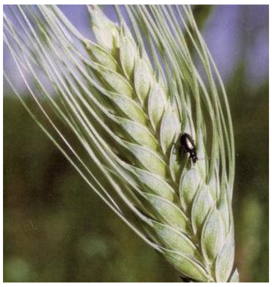
Final Report

Pest Risk Analysis (PRA) of Wheat in Bangladesh





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June 2015

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Pest Risk Analysis (PRA) of Wheat in Bangladesh.

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Executive Summary

Bangladesh is importing wheat (*Triticum* aestivum) grain from Australia, Canada, India, Pakistan, Ukraine and USA and germplasm for research purpose from CYMMIT, Mexico. No Pest Risk Analysis (PRA) for this commodity has so far been conducted and currently there is no import health standard (IHS) issued for wheat from the above mentioned countries. The present PRA was initiated as per desire of the Govt. of Bangladesh because we are importing wheat 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 Wheat in Bangladesh” for this project as per DPP has been undertaken through open bidding of qualified Consulting firms. However, Center for Resource Development Studies Limited (CRDS) was finally offered for conducting Pest Risk Analysis (PRA) of wheat in Bangladesh. The major objectives of the project included recording of major and minor insect pests, diseases and weeds of wheat and listing of quarantine insect pests, diseases and weeds of wheat. The project identified 20 major wheat growing districts namely Comilla, Lakshmipur, Noakhali, Dinajpur, Thakurgaon, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur and Barisalas study areas. Two to six upazilas under each district were also identified for field survey and data collection on insect pests, diseases and weed of wheat. In each upazila 10 blocks and under each block, 10 farmers were selected for data collection.

Wheat, a self-pollinated crop is prone to different insect pests, diseases and weeds. It is under the family Poaceae, and now cultivated worldwide. In Bangladesh, in 2013-14 cropping season wheat was grown in an area of 4.3 lac ha, the total production was 13 lac ton and the productivity was 3.03 t/ha. The major varieties grown are BARI Gom-21, 24, 25, 26 and 27. The major wheat growing areas in Bangladesh are Thakurgaon, Pabna, Dinajpur, Rajshahi, Natore, Faridpur etc.
The baseline information on insect pests, diseases and weeds, available in Bangladesh were collected from different secondary sources like published papers, books, journals, internet as well as interview with different stakeholders such as farmers, personnel from DAE, experts and professionals at BARI. Primary data were collected through field survey. For this 60 upazila under 20 districts were selected and visited during the wheat growing period in February-March. The selected 20 districts were considered as the PRA area for wheat. 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 84 pests were listed in Bangladesh among which 23 insect and mite pests, 24 diseases and 37 were weeds. In addition occurrence of two vertebrate pests (rodent) was also recorded. Two field insect pests are aphid and leaf eating caterpillar and the major storage pests are khapta beetle, rice weevil and rust-red flour beetle. Among the field diseases Bipolaris leaf blight, black point and leaf or brown rust and in storage seed rot caused by *Aspergillus* spp. are the major concern for wheat. Major weeds in wheat field include Danta/ Malanch, Chanchi, Bathua, Mutha, Durba ghas, Anguli ghas, Khude anguli, Khude Shyama, Chapra, Halencha, Gang Palong, Shatodron, Bontamak, Borobiskatali, Biskatali, Bonpalong, Tita begun, Bon masur and Masurchan.

World distribution of wheat insect pests, diseases and weeds were prepared. Comparing with world record it was evident that 22 insect species, 2 mite species are absent in Bangladesh. All of these pests 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 pests. Altogether 28 diseases (11, 4, 2 and 11 caused by fungus, bacteria, nematode and virus, respectively) are absent in Bangladesh so these were examined carefully and among these 9 diseases were considered for risk analysis and finally considered as risk hazards and management options for thesespecies are discussed and reviewed. Similarly, 8 quarantine weed species identified were *Amaranthus blitoides*, *Ambrosea artimisiifolia*, *Cardaria draba, Fumaria officinalis, Papaver rhoeas, Parthenium hysterophorus, Phalaris minor* and*Thlaspi arvense.*

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

1.0 Introduction

Wheat (*Triticum aestivum* L.) is one of the cereal food crops ranked third worldwide after maize and rice.In Bangladesh wheat is the second most important staple food after rice that accounts for about 12 percent of total cereal consumption. With the introduction of new wheat varieties developed by the Bangladesh Agricultural Research Institute (BARI), wheat yield per hectare has increased from 2.17 tons in MY 2007/08 to 3.03 tons in MY 2013/14. The total area under wheat was 4.3 lac ha while the total production was 13 lac ton in 2013/14. As an individual country China is the World leading wheat producing country that produced 126.0 million tons (mt) during 2013 when the worldproduction was 714.05 mt. In terms of production India placed in second position by producing 95.85 mt. Other leading wheat producing countries includes Russia, United States, Canada, Australia etc.

To meet the local demand Bangladesh imports huge quantity of wheat from abroad every year. In MY 2012/13, Bangladesh wheat imports are estimated at 2.6 million tons, a 47 percent increase from the MY 2011/12 import level. For the 2012/13 marketing year, the GOB wheat import target was 800,000 tons. As of February 2013, the GOB imported 50 percent of this targeted amount. The GOB procurement drive for wheat is through open tender.Bangladesh meets 75 percent of its wheat consumption needs through imports, sourcing lower quality wheat from India and Ukraine, and higher quality wheat from Canada, Australia and the USA. India's export ban on wheat led Bangladesh to also import from European and South American countries. However, with the withdrawal of the export ban, India has re-emerged as the principal wheat supplier to Bangladesh. According to trade sources, about 78 percent of wheat imported during the 2012/13 marketing year has been sourced from India. Besides for food, wheat germplasms and advanced lines are also imported from CYMMIT, Mexico for the development of modern high yielding and other stress tolerant varieties.

Wheat is vulnerable to different insect pests and diseases and cause damage to the crop leading to severe yield loss. Diseases are caused by different groups of causal agents like fungi, bacteria, virus and nematodes. Wheat is suffering from many diseases, amongst such diseases, about 50 are routinely important economically (Wiese, 1987). Among the diseases some are specific for temperate regions and others are restricted to tropical and sub-tropical climate. Comparatively less number of insect pests are known to attack wheat crops. A tolal of 16 insect pests and mites are so far recorded to affect wheat crop in the field. In storage wheat is subject to attack by storage molds and storage insect pests. There are many instances of international spread of devastating diseases of crop plants as well as wheat through international trade and also directly by international travelers. For example, the initial accidental introduction of Hessian fly from Europe to North America was probably in straw carried by Hessian troops at the time of the Revolutionary War and established as serious pest of wheat in USA. Wheat bunt (*Tilletia carries*) was observed for the first time in California in 1854 where seed imported from Australia has been sown (Bidwell, 1860). Flag smut (*Urocystis agropyri*) was introduced from Australia to Mexico (Borlaug*et al*., 1946) and to India in 1906. This disease was first observed in a wheat field in Madison country, Illinois, USA in 1919 and thought to be introduced on imported wheat but the source has not been discovered (Humphery and Johnson, 1919). Loose smut of wheat (*Ustilago tritici*) was first observed in Laos on a wheat variety Florence, imported from Israel (Reddy, 1970).Golden nematode of potato(*Globodera (Heterodera) rostochinensis*)has been introduced in Mexico and USA from Europein 1881. Such introduction of dangerous diseases not only reduced the potential yield of the crop but also added an additional restriction on international trade.

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 been started to implement the specified measures. The present activities are taken up to perform PRA for wheatto make and implement sound national and international policies to prevent or restrict entering the organisms having potential threat to wheat cultivation in Bangladesh.

2.0 Methodologyfor Data Collection

To collect the information and present status of different insect pests, diseases and weeds in wheat field and also infestation with insect pests in the storage and storage diseases, an extensive survey was conducted at 600 blocks under 60 upazilasof20 major wheat 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 concern scientists of BARI research stations using structured questionnaire to record the present status of insect pests and diseases on wheat crop. Additional information on the area of wheat 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 wheat crop in the field and storage and control measures followed by them. Primary data were collected from the standing wheat crop of the selected farmers from each upazila and recorded the incidence and severity of different insect pests and diseases available in the field. 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 AppendicesXVII, XVIII, XIX, XX and XXI.

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

Sl. No.	District	Upazila
1	Comilla	1. Homna
		2. Daudkandi
		3. Chandina
2	Lakshmipur	4. Ramganj
		5. Raipur
3	Noakhali	6. Begumganj
		7. Companiganj
4	Dinajpur	8. Ghoramara
		9. Birampur
		10. Fulbari
		11. Sadar
		12. Khanshama
		13. Birganj
5	Thakurgaon	14. Pirganj
		15. Ranishankali
		16. Haripur
6	Bogra	17. Sherpur
		18. Dhunot
7	Gaibandha	19. Polashbari
		20. Shahata
		21. Sadullapur
8	Rangpur	22. Pirganj
		23. Mithapukur
		24. Taraganj
		25. Gangachhara

Sl. No.	District	Upazila
9	Kushtia	26. Sadar
		27. Kumarkhali
10	Jhenaidah	28. Horinakundu
		29. Sadar
		30. Mohespur
11	Jessore	31. Sadar
		32. Monirampur
		33. Keshobpur
12	Sirajganj	34. Sadar
		35. Raiganj
		36. Ullahpara
13	Rajshahi	37. Durgapur
		38. Mohanpur
		39. Godagari
		40. Tanor
14	Naogaon	41. Patnitala
		42. Porsha
		43. Dhamurhat
15	Kishoreganj	44. Kotiadi
		45. Pakundia
		46. Sadar
		47. Hossainpur
16	Mymensingh	48. Sadar
		49. Muktagasa
		50. Phulpur
17	Sherpur	51. Sadar
		52. Nalitabari
18	Pabna	53. Sathia
		54. Sadar
		55. Sujanagar
19	Faridpur	56. Sadar
		57. Nagarkanda
		58. Boalmari
20	Barisal	59. Gournadi
		60. Babuganj

The Plant Quarantine Wing of Department of Agricultural Extension (DAE) has no specialist team for conducting PRA of wheat. So conducting PRA it gives this work to CRDS specialist team which has taken the following methods to conduct PRA of wheat.

Appointment and Training of Field Researchers

Field Researchers having Bachelor degree in agriculture were appointed and proper training on identification of insect pests and diseasesand weeds of wheat through power point presentation.Necessary Questionnaire and Formats were supplied to collect the appropriate information from the Farmers, SAAO, UAO, DD and Researchers.

Field Survey and Primary Data Collection

Seven teams having two members in each team made field survey and collected necessary information based on questionnaire and format from the farmers and concerned officials of 20 districts (Figure 1). Each team was supplied with colored pictures of damage symptom for diseases and insect pests.

Secondary Data Collection

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

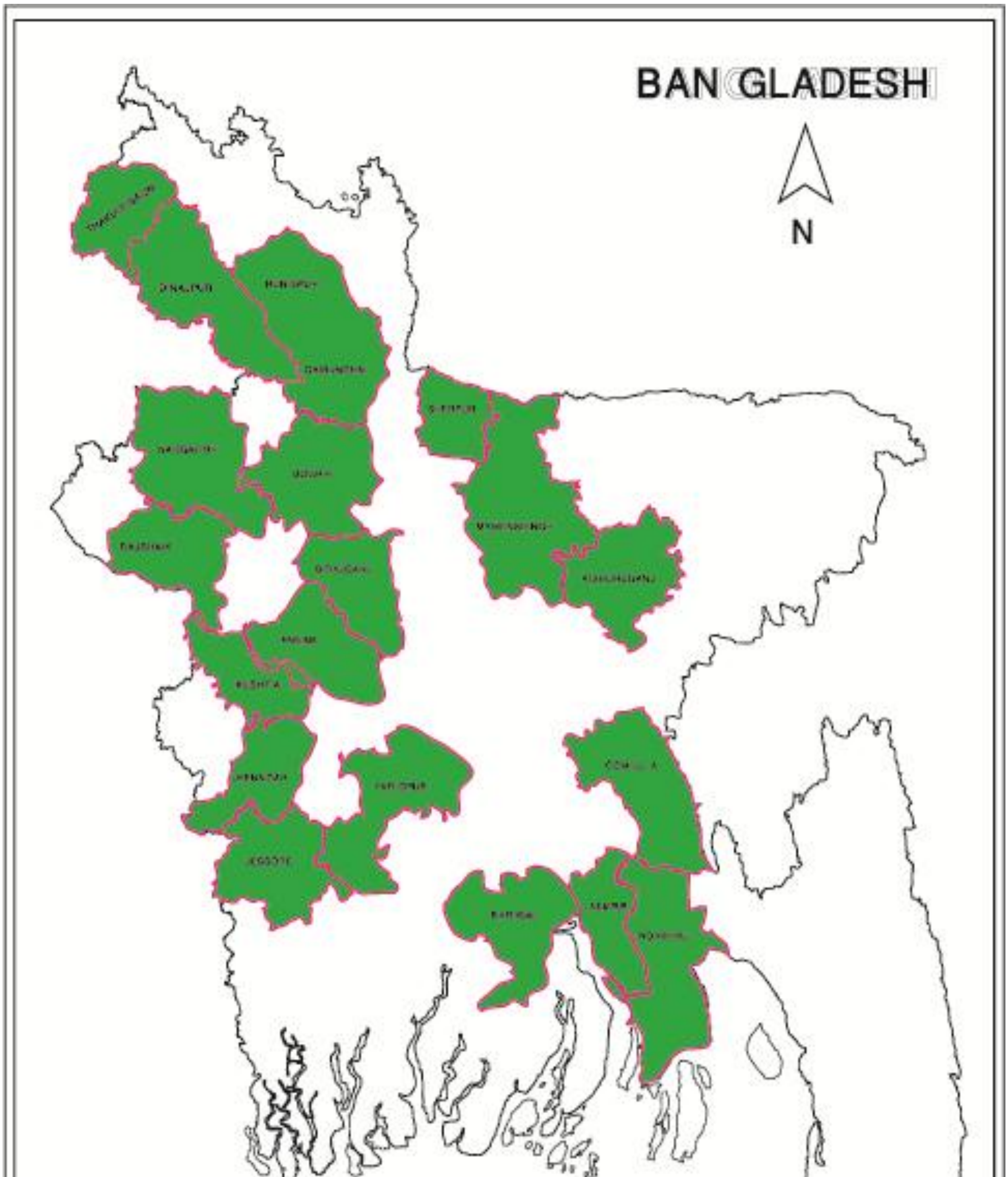
Internet Searching

The Internet searching was done to collect information on insect pests and diseases of wheat worldwide, especially in the countries from where wheat is imported to Bangladesh. Major wheat growing areas of wheat 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 wheat from different locations were analyzed and interpreted with the aim to find 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 wheat in Bangladesh in comparison with other countries of export and import importance of respective crop.

