for undertaking import risk analyses are shown in Figure 5.

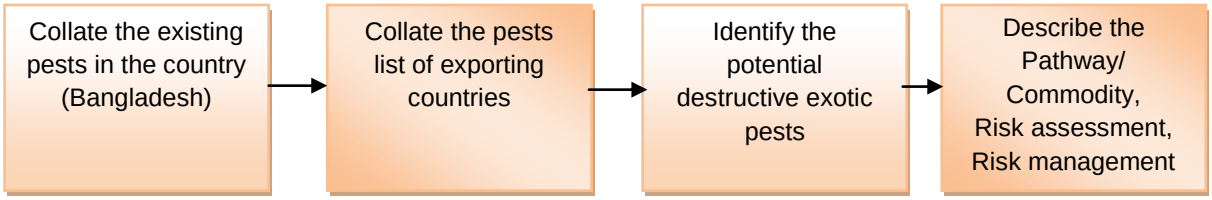


**Figure 5: A Flow Diagram of the Risk Analysis Process.**

Data on insect pests and diseases were collected through field survey of 4400 farmers' fields in 44 upazilas under 22 districts (Appendix VII, VIII, IX and X) of the country and interviewing of 4400 farmers and 440 Unit Officers of Cotton Development Board (CDB). The team also met or contacted 44 Upazila Agricultural Officer (UAO) and 22 Deputy Director, Department of Agricultural Extension (DDAE) (Appendices XVII). Information was also collected from available publications and related Scientists from Bangladesh Agricultural Research Institute (BARI) and CDB (Appendices XI). The recorded insect pests, diseases and weed of cotton from field survey of major cotton growing areas in Bangladesh are shown in Appendices IV, Vand VI, respectively. The world (Cotton exporting countries) pest situation in cotton was collected from published papers and internet resources. Lists of insect pests, diseases and weeds in cotton of the world are shown in Section-4. Through critical analysis of the collected data and comparing with the

world list, the pests, diseases and weeds absent in Bangladesh were identified. Among those pests, diseases and weeds the potential hazards under Bangladesh conditions were identified and described the pathway (Section 9).

### 5.4 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:

- The country of origin, including characteristics like climate, relevant agricultural practices, phytosanitary system;
- Pre-export processing and transport systems;
- Export and transit conditions, including packaging, mode and method of shipping;
- Nature and method of transport and storage on arrival in Bangladesh;
- Characteristics of Bangladesh climate, and relevant agricultural practices.

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

### 5.5 Hazard Identification

The first step for any risk assessment is to identify the hazard as the risk is related to hazard. Hazards are the unwanted insect pests, diseases (pathogen) or weeds which could be introduced into Bangladesh by risk goods, and are potentially capable of causing harm to cotton production, must be identified. This process begins with the collection of information on insect pests, diseases (pathogen) or weed 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. Diagrammatic representation of hazard identification is shown in Figure 6.

### 5.6 Risk Assessment of Potential Hazards

Risk assessment is the evaluation of the likelihood of entry, exposure and establishment of a potential hazard, and the environmental, economic, human and animal health consequences of the entry within Bangladesh. The aim of risk assessment is to identify hazards which present an unacceptable level of risk, for which risk management measures are required. Descriptors are used in assessing the likelihood of entry, exposure and establishment, and the economic, environmental, social and human health consequences. The approach taken in this Risk Analysis is to assume the commodity is imported without any risk management. In this risk analysis hazards have been grouped where appropriate to avoid unnecessary duplication of effort in the assessment stage of the project. Diagrammatic representation of risk assessment and risk management is shown in Figure 7.

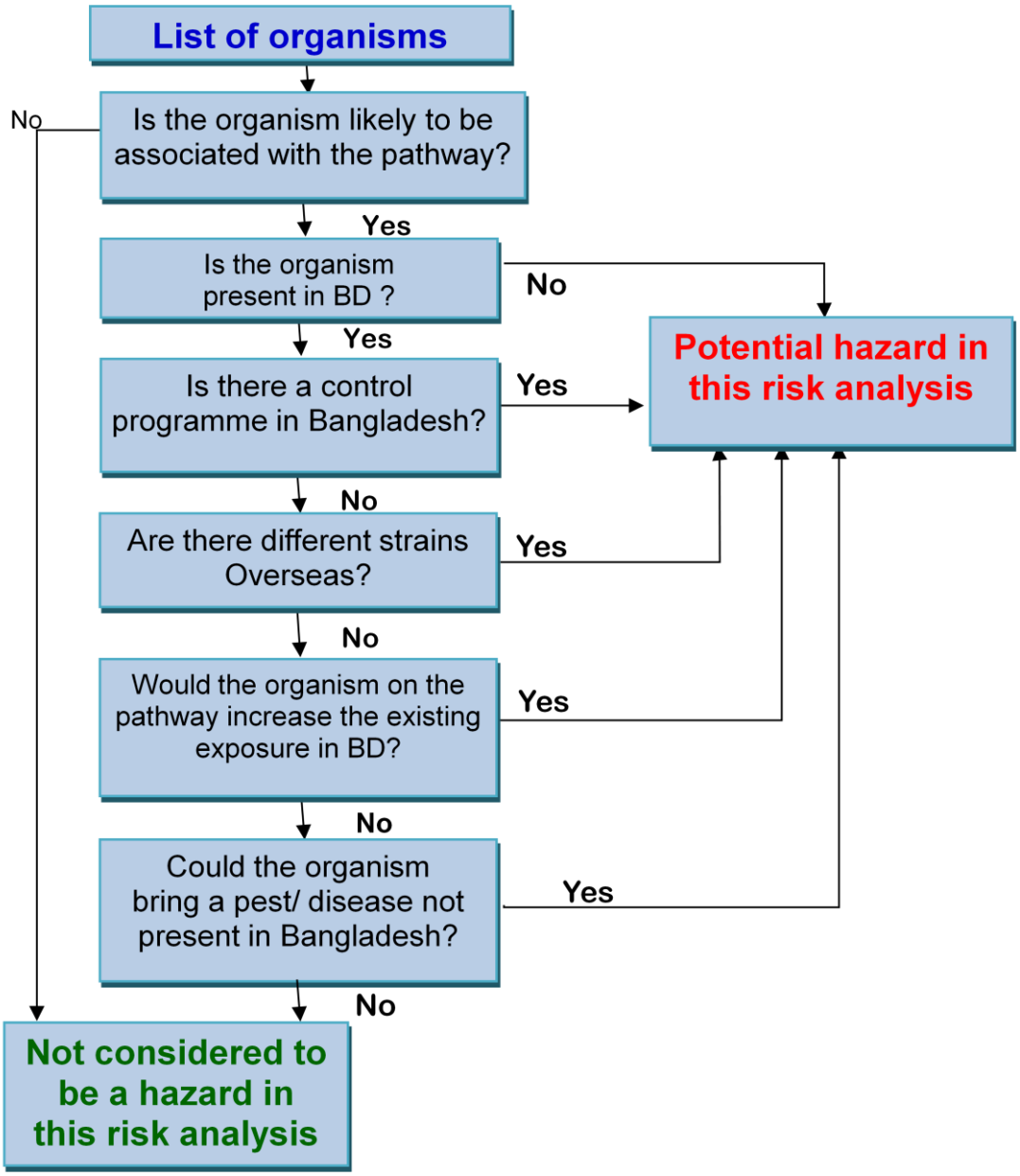


**Figure 6: Diagrammatic representation of hazard identification**

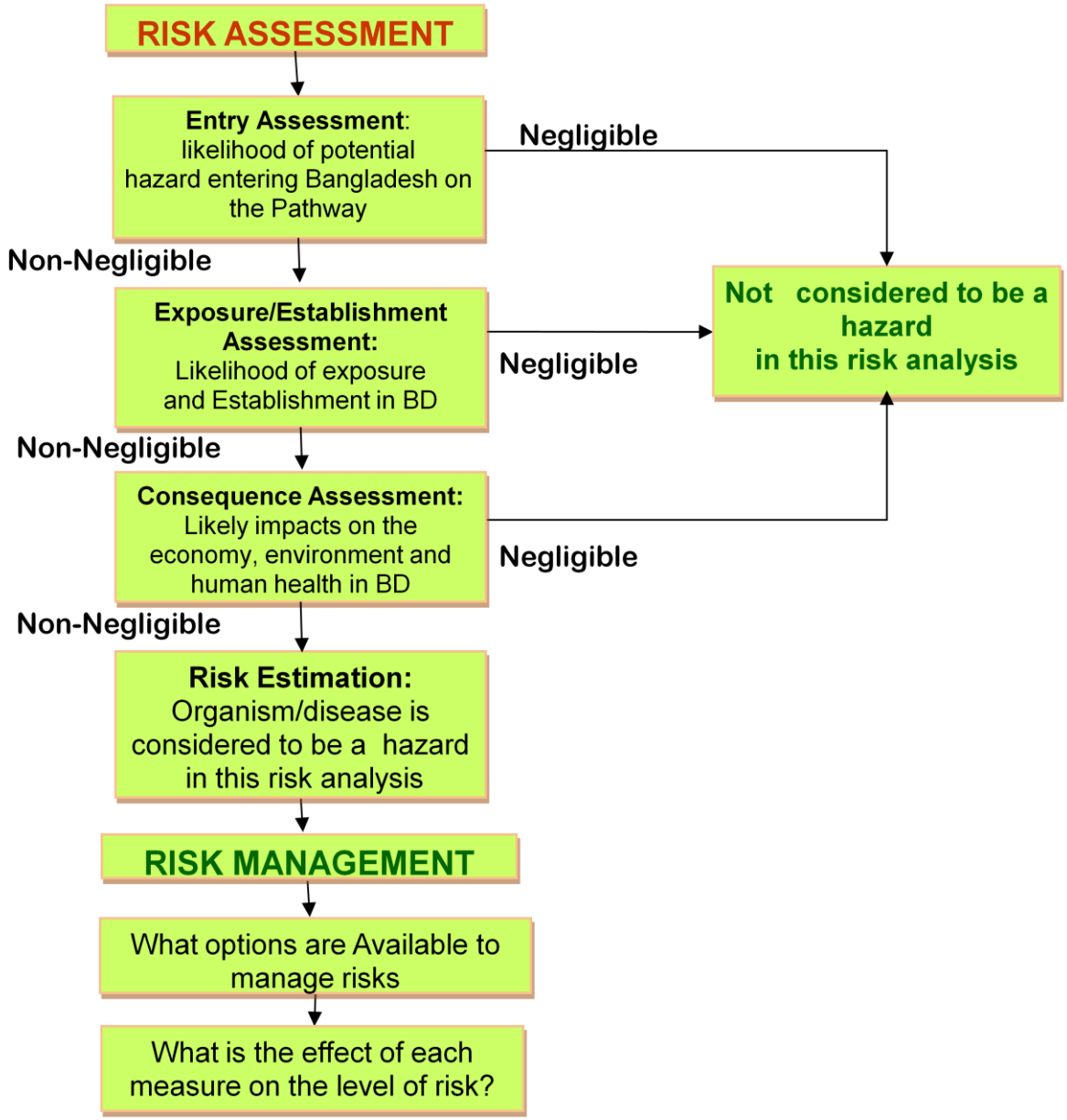


**Figure 7: Diagrammatic representation of the process followed for risk assessment and management.**

## 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. Cotton Development Board (CDB) is the only organization, which conducts research and does extension work in Bangladesh for cotton. Research works about pests of cotton are inadequate. Thus, information of insect and mite pests, diseases and weeds of cotton are not sufficient in Bangladesh. Moreover taxonimcal identification of insect pests is another problem due to lack of Taxonomist. Furthermore information on pest's interception with imported seeds and lint at different ports are scanty. So, there is a probability of unrecorded insect pests, diseases and weeds as well as interception of new pests of cotton in Bangladesh.

## 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 following framework:

## 5.9 Risk Evaluation

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

## 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 eight established pathways (China, Egypt, India, Pakistan, Turkey, USA, Uzbekistanand, Zimbabwe) for cotton 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. Cotton lint or seed can be imported from the exporting countries after only after fumigation with alluminium phosphide or methyl bromide where the quarantine insect pests are present. Furthermore, cotton lint or seed can be imported from those regions of exporting counries where quarantine insect pests are absent.

### 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 from Bangladesh. 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.

# 6.0 Import Risk Analysis

This chapter provides information on the commodity that is relevant to the analysis of biosecurity risks and common to all organisms or diseases potentially associated with the commodity. It also provides information on climate and geography of the country of origin as well as Bangladesh for assessing the likelihood of establishment and spread of potential hazard organisms when enter and exposed to Banladesh.

## 6.1 Commodity Description (Cotton- *Gossypium* spp.)

In this risk analysis cotton lint and seed are imported from India, Turkey and Uzbekistan; lint from Pakistan and only seed (hybrid) from China are considered as commodity. After harvesting of Seed Cotton all vegetative parts have been removed, processed and packed in the exporting country and then transported to Bangladesh.

### 6.1.1 Crop Phenology

Cotton is a major fibre crop of global importance and has high commercial value. It is grown commercially in the temperate and tropical regions of more than 70 countries. Specific areas of production include countries such as China, Egypt, India, Pakistan, Turkey, USA, Uzbekistan, and Zimbabwe etc. where climatic conditions suit the natural growth requirements of cotton, which includes periods of hot and dry weather and adequate moisture obtained through irrigation. Cotton is harvested as 'seed cotton' which is then 'ginned' to separate the seed and lint. The long 'lint' fibres are further processed by spinning to produce yarn which is knitted or woven into fabrics. India has the largest cotton area in the world with about 96 lakh hectares under cultivation accounting for one-fourth of the global cotton area. It contributes to 16% of the global cotton produce and has emerged as the world's second largest cotton producer in 2006-07, edging past the USA, which held the second rank until recent past. China is the world's leading cotton producer.

**Taxonomic tree of cotton**

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Malvales
Family: Malvaceae
Genus: *Gossypium*
Species: *Gossypium hirsutum*, *Gossypium* spp.

The genus *Gossypium* comprises around 50 species, making it the largest in species number in the tribe *Gossypioieae*. New species continue to be discovered. There are four species of cotton in the genus *Gossypium* (family *Malvaceae*), namely G.*hirsutum* L, G.*barbadense* L., G.*arboreum* L and G.*herbaceum* L. that were domesticated independently as sources of textile fibre. Globally, the *Gossypium* genus comprises about 50 species [4]. The place of origin of the genus *Gossypium* is not known, however the primary centers of diversity are west-central and southern Mexico (18 species), north-east Africa and Arabia (14 species) and Australia (17 species). DNA sequence data from the existing *Gossypium* species suggests that the genus arose about 10-20 million years ago.

The antiquity of cotton in the Indian subcontinent has been traced to the 4th millennium BC. The first reference to cotton is found in Rig Veda hymn. Cotton is the collective name given to four

species of plants in the genus *Gossypium*, *Gossypium hirsutum*, *Gossypium barbadense*, *Gossypium arboreum* and *Gossypium herbaceum,* which are perennial shrubs in the family Malvaceae grown for the fluffy fiber which protects the seeds of the plant. *G. hirsutum* accounts for approximately 90% of world wide cotton production today. Cotton plants possess a main stem giving rise to several branches at the top. The leaves of the plant are spirally arranged on the branches, have long petioles and have 3–5 triangular lobes. The plant produces a single flower on each axillary branch which can be red-purple, yellow or white in color and forms a leathery, oval seed capsule, or 'boll' which is 2–6 cm (0.8–2.4 in) long. Mature bolls will usually split open to reveal the characteristic white cotton fibers and the seed. The cotton plant can reach heights of 1–1.5 m (3.3–4.9 ft) and is usually cultivated as an annual, surviving only one growing season crop.

The growth of cotton plant starts with germination of seed and it depends on the availability of soil moisture, temperature and oxygen. Germination begins with the entry of moisture into the seed and embryo via the chalazal aperture at the seeds' apex (Christiansen and Moore 1959). The seed/embryo then begins to swell as it absorbs moisture. Under favorable conditions, the radicle (root tip) emerges with in 2-3 days from the seed and newly germinated seedlings emerge above the soil 5-6 days after emergence of the radicle (Oosterhuis and Jernstedt, 1999). The first cotton leaf appears 10-12 days after emergence and leaf development reaches its peak about three weeks after the first buds are formed.

The first flower-bud appears on the lowest fruiting branch 35-45 days after emergence, depending upon prevailing temperatures. The other flower buds follow at regular intervals until shortly before flowering ceases. The time taken between the appearance of first flower bud and opening of the flower may be between 25-30 days. Emergence of large number of flowers is seen for certain period and thereafter it declines. During the peak period of flowering the vegetative growth is almost negligible and once the rate of flowering declines the vegetative growth restarts. Period of flowering is reduced by late sowing, strong plant competition and moisture stress.