Figure 1: Map showing the selected 20 districts of wheat under study



3.0 Pests, Rodents, Diseases and Weeds of Wheat in Bangladesh

The insect pests, diseases, weeds and rodents of wheat in Bangladesh were studied by field survey, published reports of BARI, other concerned organizations, scientific personnel and internet searching. Summary list of insect pests, diseases,weedsand rodentsrecorded in wheatfield and also on stored seeds/grains were prepared and discussed herein.

3.1 Insect andRodent Pests of Wheat

The list of recorded insect and rodent pestsof wheat in Bangladesh is shown in Table 2.

Table 2: List of insect and rodent pests of wheat in Banglades

Sl. No.	Common name	Scientific name (Family and Order)	Order : Family	Present Status
FIELD INSECT PESTS				
01.	Grasshopper	*Melanoplus* spp.	Orthoptera: Acrididae	Minor
02.	Termite	*Odontotermes obesus*(Rambur)	Isoptera: Termitidae	Minor and sporadic
		*Microtermes obesi*Holmgren		
03.	Wheat aphid	*Rhopalosiphum maidis* (Fitch)	Homoptera: Aphididae	Major
		Rhopalosiphum padi (Linnaeus)		
		Schizaphis graminum (Rondani)		
04.	Wireworms	*Melanotus* spp.	Coleoptera: Elateridae	Minor
		Agriotes spp.		
05.	Cereal leaf beetle	*Oulema melanopus* (Linnaeus)	Colepoptera: Chrysomelidae	Minor
06.	Flea beetle	*Phyllotreta* spp.	Colepoptera: Chrysomelidae	Minor
07.	White grub	*Phyllophaga* spp.	Coleoptera: Scarabaeidae	Minor and sporadic
08.	Cutworm	*Agrotis ipsilon* Hufnagel	Lepidoptera: Noctuidae	Minor
09	Pink borer	*Sesamia inferens* (Walker)	Lepidoptera: Noctuidae	Minor
10.	Leaf eating caterpillar	*Helicoverpa armigera* Hübner	Lepidoptera: Noctuidae	Minor
		Spodoptera litura (Fabricius)		Minor and sporadic
11.	Shoot fly	*Atherigona naqvii* Steyskal	Diptera: Muscidae	Minor
STORAGE INSECT PESTS				
12.	Khapra beetle	*Trogoderma granarium Everts*	Coleoptera: Dermestidae	Major
13.	Rice weevil	*Sitophilus oryzae* (Linnaeus)	Coleoptera: Curculionidae	Major
14.	Rust-red flour beetle	*Tribolium castaneum* (Hurbst)	Coleoptera: Tenebrionidae	Major
15.	Lesser grain borer	*Rhyzopertha dominica* (Fabricius)	Coleoptera: Bostrichidae	Minor
16.	Sawtoothed grain beetle	*Oryzaephilus surinamensis* (Linnaeus)	Coleoptera: Silvanidae	Minor

Sl. No.	Common name	Scientific name (Family and Order)	Order : Family	Present Status
17.	Rice moth/ Angoumois grain moth	*Sitotroga cerealella* Olivier	Lepidoptera: Gelichiidae	Minor in wheat
18.	Rice meal moth	*Corcyra cephalonica* Stainton	Lepidoptera: Pyralidae	Minor in wheat
RODENT PESTS				
19.	Lesser bandicoot	*Bandicota bengalensis* (Gray)	Rodentia: Muridae	Major pest
20.	Soft furred field rat	*Millardia meltada* (Gray)	Rodentia: Muridae	Minor pest

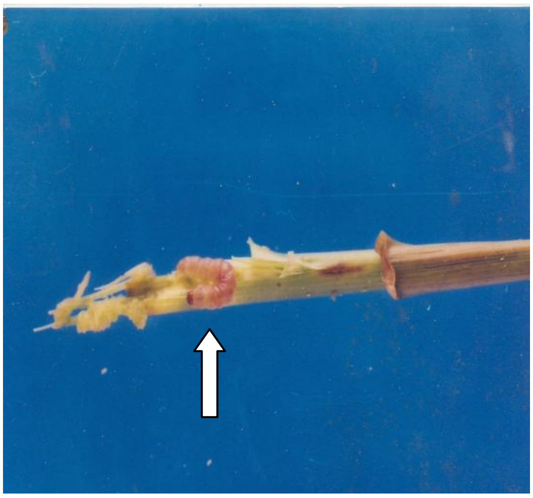
Twenty three (23) species of insect pests viz. three species of aphids, two species of termites, wireworms and leaf feeding caterpillars, grasshopper, cereal leaf beetle, flea beetle, white grub, cutworm, shoot fly, pink borer, khapra beetle, rust-red flour beetle, lesser grain borer, sawthoothed grain beetle, rice moth and rice meal moth were recorded in Bangladesh. Among them 16 species attack wheat in field during cultivation and 7 species attack in storage. Only aphid was the major insect pests of wheat in field, and rice weevil, khapra beetle and red flour beetle were the major in storage. Other insect pests were minor in status (Table 2). It was also reported that termites,whitegrub and leaf feeding caterpillars (Helicoverva aremigera and Spodoptera litura) attack sporadically but they are minor pests. Photographs of some major insect pests of wheat their damage symptoms are shown in figure 2. Two species of rodents, lesser bandicoot (Bandicota bengalensis) and soft furred field rat (Millardia meltada) were reported but lesser bandicoot was the major rodent pest and found all over the Bangladesh. Rodents cause significant damage every year and control measures are needed.

Figure 2: Photographs of some major insect pests of wheat and their damage symptoms

Aphid infested wheat stems and leaves

Aphid infested ear

Whitehead symptom showing pink borer infestation



Larva of pink borer

Cutworm infested seedlings of wheat

Cutworm larvae

Leaf feeding caterpillar infested leaves

Leaf feeding caterpillar

Rice weevil infested wheat grains grains

Red flour beetle infested wheat

3.2 Diseases of Wheat

So far a total of 22 field diseases and two storage diseases of wheat were recorded in Bangladesh. Among these, 17 diseases are caused by fungal pathogens, two by bacteria, two by virus and one by nematode (Table 3). Among the diseases three fungal diseases namely, Bipolaris leaf blight caused by Bipolaris sorokiniana, brown leaf rust caused by Puccinia triticina and black point caused by Bipolaris sorokiniana & Alternaria alternata are considering as major concern for wheat cultivation in the country. Presently all other 20 diseases are of minor importance. Earlier stem rust was a major disease which disappeared after mid 1980s but recent survey showed that this disease has reappeared but with low incidence. Another disease of importance was loose smut, but due to change in varieties this disease is now rarely found in the field. Occurrence of Fusarium head blight and the bacterial disease, black chaff are also rare in the field. Four fungal (Aschochyta leaf blight, Curvularia leaf spot, Take all and Tan spot) and two viral diseases (Mosaic and Leaf streak) reported to occur earlier were not found during the recent surveys. Photgraphs of some important diseases symptoms are shown in Figure 3.

Table 3: Diseases of wheat in Bangladesh

Sl. No.	Name of the disease	Causal organisms	Present status
FIELD DISEASES			
01	Alternaria leaf blight	*Alternaria triticina* Prasada & Prabhu	Minor
02	Ascochyta leaf blight	*Ascochyta tritici* Hori & Enj.	Reported
03	Bipolaris leaf blight	*Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.	Major
04	Bipolaris head blight	*Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.	Moderate
05	Black point	*Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.,*Alternaria alternata* (Fr.) Keiss.	Major
06	Seedling blight	*Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.	Minor
07	Black mould	*Cladosporium*, *Alternaria*, *Epicoccum*	Minor
08	Curvularia leaf spot	*Curvularia lunata* (Wak.) Boed.	Reported
09	Foot and root rot	*Sclerotium rolfsii* Sacc.	Minor

Sl. No.	Name of the disease	Causal organisms	Present status
10	Fusarium head blight	*Fusarium graminearum* Schw.	Rare
11	Loose smut	*Ustilago tritici* (Pers.) Rost.	Rare
12	Powdery mildew	*Blumeria graminis* (DC.) Speer f. sp. *tritici* Marchal	Recorded as aminordiseases ince2012
13	Leaf rust (Brown rust)	*Puccinia triticina* Eriks.Synonym *Puccinia recondita* f. sp. *tritici* (Eriks. & E.Henn.) D.M.Henderson	Major
14	Stem rust (Black rust)	*Puccinia graminis* Pers. f. sp. *tritici* Eriks. & Henn.	Rare
15	Stripe rust (Yellow rust)	*Puccinia striiformis* West. f. sp. *tritici* Eriks. & Henn.	Occasional
16	Take-all	*Gaeumannomyces graminis* (Sacc.) Arx. & Oliv.	Reported
17	Tan spot	*Pyrenophora tritici-repentis* (Died.) Drechs.	Reported
18	Black chaff	*Xanthomonas translucens* (J.J. & R.) Dows.	Rare
19	Bacterial leaf blight	*Pseudomonas syringae pv. syringae*van Hall.	Minor
20	Mosaic	*Virus*	Reported
21	Leaf streak	*Virus*	Reported
22	Root-knot	*Meloidogyne spp.*	Minor
DISEASES IN THE STORAGE			
23	Seed rot	*Aspergillus* spp.	Major
24	Seed rot	*Penicillium* spp.	Minor

Figure 3: Symptoms of some important diseases of wheat in Bangladesh


Bipolaris leaf blight early symptom


Bipolaris leaf blight


Brown leaf rust


Bipolaris head blight


Black point

3.3 Weeds in Wheat of Bangladesh

As many as 37 weeds were recorded in wheat fileds (Table 4). Most of them are major all of them are generally found at the early growing stage of the crop. They are control either by hand weeding or by using herbicides. Weed control is also done by weeder. However due to timely removal of weeds from the field, weeds could could not cause any significant loss in crop yield.

Table 4: List of common weed species recorded in wheat field in Bangladesh

Sl. No.	Bangla Name	Common Name(s)	Botanical Name	Status
01.	Danta/ Malanch	Alligatorweed	*Alternanthera philoxeroides* (Mart.) Gris.	Major
02.	Chanchi	Sessile Joyweed, Dwarf Copperleaf	*Alternanthera sessils*(L.) R.Br. ex DC.	Major
03.	Shak notey	Pig weed, Calalu, Slender amaranth	*Amaranthus viridis*L.	Minor
04.	Kata notey	Spiny pig weed	*Amaranthus spinosus*L.	Minor
05.	Akarakara	Pimpernel/red chickweed	*Anagalis arvensis*L.	Minor
06.	Kukurmuta/ Kukursonga	Kakronda	*Blumea lacera*L.	Minor
07.	Bathua	Lamb's-quarters	*Chenopodium album* L.	Major
08.	Mutha	Nut grass	*Cyperus rotundus* .L.	Major
09.	Durba ghas	Bermudagrass	*Cynadon dactylon*(L.) Pers.	Major
10.	Anguli ghas	Summer grass/Crabgrass/ Hairy crabgrass	*Digitaria sanguinalis*(L.) Scop.	Major
11.	Khude anguli	Smooth crabgrass Small crabgrass	*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.	Major
12.	Khude Shyama	Barnyardgrass	*Echinocloa colonum*L.	Major
13.	Bhringraj	False Daisy	*Eclipta alba*(L.) Hassk.	
14.	Chapra	Goose grass	*Elusine indica*(L.) Gaertn.	Major
15.	Halencha	Water Cress Marsh Herb	*Enhydra fluctuans*Lour.	Major
16.	Joina	Hoorahgrass	*Fimbristylis miliacea*(L.) Vahl	Major
17.	Gang Palong	Jersey cudweed	*Gnaphalium affine*D. Don	Major
18.	Kolmishak	Morningglories	*Ipomoea* sp.	Major
19.	Shatodron	Thumbe	*Leucas aspera*Willd.	Major
20.	Bontamak	Curled-leaved tobacco	*Nicotiana plumbaginifolia*Vivi.	Major
21.	Amrulsak	Sour grass	*Oxalis europaea*Jord.	Minor
22.	Chalaghas	Sea Hard-grass	*Parapholis strigosa*(Dumort.) C.E. Hubb.	Minor
23.	Borobiskatali	Knotweed/ Knotgrass	*Polygonium coccineum*Muhl. ex Willd.	Major
24.	Biskatali	water-pepper	*Polygonum hydropiper*L.	Major

Sl. No.	Bangla Name	Common Name(s)	Botanical Name	Status
25.	Chemti sag	Small knotweed	*Polygonum plebeium*R. Br.	Major
26.	Bonpalong	Golden dock	*Rumex maritimus*L.	Major
27.	Holud seal leza	Yellow foxtail	*Setaria glauca* (L.) Beauv.	Major
28.	Ghagra	Rough cocklebur	*Xanthium strumerium* L.	Major
29.	Foska begun	Clammy	*Physalis heterophylla* L.	Major
30.	Bon begun	Black nightshade	*Solanum nigrum* L.	Major
31.	Tita begun	Turkey Berry	*Solanum torvum*Swartz.	Major
32.	Titlia	Common sow thistle	*Sonchus oleraceous*L.	Major
33.	Lalkakri	Snake-needle grass	*Hedyotis brachipoda*(L.) Lam	Major
34.	Sada kakri	Chiclkenwort	*Stellaria media*(L.) Vill.	Major
35.	Bon masur	garden vetch	*Vicia sativa*L.	Major
36.	Masurchana	Common vetch	*Vicia hirsute* (L.) Koch	Major
37.	Sheal kata	Mexican poppy	*Argemone mexicana*	Minor

Figure 4: Showing some important weeds in wheat fields in Bangladesh


Ghagra (*Xanthium strumarium*)


Bon masur (*Vicia sativa*)


Bathua (*Chenopodium album*)


Biskatali (*Polygonum hydropiper*)


Shetodron (Leucas aspera)


Fosca begun (*Physalis heterophylla)*

4.0 Quarantine Insect pests,Diseases and Weeds of Wheat

The existing information on Insect pests,diseases and weed pestsof wheat in Bangladesh was collected from field survey, interviews with concerned personnel, various reports, books and journals available in the country. The pest problems of other countries of wheat were also collected from CABI reports, books, journals and other internet resources (Appendix XIV, XV and XVI). The collected information of both in country and outside were analyzed, assessed and finally identified the major and destructive insect pests, diseases and weeds of wheat grown in Bangladesh after analizing the exotic pests potential to cause negative impact on the economy, biodiversity and health if introduced. Identified quarantine insect pests and diseases of wheat are discussed herein.

4.1 Quarantine insect and mite pests of wheat

The quarantine insect and mite pests of wheat for Bangladesh and their pathways of introduction are shown in Table 5. A total of twenty four speces of insects (22 species) and mites (2 species) are absent in Bangladesh and they were considered as quarantine pests of wheat for Bangladesh. Among them,ten species of insects and one species of mite attack wheat in field during production. Another 12 species of insects and one species of mite attack wheat grains or its products in storage. All the storage pests are transported either with seeds or stored products. However, sunn pest (Eurygaster integriceps), two species of wheat thrips (Haplothrips tritici, Limothrips cerealium), wheat midge (Sitodiplosis mosellana) and hessian fly (Mayetiola destructor) are seed borne, and transported with soil, plant debris and tissue culture material as live/dead/dormant insects/stages. Seed borne pests are introduced with seeds and live/dead/ dormant insects/stages are introduced as contaminant with soil, plant debris and tissue culture material. Introduction of these quarnantine insect and mite pests with seeds (internally or externally), soil or plant debris will be strictly prohibited from the wheat importing countries.

Table 5:List of quarantine insect and mite pests of wheat for Bangladesh

Sl. No.	Common name	Scientific name	Order: Family	Plant parts affected	Pathways of introduction
FIELD INSECT PESTS					
01.	Wheat aphid	*Sitobion avenae* (Fabricius)	Homoptera: Aphididae	Leaf, stem, ear	As contaminant
02.	Sunn pest	*Eurygasterintegriceps*Puton	Hemiptera: Scutelleridae	Ear	Seed, as contaminant
03.	Wheat bug	*Nysius huttoni* White	Hemiptera: Lygaeidae	Ear	As contaminant
04.	Wheat thrips	*Haplothrips tritici* (Kurdjumov)	Thysanoptera: Phlaeothripidae	Leaf, ear	Seed, as contaminant
05.	Wheat thrips	*Limothrips cerealium* (Haliday)	Thysanoptera: Thripidae	Leaf, ear	Seed, as contaminant
06.	Wheat stem maggot	*Meromyza americana* Fitch	Diptera: Chloropidae	Stem	As contaminant
07.	Wheat midge	*Sitodiplosis mosellana* (Géhin)	Diptera: Cecidomyiidae	Stem	Seed, as contaminant
08.	Hessian fly	*Mayetiola destructor* (Say)	Diptera: Cecidomyiidae	Stem	Seed, as contaminant
09.	Wheat stem sawfly	*Cephus cinctus* Norton	Hymenoptera: Cephidae	Stem	As contaminant
10.	Wheat stem sawfly	*Cephus pygmeus* Linnaeus		Stem	
11.	Brown wheat mite	*Petrobia latens* **(**Müller)	Acarina: Tetranychidae	Leaf	As contaminant

Sl. No.	Common name	Scientific name	Order: Family	Plant parts affected	Pathways of introduction
STORAGE INSECT PESTS					
12.	Mottled dermastid beetle	*Trogoderma inclusum* LeConte	Coleoptera: Dermestidae	Seed	Seed, stored products
13.	Grain dermestid/ Warehouse beetle	*Trogerma varibile* Ballion	Coleoptera: Dermestidae	Seed	Seed, stored products
14.	Glaberous cabinet beetle	*Trogoderma glabrum* (Herbst)	Coleoptera: Dermestidae	Seed	Seed, stored products
15.	Granary weevil	Sitophilus granaries Linnaeus	Coleoptera: Curculionidae	Seed	Seed, stored products
16.	Confused flour beetle	*Tribolium confusum* Jaquelin DuVal	Coleoptera: Tenebrionidae	Seed, flour	Seed, stored products
17.	Large flour beetle	*Tribolium destructor* Uyttenboogaart	Coleoptera: Tenebrionidae	Seed, flour	Seed, stored products
18.	Larger grain borer	*Prostephanus truncatus* (Horn)	Coleoptera: Bostrichidae	Seed	Seed, stored products, as contaminant
19.	Rusty grain beetle	*Cryptolestes ferrugineus* (Stephens)	Coleoptera: Cucujidae	Seed	Seed, stored products, as contaminant
20.	Hairy fungus beetle	*Typhaea stercorea* (Linnaeus)	Coleoptera: Mycetophagida e	Seed	Seed, stored products
21.	Indian meal moth	*Plodia interpunctella* (Hübner)	Lepidoptera: Pyralidae	Seed	Seed, stored products
22.	Mediterranean flour moth	*Ephestia kuehniella* (Zeller)	Lepidoptera: Pyralidae	Seed	Seed, stored products
23.	Chocolate moth/ Cocoa moth	*Ephestia elutella* Hubner	Lepidoptera: Pyralidae	Seed	Seed, dried stored products
24	Flour mite	*Acarus siro* Linneaus	Acarina: Acaridae	Seed, flour	Seed, stored products

4.2 Quarantine diseases of wheat

The first report of a new bunt disease in wheat came from the region of Faizalabad (Pakistan) in 1909. This was presumably Karnal bunt, which was first formally recorded in 1930 near the north Indian city of Karnal (Mitra, 1931). Within India the pathogen spread and presently widespread in northern and central India (in regions where low winter temperatures and high humidity prevail, viz. Bihar, Delhi, Uttar Pradesh, Uttarkhand, Gujarat, Haryana, Punjab, Himachal Pradesh, Rajasthan, Madhya Pradesh, Jammu and Kashmir, West Bengal and Gujarat) (Singh et al., 1985). Subsequently Karnal bunt has been reported from Afghanistan, Brazil, Iran, Lebanon, Mexico, Nepal, Pakistan, South Africa, Syria and USA. This disease is reported to occur on bread wheat, durum wheat and triticale. Once introduced, the fungus would be almost impossible to eradicate because teliospores can remain viable in the soil for as long as five years. Internationaly bunt is considered as a quarantine pest. This disease is not present in Bangladesh; other diseases not present in Bangladesh include dwarf bunt (Tilletia controversa), common bunts (Tilletia laevis and T. tritici), downy mildew (Sclerophthora macrospora), flag smut (Urocystis agropyri), ergot (Claviceps purpurea),cephalosporium stripe (Cephalosporiumgramineum), glume blotch (Stagonospora nodorum), pink snow mold (Microdochium nivale), rhizoctonia root rot (Rhizoctonia solani), bacterial sheath rot (Pseudomonas fuscovaginae), basal glume rot (Pseudomonas syringae pv. atrofaciens), spike blight = gummosis (Rathayibacter tritici), pink seed (Erwinia rhapontici), ear-cockle (Anguina tritici), cereal cyst nematode disease (Heterodera spp.), Australian wheat striate mosaic/ Chloris striate mosaic (Chloris striate mosaic virus), Wheat American striate mosaic (Wheat American striate mosaic virus), Wheat European striate mosaic (Wheat European striate mosaic virus), Barley stripe mosaic (Barley stripe mosaic virus), Wheat spindle streak mosaic(Wheat spindle mosaic virus),Barley yellow dwarf (Barley yellow dwarf virus), Wheat soil-borne mosaic (Wheat soil-borne mosaic virus), Wheat streak mosaic (Wheat streak mosaic virus), Wheat yellow leaf (Wheat yellow leaf Virus) and Indian Peanut Clump (Indian Peanut Clump virus).Among these diseases,considering the probability of entry, exposure, establishment and consequences, 6 fungal, one nemic and two virus diseases are selected as quarantine diseases for Bangladesh (Table 6).

Table 6: List of quarantine diseases of wheat for Bangladesh

Sl. No.	Quarantine Diseases	Crops (Prohibited articles)
01.	Karnal bunt (*Tilletia indica* Mitra)	Contaminated grain or seed or contaminated plant parts of wheat
02.	Stem rust (race ug99)	Contaminated grain or seed or contaminated plant parts of wheat
03.	Common bunts (*Tilletia laevis* Kühn)	Contaminated grain or seed or contaminated plant parts of wheat
04.	Common bunts (*T. tritici*) (Bjerk.) Wint	Contaminated grain or seed or contaminated plant parts of wheat
05.	Ergot (*Claviceps purpurea)* (Fr.) Tullis	Contaminated grain or seed of wheat
06.	Glume blotch (*Phaeosphaeria nodorum*)(Müll.) Hedjar.	Infected grainor seed and plant parts of wheat
07.	Ear-cockle (*Anguina tritici* Steinbuch)	Contaminated grain or seed of wheat
08.	Barley stripe mosaic disease(BSMV)	Infected grain or seed of wheat
09.	Wheat streak mosaicdisease (WSMV)	Infected grain or seed of wheat

4.3 Quarantine weeds of wheat for Bangladesh

Collection of information available in the countries and internet resources as well discussions with relevant professionals and after thorough analysis of all the available information revealed that quite a good number of weed species are absent or present but under official control in Bangladesh. Assesment of the potentiality of entry into Bagladesh; exporure to the environment; establishment and spread in the country; and economic, environment and health consideration, seven weed species were rated having high potential and posseses high risk for Bangladesh. The species are Amaranthus blitoides S. Wats. (Spreading amaranth, Prostrate pigweed), Ambrosea artimisiifolia L. (Hogweed, Annual ragweed, Short ragweed, Hay weed, Common ragweed), Cardaria draba (L.)Desv. (Heart-podded, hoary cress, thanet cress, white top, white weed, perennial peppergrass), Fumaria officinalis L. (Common furnetory), Papaver rhoeas L. (Common poppy/ corn poppy/ field poppy), Parthenium hysterophorus (Carrot grass, bitter weed, star weed, white top, congress weed) and Thlaspi arvense L. (Pennycress/ field pennycress/ bastardcress/ fan weed/ stink weed) were selected as quarantine weed pests for Bangladesh (Table 7). Among the quarantine weed species, except P. hysterophorus all other weeds are absent in Bangladesh and P. hysterophorus is present in a limited scale. Special attention should be paid on Parthenium hysterophorus because of its versatile negative potential. Crop production is drastically reduced owing to its allelopathy and the aggressive dominance of this weed threatens biodiversity, animal husbandry and also human health. The weeds are found to grow along with different crops in the fields, irrigation canals, road side, grazing land, developing residential colonies around the towns, railway tracks, etc. Here we only consider their association with crops. All the weed species were found to be associated with quite a good number of crops. Among these the common crops for all the weeds are Triticum aestivum and Zea mays.

Table 7: List quarantine weeds of wheat for Bangladesh

Sl. No.	Scientific name	Common name	Pathway of introduction
01.	*Amaranthus blitoides* S. Wats.	Spreading amaranth, Prostrate pigweed	Weed seed as contamination with grain/seed of *Glycine max, Gossypium hirsutum, Heliathus annuus, Lycopersicon esculentum, Medicago sativa, Phaseolus vulgaris, Pisum sativum,* ***Triticum aestivum****, Zea mays*
02.	*Ambrosea artimisiifolia* L.	Hogweed, Annual ragweed, Short ragweed, Hay weed, Common ragweed	Weed seed as contamination with grain/seed of *Allium cepa, Arachis hypogaea, Capsicum annum, Glycine max, Helianthus annuus, Lycopersicon esculentum, Nicotiana tabacum, Phaseolus vulgaris, Solanum tuberosum,* ***Triticum aestivum****, Zea mays.*
03.	*Cardaria draba* (L.) Desv.	Heart- podded, hoary cress, thanet cress, white top, white weed, perennial peppergrass	Weed seed as contamination with grain/seed of *Beta vulgaris, Gossypium hirsutum, Helianthus annus, Hordeum vulgaris, Lens culinaris, Nicotiana tabacum, Solanum tuberosum,* ***Triticum aestivum****, Zea mays*
04.	*Fumaria officinalis* L.	Common furnetory	Weed seed/rhizome as contamination withgrain/seed of *Allium cepa, Beta vulgaris, Brassica napus var. napus, Hordium vulgaris, Pisum sativum, Secale cereale, Solanum tuberosum,* ***Triticum aestivum****, Zea mays*
05.	*Papaver rhoeas* L.	Common poppy/ corn poppy/ field poppy	Weed seed as contamination with grain/seed of *Allium cepa, Beta vulgaris, Brassica napus var. napus, Helianthus annuus, Hordeum vulgaris, Lens culinaris, Phaseolus sp., Solanum tuberosum,* ***Triticum aestivum****, T. turgidum, Vicia faba, Zea mays*
06.	*Parthenium hysterophorus* L.	Carrot grass, bitter weed, star weed, white top, congress weed	Weed seed as contamination with grain/seed of *Arachis hypogaea, Brassica napus, Capsicum annuum, Corchorus* spp., *Glycine max, Gossypium hirsutum, Helianthus annuus, Lactuca sativa, Lens culinaris, Lycopersicon esculentum, Oryza sativa, Phaseolus* spp., *Pisum sativum,Ricinus communis, Solanum melongena, Solanum tuberosum, Sorghum bicolor, Sorghum vulgare,* ***Triticum aestivum****,Zia mays.*
07.	*Phalaris minor* Retz.	Littleseed canarygrass	Weed seed as contamination with grain/seed *Allium cepa*, Brassica juncea var. juncea (Indian mustard), *Cicer arietinum*, *Hordeum vulgare*, *Lens culinaris* subsp. *culinaris*, *Linum usitatissimum*, *Pisum sativum*, *Solanum tuberosum*, *Trifolium alexandrinum*, ***Triticum***

			aestivum
08.	*Thlaspi arvense* L.	Pennycress/ field pennycress/ bastardcress/ fan weed/ stink weed	Weed seed as contamination with grain/seed of *Allium cepa, Avena sativa, Beta vulgaris, Brassica napus var. napus, Glycine max, Gossypium* spp., *Helianthus annuus, Hordeum vulgaris, Lens culinaris, Oryza sativa, Phaseolus* spp., *Pisum sativum, Solanum tuberosum,* ***Triticum aestivum****, Zea mays*

4.4 Distribution of quarantine insect pests, diseases and weeds among seven wheat exporting countries

4.4.1 Distribution of Quarantine insect pests among seven wheat exporting countries

The distribution of 24 quarantine insect and mite pests of wheat for Bangladesh is presented in Table 8. Among them nine quarantine pests present in Australaia, 12 in Canada, 9 in India, 9 in Mexico, 4 in Pakistan, 7 in Ukraine and 20 pests are present in USA. Five insect pests are not carried through seeds and other 19 insect pests are transported with seeds externally or internally.