The duration of annual cotton varieties/hybrids varies from 120-140 days. In most varieties the boll bursting begins 120 days after the shoot emergence. From the time of sowing until boll bursting of the cotton plant, the following five basic and phenological phases are distinguished:

- Germination and emergence of shoot – the phase of cotyledon.
- True leaf formation.
- Formation of sympodial shoot and square formation (flower bud)
- Peak flowering
- Boll development and boll bursting

The length of each phase differs, depending upon the species, varieties and weather conditions as well as the cultivation techniques followed. The flowering phase is greatly influenced by the environmental factors. Flowering in cotton is sensitive to both thermo and photoperiods. For example, varieties developed under short-day condition of southern cotton growing zone in the country may not flower in the northern zone at a particular period of time when long day conditions prevails. The day length alone or in combination with temperature determines the formulation of flowering buds.

**Root:** Cotton plant has a taproot that grows quickly and it can reach a depth of 20-25cm before the seedling has even emerged above ground. After emergence and unfolding of cotyledons,

lateral roots begin to develop; they first grow side ways and then downwards. The taproot continues to grow rapidly. Final depth of root system depends on soil moisture, aeration, temperature and variety but is usually about 180-200 cm. Under dry growing conditions, cotton roots have been known to reach a depth of 3-4m. The growth of tap root as well as lateral root is affected by excessive moisture, hard dry soil layer and degree of soil alkalinity. Lateral roots adjust their quantum to the plant spacing and soil moisture regimes.

**Stem:** Cotton plant consists of an erect main stem and a number of lateral branches. The stem has a growing point at its apex, with an apical bud. As long as this bud remains active, lateral buds situated below it remain dormant. The main stem carries branches and leaves but no flowers. Length and number of internodes determine the final height of the plant. As a rule plant with short internodes is early maturing. Length of internodes is determined mainly by the moisture supply while the number of internodes is usually a function of nitrogen supply to the plant. At the axil of each leaf there are two buds, the axillary bud from which most vegetative and fruiting branches (sympodia) develop and a lateral bud on one side of axillary bud. The lateral bud normally remains dormant; but if the axillary bud aborts, it may develop into a branch. Vegetative branches (monopodia) are morphologically similar to the main stem. They do not bear flowers or fruits directly, but carry secondary branches (fruiting branches), that are characterized by their sympodial growth habit.

**Leaves:** Leaves of cotton are generally hairy and some varieties have glabrous leaves. Hairy leaves cause fewer difficulties in mechanical harvesting and are more tolerant to jassids, but bear larger proportions of whitefly which apparently finds more sheltered conditions among the leaf hairs. The leaves have variable lobes. Size, texture, shape and hairiness of leaves vary a great deal. Nectaries are present on leaf calyx and bracts. Each leaf has two buds at its axis.

**Branching:** Lateral branches arise from the axils of the leaves of main stem and consist of two types *viz*., vegetative and fruiting. Vegetative branches are more vertical and ascending. Fruiting branches are nearly horizontal. The internodes on the fruiting branches, referred to as sympodial branches are not straight as in main stem but have a zigzag appearance with the leaves alternately placed. The flowering and fruiting are dependent on the initiation of sympodial branches.The timing of the crop for harvest is also determined by the early or late production of such sympodial branches on the plant body. Very early varieties have their fruiting branches even at first or second node to the total exclusion of vegetative branching from leaf axils. Similarly very late varieties go on producing a very large number of onopodialbefore sympodial divergence appear. Relative proportion of vegetative and fruiting branches is dependent on temperature, day-length, plant density and the rate of boll shedding.

**Floral biology**

Cotton flowers are extra-axillary, terminal and solitary and are borne on the sympodial branches. The flower is subtended by an involucre of usually three unequal leaf like bracts. Bracteoles, alternating with the bracts on the inside of the involucre or standing on either side of the small bract, may be present. The calyx, consisting of five undiverged sepals, is persistent and shaped as a shallow cup. The calyx adheres tightly to the base of the boll as it develops. The corolla is tubular, consisting of five obcordate petals alternating with calyx lobes and overlapping the next one in the series in a convolute manner. In some species, a spot of purple, sometimes called ‘petal spot’, is found on the claw (base) of the petals. On the first day after anthesis, the corolla changes into pinkish blue and then into red during succeeding days. It withers and falls off on the third day, together with the staminal column and stigma leaving the ovary, calyx and involucre intact. The stamens are numerous and united to form a tubular sheath which surrounds the pistils

except for the exposed portion of style and stigma at the tip. The pistil consists of 3-5 undiverged carpels corresponding to the locular composition of a fully mature dehisced boll. The ovules are attached to parietal placenta of each locule. The style varies in length and splits near the apex into three, four or five parts depending on the number of carpels.

**Flower:** Flower is large, axillary, terminal and solitary. On account of the sympodial development of fruiting branches, the flower opening follows a spiral course in acropetal and centrifugal succession. The innermost bud of the lowest and oldest branch is the first to open while the outermost bud of the highest and youngest branch is the last to do so. When the flower opens it is white or creamy white or yellow in the American varieties, changing to pink towards the end of the day and becoming red the following morning; on the third day the petals wither and fall.

**Bolls:** In *G.hirsutum* bolls are large, generally ranging from 4-5g. The general variation in boll weight is 3-5 g, however in some varieties it can weigh upto 8g. The bolls are pale green, smooth-skinned and with few oil glands. In contrast, bolls of *G.arboreum* are smaller (1.5 - 3g), dark green and covered with numerous glands. Cotton plants by its remarkable auto-regulatory mechanism shed the bolls that are in excess of the load capacity of the plant under given environmental conditions. As a result, the ratio of bolls to total vegetative growth is fairly constant. In general, varieties or strains with large bolls do not adjust so well to change in environment and to stress as do types with smaller bolls. Hence, shedding occurs more readily and to a large extent in the former than in the latter case. Bolls developing underfalling temperature need more days to mature than those growing under rising temperature. The bigbolled American types in India take about 40-50 days while the Asiatic cottons require 35 days. In *G.hirsutum* the boll consists of four to five locules each of which contains about 7 mature seeds. A fair percentage of the ovules remain undeveloped due to non-fertilization, heredity and environment. These are called “motes”. The size and shape of the bolls differ in diploid and tetraploid cotton.

**Pollination and Fertilization:** Cotton pollen is relatively large, heavy, sticky and watery and thus wind is not a factor in the pollination of cotton. Cross-pollination in cotton may vary from zero to more than 20 percent also. Many insects especially honey bees are attracted to the cotton flowers and they are active in cross-pollination. Pollination takes place usually in the morning during opening of flower and anther dehiscence. Fertilization takes place between 24-30 hours after pollination [4]. Corolla along with anthers and filament drops from the fertilized ovary. Initially the boll development is slow and later the growth rate is rapid and steady. About 40-50 days are required from fertilization to boll bursting, maturation of fibers and seed formation.

**Pollen Dispersal:** The pollen dispersal depends upon the insect activity and environment in which the parents are grown. The amount of cross pollination depends upon the relative abundance of pollen-carrying insects than any other factor. Generally cross pollination occurs in close vicinity; however insects may carry the pollen upto several hundred meters. In case of cotton, cotton dispersal studies have consistently demonstrated that when outcrossing occurs, it is localized around the pollen source and decreases significantly with the distance [1, 5, 8].

There are approximately 10,000 pollen grains in a flower. Under normal conditions, the pollengrains are viable upto 24 hours and thereafter lose potency and fail to effect fertilization [3]. Honey bee (*Apis mellifera* L.*)* is the main vector for pollination, apart from other honey bees (*A. dorsata, A. florea, A.indica*), bumble bees (*Bombus sp.)*, leaf cutting bees *(Hymenoptera megachilidae)* and a few dipterans help in pollination. The main pollinating insects differ due to distribution of insects and ecological conditions and their capability also differs on account of

their visiting behavior, body size. Fully pubescent insects such as yellow breast wood bee, heavy flower wasp and black spinytibial bee are highly efficient for cross pollination.

**Seed Dispersal:** As cotton does not generally reproduce vegetatively [7], spread within the environment occurs by seed dispersal. Dispersal of cotton seeds is a physical process. Observations of dispersed seeds and the occurrence of volunteer plants in northern Australian cotton trials indicate that delinted black seed has the lowest risk of unintentional spread within the environment [6]. When dispersal of black seed occurs, it is associated with spillage at sowing in cotton production areas.

Fuzzy seed is commonly used as livestock feed and therefore has a high potential for dispersal to noncotton production habitats. Unprocessed seed cotton, that retains all of the fibres attached to the seedcoat, also has a high potential for dispersal within the environment. Data from Monsanto [6] suggest that volunteers from dispersed seed cotton were relatively common in irrigation channels and drains, and along roadsides. Roadside volunteers most likely established following seed cotton spillage during transport of cotton modules from the paddock to the gin. Post-dispersal, seeds that do not germinate are likely to be removed by seed predators or rot, rather than become incorporated into a persistent soil seed bank.

**Seed:** The full-grown seed of cotton is irregularly pear-shaped, varying in size depending on the variety and conditions of growing. It may be naked or bear short hairs called “fuzz”. All cultivated cotton seeds bear long fibres named “lint” and a majority of them also have fuzz on the same seed. The lint is removed by gins while the fuzz remains attached. The colour of fibres is generally white, but may also be brown or green and that of the seed is usually grey, brownish or black. The mature seed has two cotyledons folded up that occupy the entire portion of its cavity. The cotyledons are broad and kidney shaped. Delayed germination in some of the species and varieties may be due to hard seed coat, closed micropyle and partially filled cotyledonary-cum-embryonic contents. The germination increases when the seed coat thickness is reduced by various methods of delinting. The seeds account for about 65 to70 per cent of the total yield by weight. The seeds are rich in protein (10-20%) and oil (up to 25%). The oil content in *G.barbadense* is higher than *G.hirsutum*.

**Seed hairs/Lint:** As mentioned above, lint and fuzz represent the outgrowths of epidermal cells on seeds. Some cells continue to lengthen while others stop growing after a time. The former is known as the lint and the latter is the fuzz. The lint hair is unicellular and its development is phased in two stages, the first phase is a period of elongation and the second phase is increase in thickness. A lint cell bulges first, the protoplasm inside turns granular, and the nucleus moves towards the bulge. The swelling enlarges until it is twice the diameter of the original cell and the nucleus moves to or near the tip. The elongation of cell may take upto 40 days. There is no change in thickness. The growth is not regular; slow at first but fast from about the 15th day. The rate slackens during days and quickens during nights. The cell wall thickens in the second half of boll maturation. Deposits of cellulose are formed on the inside of primary wall. They are laid in layers as seen from some fibres showing as many as 25 concentric layers. As soon as the boll dehisces, the hairs dry, collapse and flatten the cylindrical form, assuming ribbon like shape and go into spirals. The mature hair is uniform in diameter up to 3/4th length and then gradually tapers to a point. The length of lint is a varietal character and varies from 15-50mm in different varieties. Fibre quality traits such as length, fineness and strength are important as spinning are dependent on these characteristics.

### 6.1.2 Climatic and Soil Requirements

Cotton requires a daily minimum temperature of 16ºC for germination and 21ºC to 27ºC for proper crop growth. During the fruiting phase, the day temperature ranging from 27ºC to 32ºC and cool nights are needed. The sowing season of cotton varies considerably from tract to tract and is generally early (April-May) in northern India where it is mostly irrigated. It is delayed on proceeding to down south. It is cultivated largely under rainfed or dryland conditions. An annual rainfall of atleast 50 centimetre distributed through-out the growing season is required for good yield. It is mainly raised during tropical monsoon season, although in southern India it is cultivated during late-monsoon season in winter. The cotton-picking period from mid September to November must have bright sunny days to ensure a good quality.

Cotton is successfully grown on all soils except sandy, saline or water logged types. It is grown in well drained deep alluvial soils in the north to black clayey soils of varying depth in central zone and in the black and mixed black and red soils in south zone. It is moderately tolerant to salinity and is sensitive to water logging as well as frost and chilling temperature in winter

### 6.1.3 Pests and Diseases

Insect pests are one of the major limiting factors in cotton production. Of 1326 insect pests recorded on cotton worldwide, nearly 130 species occur in India. About a dozen of these arthropods are commonly present in sufficient numbers requiring their management for realizing better cotton yields.

Cotton is attacked by about 17 diseases globally of which number of diseases and major diseases varied in different countries. India listed 6 diseases as major, 5 in Pakistan and 4 in Bangladesh.The chemical control is still the predominant option for disease control in cotton.

In Bangladesh 29 species of pests were recorded of which 28 species were insect pests and one species was mite pest. Among the insect pests, thirteen species were major which caused considerable damage of cotton in field every year.

Cotton can be affected by a range of diseases that have the potential to devastate the industry. The six most serious ones are bacterial blight, Texas root rot, cotton leaf curl disease, blue disease and exotic strains of Fusarium wilt and Verticillium wilt. In Bangladesh 13 diseases were found to occur among these four diseases viz., seedling blight, Fusarium wilt, bacterial blight and boll rot are major. A number of environmental factors can affect the growth of cotton, particularly in the early stages, including heat shock, cold shock, sand blasting, hail damage and water logging. All parts of the cotton plant are used. Cotton fibre is processed into yarn and fabric, the seeds can be crushed for oil or animal feed, the remaining plant is mulched and even the linters are used to make products like cotton balls.More than 75 countries grow cotton. Cotton is grown between 45 degrees north and 35 degrees south of the equator. In 2009 cotton accounted for 31.7% of worldwide fibre production.

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## 6.2 Description of Proposed Import Pathway

For the purpose of this risk analysis cotton seed or lint are presumed to be from anywhere in China, Egypt, India, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe. The consignment may enter to Bangladesh through any of the two Sea ports-Chittagong and Mongla; three Airports namely Hazrat Shahajalal Intl. Airport, Dhaka, Shah Amanat Airport, Chittagong; Osmani Intl. Airport, Sylhet; or through any of the 17 Landports namely 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 or through one River port, Narayanganj. 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 use in the spinning mills of the country. Diagrammatic representation of import pathways of cotton is shown in Figure 8.

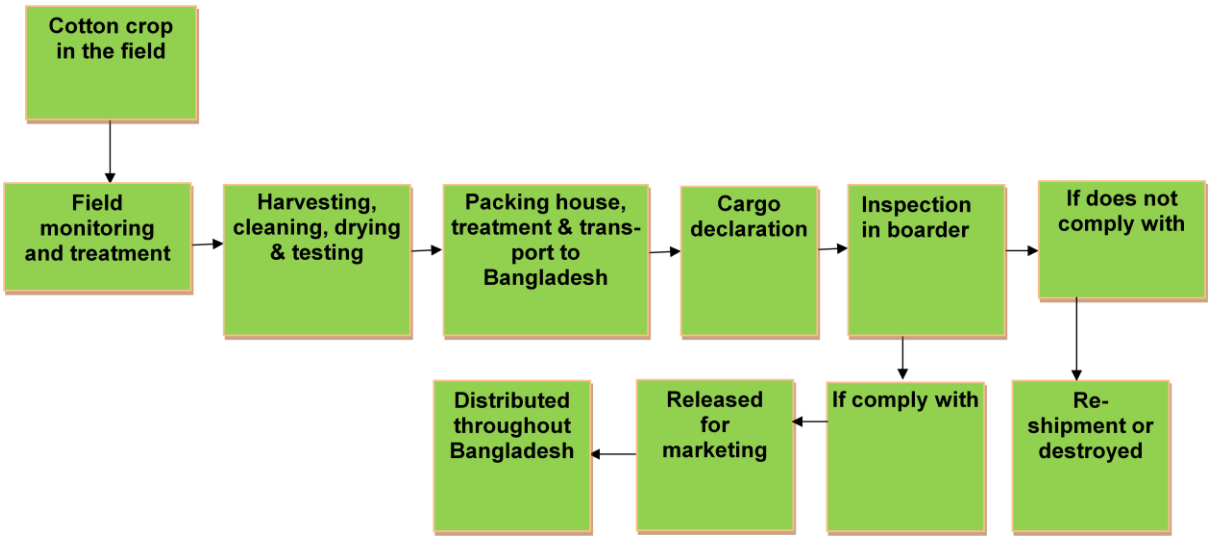


**Figure 8: Linear diagram of import pathway of cotton**

Growers intend to export their cotton 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 cleaning, drying and ginning. Cotton seed or lint for export will then be transported to packing house where necessary grading and cleaning will be done. The commodity must be inspected by a competent quarantine inspector for any quarantine pests and provide treatment (hot water/chemical for seed and fumigation for seed and lint) and accompanied with phytosanitary certificate from the NPPO 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 lint/seed, any treatments completed, or other information required helping mitigate risks. Lint or seed 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.

## 6.3 Geography, Climate, Pest Control and Pre-Export Handling in Exporting Country

### 6.3.1 China

#### 6.3.1.1 Geography and Climate

China is located in Eastern Asia at $35^0$ 00 N, $105^0$ 00 E. 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 [14].