Table 8. List of quarantine insect and mite pests in Australia, Canada, India, Mexico, Pakistan, Ukraine and USA from where wheat grain is imported

Sl. No.	Common name	Scientific name	Australia	Canada	India	Mexico	Pakistan	Ukraine	USA	Present on pathways (Seeds)
01.	Wheat aphid	*Sitobion avenae* (Fabricius)		Present	Present	Present	Present	Present	Present	No
02.	Sunn pest	*Eurygasterinte griceps*						Present		Yes
03.	Wheat bug	*Nysius huttoni*								No
04.	Wheat thrips	*Haplothrips tritici*			Present			Present		Yes
05.	Wheat thrips	*Limothrips cerealium*	Present	Present					Present	Yes
06.	Wheat stem maggot	*Meromyza americana*	Present		Present	Present	Present		Present	No
07.	Wheat midge	*Sitodiplosis mosellana*		Present					Present	Yes
08.	Hessian fly	*Mayetiola destructor*		Present				Present	Present	Yes
09.	Wheat stem sawfly	*Cephus cinctus*		Present					Present	No
10.	European wheat stem sawfly	*Cephus pygmeus*		Present				Present	Present	No
11.	Brown wheat mite	*Petrobia latens*		Present	Present				Present	No
12.	Mottled dermestid beetle	*Trogoderma inclusum*		Present	Present				Present	Yes
13.	Grain dermestid beetle	*Trogerma varibile*	Present	Present		Present			Present	Yes
14.	Glaberous cabinet beetle	*Trogoderma glabrum*		Present		Present			Present	Yes

Sl. No.	Common name	Scientific name	Australia	Canada	India	Mexico	Pakistan	Ukraine	USA	Present on pathways (Seeds)
15.	Granary weevil	*Sitophilus granaries*	Present	Present	Present	Present	Present	Present	Present	Yes
16.	Confused flour beetle	*Tribolium confusum*							Present	Yes
17.	Large flour beetle	*Tribolium destructor*		Present					Present	Yes
18.	Larger grain borer	*Prostephanus truncatus*		Present	Present	Present			Present	Yes
19.	Rusty grain beetle	*Cryptolestes ferrugineus*	Present	Present				Present	Present	Yes
20.	Hairy fungus beetle	*Typhaea stercorea*	Present	Present		Present			Present	Yes
21.	Indian meal moth	*Plodia interpunctella*	Present		Present	Present			Present	Yes
22.	Mediterranean flour moth	*Ephestia kuehniella*		Present	Present	Present			Present	Yes
23.	Chocolate moth	*Ephestia elutella*	Present	Present			Present			Yes
24.	Flour mite	*Acarus siro*	Present						Present	Yes

4.4.2 Distribution of quarantine diseases among seven wheat exporting countries

The distribution of nine quarantine diseases for Bangladesh is shown in Table 9. Our search results indicated that among the diseases, common bunt caused by T. laevis is the most widespread disease across the countries. However, common bunt caused by T. tritici is absent in Australia and Mexico. Karnal bunt (T. indica) is absent in Australia, Canada and Ukraine among the seven wheat exporting countries. Record on the presence of the devastating race of rust, UG99 was found only in USA. Among other diseases not present in the wheat exporting countries include Ear-cockle in Canada; ergot, glume blotch, wheat streak mosaic and barley stripe mosaic in India and also in Pakistan; and glume blotch and ear-cockle is absent in Mexico. Table 9 also shows that presence of the identified quarantine pests for Bangladesh in India and Pakistan is similar and least number of these pests is present in these two countries.

Table 9: Distribution of quarantine diseases for Bangladesh among the countries exporting wheat to Bangladesh.

Sl. No.	Name of disease	Causal agent	Australia	Canada	India	Mexico	Pakistan	Ukraine	USA
01.	Karnal bunt	*Tilletia indica* Mitra			Present	Present	Present		Present
02.	Common bunt	*Tilletia laevis* Kühn	Present	Present	Present	Present	Present	Present	Present
03.	Common bunt	*Tilletia tritici* (Bjerk.) R. Wolff		Present	Present		Present	Present	Present
04.	Stem rust	*Puccinia graminis f. sp. Tritici race* ug99							

Sl. No.	Name of disease	Causal agent	Australia	Canada	India	Mexico	Pakistan	Ukraine	USA
05.	Ergot	*Claviceps purpurea* (Fr.) Tull.	Present	Present		Present			Present
06.	Glume Blotch	*Stagonospora nodorum* (Berk.) Castell. et Germano	Present	Present				Present	Present
07.	Ear-cockle	*Anguina tritici* (Steinbuch) Filipjev.	Present		Present		Present	Present	Present
08.	Wheat streak mosaic	Wheat streak mosaic virus	Present	Present		Present		Present	Present
09.	Barley stripe mosaic	Barley stripe mosaic virus	Present	Present		Present		Present	Present

4.4.3 Distribution of Quarantine weeds among seven wheat exporting countries

The distribution of eight quarantine weed species for Bangladesh is shown in Table 10. It reveals from the table that among the eight weed spesies all are present in Australia and USA. Only two weeds namely Ambrosea artimisiifolia and Parthenium hysterophorus are present in India. All the weeds except P. hysterophorus are present in Canada. Among the weeds Amaranthus blitoides and A. artimisiifolia are absent in Pakistan. Among the selected quarantine weeds Fumaria officinalis, Papaver rhoeas and Thlaspi ravens were not found in Mexico. Among the selected quarantine weeds Ambrosea artimisiifolia and P. rhoeas were present in Ukraine. Phalaris minor is an important quarantine weeds, presents in Australia, India, Mexico, Pakistan and USA, but absent in Canada and Ukarine.

Table 10: Distribution of Quarantine weeds for Bangladesh in seven wheat exporting countries

Sl. No.	Common name	Scientific name	Australia	Canada	India	Mexico	Pakistan	Ukraine	USA
01.	Spreading amaranth	*Amaranthus blitoides* S. Wats.	Present	Present		Present			Present
02.	Hogweed	*Ambrosea artimisiifolia* L.	Present	Present	Present	Present		Present	Present
03.	Heart- podded	*Cardaria draba* (L.) Desv.	Present	Present		Present	Present		Present
04.	Common furnetory	*Fumaria officinalis* L.	Present	Present			Present		Present
05.	Common poppy	*Papaver rhoeas* L.	Present	Present			Present	Present	Present
06.	Carrot grass, bitter weed	*Parthenium hysterophorus*	Present		Present	Present	Present		Present
07.	Littleseed canarygrass	*Phalaris minor* Retz.	Present		Present	Present	Present		Present
08.	Pennycress	*Thlaspi arvense* L.	Present	Present			Present		Present

5.0 Risk Analysis for wheat in Bangladesh

5.1 Background

Bangladesh has been importing wheat from Australia, Canada, India, Mexico, Pakistan, Ukraineand USA. 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 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 wheat and the PRA areasare the selected 20 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 wheat in Bangladesh and to ascertain the potential hazard organisms or diseases associated with wheatgrain/seedimported from the countries mentioned above. In addition, wheat seed as germplasm or advanced lines are imported from CIMMYT, Mexico for development of varieties. 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 wheat means the seed or grain of wheat 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 6.

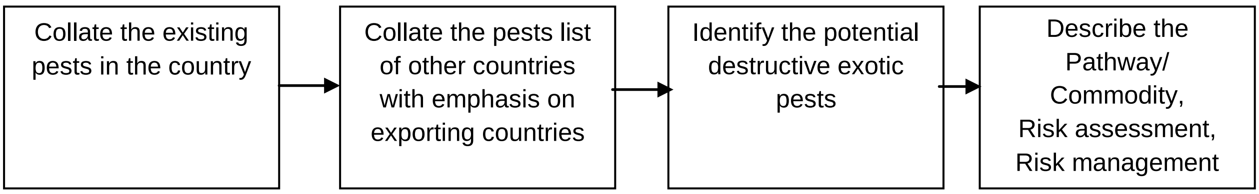


Figure 6: A Flow Diagram of the Risk Analysis Process.

Data on insect pests and diseases were collected through field survey of 6000 farmers' fields in 60 upazilas under 20 districts (Appendix I) of the country and interviewing of 6000 farmers, 600 Sub-Assistant Agricultural officers (SAAO), 60 Upazila Agricultural Officer (UAO) and 20 Deputy Director, Department of Agricultural Extension (DDAE). Information was also collected from available publications and related Scientists from Bangladesh Agricultural Research Institute (BARI). The recorded insect pests, diseases and weed of wheat from field survey of major wheat growing areas in Bangladesh are shown in AppendicesV,VIand VII, respectively. The world pest situation in wheat was collected from published papers and internet resources. Lists of insect pests,diseases and weeds in wheatof the world are shown in AppendicesXIV, XV andXVI, respectively. 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

For any risk assessment the first step is to identify the hazard as the risk is related to hazard. Hazards are the unwanted insect pests, diseases (pathogen)or weeds which could be introduced into Bangladesh by risk goods, and are potentially capable of causing harm to wheat production, must be identified. This process begins with the collation of a list of organisms that might be associated with the commodity in the country of origin. Such list is compared with the existing pests present in Bangladesh to prepare a list of exotic pests harmful for Bangladesh if 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 7.

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 8.

Figure 7: Diagrammatic representation of hazard identification

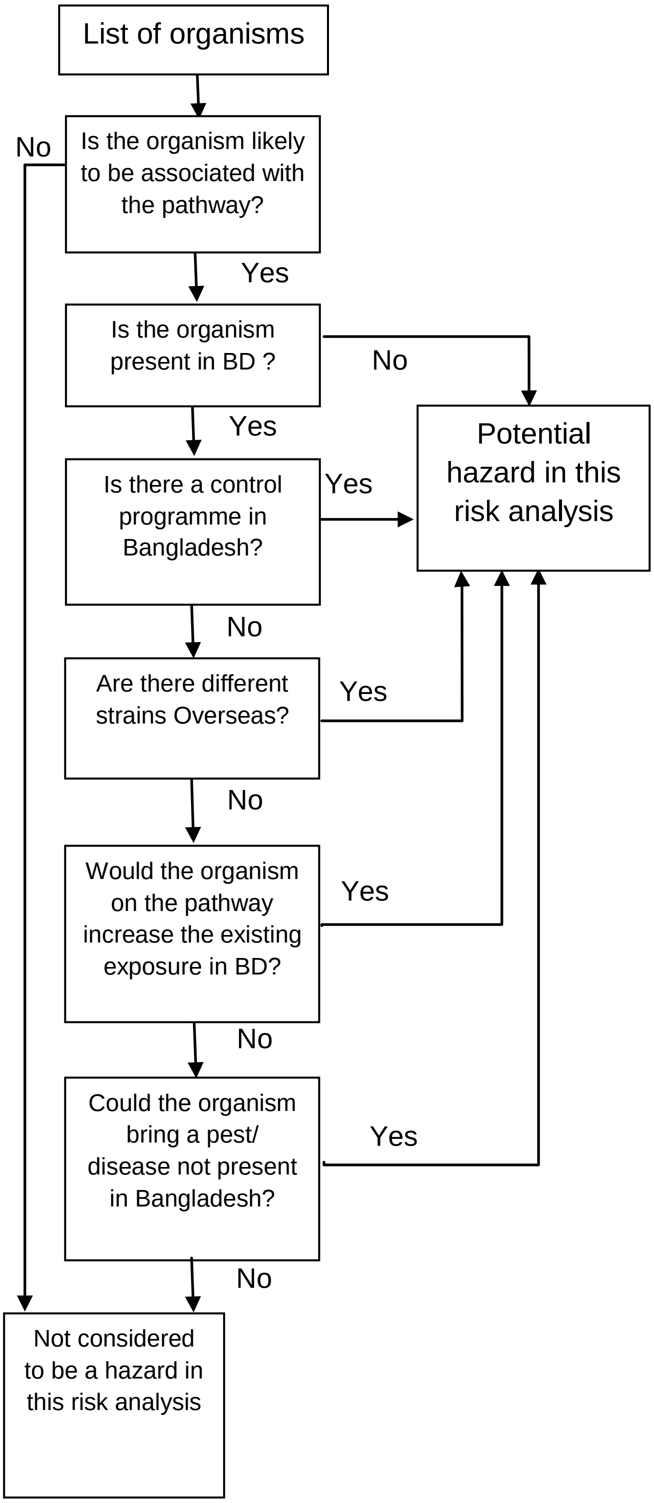
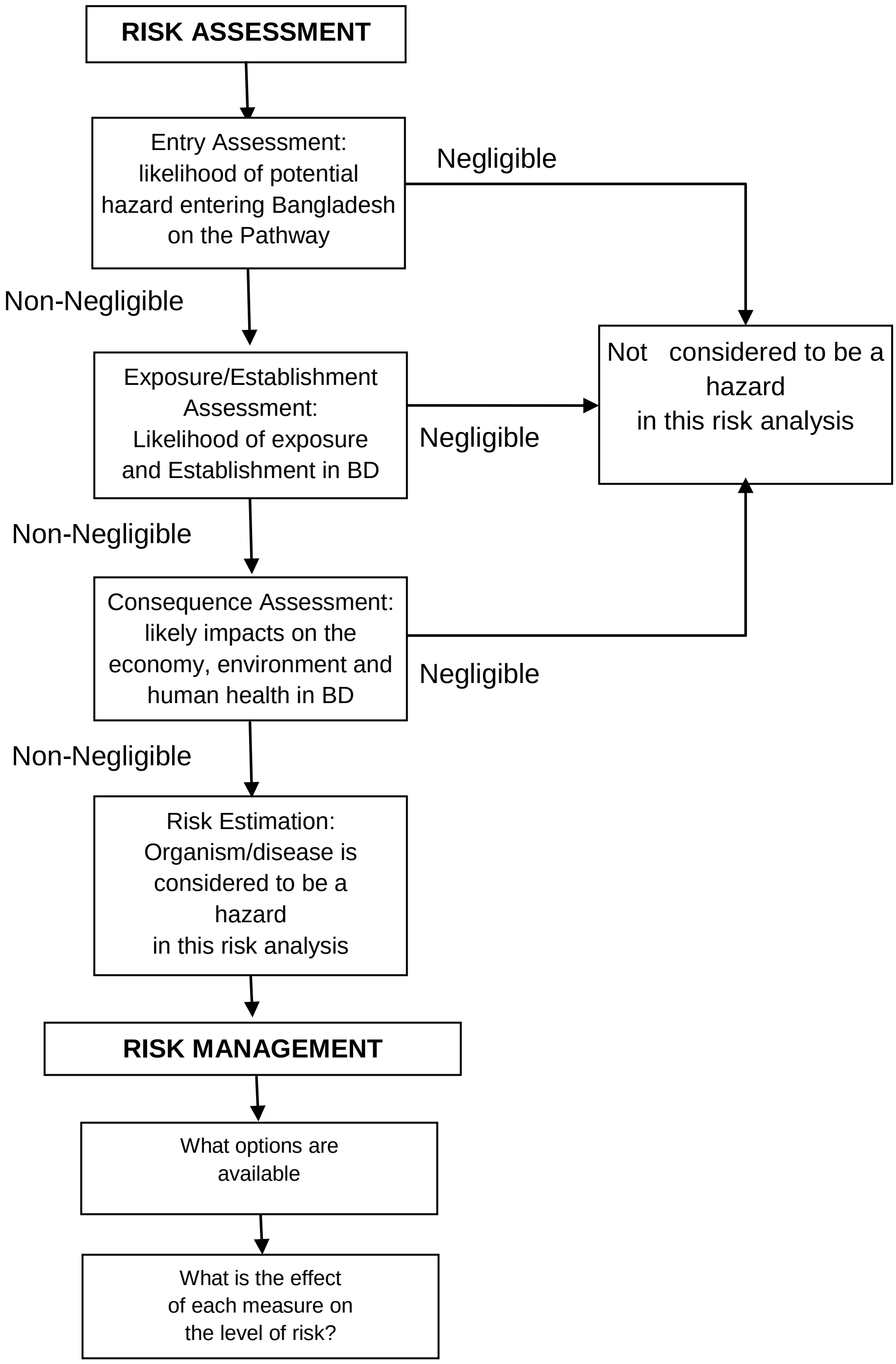