China is composed of a vast variety of highly different landscapes, with mostly plateaus and mountains in the west, and lower lands on the east. Most of China's arable lands lie along the two major rivers, the Yangtze and the Huang He, and each are the centers around which are founded China's major ancient civilizations. In the east, along the shores of the Yellow Sea and the East China Sea are found extensive and densely populated alluvial plains; the shore of the South China Sea is more mountainous and southern China is dominated by hill country and lower mountain ranges. To the west, the north has a great alluvial plain and the south has a vast calcareous table land traversed by hill ranges of moderate elevation, with the Himalayas, containing the highest point Mount Everest. The northwest also has high plateaus among more arid desert landscapes such as the Takla-Makan and the Gobi Desert, which has been expanding [15].

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 $32^0$ F and below, while in summer, temperature can rise to $100^0$ F and above.

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.

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 [16].

China is the world leader in gross value of agricultural output; rice, wheat, potatoes, corn, peanuts, tea, millet, barley, apples, cotton, oilseed; pork; fish and citrus [15, 18]. China is the leading cotton producing coutry in the world. During 2014-15 China produced 6.5 million metric ton cotton [17].

#### 6.3.1.2 Pest and Disease Control

The climate in these regions varies greatly in terms of rainfall, temperature and length of the growing seasons affecting significantly pest population [27]. Major insect pests of cotton in China are aphid, jassid, whitefly and thrips bollworm (*Helicoverpa armigera*, *Pectinonphora gossypiella*) and leaf feeding insect pest (*Spodoptera litura*). Moreover many minor insect pests are found in different cotton growing regions. Insect pests such as cotton bollworm, cotton aphid, and mirids are the major factors that contribute to a decrease in cotton production [28].

In the middle of the 20$^{th}$ Century, protection of cotton from insect pests relied solely on chemical insecticides. These chemicals were used intensively and often in fixed schedules [26].Transgenic cotton that expresses a gene derived from the bacterium *Bacillus thuringiensis* (Bt) has been deployed for combating cotton bollworm since 1997 in China, and the area of cultivation expanded rapidly from 3.7 million ha to 5.3 million ha in 2004. Field monitoring on the change of pest status derived from Bt cotton commercialization in a large scale were conducted during 1998-2004 in Hebei Province. The results indicated that Bt cotton efficiently controls cotton bollworms, while the decrease of pesticide applications allows the buildup of high populations of predators, such as lady beetles *Coccinella septempunctata*, lacewings *Chrysopa sinica*, spiders and others in mid-season. Furthermore, planting Bt cotton efficiently prevented the resurgence of cotton aphids caused by insecticide use for control of cotton bollworm [28].

The development of cotton pest management practices in China has followed a pattern seen for many crops that rely heavily on insecticides. *Helicoverpa armigera* resistance to chemical pesticides resulted in the unprecedented pest densities of the early 1990s. Transgenic cotton that expresses a gene derived from the bacterium *Bacillus thuringiensis* (Bt) has been deployed for combating *H. armigera* since 1997. The pest management tactics associated with Bt cotton have resulted in a drastic reduction in insecticide use, which usually results in a significant increase in populations of beneficial insects and thus contributes to the improvement of the natural control of some pests. Risk assessment analyses show that the natural refuges derived from the mixed-planting system of cotton, corn, soybean, and peanut on small-scale, single-family-owned farms play an important function in delaying evolution of cotton bollworm resistance, and that no trend toward Bt cotton resistance has been apparent despite intensive planting of Bt cotton over the past several years [27].

### 6.3.2 Egypt

#### 6.3.2.1 Geography and Climate

The official name is Arab Republic of Egypt. Egypt is 1,001,449 square kilometers of land and the coastal is 2,450 km. Egypt is located in northern Africa and shares borders with Gaza Strip, Israel, Libya and Sudan. Egypt's boundaries also include the Sinai Peninsula. Its topography consists mainly of desert plateau but the eastern part is cut by the Nile River valley. The highest point in Egypt is Mount Catherine at 8,625 feet (2,629 m), while its lowest point is the Qattara Depression at -436 feet (-133 m). Egypt's total area of 386,662 square miles (1,001,450 sq km) makes it the 30$^{th}$ largest country in the world. The geograpgic position of the country is its highest point is 6,668 feet and the lowest point is 436 feet below sea level. The Mediterranean Sea forms Egypt's northern border, bringing cooler weather to the seaboard city of Alexandria and providing a coastal getaway for Cairo's residents. To the east, lies the mountainous Sinai Peninsula, which borders Israel and the Palestinian Territories; to the south, the deserts of Egypt roll into the deserts of Sudan; to the west, the Great Western Desert forms an almost seamless wilderness through Libya and beyond. The area of agricultural land in Egypt is confined to the Nile Valley and delta, with a few oases and some arable land in Sinai. The total cultivated area is 3.02 million ha, representing only 3 percent of the total land area. The climate of Egypt is desert and as such it has very hot, dry summers and mild winters. Cairo, Egypt's capital which is located in the Nile valley has an average high temperature in July is 35˚C and an average low of 9˚C in January[19].

#### 6.3.2.2 Pest and Disease Control

The Cotton Leaf Worm (CLW) *Spodoptera littoralis* (Boisd) is a major polyphagous key pest in Egypt. It is active all year round without hibernation period and attacking cotton as well as more than 29 hosts from other crops and vegetables. Egypt use to spend more than 10 million dollars to combat this pest on all crops every year. Pink bollworm is the dominant cotton pest, established throughout Egypt, and SBW is concentrated in Upper Egypt (1/3 of the total area), south of the delta [25]. Cotton bollworm, pink bollworm, *Pectinophora gossypiella*, spotted bollworm, *Earias insulana* and American bollworm are the major pests of cotton in Egypt [2]. Moreover sucking insect pests such as aphid, jassid and whitefly are the major ones which cause significant yield loss. Different control approaches such as cultural control, chemical spray, Integrated Pest Management are used to control cotton pest.The Ministry of Agriculture (MOA) of Egypt had to spray the cotton crop every year despite hand picking [1]. Genetically modified cotton are developed for the management of insect pests. Egyptian cotton varieties *Gossypium barbadense* L. (Giza 80, Giza 90 and Giza 89), which was genetically modified by *Bacillus thuringiensis* (Bt) genes against bollworms, pink bollworm *Pectinophora gossypiella* and spiny bollworm *Earias insulana*. However, no variety of Bt cotton has yet been approved for commercial planting in Egypt [25].

### 6.3.3 India

#### 6.3.3.1 Geography and Climate

India, a country in South Asia lies largely on the Indian Plate. The country is situated between 8°4' and 37°6' north latitude and 68°7' and 97°25' east longitude having a total area of 3,166,414 square km. It has a land frontier of 15,200 km and a coastline of 7,517 km. India is bordered with Pakistan, Afghanistan, Bangladesh, China, Myanmar, Bhutan and Nepal.

India enjoys versatile climatic conditions and thus agriculture of this is also versatile. India has divided into eight climatic region as- (1) Tropical Rain Forest; (2) Tropical savanna; (3) Tropical

Semi-Arid Steppe Climate; (4) Tropical and Sub-Tropical Steppe; (5) Tropical Desert; (6) Humid Sub-Tropical with winter; (7) Mountain Climate and (8) drought prone area. The major cotton growing areas are Punjab, Haryana, Rajasthan, Uttar Pradesh, Rajasthan and Bihar.

Cotton is the most important fibre crop of India and is the sources of earing of millions of Indians, particularly in the northern and north-western parts of the country. India is the second largest producer of cotton in the world after China. During 2014-15 the country produced 6.4 million metric ton cotton. Cotton is a Rabi crop which is sown in the beginning of winter and is harvested in the beginning of summer. The time of sowing and harvesting differs in different regions due to climatic variations.The sowing of cotton crop normally begins in the September-October in Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh and West Bengal; October-November in Bihar, Uttar Pradesh, Punjab, Haryana and Rajasthan and Nov.-Dec. in Himachal Pradesh and Jammu & Kashmir.

The harvesting is done in Jan.- Feb. in Karnataka, Andhra Pradesh, M.P, and in West Bengal; March-April in Punjab, Haryana, U.P. and Rajasthan and in April-May in Himachal Pradesh and J&K. The growing period is variable from one agro climatic zone to the other that effects the vegetative and reproductive period leading to differences in potential yield. The important factors affecting the productivity are seeding time and methodology, crop establishment and climatic conditions during the growing season.

Cotton is primarily a crop of mid-latitude grasslands and requires a cool climate with moderate rainfall. The ideal cotton climate has winter temperature 10° to 15°C and summer temperature varying from 21°C to 26°C. The temperature should be low at the time of sowing but as the harvesting time approaches higher temperatures are required for proper ripening of the crop. But sudden rise in temperature at the time of maturity is harmful. Cotton thrives well in areas receiving an annual rainfall of about 75 cm. Annual rainfall of 100 cm is the highest limit of cotton cultivation. The 54ahlia54m of 100 cm marks the boundary between cotton growing areas on one hand and rice growing areas on the other.

### 6.3.3.2 Pest and Disease Control

India is the only country in the world where all the four species of cotton, viz. *Gossypium arboreum , G. herbaceum, G. hirsutum* and *G. barbadenses* along with intra- and inter- specific hybrids, are cultivated along the diverse agroclimatic conditions, varying from 8-32$^{o}$ N latitude and 70-80$^{o}$ E longitude. The Asiatic or diploid cottons, *G. arboreum* and *G. barbadenses* (Egyptian cotton) were introduced in India by the East India Company during the nineteenth century. The cotton is grown in North, Central and South zones in India [22].In India about 162 insect species are found damaging the crop out of which about half a dozen are of economic importance. Due to insect and diseases infestation, both quality and the quantity are greatly reduced in various ways *e.g.* premature boll opening results in lint damage and discolouration and immature fiber [6]. Termite, (*Microtermes obesi*; *Odentotermes obesus*), jassid (*Amrasca biguttula biguttula)*, whitefly (*Bemisia tabaci*), mealybugs (*Phenacoccus solenopsis*), spotted bollworm, (*Earias insulana* and *Earias vittella*), pink bollworm (*Pectinophora gossypiella*) American bollworm (*Helicoverpa armigera*), tobacco caterpillar (*Spodoptera litura*) and red cotton bug (*Dysdercus cingulatus*) are the major insect pests of cotton in India. Cotton semilooper, thrips, dusky cotton bug, grasshopper, cotton grey weevil, shoot weevil, stem weevil, leaf miner and others are considered as minor insect pests. However, some insect pests are major in several regions in several regions in India. Thrips are also reported as major pests [3].

Insect pest management practices of involved cultural practices (phytosanitation, intercropping and hand picking), chemical insecticides spray and Integrated Pest Management (IPM) approach [3] is widely used control methods in India [6]. At the global level, roughly one fourth of the total pesticides used all over the world are applied to protect the cotton crop, while in India the share of the pesticide on this crop which occupies around 5 per cent of the cultivated area, is around 40 per cent of the national agricultural consumption of pesticides. Despite heavy use of pesticides, losses caused by insect pests continue to be unacceptably high. In India, the insect pests reduce cotton crop production by around 50 per cent [8]. The adoption of IPM technology over a 15 year period resulted in 73.7 and 12.4 per cent reduction in the number of insecticide sprays for the control of sucking pests and bollworms, respectively. Properly timed sprays along with a number of cultural and mechanical practices resulted in a 38.5 per cent reduction in bollworm incidence. Adoption of Inetegrated Pest Management (IPM) practices gave 23.2% higher yield and 31.7% higher net income of farmers [8, 24].

Among the diseases, root rot, cotton bacterial blight, alternaria leaf blight, grey mildew, powdery mildew, cotton leaf curl virus, verticillium wilt and Fusarium wilt are most important. Control options for diseases include cultural, chemical and integrated approach. In some cases, use of resistant varieties found most economic and environment friendly disease management.

### 6.3.4 Pakistan

#### 6.3.4.1 Geography and Climate

Pakistan is the 36$^{th}$ largest nation by total area. It has a 1,046km coastline along the Arabian Sea and the Gulf of Oman. Pakistan is bordered by Afghanistan, Iran, India, and China. Pakistan is also very close to Tajikistan, separated by the Wakhan Corridor. Pakistan is strategically located between the regions of South Asia, Central Asia, and the Middle East. This prime location- combined with varied natural resources, a diverse geography, and interesting environment- make Pakistan a noteworthy country.

The three primary geographical regions are the northern highlands, the Indus River plain, and the Balochistan Plateau. The northern highlands include the famous K2, Mount Godwin Austen. At 8,611 meters, it is the second highest peak in the world.

The major area of the cotton in Pakistan lies in Punjab followed by Sindh. However, the yield per hectare is slightly higher in Sindh as compared to Punjab. It ranks first as a fibre crop in the country being followed up by rice only in acerage and production.

#### 6.3.4.2 Pest and Disease Control

In Pakistan, cotton was grown on 3054.3 thousand ha in 2007-2008 with an average production of 649 kg/ha. In Khyber Pakhtoonkhwa, it was grown in 2007-2008 on 0.2 thousand ha that yielded on average 425 kg/ha [21]. The key insect pests of cotton are termite, *Microtermes obesi*; cutworm, *Agrotis ipsilon*; thrips, *Thrips tabaci*; jassid, *Amrasca biguttula biguttula*; whitefly, *Bemisia tabaci*; aphid, *Aphis gossypii*; leaf-roller, *Sylepta derogata*; red cotton bug, *Dyesdercus koenigii*; mite, *Tetranychus macfarlanei*; grey weevil, *Myllocerus undecimpustuletus maculosus*; spotted bollworm, *Earias insulana*; pink bollworm, *Pectinophora gossypiella* and American bollworm, *Helicoverpa armigera* (Dhaka and Pareek, 2007). In cotton, the insect pest infestation caused deterioration in lint quality and 10–40% losses in crop production (Gahukar, 2006). Mealybug (*Phenacoccus solenopsis* Tinsley) appeared recently and has attained the status of a serious pest on a wide range of host plants in Pakistan. It was recorded from 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees [Arif *et al*., 2009].

However, *Ferrisia virgata* Ckll., has been reported earlier as major pest on cotton in Pakistan [10].

The cotton insect pest management in Pakistan is mainly dominated by the use of broad-spectrum insecticides. Foliar application of insecticides at early stages can destroy natural enemies, however seed treatment with seed protectant insecticides are not only safe for natural enemies, but provide effective control of early stage sucking pests. One option to reduce the insecticide use on cotton is the exploitation of transgenic Bt cotton as a component of integrated pest management [11]. But transgenic Bt cotton proved not to be effective against sucking insect pests and insecticides were needed to control these pests. The seed treatment provided the better protection against early-season sucking pests in transgenic cotton [5]

### 6.3.5 Turkey

#### 6.3.5.1 Geography and Climate

Turkey is located on the Black, Aegean and Mediterranean Seas. The Turkish Straits (which are made up of the Sea of Marmara, the Strait of Bosphorus and the Dardanelles) form the boundary between Europe and Asia. As a result, Turkey is considered to be in both Southeastern Europe and Southwestern Asia. The country has a varied topography that is made up of a high central plateau, a narrow coastal plain and several large mountain ranges. The highest point in Turkey is Mount Ararat which is a dormant volcano located on its eastern border. The elevation of Mount Ararat is 16,949 feet (5,166 m).

The climate of Turkey is temperate and it has high, dry summers and mild, wet winters. The more inland one gets however, the harsher the climate becomes. Turkey's capital, Ankara, is located inland and has an average August high temperature of 83˚F (28˚C) and January average low of 20˚F (-6˚C).

#### 6.3.5.2 Pest and Disease Control

Turkish cotton area and production are projected to increase about 15 percent in MY 2016 to 425,000 hectares and 650,000 MT, respectively. Low returns in corn production and high local cotton prices, partly because of the antidumping investigation, during MY 2015 persuaded farmers to plant more cotton. Lack of rains during the winter months in all regions will require additional irrigation of cotton fields during the season. The lack of adequate irrigation water may become an issue if spring rains are not within seasonal averages or above. Using irrigation water will increase production costs for farmers. Cut worm (*Agrotis ypsilon*), mite (*Tetranychus cinnabarinus),* whitefly (*Bemisia tabaci),* American bollworm *(Heliocoverpa armigera),* spotted bollworm *(Earias insulana),* Leaf feeding caterpillar *(Spodoptera littoralis*) are the major pests of cotton in the Kilikien Plain in Southern Turkey; aphid (*Aphis gossypii*), Leaf feeding caterpillar *(Spodoptera exigua),* leaf hopper *(Empoasca* spp.) are occasional pests and thrips (*Thrips tabaci*), stink bug *(Nezara viridula),* lygus *(Lygus* spp.), seed bug (*Oxycarenus hyalinipennis*) are of little importance [23]. However, thrips was reported as major insect pests of cotton in Turkey [6] which developed resistance against several groups of insecticides, such as synthetic pyrethroids, organophosphate and carbamates. Pest control is improved if the exact time of appearance and the biology and ecology of these insect pests are known. *A. ipsilon* can be controlled effectively and economically by seed treatment. Seed sterilization and the destruction of crop residues significantly reduce the offspring and infestation of *P. gossypiella* and *E. insulana*. The number of chemical treatments for *T. cinnabarinus, B. tabaci, H. armigera, S. littoralis* can be reduced by the application of economic thresholds [23].

### 6.3.6 USA

#### 6.3.6.1 Geography and Climate

The country is situated between 38.00° North and 97.00° West having a total area of 9,629,091 square km of with 97.77% land and 2.23% water. The United States shares land borders with Canada (8,893 km) and Mexico (3,327 km) and maritime (water) borders with Russia, Cuba, and the Bahamas in addition to Canada and Mexico. USA has versatile climatic conditions, West: mostly semi-arid to desert, Northeast: humid continental, Southeast: humid subtropical, Coast of California: Mediterranean, Pacific Northwest: cool temperate oceanic, Alaska: mostly subarctic, Hawaii: tropical, and thus agriculture of this is also versatile.

#### 6.3.6.2 Insect Pests and Diseases

Cotton is susceptible to a wide range of insect pests. Among the most destructive are the cotton bollworm, plant bugs, stink bugs, aphids, thrips, and spider mites. Boll weevil also present in USA. Regardless of the pest, insect pest management is the highest variable cost associated with production of the cotton crop. The overall objective of the insect pest management research program is to develop and evaluate pest management strategies that are cost effective yet environmentally acceptable. Emphasis is placed on integrated pest management (IPM) techniques. Areas of research include threshold development; efficacy and resistance management of crop protection products; and development of methods to avoid insect pest problems through crop management, resistant varieties, and better understanding of the pest's biology/ecology and molecular genetics.

The major diseases of cotton are angular root rot, Verticillium wilt, leaf spot, boll rots, leaf spot, bacterial blight, root–knot, leaf curl and a physiological disease. Control options for diseases include cultural, chemical and integrated approach. Use of resistant varieties found most economic and environment friendly disease management in some cases.

### 6.3.7 Uzbekistan

#### 6.3.7.1 Geography and Climate

Uzbekistan is a country of Central Asia, located north of Turkmenistan and Afghanistan. With an area of 447,000 square kilometers, Uzbekistan stretches 1,425 kilometers from west to east and 930 kilometers from north to south. Bordering Turkmenistan to the southwest, Kazakhstan to the north, and Tajikistan and Kyrgyzstan to the south and east, Uzbekistan is not only one of the larger Central Asian states but also the only Central Asian state to border all of the other four. Uzbekistan also shares a short border with Afghanistan to the south. As the Caspian Sea is an inland sea with no direct link to the oceans, Uzbekistan is one of only two "doubly landlocked" countries—countries completely surrounded by other landlocked countries.

Uzbekistan's climate is classified as continental, with hot summers and cool winters. Summer temperatures often surpass 40 °C (104 °F); winter temperatures average about −2 °C (28 °F), but may fall as low as −40 °C (−40 °F). Most of the country also is quite arid, with average annual rainfall amounting to between 100 and 200 millimeters (3.9 and 7.9 in) and occurring mostly in winter and spring. Between July and September, little precipitation falls, essentially stopping the growth of vegetation during that period of time.

#### 6.3.7.2 Pest and Disease Control

Aphid and whitefly are the major sucking pests of cotton in Uzbekistan. In recent years abundances of lygus bug have become menacing for the cotton. The loss of crop yields from

bugs averages from 22.7 to 60% during the 1989-1996 period depending on the cotton variety [18]. The highest abundances of thrips, *Thrips tabaci* was observed from May up to middle of June. Nevertheless, American bollworm, *Helicoverpa armigera*; leaf feeder *Spodoptera exigua* red spider mite, *Tetranychus urticae* are the major pests of cotton in Uzbekistan which cause considerable damage of cotton every [19]. Cutworm noctuid is one of the most widely distributed pests in irrigated areas of cotton production. Management approaches for cotton pests are physical methods, application of chemical pesticides and biocontrol agents and Integrated Pest Management approaches. Some researchers [5] recommend early sowing of cotton, which decreases damage to shoots from winter-annual noctuid caterpillars. The upper plant parts should be removed from the field and destroyed in order to reduce the number of eggs and caterpillars of young cotton noctuids [19]. It has now been established that in Uzbekistan more than one hundred species of ladybirds (Coccinellidae) belonging to 25 genera exist [20]. The overwhelming majority of coccinellids attack whiteflies, red spider mites, eggs and caterpillars of younger noctuids on cotton. *Trichogramma evanescens* and *Bracon* sp. are used as parasitoids for the management of cotton insect pests [19].

### 6.3.8 Zimbabwe

#### 6.3.8.1 Geography and Climate

Zimbabwe is a landlocked country in southern Africa lying wholly within the tropics. It straddles an extensive high inland plateau that drops northwards to the Zambezi valley where the border with Zambia is and similarly drops southwards to the Limpopo valley and the border with South Africa. The country has borders with Botswana 813 km, Mozambique 1,231 km, South Africa 225 km, Zambia 797 km and meets Namibia at its western most point.

The climate is tropical, although markedly moderated by altitude. There is a dry season, including a short cool season during the period May to September when the whole country has very little rain. The rainy season is typically a time of heavy rainfall from November to March. The whole country is influenced by the Inter tropical Convergence Zone during January. In years when it is poorly defined there is below average rainfall and a likelihood of serious drought in the country (as happened in 1983 and 1992). When it is well-defined rainfall is average or well above average, as in 1981 and 1985.

Main land use type based on annual rainfall –

1. Above 1050 mm/annum with some precipitation in all months of the year Afforestation, fruit, tea, coffee and intensive livestock production
2. 750–1000 mm/annum seasonally confined with well-defined dry season Large scale intensive crop and livestock production
3. 650–800 mm/annum with regular mid-season dry spells Livestock production with fodder crops. Marginal production of maize, tobacco and cotton
4. 450-650 mm/annum with periodic seasonal drought and severe rainy season dry spells Livestock production and drought resistant crops
5. Too low and erratic for even drought resistant fodder and grain crops Extensive livestock and/or game ranching.

Cotton is Zimbabwe's second largest export crop after tobacco. The crop is produced mainly by smallholder farmers that cultivate small plots of between one and two hectares under rain fed conditions. There are three main cotton production areas in Zimbabwe. Approximately 98 percent of the cotton crop in Zimbabwe is grown through contract farming arrangements since smallholder farmers lack collateral to access money independently from banks. The area planted

with cotton seed in the 2014/15 MY is estimated at 210,000 hectares with annual production of 126,000 metric tons seed cotton and 51,660 metric tons lint production.

#### 6.3.8.2 Insect Pests and Diseases Of Cotton

Many insect pests attack cotton of which pink bollworm, the chilli thrips, the cotton seed bug, the tarnish plant bug and the armyworm are major ones. Chemical insecticides are therefore indispensible cotton growing components. In Africa, crop protection is still centered on chemical control of pests and alternative approaches are still minimal. The government of Zimbabwe prohibits the commercial production of transgenic cotton but allows for confined non-commercial testing of Genetically Engineered (GE) varieties, under the supervision of the Biotechnology Authority of Zimbabwe. Entry of GE varieties in the country is regulated through the National Biotechnology Act.

Root rot, cotton bacterial blight, alternaria leaf blight, grey mildew, powdery mildew, cotton leaf curl virus, verticillium wilt and Fusarium wilt are important diseases of cotton. Control options for diseases include cultural, chemical and integrated approach. In some cases use of resistant varieties is found to most economic and environment friendly disease management.

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# 7 Hazard Identification

## 7.1 Potential Hazard Groups

Eighty seven organisms are identified as potential hazards associated with cotton in different cotton growing countries of the world. Of of these 38 species were insect pests and one mite pest (Table 5), sixteen diseases [12 are caused by fungi, two by bacteria, one by virus and one by nematode (Table 7) and 32 weeds (Table 9)].

These insect pests feed on leaves, shoots and roots of cotton, suck the cell sap from different parts of the plant, bore the bolls and flowers, and cut the base of seedling. Some insect pests inject toxic substance during sucking and transmit diseases. Among the insect and mite pests, 21 species were major and 18 species were minor pest. Ten species of insect pests are absent in Bangladesh and they are considered as quarantine pests of cotton for Bangladesh. Among them, three species viz., *Phenacoccus gossypii*, *Lygus lineolaris* and *Anthonomus grandis* are present in North and Central America, and seven species of insect pests such as *Phenacoccus solenopsis, Cerococcus indicus, Alcidodes affaber, Pempherulus affinis*, *Myllocerus undecimpustulatus, Liriomyza trifolii and Dasineura gossypii* are present in China, India, Pakistan, Turkey, Egypt and other Asian countries. Cotton seed and lint are imported from China, India, Egypt, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe. Phytosanitary measures should be taken to import cotton seed, lint or other plant parts to which quarantine pests are associated.

Out of 16 diseases of cotton recorded in eight cotton exporting countries, two were identified as quarantine organism for Bangladesh namely Verticillium wilt and leaf curl virus. Both the diseases are destructive. Thirty two weeds were recorded from cotton fields in Bangladesh as well as in the world. Although parthenium is present in Bangladesh in limited area, yet it was considered as a quarantine weed.

## 7.2 Organisms Intercepted at the Border on Cotton on Existing Pathways

Information is scant about organisms intercepted at the border with cotton seed and lint in Bangladesh.

## 7.3 Other Risk Characteristics of the Commodity

Although many pests dealt with in this risk analysis have 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.

### 7.3.1 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 will 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 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 in course of time.

### 7.3.2 Symptomless Micro-Organisms

Pests such as microbes and fungi infect seed/lint 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 half-filled grain and or plant debris associated with the grain rather than taking it to a diagnostic laboratory so there is little data on post entry appearance of “invisible organisms.

## 7.4 Assumptions and Uncertainties

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.

### 7.4.1 Hazard Biology and Identification

- The biology of insectpests 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-ovipositional 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 greenhouse was longer and higher than those in a growth chamber with similar conditions.

- It is difficult to predict how a specimen 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 surviving on 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. *Anthonomus grandis* and *Phnacoccus solenopsis* 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.

### 7.4.2 Assumption Regarding Transit Time of Cotton Seed and Lint

An assumption is made around the time of cotton seed and lint take to get from the field in India, China, Pakistan, Egypt, Turkey and Uzbekistan 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 otherhand, time required for importing from India by road may take 10-15 days.

### 7.4.3 Assumption and Uncertainty around Disposal

It is not known what proportion of imported cotton seed will be discarded during cleaning before crushing. It is assumed that a portion of bolls that might have been infested or contaminated will be disposed-off in a manner that exposes any potential hazard organisms on that bolls to

suitable hosts. Disposal would include discarding plant debris on urban or rural roadsides, in bush reserves, in open rubbish bins in public places, and on open composts in domestic areas.

### 7.4.4 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. None of the registered fungicide could kill the spores; rather inhibit germination when tested after treatment.

This approach makes the following assumptions, that:

- 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 cotton. In the absence of efficacy data, assumptions are made on the basis of data for similar species or similar treatments.

# 8 Review of Management Options

## 8.1 Introduction

This chapter provides background information on possible measures to mitigate the biosecurity risk associated with importing cotton from China, Egypt, India, Pakistan, Turkey, USA, Uzbekistan and Zimbabwe.

## 8.2 Production and Post-Harvest Measures

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

### 8.2.1 Monitoring Programs in Production Areas

Monitoring of infield pest and pathogens is the key to optimize production while reducing pest and/or disease-related problems, for instance:

- insect pests- regular inspection of leaves, stems, flowers etc. of cotton in field to monitor invertebrate population levels.
- 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.

### 8.2.2 In-field Sanitation

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

### 8.2.3 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 insects such as certain bollwroms, and the introduction of biocontrol agents such as entomophagic fungi or parasitizing insects.

### 8.2.4 Selection of Bolls and Lint from Areas Free of Pests (Area Freedom)

Several species identified as of quarantine concern to Bangladesh appear to have restricted distributions in the importing countries. If it is possible to guarantee the source of seed and lint, obtaining it from insect or disease free areas will reduce the risk of importation of these species, although it will not completely eliminate the risk.

## 8.3 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.

### 8.3.1 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. Phosphine or Methyl Bromide is used to disinfest the cotton lint, seed or other cotton products

#### 8.3.1.1 Phosphine Fumigantion

Phosphine fumigants are sold as solid aluminum or magnesium phosphide, both of which give off the highly toxic phosphine gas. Phosphine fumigants provide control at all stages of insect pests. The fumigants are available as tablets or pellets. Tablets 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 with moisture and temperature. The higher the temperature and moisture, the faster the fumigant will be evolved. Conversely, the lower the temperature and moisture, the slower the fumigation. However, when the temperature of 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 resalable aluminum flasks containing 30, 100 or 500 tablets each. The pellets weigh approximately 0.6 grams and release 0.2 gram of phosphine gas. They are about 9 mm in diameter and are packaged in resalable flasks containing about 166, 500 or 1666 pellets.

#### 8.3.1.2 Dosage and Exposure Time

To determine the dosage and exposure time, always read the label. Dosage and exposure time varies with temperature and the air tightness, or storage facility. Increasing dosage cannot compensate for a shortened exposure.

When fumigating, the dosage is usually 180-500 tablets or 880-2500 pellets tablets per 100 cubic metres. The higher end of the dosage range may be required under sub-optimal conditions, where diffusion may be slow and a larger amount is needed to achieve effective phosphine levels.

Exposure time is related to the temperature of the as indicated in Table 11. Raw lint of cotton or seed which are to be fumigated must have an accurate temperature reading before fumigation is initiated. The use of a probe thermometer placed approximately 1 meter into the top of the bales is recommended. High temperature may have to be turned shortly after the fumigation is complete to prevent spoilage.

**Table 11: Alluminium Fumigant Exposure Time based on the Temperature of the Commodity**

| Temperature of the prdouct | Fumigant Exposure Time for Aluminum Phosphide |
|---|---|
| above $20^0$C | 3 days |
| $16^0$C to $20^0$C | 4 days |
| $13^0$C to $15^0$C | 5 days |
| $5^0$C to $12^0$C | 10 days |
| below $5^0$C | DO NOT FUMIGATE |

### 8.3.2 Methyl Bromide Fumigantion

Chemical composition methyl bromide is $CH_3Br$ and it is also known as bromomethane. It is produced from both human sources and natural ones. The properties of methyl bromide make this an effective and versatile fumigant used to kill unwanted pests. The most important advantage is its ability to penetrate quickly and deeply into sorptive materials at normal atmospheric pressure. Also, at the end of a treatment, desorbtion and vapours dissipate rapidly allowing the safe handling of commodities. Methyl Bromide is used most commonly for the eradication of quarantine pests from import and export cargo. While it still remains a useful tool at the border, it is an ozone depleting substance and efforts are being made to reduce both the use and emissions of the gas.

Methyl bromide is a colourless, odourless, nonflammable and non-explosive gas under ordinary circumstances. It is three times heavier than air and can accumulate in poorly ventilated or low-lying areas. However the application methods of heating the gas on input and circulation by fans in the enclosure assist in the even distribution of the gas.

### 8.3.3 Dosage and Exposure Time

To determine the dosage and exposure time, always read the label. Dosage and exposure time varies with temperature and the air tightness, or storage facility. Increasing dosage cannot compensate for a shortened exposure. The dosage and exposure time for raw lint of cotton (*Gossypium* spp.), seed, waste fabric, waste cotton, cotton seed cake, meal, bags that have been used as a container for lint or any form of unmanufactured cotton are shown in Table 12.

**Table 12: Methyle bromide fumigation for cotton and cotton products at atmospheric pressure against boll weevil**

| Temperature | Initial Dosage | Exposure Time |
|---|---|---|
| 4.5-9.5°C | 96 g $m^{-3}$ | 8 h |
| 10-12.5°C | 80 g $m^{-3}$ | 4 h |
| 13-15°C | 80 g $m^{-3}$ | 3 h |
| 15.5-20.5°C | 64 g $m^{-3}$ | 3 h |
| 21-26°C | 64 g $m^{-3}$ | 3 h |
| 26.5-31.5°C | 48 g $m^{-3}$ | 2 h |
| 32°C | 40 g $m^{-3}$ | 2 h |

## 8.4 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.

# 9 Potential Hazard Organisms: Risk Analyses

## INSECTS

## 9.1 Cotton mealybug (*Phenacoccus solenopsis*)

### 9.1.1 Hazard identification

**Common name:** Cotton mealybug
**Scientific name:** *Phenacoccus solenopsis* Tinsley
**Synonyms:** *Phenacoccus cevalliae* Cockerell 1902, *Phenacoccus gossypiphilous* Abbas et al. [1]
**Taxonomic tree**

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

**Bangladesh status:** Not present in Bangladesh [4]

**EPPO code:** PHENSO. This pest has been included in EPPO alert list [5].
*P. solenopsis* is a native to USA [9] and introduced to many Asian countries. It is highly invasive species [4, 5].

### 9.1.2 Biology

Females of this ovoviviparous, bisexual species have been reported as capable of producing from 150 to 600 eggs, protected within a waxy ovisac. 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 [8].