Figure 8: Diagramatic representation of the process followed for risk assessment and management



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.

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 seven established pathways (Australia, Canada, India, Mexico, Pakistan, Ukraine and USA) for wheat 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.

5.11 Review and Consultation

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

6.0 Import Risk Analysis

This chapter provides information on the commodity that is relevant to the analysis ofbiosecurity 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

In this risk analysis wheat grain from Australia, Canada,India, Mexico, Pakistan,Ukraneand USA and seed from Mexico is defined as the harvest of *Triticum aestivum* with all vegetative parts removed and that have been cultivated, harvested, packed in the exporting country andtransported to Bangladesh.

Description: Wheat is one of the first cereals known to have been domesticated, and its ability to self-pollinate greatly facilitated the selection of many distinct domesticated varieties. Cultivation and repeated harvesting and sowing of the grains of wild grasses led to the creation of domestic strains, as mutant forms of wheat were preferentially chosen by farmers. In domesticated wheat, grains are larger, and the seeds remain attached to the ear by a toughened rachis during harvesting. In wild strains, a more fragile rachis allows the ear to easily shatter and disperse the spikelets. As the traits that improve wheat as a food source also involve the loss of the plant's natural seed dispersal mechanisms, highly domesticated strains of wheat cannot survive in the wild.

The seed, grain or kernel of wheat (caryopsis) is a dry indehiscent monocot. The dorsal side (with respect to the spikelet axis) is smoothly rounded, while the ventral side has the deep crease. The embryo or germ is situated at the point of attachment of the spikelet axis, and the distal end has a brush of fine hairs. The embryo is made up of the scutellum, the plumule (shoot) and the radicle (primary root). The scutellum is the region that secretes some of the enzymes involved in germination and absorbs the soluble sugars from the breakdown of starch in the endosperm. Surrounding the endosperm is the aleurone layer, the testa or seed coat and the pericarp or fruit coat. The coleoptile is well developed in the embryo, forming a thimble-shaped structure covering the leaf primordia and the shoot meristem. At germination, it bursts through the pericarp and testa and grows through the soil mainly by the action of an intercalary meristem, which forms about 10 mm behind the tip and stays at this position throughout the growth of the coleoptile.

The fully elongated coleoptile is a tubular structure typically about 50 mm long and 2 mm in diameter. It is white in colour except for two lateral strands of chlorophyllous tissue associated with the vascular strands. The end of the coleoptile is bullet-shaped and closed except for a small pore 0.25 mm long a short distance behind the tip and on the side opposite the scutellum.

When a seed is sown in a suitable moist and aerated soil it germinates. The radicle emerges first and then the plumule. As growth continues, the radicle and about four other seminal roots develop. The coleoptile emerges shortly after the radicle and forms a sheathing structure through which the developing leaves grow. The coleoptile increases in length until it emerges through the soil surface, when further elongation ceases. If the seed is very deep seeded, the coleoptile may cease growth before it reaches the soil surface.

The shoot is made up of a series of repeating nodes and internodes. The internodes are hollow inside. The portion of the shoot with elongated internodes is the elongated stem or culm. In the proximal or basal units, the internode remains short and the nodes are packed closely together. A leaf is inserted at each node although at maturity the basal leaves are usually dead and may have disappeared. Each leaf comprises the sheath, wrapping around the subtending leaf, and a lamina (blade). At the junction of the sheath and lamina, there is a membranous structure, the ligule, and a pair of small, hairy projections, the auricles. The base of the leaves on the culm is thickened to form a hard knot or pulvinus.

The shoot is terminated by an ear or spike bearing the spikelets. In the ear, the phytomer is made up of the spikelet (the axillary bud) and the rachis (node and internode); the development of the leaf is suppressed.

The wheat plant has two types of roots, the seminal (seed) roots and roots that initiate after germination, the nodal (crown or adventitious) roots. The seminal root system may grow to 2 m in depth and support the plant until the nodal roots appear. Nodal roots are associated with tiller development and are usually first seen when the fourth leaf emerges and tillering starts. Compared with the seminal roots, they are thicker and emerge more or less horizontally; when they first appear they are white and shiny. Nodal roots occur on the lower three to seven nodes (depending on environmental conditions and final number of leaves on the shoot). The uppermost node on which roots occur, at the base of the culm, may be above soil level, and the roots may not penetrate the soil but appear as short pegs protruding from the stem. At maturity, the root system extends to between 1 and 2 m deep or more depending on soil conditions. Most roots occur in the top 30 cm of soil.

Tiller buds are initiated in the axils of the basal leaves of the main shoot. Buds are usually positioned adjacent to the overlapping margin of the subtended leaf and thus tend to be arranged asymmetrically, not on the midline (Williams, 1975). Subsequent development of tiller is similar to that of the main shoot. At anthesis, only some of the tillers that have developed survive to produce an ear. Others die and may be difficult to find in the mature plant.

As it approaches anthesis, the ear is completely formed and the pollen grains and carpel are fully developed. After anthesis, the florets open, pollen is released and the carpels are pollinated. The stamens and lodicules, their role fulfilled, die and shrivel, and further growth and development takes place in the carpels, the developing grains. At this stage, the ear consists of the main axis or rachis with each internode ovoid in section and curving around the spikelet. A single spikelet is attached at each node, and the rachis terminates in a spikelet set at right angles to the lateral spikelets. There is a gradient of size and maturity along the ear, with the largest and most advanced spikelets situated in the mid-part of the ear. Under unfavourable growing conditions, the lowermost spikelet and those at the top of the ear may be poorly developed and devoid of fertile florets.

Each spikelet comprises an axis, the rachilla, which bears two glumes and a number of florets. Within each spikelet, there are usually from two to four potentially fertile florets. The floret has two sheathing structures, the outer lemma and the inner palea; these envelope two lodicules, three stamens and the carpel. Each stamen is made up of a filament, which is very short at this stage, and a yellow anther. The anther is about 3 mm long and has four chambers or loculi containing numerous pollen grains. The spherical pollen grain has a small circular pore and contains a single nucleus and starch grains (Percival, 1921).

The basal part of the carpel, the ovary, is obconical or obovate and white in colour with a smooth surface except at the tip, which has numerous unicellular hairs. The ovary contains a single ovule oriented so that the nucellar apex (micropyle) is slightly below the horizontal mid-plane of the ovule. The ovule has two integuments enclosing the nucellus embedded in which is the embryo sac (Percival, 1921). The embryo sac contains an egg nucleus with two associated nuclei (the egg apparatus), two polar nuclei and between 20 and 30 antipodal cells, which are highly polyploid (Bennett *et al*., 1973).

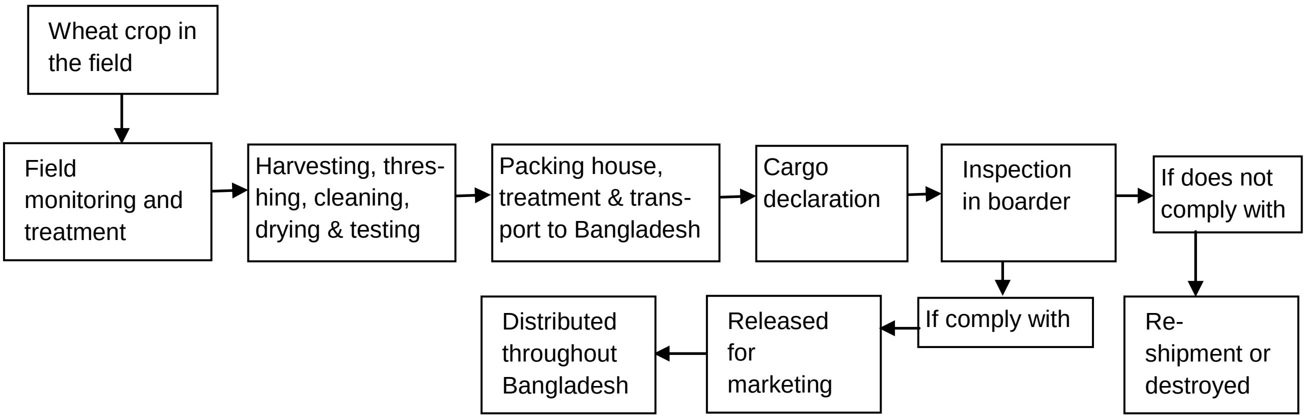
Carl Linnaeusrecognized five domesticated species of wheat as follows:

- *T. aestivum* Bearded spring wheat
- *T. hybernum* Beardless winter wheat
- *T. turgidum* Rivet wheat
- *T. spelta* Spelt wheat
- *T. monococcum* Einkorn wheat

6.2 Description of proposed import pathway

For the purpose of this risk analysis wheat seed or grain are presumed to be from anywhere in Australia, Canada, India, Mexico, Pakistan, Ukraine and USA. Grains are/ would be sea or terrestrialand seed by air freighted to Bangladesh through any of the two Sea ports-Chittagong and Mongla; three Airports namely Hazrat Shahajalal Intl. Airport, Dhaka and 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 sale and consumption. Diagrammatic representation of import pathways of wheat is shown in Figure 9.

Figure 9: Linear diagram of import pathway of wheat



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

The harvesting of the crop will be done at full maturity followed by threshing, cleaning, dryingand seed health testing. Wheat seed or grainfor export will then be transported to packing housewhere 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) and accompanied with phytosanitary certificatefrom the PPO of the country of origin and packing to be done for shipment to Bangladesh.

The consignment must accompany appropriate certification, e.g. a phytosanitary certificate attesting to the identity of the grain/seed, any treatments completed, or other information required helping mitigate risks. Grains/seedsare 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 Australia

Australia is a country, as well as a continent. It is located in Oceania between the Indian Ocean and the South Pacific Ocean. It is the sixth largest country in the world with a total area of 7,686,850 square kilometers (2,967,909 sq. mi) (including Lord Howe Island and Macquarie Island).

The Australian mainland has a total coastline length of 35,876 km with an additional 23,859 km of island coastlines. There are 758 estuaries around the country with most located in the tropical and sub-tropical zones. Australia has the largest area of ocean jurisdiction of any country on earth. It has no land borders. The northernmost points of the country are the Cape York Peninsula of Queensland and the Top End of the Northern Territory. The western half of Australia consists of the Western Plateau, which rises to mountain heights near the west coast and falls to lower elevations near the continental centre. The Western Plateau region is generally flat, though broken by various mountain ranges such as the Hamersley Range, the MacDonnell Ranges, and the Musgrave Range. Surface water is generally lacking in the Western Plateau, although there are several larger rivers in the west and north, such as the Murchison, Ashburton, and Victoria river.

The Eastern Highlands, or Great Dividing Range, lie near the eastern coast of Australia, separating the relatively narrow eastern coastal plain from the rest of the continent. These Eastern Australian temperate forests have the greatest relief, the most rainfall, the most abundant and varied flora and fauna, and the densest human settlement.

Between the Eastern Highlands and the Western Plateau, lie the Central Lowlands, which are made up of the Great Artesian Basin and Australia's largest river systems, Murray-Darling Basin and Lake Eyre Basin.

Off the eastern coast of Australia is the world's largest coral reef complex, the Great Barrier Reef. The State of Tasmania, a large and mountainous island, resides in the south-eastern corner of Australia.Australia is a major agricultural producer and exporter. Agriculture and its closely related sectors earn $155 billion-a-year for a 12% share of GDP. Australian farmers and graziers own 135,997 farms, covering 61% of Australia's landmass.[1] Across the country there is a mix of irrigation and dry-land farming.

There are three main zones: the high rainfall zone of Tasmania and a narrow coastal zone (used principally for dairying and beef production); wheat, sheep zone (cropping (principally winter crops), and the grazing of sheep (for wool, lamb and mutton) plus beef cattle) and the pastoral zone (characterised by low rainfall, less fertile soils, and large scale pastoral activities involving the grazing of beef cattle and sheep for wool and mutton). An indicator of viability of agriculture in the state of South Australia is whether land is within Goyder's Line.

Cereals, oilseeds and grain legumes are produced on a large scale in Australia for human consumption and livestock feed. Wheat is the cereal with the greatest production in terms of area and value to the Australian economy. The major wheat growing areas are Western Australia, New South Wales, South Australia, Victoria and Queensland.

By far the largest part of Australia is arid or semi-arid. A total of 18% of Australia's mainland consists of named deserts, while additional areas are considered to have a desert climate based on low rainfall and high temperature. Only the south-east and south-west corners have a temperate climate and moderately fertile soil. The northern part of the country has a tropical climate: part is tropical rainforests, part grasslands, and part desert.

Rainfall is highly variable, with frequent droughts lasting several seasons thought to be caused in part by the El Niño-Southern Oscillation. Occasionally a dust storm will blanket a region or even several states and there are reports of the occasional large tornado. Rising levels of salinity and desertification in some areas is ravaging the landscape.

Pests and disease control: Aphid (*Rhopalosiphum* spp.), wheat thrips (*Limothrips cerealium*), wireworm, cutworm, pink borer, leaf feeding caterpillar (*H. armigera*) etc. are the insect pests whichattack on wheat during production. Usually chemical insecticides spray, biocontrol agents and different cultural control are applied for the management of these obnoxious pests. The most common insect pests of stored wheat grains in Australia are rice weevils *(Sitophilus*spp.), lesser gain borer *(Rhyzopertha dominica)*, rust red flour beetle *(Tribolium spp.)*, sawtooth grain beetle *(Oryzaephilus spp.)*, flat grain beetle *(Cryptolestes spp.)*, Indian meal moth *(Plodia interpunctella)* and Angoumois grain moth *(Sitotroga cerealella)*. Fumigation is used to control these stored grain insect pests.

Stem rust is ranked as potentially the most important foliar disease of wheat in most regions. Other major foliar diseases were stripe rust, flag smut, septoria tritici blotch and leaf rust. Yellow spot has increased in importance since 1975 with the adoption of stubble retention farming in north-eastern Australia and Western Australia. Root rots of major importance were take-all, crown rot, Rhizoctonia bare patch and cereal cyst nematode. Bunt is potentially the most serious disease of the inflorescence but it is very rare because it is effectively controlled by seed-treatment by fungicides. Most biotrophic foliar diseases are well controlled by selection for resistance. Cultural practices and crop rotation are the main control options for root diseases, while fungicides are mainly used for control of inflorescence diseases.

6.3.2 Canada

The geographic features of Canada, the world's second largest country in total area are briefly described below.

Canada is situated in northern North America (constituting 41% of the continent's area), spans a vast, diverse territory between the North Pacific Ocean to the west and the North Atlantic Ocean to the east and the Arctic Ocean to the north, with the United States to the south (contiguous United States) and northwest (Alaska). Greenland is to the northeast; off the southern coast of Newfoundland lies Saint-Pierre and Miquelon, an overseas collectivity of France. Since 1925, Canada has claimed the portion of the Arctic between 60°W and 141°W longitude to the North

Pole; however, this claim is contested. While the magnetic North Pole lies within the Canadian Arctic territorial claim as of 2011, recent measurements indicate it is moving towards Siberia.

Covering 9,984,670 km^2 (land: 9,093,507 km^2 and freshwater: 891,163 km^2), Canada is slightly less than three-fifths as large as Russia and slightly larger than Europe. In total area, Canada is slightly larger than both the U.S. and China.However, Canada ranks fourth in land area. The population of Canada, some 34,980,000 as of November 2012, is concentrated in the south in proximity to its border with the contiguous U.S.; with a population density of 3.5 people per square kilometre, it is one of the most sparsely populated countries in the world. The northernmost settlement in Canada—and in the world—is Canadian Forces Station (CFS) Alert (just north of Alert, Nunavut) on the northern tip of Ellesmere Island at 82°30′N 62°19′W, just 834 kilometres from the North Pole.

Canada has a diverse climate. The climate varies from temperate on the west coast of British Columbia to a subarctic climate in the north. Extreme northern Canada can have snow for most of the year with a Polar climate. Landlocked areas tend to have a warm summer continental climate zone with the exception of Southern Ontario which has a hot summer humid continental climate. Parts of Western Canada have a semi-arid climate, and parts of Vancouver Island can even be classified as cool summer Mediterranean climate. Temperature extremes in Canada range from 45.0 °C in Midale and Yellow Grass, Saskatchewan on July 5, 1937 to -63.0 °C in Snag, Yukon on Monday, February 3, 1947. Canada covers various geoclimatic regions. There are 8 main regions. Canada also encompasses vast maritime terrain, with the world's longest coastline of 202,080 kilometres.

A wide range of agriculture is practised in Canada, from sprawling wheat fields of the prairies to summer produce of the Okanagan valley. In the federal government, overview of Canadian agriculture is the responsibility of the department of Agriculture and Agri-Food. Alberta is the second largest producer of wheat in Canada. Manitoba, Saskatchewan and Alberta are the main wheat producing areas. Wheat is a staple crop for Canada.

Within Canada, wheat is the most important cultivated crop, though canola is increasing in significance. Only one class of durum is grown, amber durum; however, there are several classes of common wheat, based on factors including seed hardness and colour, sowing time (autumn or spring) and the region where the varieties are grown. Canada is not only renowned for the quantity of wheat it produces, but also for the quality of its wheat. As a major wheat producing nation, nearly 52,000 Canadian farms grow wheat on more than 9.26 million hectares. In 2012, more than 27 million tonnes of wheat were produced across the country, making Canada the 7th largest wheat producing nation in the world. The majority of Canadian wheat is produced in Western Canada.On an annual basis, Canada exports more than 17,000,000 tonnes of wheat, durum and wheat flour to countries around the world. The top five major importers of Canadian wheat include Mexico, Japan, Iraq, United States, and Colombia. Canada's annual wheat export revenues are close to $5.4 billion.

Pest and disease control: Major insect pests of wheat in Canada infesting wheat are grasshoppers, cutworms, wheat stem saw fly, wheat midge are the major pests, and aphids, hessian fly, and wireworms are the minor insect pests in field. Different hemical insecticides are applied for the mangament of major insect pests. However, different cultural control methods like early seeding, crop reation and tillage are practiced to reduce the population of particular insect pests. Resistant varieties are cultivated against the specific crop pests (eg. solid stem varieties against wheat stem saw fly). Parasitic wasps are used to control some specific pests of wheat (Goodwin, 2005). Moreover, major diseases in Canada inflicting wheat includes dwarf bunt, common bunts (caused by both *T. laevis*and *T. tritici*), flag smut, yellow rust,brown leaf rust, stem rust, take-all, glume blotch, pink snow mold, black chaff, cereal cyst nematode, barley yellow dwarf and wheat American striate mosaic.Seed treatment with fungicides, use of resistant varieties and crop rotation are followed for controlling dwarf bunt and common bunts. Other foliage diseases are controlled by application of foliar fungicides, use of resistant varieties, crop rotation and sanitation. For controlling soil-borne diseases the measures adopted include increase of phosphate level in soil, fungicidal seed treatment, resistant varieties and crop rotation. Application of foliar fungicides and use of resistant varieties are following for controlling rusts but no control available for most viral diseases; for wheat streak mosaic virus, avoid overlap of volunteer spring wheat and fall wheat planting; resistant varieties being developed.

6.3.3 India

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 wheat growing areas are Punjab, Haryana, Rajasthan, Uttar Pradesh, Rajasthan and Bihar.

Wheat is the most important food-grain of India and is the staple food of millions of Indians, particularly in the northern and north-western parts of the country. India is the second largest producer of wheat in the world after China. Wheat 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 wheat 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.- Dee. 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 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.

Wheat is primarily a crop of mid-latitude grasslands and requires a cool climate with moderate rainfall. The ideal wheat 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. Wheat thrives well in areas receiving an annual rainfall of about 75 cm. Annual rainfall of 100 cm is the highest limit of wheat cultivation. The isohyet of 100 cm marks the boundary between wheat growing areas on one hand and rice growing areas on the other.

Pest and disease control: The reported insect pests of wheat in Inida are aphids (*Sitobion avenae, Rhopalosiphum padi* and other species), armyworm, termites (*Odontotermes obeseus,* *Microtermes obesi*), legume pod borer (*Helicoverpa armigera*), pink borer and brown wheat mite are reported in India. The damage due to insect pests in wheat is not much and very little pesticides are needed to control for the insect pests. However, in specific cases, insecticides may be used. Seed treatement with chemical insecticides are practiced for the control of termites and insecticides are applied for the ontrol of aphid, armyworm, *H. armigera*. Cultural and mechanical control methodd are used and biological control agents are sometimes released in the the field (Ragunathan, 2002). Plant products like neem seed kernel, neem oil, neem leaf dust etc. are used to prevent and control insect pests associated with stored wheat.

Among the fungal diseases, rusts (yellow, brown and black), Karnal bunt,powdery mildew, foliar blights and loose smut are important. Among the nematode diseases ear-cockle and cereal cyst nematode are of major concern. Control of rusts is more critical for achieving the higher yields. India in particular has not faced any rust epidemic since last three and half decades because of proper deployment of rust resistance genes in wheat breeding programmes. Wheat and wheat rusts have evolved hand in hand for centuries. With the domestication of wheat, new rust resistance genes were introgressed. However, rust pathogens are also evolving consequentially. The rust pathogens are highly variable. The evolution of new pathotypes occurs in each rust render a resistant variety susceptible. Monitoring of rusts is being done every year through extensive surveys and planting trap plot nurseries at hot spot locations. This has helped in identifying rust pathotypes and rust management. For controlling other diseases the recommended options are uses of resistant varieties, use seed from disease free source or seed treatment with fungicides and solarization. For nematode control use of resistant varieties, healthy seed, deep-ploughing, early sowing and application of nematicides are in practice.

6.3.4 Mexico

Mexico is a country in the Americas. It is located at about 23° N and 102° W in the southern portion of North America. From its farthest land points, Mexico is a little over 3,200 km in length. The total area of the country is 1,972,550 km^{2}including approximately 6,000 square kilometers of islands in the Pacific Ocean, Gulf of Mexico, Caribbean Sea, and Gulf of California. of which land occupies 1,923,040 km^2 and water 49,510 km^2. In the north Mexico is bordered with the United States (specifically, from west to east, by California, Arizona, New Mexico, and Texas), to the west and south by the Pacific Ocean, to the east by the Gulf of Mexico, and to the southeast by Belize, Guatemala, and the Caribbean Sea. The northernmost constituent of Latin America, it is the most populous Spanish-speaking country in the world. Mexico is three times the size of Texas.

Almost all of Mexico is on the North American Plate, with small parts of the Baja California Peninsula in the northwest on the Pacific and Cocos Plates. Some geographers include the portion east of the Isthmus of Tehuantepec including the Yucatán Peninsula within North America. This portion includes Campeche, Chiapas, Tabasco, Quintana Roo, and Yucatán, representing 12.1 percent of the country's total area. Alternatively, the Trans-Mexican Volcanic Belt may be said to delimit the region physiographically on the north. Geopolitically, Mexico is generally not considered part of Central America. Politically, Mexico is divided into thirty-one states and a federal district, which serves as the national capital.

The Tropic of Cancer effectively divides the country into temperate and tropical zones. The land situated at north of the twenty-fourth parallel experiences cooler temperatures during the winter months. South of the twenty-fourth parallel, temperatures are fairly constant year round and vary solely as a function of elevation.

Areas south of the twentieth-fourth parallel with elevations up to 1,000 meters have a yearly median temperature between 24 and 28 °C. Temperatures here remain high throughout the year, with only a 5 °C difference between winter and summer median temperatures. Although low-lying areas north of the twentieth-fourth parallel are hot and humid during the summer, they generally have lower yearly temperature averages from 20 to 24 °C because of more moderate conditions during the winter.

Between 1,000 and 2,000 meters, one encounters yearly average temperatures between 16 and 20 °C. Above 2,000 meters, temperatures drop as low as an average yearly range between 8 and 12 °C in the Cordillera Neovolcánica. At 2,300 meters, Mexico City has a yearly median temperature of 15 °C with pleasant summers and mild winters. Average daily highs and lows for May, the warmest month, are 26 and 12 °C, and average daily highs and lows for January, the coldest month, are 19 and 6 °C.

Rainfall varies widely both by location and season. Arid or semiarid conditions are encountered in the Baja California Peninsula, the northwestern state of Sonora, the northern altiplano, and also significant portions of the southern altiplano. Rainfall in these regions averages between 300 and 600 millimeters per year, although even less in some areas, particularly in the state of Baja California. Average rainfall totals are between 600 and 1,000 millimeters in most of the major populated areas of the southern altiplano, including Mexico City and Guadalajara. Low-lying areas along the Gulf of Mexico receive in excess of 1,000 millimeters of rainfall in an average year, with the wettest region being the southeastern state of Tabasco, which typically receives approximately 2,000 millimeters of rainfall on an annual basis. Parts of the northern altiplano, highlands and high peaks in the Sierra Madres occasionally receive significant snowfalls.

Mexico has pronounced wet and dry seasons. Most of the country experiences a rainy season from June to mid-October and significantly less rain during the remainder of the year. February and July generally are the driest and wettest months, respectively. Mexico City, for example, receives an average of only 5 millimeters of rain during February but more than 160 millimeters in July. Coastal areas, especially those along the Gulf of Mexico, experience the largest amounts of rain in September. Tabasco typically records more than 300 millimeters of rain during that month. A small coastal area of northwestern coastal Mexico around Tijuana has a Mediterranean climate with considerable coastal fog and a rainy season that occurs in winter.

Pre-shipment activities performed at CIMMYT: Seed multiplication in Mexicali, Baja California, Mexico (Karnal bunt-free area).The procedures include field inspections of seed plots for detecting insect pests and diseases in the crop several times at different growing stages followed by laboratory analysis of the symptoms and diagnosis. Harvest at right maturity and remove the seed from the field immediately to avoid contamination. Store-houses can be cleaned by washing surfaces with 1% sodium chloride solution or with a mild soap water solution before storing new harvested seed. In case ofinsect infestation, fumigation with phosphine every 2-3 months. Thetesting can be focused on the pathogens ofquarantine importance and depending on theresults it is determinedif the seed issuitable for shipping. Seed can be alsotested for viability and vigor if necessary.