### 9.1.3 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 [3]. 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].

### 9.1.4 Geographic Distribution

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, India, Indonesia, Iran, Iraq, Japan, Pakistan, Sri Lanka (localized), Taiwan (localized),Thailand (localized) [4, 5], Turkey [7], Vietnam (localized).
**Africa:** Bennin, Cameroon, Egypt [2], Ghana, Mali, Mauritius, Nigeria, Senegal.
**North America:** Canada (present but few occurrences), Mexico (present but few occurrences), USA **(Native).**
**Central America and Caribbean**: Belize, Cuba, Dominican Republic, Jamaica, Nicaragua. Panama [4, 5].
**Europe:** Cyprus, Netharlands [4, 5].
**Oceania:** Australia (restricted distribution) [4, 5].

### 9.1.5 Hazard Identification Conclusion

Considering the facts that *Phenacoccus solenopsis* –

- is not known to be present in Bangladesh [4, 5];
- is potentially economic important to Bangldesh because it is an important pest of cotton in Egypt, South Africa, Asia (China, India, Pakistan, Vietnam, Iran, Iraq and other Asian countries), Africa (Egypt and other countries) [4, 5] from where cotton seeds and lint are imported to Bangladesh.
- can become established in Bangladesh through imports of the cotton seed or lint or plant parts. It has capability to cause direct economic and ecological damage to many valuable cultivated crops [5].

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

### 9.1.6 Risk Assessement

#### 9.1.6.1 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. It has been introduced in many new countries with plant trades recently [4, 5].The probability of entry into Bangladesh with cotton seed and lint is medium.

#### 9.1.6.2 Exposure Assessment

After entering 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.

#### 9.1.6.3 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.Morover, environmental conditions are also favourable for its growth, development and reproduction. Therefore, the probability of establishment of the insect pest in the PRA area is high.

#### 9.1.6.4 Determination of likelihood of the pest establishing via this pathway in Bangladesh

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

| Description | The Establishment Potential is: |
|---|---|
| • This pest has established in several new countries in recent years, and (**Yes**– *Many Asian countries* [4, 5]).<br>• The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, cotton seed, lint or parts of different host plants are the means of dispersal of this pest* [4]).<br>• Its host(s) is 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<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established | Low |

### 9.1.7 Consequence Assessment

#### 9.1.7.1 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.

#### 9.1.7.2 Environmental consequence

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.

#### 9.1.7.3 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. 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, | High |

| | |
|---|---|
| 6,10].This mealybug caused serious damage to cotton in Pakistan in 2005 and India.<br><br>• This is a serious pest of several important crops (tomato, brinjal, okra, sesame) for Bangladesh | |
| • Not as above or below | Moderate |
| • This is not likely to be an important pest of common crops grown in Bangladesh. | Low |

### 9.1.8 Risk estimation

Calculation of risk of this pest via this pathway in Bangladesh

| | | | | |
|---|---|---|---|---|
| **Establishment Potential** | **X** | **Consequence Potential** | **=** | **Risk** |

**Table 3: Calculation of risk**

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

**CALCULATED RISK RATING–High**

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

### 9.1.9 Possible Risk Management 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.
- Avoid importation of seeds or bolls of cotton 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.

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## 9.2 Mexican mealybug (*Phenacoccus gossypii*)

### 9.2.1 Hazard Identification

**Common name:** Mexican mealybug or Cassava mealybug
**Scientific name:** *Phenacoccus gossypii* Townsend and Cockerell
**Synonyms:** *Phenacoccus helianthi gossypii* (Cockerell, 1899)

**Taxonomic tree**

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

**Bangladesh status:** Not present in Bangladesh [7].

**EPPO code:** PHENGO [6].

### 9.2.2 Biology

The life cycle of *P. gossypii* was studied with females placed on excised cassava stems (M Col 113) in the laboratory (Temperature $26^0$C -$28^0$C, 75-85% RH). Three nymphal instars averaged 8.6. 5.7 and 6.3 days, respectively. Adult females survived up to 21 days. Oviposition started between the fifth and seventh day and continued for 5 days. An average of 328 eggs per female was oviposited with most eggs produced the first day and steadily decreasing thereafter. All eggs remain in an egg pouch on the posterior part of the female's body until the nymphs hatch. While nymphs in all ins tars are mobile they may feed in one site for several days. They prefer to feed on the underside of leaves or on tender stems. The female is wingless, whereas males have wings enabling flight. Males pass through two nymphal stages, (8.5 and 6.0 days, respectively), a prepupal (2.1 days) and pupal (2.1 days) stage before adults emerge. Adult males live up to 3 days.

### 9.2.3 Hosts

Hosts include cotton (*Gossypium* spp), cassava (*Manihot esculenta*)**,** ornamental plants such aschrysanthemum, English ivy, geranium, Gynura, hollyhock, Ixia, lantana, and poinsettia [6].

### 9.2.4 Geographic Distribution

North America as whole, USA, Mexico, Bahamas, Bemuda, Cuba, Puerto Rico, Hawaii [5], Brazil, Colombia, Peru [3] Japan, Spain [6].

### 9.2.5 Hazard Identification Conclusion

Considering the facts that *P. gossypii* –

- is not known to be present in Bangladesh [4, 5];
- is not likely potentially economic importance to Bangladesh because it is an important pest of cotton in North America (USA, Mexico) but minor in India. Cotton is imported for seed and lint only from India where it is a minor pest. The probability of iIntroduction of this pest through imported cotton bolls, seed or lint is low [7].

- is not likely to establish in Bangladesh through imports of the cotton seed or lint or plant parts from India.

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

### 9.2.6 Risk Assessement

#### 9.2.6.1 Entry Assessment

Nymphs and adults of*P. gossypii* are transported with flowers, leaves, stems, inflorescences, shoots, trunks. It can be transported with cargo and aircraft for long distance. The pathway of of entry in Bangladesh does not appear good for the pest. The probability of entry into Bangladesh with cotton seed and lint is low.

#### 9.2.6.2 Exposure Assessment

After entering 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. Host plants of *P. gossypii* are not available in Bangladesh. Therefore, the probability of exposure of *P. gossypii*in Bangladesh environment is low.

#### 9.2.6.3 Establishment Assement

Host plants of *P. gossypii* are not common in Bangladesh other than cotton. But environmental conditions are favourable for its growth, development and reproduction. The pest does not established in new countries recently. Therefore, the probability of establishment of the insect pest in the PRA area is low.

#### 9.2.6.4 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 **NO**<br>• The pathway appears good for this pest to enter Bangladesh and establish, and<br>• Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established | No |
| • Not as above or below | Moderate |
| • This pest has **not** established in new countries in recent years, and **YES**<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and **YES**<br>• Its host(s) is**not** common in Bangladesh and its climate is **not** similar to places it is established. Its hosts are fairly common but climate is favorable for its establishment. | **Low** |

### 9.2.7 Consequence Assessment

#### 9.2.7.1 Economic

Nymphs and adults of *P. gossypii* suck the cell sap from different parts of cotton plant and casuse stunting and wilting of the plant. But it does not cause major damage. Therefore, once the pest is established in Bangladesh the probability of causing economic damage to the crop is low.

#### 9.2.7.2 9.2.7.2 Environmental

No environmental impact has been reported for the pest.

#### 9.2.7.3 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, or **NO**<br>• This is a fairly serious pest of several important crops for Bangladesh.**NO** | High |
| • Not as above or below | Moderate |
| • This is not likely to be an important pest of common crops grown in Bangladesh. **YES** | **Low** |

### 9.2.8 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–LOW**

Considereing all these *P. solenopsis*is not a potential risk organism for Bangladesh. However, risk management to prevent entry of this pest is necessary.

### 9.2.9 Possible Risk Management Measures

- Planting material of host-plant species of *P. gossypii* should be inspected in the growing season previous to shipment and be found free of infestation.
- Avoid importation of seeds or bolls of cotton or other host plants from countries where *P. gossypii* occurs.
- It is relatively easy to detect the *P. gossypii* 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. gossypii* after the consignment has arrived in Bangladesh.

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## 9.3 Yellow cotton scale (*Cerococcus indicus*)

### 9.3.1 Hazard Identification

**Common name:** Yellow cotton scale
**Scientific name:** *Cerococcus indicus* (Maskell)
**Synonyms:** Yellow scale, spiny brown coccid
**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Homoptera
Family: Cerococcidae
Genus: *Cerococcus*
Species: *Cerococcus indicus*

**Bangladesh status:** Not present in Bangladesh.
This species is commonly known as the yellow scale of cotton (however, it is not an important pest of cotton) though isolated plants are often badly covered [6]. This species is a serious pest of *Acacia* sp.and that young trees severely infested appear white because of the high number of scales [5].

### 9.3.2 Biology

*Ceroccus* has one generation each year and overwintering takes place in the egg stage inside of the female test. Eggs hatch in the spring and first instars leave the test through a small hole at the posterior end. Second instars appear in early summer and adults occur in mid to late summer. Eggs are laid in the test in the fall. Males occur in most species. This species occurred from March to November [7]. Female insect is covered by a compact test which varies considerably in color and texture.

Some are thickly coated with pinkish tomentum from which many coarse glassy filaments project. Others have a more compact globular test of a dull brown color with a superimposed scurfy covering of yellow secretion. Adult female is broadly pyriform, abdominal segments narrowed and tapering to posterior extremity [3].

### 9.3.3 Hosts

Cerococcids are normally collected on woody shrubs or trees and are not recorded from grasses (with the exception of an incidental record of *Cerococcus indicus* (Maskell)) and most herbaceous plants. They are most commonly found on the stems and twigs of their hosts and apparently prefer 1- or 2-year old growth. This pest is reported from 17 genera and under 9 families which include Malvaceae, Fabaceae, Poaceae, Solanaceae, Myrtaceae, Rubiaceae, Achariaceae, Boraginaceae and Cochlospermaceae. But most of the genera (12) are under Malvaceae family which are *Abelmoschus esculentus*,*Corchorus capsularis*, *Gossypium*, *Gossypium herbaceum*,*Grewia biloba*, *Helicteres isora*, *Hibiscus cannabinus, Hibiscus liliiflorus, Hibiscus mutabilis, Hibiscus rosa-sinensis, Hibiscus syriacus,and Thespesia populnea* [4, 6].

### 9.3.4 Geographic Distribution

Myanmar [2], China, India [2, 7, 8, 9], Malaysia, Kenya, Pakistan [1], Saudia Arabia, Sri Lanka, Tanzania and Fiji [7].

### 9.3.5 Hazard Identification Conclusion

Considering the fact that *C. indicus*-

- is not known to be present in Bangladesh;
- is not likely potentially economic importance to Bangladesh because it is minor pest in India. The probability of iIntroduction of this pest through imported cotton bolls, seed or lint is low.
- probability to establish in Bangladesh through imports of the cotton seed or lint or plant parts is low.

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

### 9.3.6 Risk Assessment

#### 9.3.6.1 Entry Assessment

Nymphs and adults of *C. indicus* are transported with flowers, leaves, stems, inflorescences, shoots, trunks. It can be transported with cargo and aircraft for long distance. The pathway of of entry in Bangladesh does not appear good for the pest. The probability of entry into Bangladesh with cotton seed and lint is low.

#### 9.3.6.2 Exposure Assessment

After entering into Bangladesh, *C. indicus* 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. Host plants of *P. gossypii* are not available in Bangladesh. Therefore, the probability of exposure of *C. indicus* in Bangladesh environment is low.

#### 9.3.6.3 Establishment Assessment

Host plants of *C. indicus* are not common in Bangladesh other than cotton. But environmental conditions are favourable for its growth, development and reproduction. The pest does not established in new countries recently. Therefore, the probability of establishment of the insect pest in the PRA area is low.

#### 9.3.6.4 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**<br>• The pathway appears good for this pest to enter Bangladesh and establish, and **NO** | High |

| Description | The Establishment Potential is: |
|---|---|
| • Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established **YES** | |
| • Not as above or below | Moderate |
| • This pest has **not** established in new countries in recent years, and **YES**<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and **YES**<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established It | **Low** |

### 9.3.7 Consequence Assessment

#### 9.3.7.1 Economic

Nymphs and adults of *C. indicus* suck the cell sap from different parts of cotton plant and casuse stunting and wilting of the plant. But it does not cause major damage. Therefore, once the pest is established in Bangladesh the probability of causing economic damage to the crop is low.

#### 9.3.7.2 Environmental

No environmental impact has been reported for the pest.

#### 9.3.7.3 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, or<br>• This is a fairly serious pest of several important crops for Bangladesh. | |
| • Not as above or below | Moderate |
| • This is not likely to be an important pest of common crops grown in Bangladesh. | **Low** |

### 9.3.8 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 |

| 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–LOW**

Considereing all these *C. indicus* is not a potential risk organism for Bangladesh. However, risk management to prevent entry of this pest is essential.

### 9.3.9 Possible Risk Management 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.
- Avoid importation of seeds or bolls of cotton or other host plants from countries where the pestoccurs.
- Visual inspection at the border when consignment has arrived

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## 9.4 Tarnished plant bug (*Lygus lineolaris* )

### 9.4.1 Hazard Identification

**Common name:** Tarnished plant bug
**Scientific name:** *Lygus lineolaris* Palisot de Beauvois
**Synonyms:** Cotton lygus

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Hemiptera
Family: Miridae
Genus: *Lygus*
Species:*Lygus lineolaris*

**Bangladesh status:** Not present in Bangladesh.

**EPPO Code:** LYGULI [3]

*L. lineolaris* causes significant yield losses in cotton (*Gossypium hirsutum*), canola/oilseed rape (*Brassica napus*), mustard (*Sinapis alba*), seed 81ahlia81 (Medicago sativa), vegetable crops such as *Phaseolus vulgaris* and *P. lunatus,* fruit crops such as strawberry (Fragaria x ananassa), apple (*Malus domestica*) and peach (*Prunus persica*), and nursery stock. It is the principal 81ahli pest of these crops in the eastern and southern USA [11]. Yield losses of up to 32% due to direct damage (square shedding) and indirect damage (changes in fruiting branch development) by *L. lineolaris* were reported in Mississippi, USA, with the highest insect densities recorded delaying crop maturity by two weeks [2].

### 9.4.2 Biology

Overwintering as adults, *Lygus lineolaris* can be found in dead weeds, leaf litter, under tree bark, and in rock piles in fields, timber margins, stream and ditch banks, and road rights-of-way. Adults become active in early spring and feed on newly developing buds and shoots. Most nursery damage occurs from mid-April to late June [1, 5, 7].

Oviposition is apparently restricted to composite host plants (non-conifers). Eggs are often deposited in leaf petioles or at the base of the leaf blade, but the preferred location varies with the crop attacked [4]. In conifers, eggs are inserted into flowerlets or blossoms. Eggs are usually deposited singly, but occasionally more than one egg will be found in an oviposition site [4]. After seven to 10 days, ca. 1 mm long, yellowish-green nymphs emerge and begin feeding. There are five nymphal stages. The life cycle is completed in three to four weeks. There are two to three generations per year [7, 9, 12]. Population peaks for adults generally occur in early July, early August, and early September [9, 10].

### 9.4.3 Hosts

At least 385 host plants have been recorded for *Lygus lineolaris*. A majority of the hosts are in the subclasses Rosidae and Asteridae. Major hosts are *Gossypium hirsutum* (Cotton), *Amaranthus cruentus* (redshank), *Apium graveolens* (celery), *Brassica napus var. napus* (rape), *Brassica oleracea var. botrytis* (cauliflower), *Fragaria ananassa* (strawberry), *Medicago sativa* ( 81 ahlia 81 ), *Phaseolus lunatus* (lima bean), *Phaseolus vulgaris* (common bean), *Prunus*

*persica*(peach), *Solanum tuberosum* (potato), *Trifolium incarnatum* (*Crimson clover*), *Vicia sativa* (common vetch), *Zea mays* subsp. *Mays* (sweetcorn) [3].

### 9.4.4 Geographic Distribution

*Lygus lineolaris* occurs in all Canadian provinces, the continental United States, and most of the states of Mexico [6, 7, 12], Burmuda, El Salvador, Honduras [6].

### 9.4.5 Hazard Identification Conclusion

Considering the fact that *L. lineolaris* –

- is not known to be present in Bangladesh;
- is not likely potentially economic importance to Bangladesh because it is not present in India, Pakistan, China, Egypt and other Asian countries.
- is not likely to establish in Bangladesh through imports of the cotton seed or lint or plant parts through this pathway.

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

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## 9.5 Cotton boll weevil (*Anthonomus grandis*)

### 9.5.1 Hazard Identification

**Common name:** Cotton boll weevil
**Scientific name:** *Anthonomus grandis* Boheman, 1843
**Synonyms:** Mexican cotton boll weevil

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Curculionidae
Genus: *Anthonomus*
Species: *Anthonomus grandis*

**Bangladesh status:** Not present in Bangladesh [2, 6].
**EPPO Code:** ANTHGR, *A. grandis* is listed as an A1 list No. 31 quarantine pest by EPPO [2, 6].