Seed treatment: Treatment can be applied to seed (a) to eliminatie of a pathogen that penetrated into living cells of the seed and became established; (b) to control surface –borne spores or other forms of pathogenic organisms and (c) to protect the seed and young seedling from pathogenic organisms in soil.

Seed packing must be carried out in a clean closed area, after having disinfected floor and surfaces either with chlorine water solution (1%) or by washing with a mild soap. New envelopes and boxes should also be used. Necessary documents are also accompanied the seed as per requirement of the importing country.

Pest and disease control: Aphids of various species, grasshoppers, thrips, shoot fly, armyworms, wireworms, cereal leaf beetle, white grub, cutworm etc. are the insect pests of wheat in field. Usually insecticides spray is the common practice for the management of these insect pests. However, cultural control methods viz. early seeding, use of resistant varieties, clean cultivation, removal of insect infested plant etc. are practiced by the growers. Leaf rust, stem rust, stripe rust, alternaria leaf blight, ergot, Karnal bunt, common bunt, flag smut, septoria leaf blotch, bacterial sheath rot and barley yellow dwarf are the diseases of major concern in Mexico. The main disease control option is the use of resistant varieties, especially against rusts, smuts and bunts. For seed-borne diseases use of healthy seed or seed treatment is being practiced. Other general management practices include crop rotation, fertilizer and water management, foliar spray of fungicides and shifting of sowing date to escape the disease. For controlling barley yellow dwarf generally resistant varieties are grown and also control the aphid vector of the virus can either be prophylactic or based on a forecasting system.

6.3.5 Pakistan

Geography and climate: Pakistan is the 36th 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 wheat 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 cereal crop in the country being followed up by rice only in acerage and production.

Pest and disease control: Insects recorded from the literature as attacking the growing plant in the field are *Microtermes obesi* Hlmgr., *Odontotermes obesus* (Ramb.), *Eurygaster integriceps* Put., *Sesamia inferens* (Wlk.), *Atherigona naqvii* Steyskal, *Sitobion avenae* (F.), *Myzus persicae* (Sulz.), *Mythimna separata* (Wlk.) *M. loreyi* (Dup.), *Agrotis ipsilon* (Hfn.), *Ochropleura flammatra* (Schiff.) and *A. spinifera* (Hb.) . Those recorded from wheat or wheat products in storage are *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L.), *S. granarius* (L.), *Tribolium castaneum* (Hbst.), *Corcyra cephalonica* (Stnt.), *Sitotroga cerealella* (Ol.) and *Tenebroides mauritanicus* (L.). Notes are given on the distribution of these pests, on the conditions conducive to infestation by them and on the damage caused. Usually cultural practices such as cultivation of resistant varieties; adjustment of sowing time; judicious fertilizer and water management; crop rotation; **c**ollection and burning of infected earheads and crop residues are practiced for the management of wheat insect pests. However, chemical insecticides are sprayed to the field when insect population becomes high.

The major diseases reported from Pakistan include leaf rust, powdery mildew, spot blotch, yellow rust, loose smut, flag smut, karnal bunt and ear-cockle. The general methods followed for disease control include cultivation of resistant varieties specially against rusts; for controlling loose smut the options are uase of resistant varieties, use of healthy seed or seed treatment and rogue out and destroy the diseased ears; adjustment of sowing time; judicious fertilizer and water management; Crop rotation; **c**ollection and burning of infected earheads and crop residues; avoiding threshing a diseased crop in the field; sclerotia and seed galls removed by winnowing and sieving or floating in ordinary water or 20% common salt solution followed by washing with fresh water; destroying the weed plants and diseased tillers; to rogue out and destroy the diseased ears for controlling seed-borne diseases perform seed treatment as follows:

Seed treatment

By Solar energy method: Soak the seed for 4-5 hours in ordinary water, in the month of May-June or July on hot day, when temperature become high, dry it in a thin layer (of about 3 inches) from 8 to 12 noon and kept it for planting.

By Tapke's method: Direct soaking of seed in hot water at 48°c for one hour and fifty minutes. Cool and dry before planting.

By Hot water treatment: Initially, soak the seed in ordinary water for about 4 hours, than dip in hot water at 52°c for 10 minutes. After that cool and dry it in shade before planting.

By Anaerobic seed treatment: The seed may soak for 6 hours in water, drain, place in air tight container for 30 hours at 28°c, dry and use for planting.

By Chemical seed treatment: Treat the seed before sowing by using seed dressing fungicides vis: Vitavax, Benlate, Baytan, Topsin etc. at the rate of 2 g/kg seed.

6.3.6 Ukraine

Ukraine is situated between 44 and 52 degrees latitude in the continental temperate zone in Eastern Europe and has an area of 603,000 km2. It borders Belarus on the north, Poland, Slovakia, Hungary, Romania, and Moldova on the west, and Russia on the east. Its southern border is washed by the Black Sea, which connects to the Mediterranean Sea through Turkey. The landscape tends to be rolling with pronounced river valleys and escarpments. There are mountains on the Crimean peninsula in extreme southern Ukraine (rising to 1545 meters above sea level) and the extreme west (rising to 2061 meters in the Carpathians). The highest Carpathian peaks (Hoverla and others) are above about 1800 m and have alpine meadows.

Yearly precipitation ranges from a semi-arid, 350 mm in parts of Crimea and the extreme. Hours of sunlight per year are between 1600 and 2400, excepting the misty Carpathian peaks. 90 percent of Ukraine has snow on the ground between 40 and 100 days a year. Water temperatures at Black Sea beaches in summer months (June-September) are usually between 18 and 24° C (64.4 - 75.2° F). The warmest water — up to 27° C — is to be found in the Azov Sea — a large, shallow sea separated from the Black Sea by Kerch Strait. Average temperatures in January range from 0 degrees Celsius (32° F) on Crimea's South Shore to -8° C (17.6° F) on the northeast border with Russia and between 18 (64.4° F) and 23° C (73.4° F) in July. Average yearly temperatures are 8-10° C over most of the country, with extremes from about -40° C to +40° C. There are four distinct seasons of the year.
Out of the total land area 32.4 mha (54%) is ploughed land. Area under forest is 19%, characterized by lowlands relief havingcontinental climate with warm and humid summers and cold winters. Forest-prairie zone crops include winter wheat, sugar beet, sunflower, corn and barley. About 95 percent of Ukraine wheat is winter wheat, planted in the fall and harvested during July

andAugust of the following year. On the average, approximately 15 percent of fall-planted crops fail to survive the winter. The amount of winterkill varies widely from year to year, from 2 percent in 1990 to a staggering 65 percent in 2003, when a persistent ice crust smothered the crop. Wheat yield declined during the 1990's following the breakup of the Soviet Union and the loss of heavy Statesubsidies for agriculture. The main crops in steppe prairie zone are winter wheat, sunflower, corn and soybean.

A six-year crop rotation will often include two consecutive years of wheat and one season of "cleanfallow," during which no crop is sown. The main reason for including fallow in the rotation is to replenish soil-moisture reserves, and it is more widely used in southern eastern Ukraine where drought are common. Wheat, which is typically the priority crop, almost always follows fallow to benefit from the reduced weed infestation and moisture. Some crop rotations include 2 to 4 consecutive years of legumes such as alfalfa.

Criemean Peninsula is characterized by highland areas, sub-Mediterranean, mild continental climatewith hot dry summers and usually has mild winters. Grapes, watermelons, melons, tea, essentialoil crops, and tobacco are the main crops in this area.

In the year 2013, total wheat production in Ukraine was 23 mmt and ranked 11 among the wheat producing countries of the world.

Pest and disease control: Aphid (*Rhopalosiphum* spp. *S. Avenae*), sunn pest (*Eurygasterintegriceps*), wheat thrips (*Haplothrips tritici*), hessian fly (*Mayetiola destructor*), wheat stem saw fly (Cephus pygmeus) attack wheat in field during production. Cutural methods and chmical insecticides spray are used to combat the major insect pests. Maiz weevil (*Sitophilus zeamais*), granary weevil (Sitophilus granarius), rust red flour beetle (Tribolium casteneum), rusty grain beetle (*Cryptolestes ferrugineus*), angoumois grain moth *(Sitotroga cerealella)* are the commonest insect pest of wheat in storage.

The diseases of major concern in Ukraine includes dwarf bunt, common bunt, ria glume blotch, pink snow mold, bacterial leaf blight, black chaff, ear-cockle, barley stripe mosaic and wheat streak mosaic. Use of resistant varieties is the most important management option followed against rusts and bacterial diseases. Other control measures include crop rotation, planting time, application of pesticides and seed treatment. The diseases of major concern in Ukraine includes dwarf bunt, common bunt, glume blotch, pink snow mold, bacterial leaf blight, black chaff, ear-cockle, barley stripe mosaic and wheat streak mosaic. Use of resistant varieties is the most important management option followed against rusts and bacterial diseases. Other control measures include crop rotation, planting time, application of pesticides and seed treatment.

6.3.7 USA

Geography and climate: The country is situated between 38.00° North and 97.00° West8°4' 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.

It is generally accepted that wheat is beneficial to grow in the off season compared to other crops as its planting occurs, depending on the agro-climatic condition, in late fall or early spring. This results in reduced application of fertilizers and pesticides and less need for irrigation, and helps in preventing soil erosion. However some of the negative effects identified in a study conducted by the FAO are natural habitat loss due to encroachment into new lands after degraded lands are abandoned, loss of indigenous species affecting the biodiversity, and milling operation causing dust pollution. Historically, habitat conversion in the US has occurred in agropastoral land areas as in many other countries and is considered a natural development. In the western US, habitat conversion is still an ongoing process due to the subsidies provided by the government for wheat and other crops in the US has made it financially profitable to develop areas which otherwise would lie fallow; blue stern prairie is one such area. However, habitat expansion for wheat has stabilized since 2000. In the North American plains, the axis which extends over a length of 1,500 miles in a north-south direction is known as the Wheat Belt. The US states falling in this line are the central Alberta and central Texas, where the two categories of wheat, summer and winter wheat, are both grown. The southern states of American where red winter wheat is grown are Kansas, Oklahoma, Texas, Nebraska, and Colorado. In the hot climatic conditions of these states, winter wheat is raised by planting in fall and harvesting in July, taking advantage of autumn rains. Under harsh cold weather conditions in parts of Montana, North Dakota, South Dakota, and Minnesota where wheat can not be grown, the crop is raised during from early summer to hot weather conditions at high altitude. Of wheat grown in the United States, 36% percent is consumed domestically by humans, 50% is exported, 10% is used for livestock feed, and 4% is used for seedlings. Various American-style wheat beers are produced in the US. Wheat in the U.S. is grown under two major categories based on climate: winter wheat and summer wheat. The majority is winter wheat, accounting for, on average, 75% of wheat production. Wheat may be further classified as follows:

1. **Hard red winter wheat** (**HRW**) with 40% production, the flour variety reported from the plains which extends from Texas north through Montana.
2. **Hard red spring** (**HRS**) wheat (also has a sub-classification of Dark Northern Spring Wheat) of high protein value, about 20% production preferred for making bread is from the states of North Dakota, Montana, Minnesota, and South Dakota.
3. **Soft red winter** (**SRW**) wheat with an average production of 20% raised in the states of Washington, Oregon, Idaho, Michigan, and New York, the flour from this wheat is used in making cakes, cookies, and crackers.
4. **White wheat**, which accounts for an average of 12.5% production in the states of Washington, Oregon, Idaho, Michigan, and New York with its flour used in making products of noodle, crackers, cereals, and white-crusted breads.
5. **Durum wheat**, the preferred variety for making pasta; grown mostly in the states of North Dakota and Montana to an average production level of 4%. The byproducts resulting from milling of all the above varieties is used to feed animals.

Pest and disease control: Aphids (various species), stink bugs, armyworms, cutworms, stalk borers (various species), thrips, hessian fly, wheat stem maggot, sawfly, cereal leaf beetle, white grubs (various species), wireworms (various species), grasshoppers and cricket (various species) and mites (various species) have been reported as wheat pest in USA. Among the aphids, thrips, hessian fly, wheat stem maggot, sawfly cause considerable damage to wheat. Rice weevil (*Sitophilus oryzae*) and the lesser grain borer (*Rhyzopertha dominica*) are the most damaging insect pests in storage. Management strategies and tactics for these pests are shifting with changing agronomic practices and their effectiveness is mixed. For example, volunteer wheat is important in maintaining Hessian fly populations throughout the year. Elimination of volunteer wheat can reduce population abundance below economically damaging levels (Zeiss *et al*. 1993). Chemical insecticides are also used to control these insect pests in field. However cultural and mechanical control mehthods are practices for wheat pest management. Integrated Pest Management practices are also used for mangagement of insect pests of field and storage.

Dwarf bunt, Karnal bunt or partial bunt, Common bunt, leaf rust, stripe rust, stem rust, bipolaris leaf blight, fusarium head blight, take-all, ergot, Glume Blotch, Bacterial leaf blight, ear-cockle and barley yellow dwarf are the diseases of major concern.Cultivation of wheat varieties resistant to disease or to lodging; avoiding threshing a diseased crop in the field; separate out the galls by winnowing and sieving or by floating in ordinary water or 20% common salt solution, but salt should be removed/washed out with water, and seed dried before sowing. Control of volunteer wheat and seeding dates. The use of fungicide sprays. Use the seed obtained from healthy crop. Seed treatment with suitable fungicides; adjustment of sowing time; practicing crop rotation; using the wet method of sowing i.e. irrigating just after sowing and rogue out and burn the infected plants.

6.3.8 Bangladesh

The geographic position of Bangladesh is at 20°34 and 26°38 N, and 88°01 and 92°41-EL. Mean humidity is highest (99%) in July and lowest (36%) in December. Average annual rainfall ranged from 1429 mm to 4358 mm. The optimum date of sowing of wheat is mid-November, however it may continue up to first week of December when the temperature is in downward trend. The life cycle of wheat varieties ranged from 100-115 days. Average Maximum and minimum temperature in winter (December-February) is 29°C and 11°C respectively. In Bangladesh during winter (wheat growing period) rainfall is generally scarce. Therefore, irrigation is needed in most cases. In some years there is rainfall during grain filling stage that favors disease development and lower the grain quality.
Local demand is mostly met through import.Upon arrival in the port of entry the commodity must be inspected by the competent inspector and if found free from any quarantine pest would be released for marketing and distribution throughout the country.