### 9.5.2 Biology

The life cycle of *A. grandis* is completed in 17-21 days under favourable conditions and as many as seven generations may develop in a year. They feed on developing cotton foliage and the females lay eggs singly in cotton flower buds. In cases of high weevil populations and shortages of buds, two or more eggs may be laid in one bud; however, this is of minor significance since only one weevil matures in a flower. Eggs hatch in 3-5 days; 50-51 h is the minimal time for egg development at 30°C. The larvae feed for 7-12 days inside the flower or boll and then pupate. This stage lasts 3-5 days. The emerging adults cut their way out of the flowers or bolls and after feeding for 3-7 days they mate. The females begin egg-laying within 20 min of mating, depositing one egg per hour in daylight. Successive multiple mating occur, the females being attracted by a male pheromone. A temperature of 35°C prolonged the developmental period. There is extremely high mortality in weevil populations. About 95% of the hibernating adults die; heat, dry weather, insect parasites and predators and birds help materially to check rapid multiplication [2].

### 9.5.3 Hosts

The principal host of *A. grandis* is cotton, including *Gossypium barbadense*, *G. hirsutum* and wild *Gossypium* spp. There is also significant reproduction of boll weevils in nature on a number of wild malvaceous hosts, including weeds [3].

### 9.5.4 Geographic Distribution

*A. grandis* is indigenous to Central America (probably originating in southern Mexico and Guatemala) and spread into the USA [1], where it was first recorded in Texas in 1898, and into the Caribbean. It has since spread to all cotton-growing areas of the USA and recently to Brazil.
**EPPO region**: Absent [2, 3, 4].
**Asia:** Absent
**Africa**: One or two records appearing in the literature are unconfirmed.
**North America**: South-eastern USA (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina (eradicated), Oklahoma, South Carolina, Tennessee, Texas, Virginia (eradicated)) and north-eastern Mexico. **Central America and Caribbean**: El Salvador, Haiti and the Dominican Republic, Belize, Costa Rica, Guatemala, Honduras,

Nicaragua and Caribbean (Cuba) **South America**: Argentina, northern Colombia, Ecuador, Paraguay and Venezuela, and Brazil. It is under eradication in São Paulo.
**EU**: Absent [2, 4].

### 9.5.5 Hazard Identification Conclusion

Considering the fact that *A. grandis*

- is not present in Bangladesh [2, 4]
- is not likely potentially economic importance to Bangladesh. Because it is a subtropical pest and an serious pest of cotton in North America (USA, Mexico), Central America and Caribbean region and South America [2, 6] from where cotton is not imported.
- can become establish in Bangladesh if is it is introduced with cotton seeds or bolls, with raw cotton and various cotton products from the country of its establishment [3].

It is a **quarantine pest** for Bangladesh and may be considered as **potential hazard organism** in this risk analysis.

### 9.5.6 Risk Assessment

#### 9.5.6.1 Entry Assessement

In international trade, larvae and pupae of boll weevils may be carried with cotton seeds or bolls, with raw cotton and various cotton products. The pathway appears good for this pest to enter Bangladesh. So the probablilty of entry is medium.

#### 9.5.6.2 Exposure Assessment

After entering into Bangladesh, *A. grandis* may be carried to different places of the country. During loading and unloading at different locations, larva and pupae of boll weevil may be exposed to the environment and attack different host plants. Host plants of *A. grandis* are not available in Bangladesh. Therefore, the probability of exposure of *A. grandis* in Bangladesh environment is medium.

#### 9.5.6.3 Establishment Assessment

Host plants of *A. grandis* are not common in Bangladesh other than cotton. But environmental conditions are favourable for its growth, development and reproduction. The pest does not established in new countries recently. Therefore, the probability of establishment of the insect pest in the PRA area is low.

#### 9.5.6.4 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*** [3].<br><br>• The pathway appears good for this pest to enter Bangladesh and establish, and (**NO,** Bangladesh does not import cotton seed, boll or lint from USA and Mexico. The major pathway of dispersal is through cotton seeds or bolls, with raw cotton and various cotton products [4]. | 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** | |
| • Not as above or below | **Moderate** |
| • This pest has **not** established in new countries in recent years, and ***YES***<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and ***YES***<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established (***No****, Cotton is not widely cultivated in Bangladesh*). **[2]** | **LOW** |

### 9.5.7 Consequence Assessement

#### 9.5.7.1 Economic

Since its entry into Texas in the 1890s from Central America, the boll weevil has destroyed and reduced the quality of several billion dollars' worth of cotton, over 3 million ha. In the 1970s, USA cotton producers lost 200 million US$ or more annually; suppression costs an additional 75 million US$ annually; in fact, nearly one third of all pesticides applied to crops in the USA are used to control this pest. Cotton is not widely cultivated in Bangladesh. It is not pest of other important crops in Bangladesh. So the economic consequence of this pest is moderate.

#### 9.5.7.2 Environmental

It is a major pest of cotton and cause huge damage during production. More insecticides will require for its management that will create environmental pollution.

#### 9.5.7.3 Determination of Consequence of the Pest Establishing Via This Pathway in Bangladesh

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

| Description | Consequence |
|---|---|
| • This is a serious pest of an important crop for Bangladesh, or (**YES,** The host range of *A. grandis* is cotton, including *Gossypium barbadense*, *G. hirsutum* and wild *Gossypium* spp. Cotton is not widely cultivated in Bangladesh [4]).<br>• This is a fairly serious pest of several important crops for Bangladesh. **NO [2]** | High |
| • Not as above or below | **Moderate** |
| • This is **not** likely to be an important pest of common crops grown in Bangladesh. | Low |

### 9.5.8 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-LOW

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

### 9.5.9 Possible risk management measures

- Avoid importation of seeds or bolls of cotton from countries where *A. grandis* occurs [5].
- Raw cotton from the same origin (including waste fabric, waste cotton, cotton seed cake, meal, bags that have been used as a container for lint or any form of unmanufactured cotton) should be fumigated with phosphine @ 64 g $m^{-3}$ for 3 hoursat 15.5 -2 0.5$^0$C temperature or methyl bromide @ 1.3 g $m^{-3}$ for 3 hours at >10$^0$C temperature [5].
- Quarantine or fumigation of cottonseed and cotton bales to guard against boll weevil introductions is unnecessary because ofno chance of a boll weevil being segregated alive into the cottonseed or of one surviving in the lint to approach the bale press[7].
- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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## 9.6 Cotton shoot weevil (*Alcidodes affaber*)

### 9.6.1 Hazard Identification

**Common name:** Cotton shoot weevil
**Scientific name:** *Alcidodes affaber* Aurivillus
**Synonyms:** Internode borer

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Curculionidae
Genus: *Alcidodes*
Species: *Alcidodes affaber*

**Bangladesh status:** Not present in Bangladesh.
*Alcidodes affaber* is one of the major pests of cotton in Karnataka, India [3]. It is also reported as major pest of all over the South India [1]. The younger plants are especially susceptible to this borer.

### 9.6.2 Biology

The biology of cotton shoot weevil, *Alcidodes affaber* Aurivillius was studied under laboratory condition during 2013 and 2014 at the Agricultural Research Station, Dharwad farm, University of Agricultural Sciences, Dharwad, Karnataka. The incubation period was 4.5±0.50 (4-5 days) and 4.4±0.49 days (4-5 days) during 2013 and 2014, respectively. Larval period was 73.2±2.88 days with a range of 64 to 78 days during 2013 while; it was 71±2.01 days with the range of 66 to 75 days during 2014. Pre pupal period was only one day during both the years. Pupal period was 10.76±0.89 (10-12 days) and 10.73±0.90 days (10-12 days) during 2013 and 2014, respectively. The total life span from egg to adult varied from 79 to 94 days with an average of 89.46±3.04 days during 2013 and it varied from 81 to 92 days with an average of 87.13±2.01 days during 2014. In the present study we recorded only one generation in both the years [4].

### 9.6.3 Hosts

Cotton [1, 2, 5], Okra, *Hibiscus panduraeformis* and other malvaceous plants [1].

### 9.6.4 Geographic Distribution

India [1, 2, 3, 4, 5]

### 9.6.5 Hazard Identification Conclusion

Considering the fact that *A. affaber* –

- is not known to be present in Bangladesh.
- is not likely potentially economic importance to Bangladesh. It is a minor pest in India but key pest only in South India [1, 3, 4, 5].
- is not likely to become established in Bangladesh through importation of cotton bolls, seeds and lint.

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

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## 9.7 Cotton stem weevil (*Pempherulus affinis*)

### 9.7.1 Hazard Identification

**Common name:** Cotton stem weevil
**Scientific name:** *Pempherulus affinis* (Faust)

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Cuculionidae
Genus: *Pempherulus*
Species: *Pempherulus affinis*

**Bangladesh status:** Not present in Bangladesh.

**EPPO Code:** PEMHAF

Minor but assumes a key pest status in South India. It caused 65.8% plant mortality, 72.0% reduction in boll production and 78.9% reduction in yield of seed cotton 50 days after sowing there was. When infestation was noticed at 80 days after sowing the crop loss was significantly less [6]. It has been reported as a major pest of “Cambodia cotton” in South India. Infestation occurs on 12 to 15 days old seedlings, which can cause the mortality up to 90% [5].

### 9.7.2 Biology

It lays globular or oval shaped eggs singly in the cavities scrapped out by the weevil at the nodal region of the plants.A female weevil lays an average of 50 eggs with a maximum of 121 eggs. The egg period is 6-10 days. Grub: white, apodous. The grub feeds on stem tissues internally. The larval period lasts 35-37 days. The pupation takes place inside pupal chamber in stem and this stage lasts from 25 to 30 days [2]. The adult may live for 25 – 30 days. There are 5 generations year.

### 9.7.3 Hosts

Cotton (*Gossypium* spp.), Jute, *Abutilon indicum*, *Hibiscus rosasinesnsisand H. cannabinus* and and other Malvaceous and Tiliaceous plants. Cotton is the most preferred host [3, 4].

### 9.7.4 Geographic Distribution

India (Tamil Nadu, Andhra Pradesh, Karnataka, Kerala, Bihar, Orrisa, Rajasthan, Uttar Pradesh, Gujrat and Assam) [1, 2, 5, 6], Myanmar, Thailand and Philippines.

### 9.7.5 Hazard Identification Conclusion

Considering the fact that *P. affinis* –

- is not known to be present in Bangladesh.
- is not likely potentially economic importance to Bangladesh. It is a minor pest in India but key pest only in South India [2, 5, 6].
- is not likely to become established in Bangladesh through importation of cotton bolls, seeds and lint.

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

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## 9.8 Cotton grey weevil (*Myllocerus undecimpustulatus*)

### 9.8.1 Hazard Identification

**Common name:** Cotton grey weevil
**Scientific name:** *Myllocerus undecimpustulatus* Faust
**Synonyms:** *Myllocerus maculosus* Desbrochers

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Coleoptera
Family: Cuculionidae
Genus: *Myllocerus*
Species: *Myllocerus undecimpustulatus*

**Bangladesh status:** Not present in Bangladesh.

### 9.8.2 Biology

The life cycle of this species currently is under study in a laboratory in Homestead Florida (Jorge Peña, pers. 91ahli.). The adults do not glue the eggs together in a mass on the host plants leaves, but insert them singly in soft organic matter on the ground. The larvae burrow through the soil feeding on the roots of their host plants, and pupate in the soil. The adults emerge from the soil to feed on a wide variety of host plants [3].

The ratio of female to male in a laboratory population was 2:3. Pre-ovipositional period for females varied from 3-4 days and 1-2 days after pairing. A single female laid 90-95% eggs in its life span. Egg viability per female was 100%. At room temperature eggs hatched in about 7-9 days, larval development to pupation on roots averaged the first, second, third and fourth instars occupied 9-10 days, 11- 16days, 17-22 days and 18-22 days respectively and the pupal period lasted approximately 23-33 days. Total developmental time from egg to adult ranged from 38-56 days, in certain cases total larval period extended up to 60-70 days. Four larval instars were observed, moulting occurred in every instar days [4].

### 9.8.3 Hosts

*Abelmoschus moschatus* (muskmallow), *Aegle marmelos* (golden apple), *Arachis hypogaea* (groundnut), *Cajanus cajan* (pigeon pea), *Glycyrrhiza glabra* (Licorice), *Justicia adhatoda* (Malabar nut), *Morus* (mulberry tree), *Sorghum bicolor* (sorghum), *Syzygium cumini* (black plum), *Vigna radiata* (mung bean), *Ziziphus mauritiana* (jujube) and cotton (*Gossypium* spp) [2]. It has been reported from 81 plant species in Florida [3]

### 9.8.4 Geographic Distribution

India (Delhi, Karnataka, Uttar Pradash [2], Indonesia, Pakistan [1] and Florida (USA) [3].

### 9.8.5 Hazard Identification Conclusion

Considering the fact that *M. undecimpustulatus* –

- is not known to be present in Bangladesh.

- is not likely potentially economic importance to Bangladesh. It is a minor pest in India and Pakistan [2].
- is not likely to become established in Bangladesh through importation of cotton bolls, seeds and lint.

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

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## 9.9 Leaf miner (*Liriomyza trifolii*)

### 9.9.1 Hazard Identification

**Common name:** Leaf miner
**Scientific name:** *Liriomyza trifolii* Burgess in Comstock
**Synonyms:** American serpentine leafminer, serpentine leafminer, chrysanthemum leafminer.

**Taxonomic tree**

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

**Bangladesh status:** Not present in Bangladesh.
**EPPO Code:** LIRITR. *L. trifolii* is listed as an A2 quarantine pest by EPPO [9]. It is one of the most important recent introductions to the EPPO region [CABI, 2007].

*L. trifolii* is an economically important key pest of both ornamental crops [1] and vegetables [3]. Damage is caused by *L. trifolii* larvae mining into leaves and petiole. The photosynthetic ability of the plants is often greatly reduced as the chlorophyll-containing cells are destroyed. Severely infested leaves may fall, exposing plant stems to wind action, and flower buds and developing fruit to scald. *L. trifolii* is also known to be a vector of plant viruses [Zitter *et al*., 1980]. Leaves, seedlings and micropropagated plants are liable to carry eggs and larvae of this pest and symptoms are usually visible to the nacked eye [2].

### 9.9.2 Biology

Female *L. trifolii* flies puncture the leaves of the host plants causing wounds which serve as sites for feeding or oviposition. Feeding punctures cause the destruction of a large number of cells and are clearly visible to the naked eye. About 15% of oviposition punctures made by *L. trifolii* contain viable eggs. Male *L. trifolii* are unable to puncture the leaves but have been observed feeding at punctures made by females. Both male and female *L. trifolii* feed on dilute honey (in the laboratory) and take nectar from flowers [10].

*L. trifolii* eggs are inserted just below the leaf surface. Eggs hatch in 2-5 days according to temperature and took e 4-7 days at 24°C[6]. Many eggs may be laid on a single leaf. The duration of larval development also depends on temperature and probably host plant. Several generations can occur during the year, breeding only being restricted by the temperature and the availability of fresh plant growth in suitable hosts [13]. *L. trifolii* pupariation occurs outside the leaf, in the soil beneath the plant. Puparial development will vary according to season and temperature. Adult emergence occurs 7-14 days after pupariation at temperatures between 20 and 30°C [8]. Peak emergence of adult *L. trifolii* occurs before midday [8]. Males usually emerge before females. Mating takes place from 24 hours after emergence and a single mating is sufficient to fertilize all a female's eggs. Adult Peak emergence of adult *L. trifolii* occurs before midday [8]. Males usually emerge before females. Mating takes place from 24 hours after emergence and a single mating is sufficient to fertilize all a female's eggs.

On celery *L. trifolii* completes its life cycle (oviposition to adult emergence) in 12 days at 35°C, 26 days at 20°C, and 54 days at 15°C [7]. On chrysanthemums the life-cycle is completed in 24

days at 20°C but on *Vigna sinensis* and *Phaseolus lunatus* it takes only 20 days at this temperature [12]. Adults of *L. trifolii* live between 15 and 30 days. On average, females live longer than males.

### 9.9.3 Hosts

*L. trifolii* is polyphagous pest attack leaves of large number of host plants.It is highly polyphagous and has been recorded from 25 families [14]. Major host plants are *Abelmoschus esculentus* (okra), Ageratum , *Allium* (onions, garlic, leek, etc.), *Allium sativum* (garlic), *Arachis hypogaea* (groundnut), Aster , *Beta vulgaris* var. *saccharifera* (sugarbeet), Bidens (Burmarigold), *Brassica rapa* subsp. *Chinensis* (Chinese cabbage), *Callistephus*, *Capsicum annuum* (bell pepper), Chrysanthemum (daisy), *Chrysanthemum morifolium* (chrysanthemum (florists')), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita pepo* (ornamental gourd), Cucurbitaceae (cucurbits), Dahlia , *Dianthus* (carnation), Gaillardia , Gerbera (Barbeton daisy), *Glycine max* (soyabean), ***Gossypium* spp. (cotton),** Gypsophila (baby's breath), *Helianthus* (sunflower), *Lactuca sativa* (lettuce), *Lathyrus* (Vetchling), Lycopersicon , *Lycopersicon esculentum* (tomato), *Medicago sativa* (94ahlia94), *Phaseolus* (beans), Phaseolus lunatus (lima bean), *Phaseolus vulgaris* (common bean), *Pisum sativum* (pea), Salvia (sage), Senecio (Groundsel), *Solanum melongena* (aubergine), *Solanum tuberosum* (potato), *Spinacia oleracea* (spinach), Tagetes (marigold), Trifolium (clovers), *Trifolium repens* (white clover), Tropaeolum , Vicia (vetch), *Vigna unguiculata* (cowpea), Zinnia. Fifty five (55) hosts are reported from Florida, which include bean, beet, carrot, celery, cucumber, eggplant, lettuce, melon, onion, pea, pepper, potato, squash, and tomato [15].

### 9.9.4 Geographic Distribution

**Africa:** Benin, Cote d'Ivoire, **Egypt**, Ethiopia, Guinea, Kenya, Madagascar, Mauritius, Mayotte, Morocco, Nigeria, Réunion, Senegal, South Africa, Sudan, Tanzania, Tunisia, Zambia, **Zimbabwe** [4]
**Asia: China, India**, Iran, Israel, Japan, Jordan, Republic of Korea, Lebanon, Oman, Philippines, Saudi Arabia, Taiwan, Vietnam, Yemen [4].
**Central America:** Argentina, Bahamas, Barbados, Bermuda, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, French Guiana, Guadeloupe, Guatemala, Guyana, Martinique, Netherlands Antilles, Peru, Puerto Rico, Trinidad and Tobago, Venezuela, British Virgin Islands, U.S. Virgin Islands.
**Europe:** Austria, Belgium, Central Russia, Croatia, Cyprus, France, Greece, Italy, Malta, Netherlands, Norway, Portugal, Romania, Russian Federation, Slovenia, Southern Russia, Spain, Switzerland,**Turkey**.
**North America:** Canada, Mexico, USA [4]
**Oceania:** American Samoa, Guam, Federated States of Micronesia, Northern Mariana Islands, Samoa, Tonga [2]

### 9.9.5 Hazard Identification Conclusion

Considering the fact that *L. trifolii* –

- is not known to be present in Bangladesh; [2]
- is potentially economic importance to Bangladesh because it is an important pest of cotton and other crops in Egypt, China, India, Turkey, [2] from where cotton seeds and lint are imported to Bangladesh.
- can become established in Bangladesh through imports of the plant parts. It has capability to cause direct economic and ecological damage to many valuable cultivated crops.

*L. trifolii* is a **quarantine pest** and is considered as a **potential hazard** for this risk analysis.

### 9.9.6 Risk Assessment

#### 9.9.6.1 Entry Assessment

Egg andlarvae of *L. trifolii* are transported through infested leaves, seedlings and microporpagated plants. There is no chance of entry with cotton seed or lint but is likely to be carried with leaves of other ornamentals or vegetables host. So, the probablility of entry with cotton seed or lint is low.

#### 9.9.6.2 Exposure Assessment

After entering into Bangladesh, may be carried to different places of the country. During loading and unloading at different locations, *L. trifolii* may be exposed to the environment and attack different host plants. Host plants of *L. trifolii* are available in Bangladesh. Therefore, the probability of exposure of *L. trifolii* in Bangladesh environment is high.

#### 9.9.6.3 Establishement Assessment

*L. trifolii* has many host species in Bangladesh other than cotton. It can attack many vegetables hosts which are available in most of the places in Bangladesh. Morover, environmental conditions are also favourable for its growth, development and reproduction. Therefore, the probability of establishment of the insect pest in the PRA area is high.

#### 9.9.6.4 Determination of Likelihood of the Pest Establishing Via this Pathway in Bangladesh

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

| Description | The Establishment Potential is: |
|---|---|
| • This pest has established in several new countries in recent years, and (**YES-** it is introduced and established in India, Turkey [5].<br>• The pathway appears good for this pest to enter Bangladesh and establish, and **NO** – Eggs and larvae are borne internally with leaves and micropropagated plants which are visible to naked eye [2]. Cotton bolls and lint are not likely to carry this pest.<br>• Its host(s) are fairly common in Bangladesh and the climate is similar to places it is established (**Yes–**Many of its host are common in Bangladesh and climate also favourable [2]). | High |
| • Not as above or below | **MODERATE** |
| • This pest has **not** established in new countries in recent years, and<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established | Low |

### 9.9.7 Consequence Assessment

#### 9.9.7.1 Economic

*L. trifolii* is an economically important key pest of both ornamental crops and vegetables. In Kenya, chrysanthemums were grown commercially before 1976, but *L. trifolii* was thought to have been introduced in contaminated cuttings from Florida (USA) in 1976, at a large propagating nursery at Masongaleni. By 1979 the nursery was closed, but the establishment of the pest in local wild hosts, and the dissemination of cuttings from the nursery to other parts of the country as well as abroad, has added *L. trifolii* to the other pests of East Africa. It has caused considerable crop losses and loss of overseas markets due to quarantine requirements.

Vegetable losses in the USA are also considerable. For example, losses for celery were estimated at US$ 9 million in 1980. It was noted, however, that damage to celery during the first 2 months of the 3-month growing season was insignificant and largely cosmetic, whereas considerable yield loss resulted from pest presence during the final month. 1.5 million larval mines per hectare were recorded from onions in Iowa.

#### 9.9.7.2 Environmental

No environmental impact of this pest has been reported.

#### 9.9.7.3 Determination of Consequence of the Pest Establishing Via this Pathway in Bangladesh

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

| Description | Consequence |
|---|---|
| • This is a serious pest of an important crop for Bangladesh, or **YES** – many of its hosts are cultivated in Bangladesh<br>• This is a fairly serious pest of several important crops for Bangladesh.**YES** – many of its hosts are cultivated 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 |

### 9.9.8 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 *L. trifolii* been classified as a risk organism for Bangladesh and risk management is justified.

### 9.9.7 Possible Risk Management Measures

- To avoid the introduction of *L. trifolii* EPPO recommends that propagating material (except seeds) of *Capsicum*, carnations, celery, chrysanthemums, *Cucumis*, *Gerbera*, *Gypsophila*, lettuces, *Senecio hybridus* and tomatoes from countries where *L. trifolii* occurs must have been inspected at least every month during the previous 3 months and found free from the pests [11].

- A phytosanitary certificate should be required for cut flowers and for vegetables with leaves.

- Visual inspection will be undertaken in Bangladesh after the consignment has arrived.

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## 9.10 Flower bud maggot (*Dasineura gossypii*)

### 9.10.1 Hazard Identification

**Common name:** Flower bud maggot
**Scientific name:** *Dasineura gossypii* Fletcher
**Synonyms:** Gall midge of cotton

**Taxonomic tree**

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Uniramia
Class: Insecta
Order: Diptera
Family: Ceceidomyidae
Genus: *Dasineura*
Species: *Dasineura gossypii*

**Bangladesh status:** Not present in Bangladesh.
Flower bud maggot, *D. gossypii* appeared as potential pest for first time during 2009 in Karnataka with severe incidence in farmer's field at Hesarur village. More than 90%fruiting body damage was recorded in largely cultivated Bt cotton cultivars [1].

### 9.10.2 Biology

Females of *D. gossypii* preferred to lay eggs in square tips, where they lay 42-45. Eggs.Eggs are inserted inside the tender squares by the female flower bud maggot with its long, sharp ovipositor. Number of females use to lay eggs in a same square. From field collected samples 30.6 ± 3.77 numbers of eggs per square have been traced. There are 3 larval instars in the life history. The duration of different life stages of *D. gossypii* viz.eggs, first instar maggot, second instar maggot, third instar maggot, pupal period, adult stage (male) and adult stage (female) was of 1.5 ± 0.5, 1.2 ± 0.4, 1.7 ± 0.45, 2 ± 0.0, 4.4 ± 0.66, 1.2 ± 0.4 and 1.3 ± 0.45 days, respectively. Pupation usually occurs inside the bract but sometimes in soil also [1]. Both adult male and female are minute, soft bodied, orange in colour, weak flier and short lived. Males and females can be easily distinguished by the presence of ovipositor or by intensity of hairs in antennae which were more in males compare to females. In laboratory condition fertility, sex ratio (female: male) and per cent adult emergence was recorded as 30 per cent, 1.45:1 and 85.71, respectively. The longevity of male, with food and withoutfood was recorded as, 1.2 ± 0.4 days and 1.1 ±0.3 days, respectively. The longevity of female, with food and without food was recorded as, 1.3 ± 0.45 days and 1.2 ± 0.4 days respectively. The peak mating period was observed between 12.00 to 13.00 hours though maximum oviposition was observed between 09.00 to 11.00 hours. The number of generations per year was recorded as 8-10 [1, 3].

### 9.10.3 Hosts

Cotton (*Gossypium* spp.)

### 9.10.4 Geographic Distribution

India [2,3]

### 9.10.5 Hazard Identification Conclusion

Considering the facts that *Dasineura gossypii* –

- is not known to be present in Bangladesh;
- is not likely an economic important pest to Bangladesh because it is only serious pest of Bt cotton at Karnataka, India recently but not previous year [3];
- the probability of establishment is not likely because its host is not available in Bangladesh.

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

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## FUNGUS

# 9.11 Verticillium Wilt of cotton *(Verticillium dahliae*)

### 9.11.1 Hazard Identification

**Name of Disease:** Verticillium Wilt of cotton
**Pathogen:** *Verticillium dahliae* Kleb. 2013
**Synonyms:** *Verticillium albo-atrum var. chlamydosporale, Verticillium albo-atrum var. dahliae, Verticillium albo-atrum var. medium, Verticillium dahliae f. chlamydosporale , Verticillium dahliae f. medium,Verticillium ovatum, Verticillium tracheiphilu.*

**Taxonomic tree**

Kingdom: Fungi
Phylum: Ascomycota
Class: Sordariomycetes
Subclass: Hypocreomycetidae
Order: Hypocreales
Family: Incertaesedis
Genus: *Verticillium*
Species: *V. dahliae* Kleb. (1913)

**Bangladesh Status:** Not present in Bangladesh.

### 9.11.2 Biology

*Verticilliumdahliae* naturally occurs at low levels in soils and grows better at slightly higher temperatures 25 -28 $^{o}$C. The fungus can overwinter as mycelium in perennial hosts, plant debris, and vegetative propagative parts. The fungus can survive for many years (10 years or more) in soil in the form of tiny, black, seed-like structures called microsclerotia. Microsclerotia can even form on and in the fine roots of many species of resistant plants without causing symptoms. Microsclerotia are stimulated to germinate by root exudates of both host and non-host plants. The fungus penetrates a root of a susceptible plant in the region of elongation and the cortex is colonized. From the cortex, the hyphae penetrate the endodermis and invade the xylem vessels where conidia are formed. Vascular colonization occurs as conidia are drawn up into the plant along with water. As the diseased plant senesces, the fungus ramifies throughout cortical tissue then produces microsclerotia, which are released into the soil with the decomposition of plant material (1, 3, 4, 5).

Long distance dissemination of the pathogen occurs via infected seed of cotton (6) seed tubers of potato (4, 5), and planting stock. In bare root or vegetatively propagated plants such ornamentals, a nursery may spread the fungus by selling non-symptomatic, but infected, planting stock. Once established in a field or landscape, spread of the pathogen occurs primarily by soil cultivation and movement of soil by wind or water. Inoculum densities and disease severity tend to increase from year to year when susceptible crops are planted.

Damage caused by *V*. *dahliae* to the plants is often more severe in fields infested with the root-lesion nematode, *Pratylenchus penetrans*. This nematode may increase the severity of the disease by altering the host physiology, thus making the plant more susceptible to damage. Symptoms may develop even when population densities of *Verticillium* and *P*. *penetrans* individually are too low to cause significant disease. In addition to wilt this can also cause severe defoliation in many hosts including cotton (2, 7).

### 9.11.3 Hosts

Over 300 woody and herbaceous plant species are known to be susceptible to *V.dahliae* including tomato, eggplant, pepper, potato, peppermint, chrysanthemum, cotton, asters, fruit trees, strawberries, raspberries, roses, alfalfa, maple, and elm. Resistant plants include all monocots, all gymnosperms, apple, crabapple, mountain ash, beech, birches, dogwood, hackberry, hawthorn, linden, honeylocust, oaks, sycamore, poplar, walnut, and willow. V. *dahliae* occurs worldwide but is more important in temperate zones (4, 5).

### 9.11.4 Geographic Distribution

Almost worldwide distribution

### 9.11.5 Hazard Identification Conclusion

Considering the facts that:

- *Verticillium dhaliae* is not known to be present in Bangladesh;
- is present in China, India, Pakistan, Turkey, and Uzbekistan and can be carried by infected seed, plant parts or sapling of other host plants
- *Verticillium dhaliae is* considered to be a potential hazard organism for this commodity in this risk analysis.

### 9.11.6 Risk Assessment

#### 9.11.6.1 Entry Assessment

*Verticillium dahliae* is reported to be a soil-borne fungal pathogen. It also causes infection to the vascular bundle of cotton plant. Therefore there is medium probability of entering this organism through this pathway with infected plant parts as contaminant. As this has a very wide host range including many agricultural, woody and herbaceous plants (1, 4, 5, 7), this could also enter through infected plant parts and soil particles those plant species if imported from area where this disease is present.

#### 9.11.6.2 Exposure

Bangladesh is importing huge amount of cotton every year mostly from countries, where the presence of *V. dahliae* has been reported. Similarly, hybrid seeds of cotton are being imported from China for cultivating in Bangladesh. After entry, the seed or lint are transported to different parts of the country. During handling and transport operations of the commodity the infected or contaminated grain or infected plant parts associated with seed or lint get exposed to the nature.Since the microsclerotia remains inside infected plant parts or seed carrying the pathogen come in contact to soil. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

#### 9.11.6.3 Establishment

The inoculum of *V. dahliae* once exposed to the environment will get its host readily. Because besides cotton this organism has many other hosts like tomato, eggplant, pepper, potato, peppermint, and many other herbaceous and woody plants. Moreover, as microsclerotia it can remain dormant and survive in soils for 10 years or more. *Verticilliumdahliae* naturally occurs at low levels in soils and grows better at slightly higher temperatures 25 -28 $^{o}$C. Such temperature is also available in Bangladesh. Therefore the establishment potential of this pathogen in the PRA area is high.

#### 9.11.6.4 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**.<br>• The pathway appears good for this pest to enter Bangladesh and establish, and **No.**<br>• 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<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established | Low |

### 9.11.7 Consequence Assessment

#### 9.11.7.1 Economic Impact

Verticillium Wilt is the extremely harmful disease of cotton as it may affect more than 60% of plants. The disease causes the greatest harm to long-fibrous cotton (*Gossypium hirsutum*). Thin-fibrous cotton (*Gossypium barbadense*) is also affected by the Verticillium Wilt, but shows expressed tolerance to causative agent; therefore, having significantly smaller yield losses. Since the pathogen has the ability to continuously widen its host range and develop races/pathotypes that can overcome host resistance or be more virulent on known hosts and host cultivars that would create additional economic consequences.

#### 9.11.7.2 Environmental Impact

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

#### 9.11.7.3 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 |
|---|---|
| This is a serious pest of an important crop for Bangladesh, or This species has been documented infecting over 300 woody and herbaceous plant species representing with a distribution in Africa, Asia, Europe, North America and South America and Oceanic regions including the Caribbean nations. The susceptible hosts includes | **High** |

| Description | Consequence |
|---|---|
| tomato, eggplant, pepper, potato, peppermint, cantaloupe cotton, pumpkin, watermelon asters, fruit trees, strawberries, raspberries, alfalfa, spinac, maple, elm, numerous ornamentals including chrysanthemum, dahlia, lilac, peony, petunia, rose, snapdragon, spirea, sunflower etc. Certain frequently encountered weed species such as dandelion (*Taraxacum officinale*), groundsel (*Senecio vulgaris*), lamb's quarters (*Chenopodium album*), nightshade (*Solanum* spp.), pigweed (*Amaranthus* spp.), sagebrush (*Artemisia* spp.), and shepherd's purse (*Capsella bursa-pastoris*) are also hosts to Verticillium species [2, 3].<br><br>• This is a serious pest of several important crops (cotton, tomato, brinjal, okra, sesame) for Bangladesh | |
| • Not as above or below | Moderate |
| • This is not likely to be an important pest of common crops grown in Bangladesh. | Low |

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**

### 9.11.8 Possible Risk Management Measures

- Planting material of host-plant species of *Vertiillium dahliae* should be inspected in the growing season previous to shipment and be found free of infestation.
- Avoid importation of seeds or bolls of cotton or other host plants from countries where *Vertiillium dahliae* occurs.
- The fungus is very difficult to eradicate once it has been introduced into a field. Preventing the introduction of Verticillium into non-infested fields is important considering the ability of the pathogen to survive in soils without a host. Exclusion is particularly imperative in situations where perennial and woody (more than 1 year) crops are being grown because there are no curative treatments that can be employed once the plant becomes infected. Care should also be taken to prevent introducing the pathogen into fields that have received fumigation or other management practices aimed at reducing primary inoculum.

- Management practices for Verticillium wilt should focus on reducing the amount of initial inoculum since curative measures do not exist.
- Use practices aimed at preventing the introduction (use of pathogen free-propagative materials), build-up (removing infected plants and infested debris, controlling weedy volunteers and hosts), and spread (reducing tillage and other cultural practices that move soil and infested debris, cleaning equipment between plants/fields). Fumigation with meta sodium can be effective at eliminating soil-borne inoculum of *V. dahliae* and is often performed before growing higher value crops such as potato and strawberry. Precautions should be taken to avoid re-infesting the field after fumigation.
- Planting resistant or non-host crops can be effective at reducing the impact of Verticillium wilt.
- Any shipments of fresh plant material from an infested country should be examined thoroughly to detect *Verticillium dahliae* after the consignment has arrived in Bangladesh.

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## 9.12 Leaf curl Disease of Cotton (*Leaf curl virus*)

### 9.12.1 Hazard Identification

**Name of Disease:** Leaf curl disease
**Pathogen:** *Leaf curl virus*

**Taxonomic Tree**
Group: Group II (ssDNA)
Family: *Geminiviridae*
Genus: *Begomovirus*
Species: *Cotton leaf curl virus*

**Bangladesh Status:** Not present in Bangladesh

### 9.12.2 Biology

Symptoms of CLCuD on infected cotton plants usually appear within 2−3 weeks. Early symptoms include deep downward cupping of the youngest leaves accompanied by swelling and darkening of leaf veins (1).
Cup shaped, leaf like structures (enations) may form along leaf veins, typically on the underside of leaves. Cotton leaf curl disease (CLCuD) complex is a debilitating disease of cotton that results in leaf curling, development of leaf-like enations on the undersides of leaves, overall stunting of the plant, and reduced yield and quality. The disease is caused by one or more whitefly-transmitted geminiviruses (genus, *Begomovirus;* family, *Geminiviridae*) that serve as the „helper virus" (that replicates non-viral satellites, which are associated with virulence and symptom expression) for two different types of DNA satellite molecules of non-viral origin. The two types of satellites are referred to as betasatellites and alphasatellites, representing two different types of small, half unit sized (in comparison to the viral genome), circular ssDNAs. The satellites contribute to host defense suppression, leading to increased virulence of the helper virus resulting in systemic infection and the production of severe disease symptoms. In at least one instance, an alphasatellite has been shown to down-modulate helper virus-beta satellite symptoms and reduced betasatellite accumulation in tomato plants (4).

Worldwide, infection of cotton by whitefly-transmitted geminiviruses is most damaging when cotton plants become infected during early growth stages, compared to mid- or late- season stages (2). Over the past 25 years, Pakistan and India have experienced two epidemics of the disease, the most recent of which involved a virus and satellite that are resistance breaking (3).

Currently, no disease resistance is available to CLCuD in cultivated cotton or any other cultivated host species (vegetable or ornamentals). Even so, the reliance on genetic resistance for disease management has been the primary means considered for management in Pakistan and India. The ability of this highly differentiated virus complex and its satellites to break the resistant varieties developed and widely grown by 2001, during 2004 (5).

Like other well-studied members of the geminiviruses, the viruses of the CLCuD complex are not seed transmitted. The CLCuD virus complex is transmitted from plant to plant through by the whitefly *Bemisia tabaci* (Genn.) [Hemiptera: s.o. Homoptera, Aleyrodidae) sibling species group in a circulative and persistent manner, and so once acquired, can be carried and transmitted for the life of the vector. Begomoviruses are transovarially (passed through the egg) or sexually

transmitted, nor are they propagative (replicative) in the vector (albeit, one exception has been reported) (1). And, mechanical transmission has not been demonstrated for any members of the CLCuD complex. The viruses can, however, be experimentally transmitted by grafting, and by inoculation of plants with infectious viral clones using biolistic inoculation, particle bombardment, or agroinoculation. Using the latter types of inoculation methods, it has not been possible to demonstrate the development of wild type disease symptoms in cotton, suggesting either that unidentified components remain unidentified, or that cotton is particularly recalcitrant to inoculation using other than the whitefly vector.

### 9.12.3 Hosts

Preferred hosts of CLCuD are cotton and closely related species. Cotton leaf curl viruses can also infect soyabean, okra, eggplant, tomato, chilli, cowpea, radish, tobacco, cucumber, melons and hibiscus (2).

### 9.12.4 Geographic Distribution

Cotton leaf curl disease is known to occur in Pakistan, India, Egypt, Nigeria, Tanzania, Sudan, and more recently China and the Philippines. There are a number of different cotton leaf curl viruses known to cause CLCuD and their occurrence varies in areas of known distribution. Neither viruses causing CLCuD nor betasatellites are known to occur in Australia.

### 9.12.5 Hazard Identification Conclusion

Considering the facts that:

- Cotton leaf curlis not known to be present in Bangladesh;
- is present in some African countries, Pakistan, India, Egypt, Nigeria, Tanzania, Sudan, and more recently China and the Philippines and can be carried with infested insect vector *Bemisia tabaci* or infested eggs of this insect;

Cotton leaf curl is considered to be a potential hazard organism in this risk analysis.

### 9.12.6 Risk Assessment

#### 9.12.6.1 Entry assessment

Cotton leaf curl virusis reported to transmit only by an insect vector, whitefly *Bemisia tabaci.* The mode of transmission is transovarial (1). Therefore, when an insect acquire the virus it remains throughout its life time and able to transmit the virus through eggs to next generation. The nymphs or adult insect from those eggs also carry the virus and transmit it to new plants. Under such situation there is possibility of entering the virus either through adult, egg or nymph along with cotton seed or lint.However, the probability of entry into Bangladesh is moderate.

#### 9.12.6.2 Exposure

Bangladesh is importing huge amount of cotton every year mostly from countries where the presence of leaf curl virus disease of cottonhas been reported. Similarly, hybrid seeds of cotton are being imported from China for cultivating in Bangladesh. After entry, the seed or lint are transported to different parts of the country. During handling and transport operations there is risk of exposure of whitefly carrying the leaf curl virus to the nature.

#### 9.12.6.3 Establishment

The whitefly is also present in Bangladesh. Therefore, the newly introduced whitefly along with cotton seed or lint once exposed to nature will get their hosts readily. Besides cotton this insect can also survive on many other hosts. The leaf curl virus get transmitted to cotton plants or any

other host once the viruliferous insect feed on them and get established. Therefore the establishment potential of this virus in the PRA area is high.

#### 9.12.6.4 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**).<br>• The pathway appears good for this pest to enter Bangladesh and establish, and *(***Yes***, it is dispersed by whitefly* [1, 3]).<br>• Its host(s) is 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<br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and<br>• Its host(s) are **not** common in Bangladesh and its climate is **not** similar to places it is established | Low |

### 9.12.7 Consequence Assessment

#### 9.12.7.1 Economic Impact

Worldwide, infection of cotton by whitefly-transmitted geminiviruses is most damaging when cotton plants become infected during early growth stages, compared to mid- or late- season stages (2). Over the past 25 years, Pakistan and India have experienced two epidemics of the disease, the most recent of which involved a virus and satellite that are resistance breaking (3).

#### 9.12.7.2 Environmental Impact

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

#### 9.12.7.3 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 |
|---|---|
| Preferred hosts of CLCuD are cotton and closely related species. Cotton leaf curl viruses can also infect soyabean, okra, eggplant, tomato, chilli, cowpea, radish, tobacco, cucumber, melons and hibiscus (2). | **High** |
| • Not as above or below | Moderate |
| • This is not likely to be an important pest of common crops grown in Bangladesh. | Low |

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**

### 9.12.8 Risk Management

- The only effective management of cotton leaf curl is the control of the vector whitefly. Resistant variety is not effective as it was found to breakdown readily.
- The leaf curl disease of cotton crops is primarily managed by the use of pesticide treatments; often frequent, to kill the whitefly vector to reduce virus transmission by the vector. The lack of alternative control options has led to the profuse, and often overuse, of pesticides to reduce vector populationsh, which, however, leads to the development of insecticide resistance in the whitefly vector.
- Ornamentals or vegetable seedlings transported from high-risk areas could provide a unexpected route of entry of the leaf curl virus complex. Therefore, importing those materials from high-risk areas should be avoided.

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## 9.13 Parthenium weed (*Parthenium hysterophorus* L.)

### 9.13.1 Hazard Identification

**Common name:** Parthenium weed

**Scientific name:** *Parthenium hysterophorus* L.

**Synonyms:** Carrot grass, Bitter weed, star weed, white top, congress weed

**Taxonomic tree**

Domain: Eukaryota
Kingdom: Plantae
Subkingdom: Tracheobionta
Class: Magnoliopsida
Subclass: Asteridae
Order: Asterales
Family: Asteraceae
Genus: *Parthenium*
Species: *Parthenium hysterophorus L*.

**Bangladesh status:** Present in Bangladesh in limited area.

**EPPO code:** PTNHY [2].

It has been accidentally introduced into several countries and has become a serious agricultural and rangeland weed in parts of Australia, Asia, Africa and the Pacific Islands [2].

### 9.13.2 Biology

*Parthenium hysterophorus* is an aggressive ubiquitous annual herbaceous weed. The plant is erect and much branched. Due to its high fecundity a single plant can produce 10,000 to 15,000 viable seeds and these seeds can disperse and germinate to cover large areas. Individuals are able to germinate, grow and flower over a wide range of temperatures and photoperiods and established plants can survive at least one mild frost of — 2°C. Parthenium grows luxuriantly in wastelands, public lawns, orchards, forestlands, flood plains, agricultural areas, urban areas, overgrazed pastures, industrial areas, playgrounds, roadsides, railway tracks, and residential plots. Drought and subsequent reduced pasture cover create the ideal situation for the parthenium weed to establish. Although parthenium weed is capable of growing in most soil types, it is most dominant in alkaline, clay loam soils. The seeds are mainly dispersed through water currents, animals, movement of vehicles, machinery, grains, stock feed and to a lesser extent by the wind. Most of the long distance spread is through vehicles, farm machinery, and flooding. The spread of seeds plus their ability to remain viable in the soil for many years pose one of the most complex problems for control. Seeds do not have a dormancy period and are capable of germinating anytime when moisture is available. Seeds germinate within a week with the onset of monsoon and flowering starts after a month and continues up to another three months. In Australia, parthenium weed germinates mainly in spring and early summer. It produces flowers and seeds throughout its life and dies in late autumn [8]. In northwest India, parthenium germinates mainly in the months of February-March, attaining peak growth after rains in June-July and produces seeds in September-October. It normally completes its life cycle within 180–240 days. It can grow at any time of the year as long as there is moisture [11, 12]. It is unable to reproduce vegetatively from plant parts or by apomixis, but is a prolific seed producer (15,000-25,000 achenes per plant) [5, 8], and continues to flower and fruit until senescence.

### 9.13.3 Hosts

*Arachis hypogaea*, *Avena sativa*, *Brassica napus*, *Capsicum annuum*, *Citrullus vulgaris*, *Corchorus* spp.,*Eragrostis tef*, *Glycine max*, *Gossypium* spp., *Helianthus annuus*, *Lactuca sativa*, *Lens culinaris*, *Linum usitatissimum*, *Lolium perenne*, *Lycopersicon esculentum*, *Oryza sativa*, *Pennisetum glaucum*, *Phaseolus* spp., *Pisum sativum*, *Ricinus communis*, *Solanum melongena*, *Solanum tuberosum*, *Sorghum bicolor*, *Sorghum vulgare*, *Triticum aestivum*, *Zia mays*[2].

### 9.13.4 Geographic Distribution

**Asia**: Bangladesh (introduced) present in limited area [2,5], Bhutan [2]China [1,2], widespread India [2,4], Israel, Japan, Malaysia, Nepal [1,2, 3, 7], Pakistan [2, 10], Sri Lanka, South Korea, Taiwan, Vietnam, Yemen [2].
**Africa**: Egypt [2, 13] Ethiopia, Kenya, Madagascar, Somalia, South Africa, Uganda, Zimbabwe [2, 6].
**Central/ Caribbean America**: Barbados, Curacao, Dominica, Guadeloupe, Jamaica, Martinique, Puerto Rico, Tobago, Trinidad, Virgin Islands [2].
**North America**: Widespread in Mexico, USA [2], present in Burmuda [2].
**South America:** Argentina, Bolivia, Brazil, Chile, Equador, Gayana, Paraguay, Peru, Uruguay, Venezuela [2].
**Oceania**: Australia, Vanuatu [2].

Native to southern United States, Mexico and Central and South America [2]

### 9.13.5 Hazard Identification Conclusion

Considering the facts that *Parthenium hysterophorus*-

- is known to be present in Bangladesh in limited scale [2]
- is likely potentially economic importance to Bangladesh because is present in China [1,2], India [2,4], Egypt [2.13], Pakistan [2,10], USA [2], and Zimbabwe[2,6];It has established in many asian countries [2] and can cause economic damage to the crops.
- is likely to establish in Bangladesh through imports of the cotton seed or lint or plant parts other host species as contaminant through this pathway.

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

### 9.13.6 Risk Assessment

#### 9.13.6.1 Entry Assessment

The weed is reported from Australia, Canada, Mexico, Pakistan and USA from where Bangladesh is importing cotton. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with cotton litnt. Therefore the probability of entry into Bangladesh through this pathway is considered low.

#### 9.13.6.2 Exposure Assessment

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that before milling the grains are generally cleaned and disposed the light weighted or unfilled grains along with dirt which may contain the weed seed. The probability of exposure to the nature is high.

#### 9.13.6.3 Establishment Assessment

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. Therefore the probability of establishment in the PRA area is high.

#### 9.13.6.4 Determination of Likelihood of the Pest Establishing Via this Pathway in Bangladesh

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

| Description | The Establishment Poten]tial is: |
|---|---|
| • This pest has established in several new countries in recent years, and ***NO*** [2]<br><br>• The pathway appears good for this pest to enter Bangladesh and establish, and ***NO*** [Parthenium weed seed can be moved and spread via water, farm machinery, industrial machinery, feral animals, humans, vehicles, stock fodder, movement of stock, grain and seed [9]. It can also be spread by the wind because its seeds are small (1-2 mm diameter) and light (50 µg) and able to travel long distances [8, 12]. The transportation of soil, sand and gravel from *Parthenium*-infested areas to non-infested areas for construction purposes may be the reason for the high infestation along the roadsides and around buildings [12].<br><br>• Its host(s) is fairly common in Bangladesh and the climate is similar to places it is established.***YES*** | No |
| • Not as above or below | **Moderate** |
| • This pest has **not** established in new countries in recent years, and **NO**<br><br>• The pathway does **not** appears good for this pest to enter in Bangladesh and establish, and **YES**<br><br>• Its host(s) are common in Bangladesh and its climate is similar to places it is established. Its hosts are common and climate is favorable for its establishment. | Low |

### 9.13.7 Consequence Assessment

#### 9.13.7.1 Economic Consequence

Parthenium hysterophorus is a noxious weed. Crop production is drastically reduced owing to its allelopathy. Also aggressive dominance of this weed threatens biodiversity. At 4% (w/ v) concentration of shoot extract of P. hysterophorus, root growth of velvetleaf and wheat were reduced by 60 and 75%, respectively.

#### 9.13.7.2 Environmental Consequence

Parthenium weed lacks predators, and cattle and livestock usually do not feed on it. As a result, the food chain is disturbed and the trophic structure changes, leading to an ecological imbalance in the invaded area. It causes a prolonged toxic effect to the soil environment – for instance, the leachates from parthenium weed have an inhibitory effect on nitrogen fixing and nitrifying bacteria.Parthenium weed is also an environmental weed that can cause irreversible habitat changes in native grasslands, woodlands, river banks and floodplains in both India and Australia. Huge stands of parthenium weed are common in almost all open areas.

#### 9.13.7.3 Health Consequence

This weed is considered to be a cause of allergic respiratory problems, contact dermatitis, mutagenicity in human and livestock.

#### 9.13.7.4 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***or<br>• This is a fairly serious pest of several important crops 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.***NO*** | Low |

### 9.13.8 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**

### 9.13.9 Possible Risk Management Measures

- Eradication of *P. hysterophorus* by burning, chemical herbicides, eucalyptus oil and biological control by leaf-feeding beetle, stem-galling moth, stem-boring weevil and fungi have been carried out with variable degrees of success.
- Mechanical, chemical and biological control strategies have been proved futile individually to curb proliferation of *P. hysterophorus*. So, integrated approaches are warranted to restrict the invasion of this weed.
- To address this problem, public awareness has to be developed and participatory approach to control the invasive weeds should be adopted.

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