Pest and disease control: Fifteen insect pests, which attack in field during production of wheat, are reported in Bangladesh, among which aphids are considered as major insect pests but its infestation is not exceed 5%. So, no control measures are applied for the management of insect pests. Sometimes, termites cause considerable damage in high land at seedling stage of wheat sporadically. Other insect pests are minor in status. Farmers usually use high yielding varieties which are resistant/tolerant to insect pests and diseases. However, Agronomic practices like clean cultivation, use of clean seed, early sowing, fertilizer and irrigation etc. reduce the insect pest infestation in the field. Seven stored grain pests are reported to attack wheat gains and products in storage. Reducing moisture level, sun drying, sieving, winnowing, storage in air tight container and plant materials like neem leaf powder, garlic, termeric powder etc. are used to prevent and control the storage insect pests in Bangladesh.

So far, 22 diseases of wheat are reported from Bnagldesh among them Bipolaris leaf blight and leaf rust are considered as major. For controlling Bipolaris leaf blight (*Bipolaris sorokiniana)* use of healthy seed; seed treatment with fungicide; field application of fungicides and burning of infected crop residue are the current recommended practices.

7.0 Hazard Identification

7.1 Potential hazard groups

One hundred and forty four organisms are identified as potential hazards associated with wheat grain/ seed in different wheat growing countries of the world. Of which 49 species were insects (47) and mites (2) (Appendix XIV), 49diseases (28 are caused by fungi, four by nematodes, seven by bacteria and 10 by viruses) (Appendix XV) and 46 weeds (Appendix XVI).Twenty four (22 species insect pests and 2 species mite pests) species of insect and mites pests are absent in Bangladesh and they considered as quarantine pests of wheat for Bangladesh. Among them, 10 species of insects and one species of mite pests attack in field during production (Table 8). Five insect pests of them are transported with seed or as contaminat with soil, plant debris or tissue culture materials. Other 5 species (4 insects and one mite pests) are transported as contaminant with soil, plant debris or tissue culture materials. The rest 12 species of insect and one species of mites cause infestation on wheat or stored products during storage, which are considered as stored grain pests. They are transported externally or internally with seeds or stored products.

Alltogether 25 diseases are absent in Bangladesh. Among these, nine diseases like karnal bunt (*Tilletia indica* Mitra),common bunts (*Tilletia laevis* Kühn), common bunts (*T. tritici*),ergot (*Claviceps purpurea)*, glume blotch (*Phaeosphaeria nodorum*), ear-cockle (*Anguina tritici*), barley stripe mosaic disease(BSMV) and wheat streak mosaicdisease (WSMV) were considered as quarantine diseases for Bangladesh based on the risk assessment where these diseases showed medium to high probability of entery, exposure, establishment and also showed high level of economic impact andnegative impact on environment or health (Table 8). Eight quarantine weed species identified were *Amaranthus blitoides*, *Ambrosea artimisiifolia*, *Cardaria draba, Fumaria officinalis, Papaver rhoeas, Parthenium hysterophorus, Phalaris minor* and*Thlaspi arvense* (Table 11).

Table 11: List of quarantine organisms identified as hazards on wheat grain/seedimported for Bangladesh

Sl. No.	Common name	Scientific name
Insects and mites		
01.	Wheat aphid	*Sitobion avenae* (Fabricius)
02.	Sunn pest	*Eurygasterintegriceps* Puton
03.	Wheat bug	*Nysius huttoni* White
04.	Wheat thrips	*Haplothrips tritici* (Kurdjumov)
05.	Grain thrips	*Limothrips cerealium* (Haliday)
06.	Wheat stem maggot	*Meromyza americana* Fitch
07.	Wheat midge	*Sitodiplosis mosellana* (Géhin)
08.	Hessian fly	*Mayetiola destructor* (Say)
09.	Wheat stem sawfly	*Cephus cinctus* Norton
10.	Wheat stem sawfly	*Cephus pygmeus* Linnaeus
11.	Brown wheat mite	*Petrobia latens* **(**Müller)
12.	Mottled dermastid beetle	***Trogoderma inclusum* LeConte**
13.	Grain dermestid/ Warehouse beetle	***Trogerma varibile* Ballion**
14.	Glaberous cabinet beetle	*Trogoderma glabrum* (Herbst)

15.	Granary weevil	*Sitophilus granaries* Linnaeus
16.	Confused flour beetle	*Tribolium confusum* Jaquelin DuVal
17.	Large flour beetle	***Tribolium destructor*** Uyttenboogaart
18.	Larger grain borer	*Prostephanus truncatus* (Horn)
19.	Rusty grain beetle	*Cryptolestes ferrugineus* (Stephens)
20.	Hairy fungus beetle	*Typhaea stercorea* (Linnaeus)
21.	Indian meal moth	*Plodia interpunctella* (Hübner)
22.	Mediterranean flour moth	*Ephestia kuehniella* (Zeller)
23.	Chocolate moth/ Cocoa moth	*Ephestia elutella* Hubner
24.	Flour mite	*Acarus siro* Linneaus
Diseases		
25.	Karnal bunt	*Tilletia indica* Mitra
26.	Stem rust (race ug99)	*Puccinia graminis tritici*
27.	Common bunts	*Tilletia laevis* Kühn
28.	Common bunts	*T. tritici* (Bjerk.)
29.	Ergot	*Claviceps purpurea* (Fr.)
30.	Glume blotch	*Phaeosphaeria nodorum* (Müll.)
31.	Ear-cockle	*Anguina tritici* Steinbuc
32.	Barley stripe mosaic disease	*Barley stripe mosaic virus* (BSMV)
33.	Wheat streak mosaic disease (WSMV)	*Wheat streak mosaic virus* (WSMV)
Weeds		
34.	Spreading amaranth	*Amaranthus blitoides* S. Wats.
35.	Hogweed	*Ambrosea artimisiifolia* L.
36.	Heart- podded	*Cardaria draba* (L.)
37.	Common furnetory	*Fumaria officinalis* L.
38.	Common poppy	*Papaver rhoeas* L.
39.	Carrot grass	*Parthenium hysterophorus* L.
40.	Littleseed canarygrass	*Phalaris minor* Retz.
41.	Pennycress	*Thlaspi arvense* L.

7.2 Organisms intercepted at the border on wheat on existing pathways

No information is available about organisms intercepted at the border with wheat grain or seed in Bangladesh.

7.3 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

7.3.1 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 grain/seed before transit and may not produce symptoms and mislead the lot as healthy. However, the pathogen introduced as symptomless with the commodity become apparent only when they reach a suitable climate to sporulate or reproduce. Many fungi can infect grains after arrival making it difficult to distinguish the origin of saprobes and pathogens without adequate identification. Consumers tend to throw away 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.

7.3.3 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, preovipositional 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 aphidsin a greenhouse was longer and higher than those in a growth chamber with similar conditions.
- It is difficult to predict how a species will behave in a new environment, particularly if it has not become established as a pest elsewhere outside its natural range. Therefore there will be considerable uncertainty around the likelihood of an organism colonising new hosts or the consequences of its establishment and spread on the natural environment. Where indigenous plants are discussed as potential hosts this is extrapolated from the host range (at genus and family level) overseas and is not intended as a definitive list.
- Where there is uncertainty about the identity of an organism, e.g. *Rhopalosiphum maidis*vs *R. padi*, the more serious pest is considered in the PRA. The conclusions may need to be revisited if evidence to the contrary becomes available.
- There is uncertainty around the efficacy of risk management measures for many of the hazards identified in this Risk Analysis. In some cases efficacy data for similar species has had to be used.

7.3.4 Assumption regarding transit time of grains

An assumption is made around the time the grains take to get from the field in Australia/Canada/Pakistan/ Ukraine or USA 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.

7.3.5 Assumption and uncertainty around disposal

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

7.3.6 Assumption and uncertainty around risk management measures

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

This approach makes the following assumptions, that:

- The consignment is homogeneous (grains/seeds are harvested inspected and packaged in similar conditions, and have received similar treatments before arrival into Bangladesh). Heterogeneous or non-randomly distributed consignments would require a higher sampling rate to achieve the same confidence levels. Level of sampling depends on the degree of heterogeneity;
- The samples are chosen randomly from the consignment;
- The inspector is 100 percent likely to detect the pest if it is present in the sample. Because of uncertain distribution of pests within the consignment some pests will not be detected if they are present outside the sample. Some pests are difficult to detect because of their small size and behaviours;
- It is acceptable that the sampling system is based on a level (percentage) of contamination rather than a level of surviving individuals;

Interception records can rarely be used quantitatively because of limitations in the identification and recording processes.

There is a paucity of information on the efficacy of the available risk mitigation options in managing the hazards associated with wheat. In the absence of efficacy data, assumptions are made on the basis of data for similar species or similar treatments.

8.0 Review of Management options

8.1 Introduction

This chapter provides background information on possible measures to mitigate the biosecurity risk associated with importing wheatfrom Australia, Canada, India, Mexico, Pakistan, Ukraine and USA.

8.2 Production and post-harvest measures

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

8.2.1 Monitoring programmes in production areas

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

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

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

8.2.2 In-field sanitation

In-field sanitation requires the removal of plant debris, weeds, alternate hosts and diseases infested plant that can harbour disease or pests from wheat field. Any infected plant, leaves or plant parts should be cut or removed from the filed. Regular inspection and removal of infected plants, weedsfacilitate 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 invertebrates such as certain moth species or scale insects, and the introduction of biocontrol agents such as entomophagic fungi or parasitizing invertebrates.

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

8.2.4 Selection of grains from areas free of pests (Area Freedom)

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

8.2.5 Grain quality

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

8.2.6 Prevention of infestation during transportation, storage and handling

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

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

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 Heat treatment

Heat can be used for the processing or devitalisation of grain and may be insecticidal. Temperatures above 50°C are insecticidal, and becomes rapidly more insecticidal as temperature increases above this. All storage pests are killed by a few minutes actual exposure to either wet or dry heat of 65°C (Fields, 1992). Time allowance needs to be made for the heat to penetrate the grain kernel to this temperature.

8.3.2 Cold treatment

Turning the grain during cold (-30ºC) weather will cool any heating spots, and kill some beetles. Effective control depends on how quickly the beetles are cooled. A drop from +5ºC to -20ºC overnight will effectively kill the beetles. Slow cooling will not kill the insects, but will slow down insect activity until the grain can be milled and fed to livestock, or held until spring when the grain can be fumigated. If the grain is heating, turning is the only procedure that will reduce damage, since most heating is caused by fungi that cannot be controlled effectively by chemical fumigants.

8.3.3 Fumigation

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

8.3.3.1 Phosphine Fumigants

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

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

Aluminum phosphide pellets and tablets are prepared in two spherical shapes. The rounded tablets weigh approximately 3 grams and release 1 gram of phosphine gas. They are about 16 mm in diameter and are bulk packaged in resealable aluminum flasks containing 30, 100 or 500 tablets each. The pellets weigh approximately 0.6 grams and release 0.2 gram of phosphine gas. They are about 9 mm in diameter and are packaged in resealable flasks containing about 166, 500 or 1666 pellets.

8.3.3.2 Dosage and Exposure Time

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

Dosage

When fumigating grain, the dosage is usually 180-500 tablets or 880-2500 pellets tablets per 100 cubic metres (for grain bins or 100-300 tablets or 500-1500 pellets per 100 cubic metres for other storage facilities. 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

When fumigating grain, exposure time is related to the temperature of the grain as indicated in Table 12. All stored grain which is to be fumigated must have an accurate temperature reading before fumigation is initiated. The use of a probe thermometer placed approximately 1 metre into the top of the grain is recommended. Hot grain may have to be turned shortly after the fumigation is complete to prevent spoilage.

Table 12: Fumigant Exposure Time based on the Temperature of the Commodity (McLean et al., 2007)

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

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.

9.0 Potential Hazard Organisms: Risk Analyses

9.1 *Sitobion Avenae*(Wheat aphid)

9.1.1 Hazard identification

Common name: wheat aphid, English grain aphid, grain aphid

Scientific name:*Sitobion avenae* (Fabricius)

Synonyms:*Macrosiphum avenae* (Fabricius), *Amphorophora avenae* (F.), *Aphis cerealis* Kaltenbach, *Aphis granaria* Kirby, *Macrosiphum allii* Jackson, *Macrosiphum cerealis* (Kaltenbach), *Macrosiphum granarium* (Kirby), *Nectarophora cerealis* (Kaltenbach), *Siphonophora cerealis* (Kaltenbach), *Sitobion cerealis* (Kaltenbach), *Sitobion granarium* (Kirby), *Macrosiphon avenae* (F.), *Sitobium avenae* (F.), *Aphis avenae* Fabricius

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Homoptera
        - Family: Aphididae
          - Genus: *Sitobion*
            - Species: *Sitobion avenae*

Bangladesh status:Not present in Bangladesh.

The wheat aphid, *Sitobion avenae* (F.), is an important pest in agricultural systems and vector of barley yellow dwarf virus (BYDV). The pest causes the greatest damage to summer and winter wheat, summer and winter barley, rye, oats, sorghum and maize.

9.1.2 Biology

Apterous female with green or yellow-brown fusiform body and long legs. Its length varies from 2.7 to 2.9 mm. Antenna is longer than body. Siphunculi are black (1.5 times as long as light-green tail). Winged female has red-brown thorax and green abdominal segments. Eggs are oval and black. Over-wintering takes place during the egg phase on winter cereals, and also on cereal weeds. In the southern areas it takes place during the adult phase. Sexual agamous generations are present during the aphid life cycle. Larval period lasts 8-12 days. In the zone of strong harm the hatching of larvae giving fundatrices is observed in April. Life span of apterous parthenogenetic females is about 30-60 days and they produce 20-40 larvae. The pests feed on winter cereals at first and later on spring crops. The insects prefer the upper part of the ears of plants. The aphids are active and they do not form big colonies. In September, when the sprouts of winter cereals appear, the aphids migrate from summer reservations. At the end of September and the beginning of October viviparous individuals (viginoparae) appear, giving birth to females and males. The eggs are laid at the end of October-November. The female produces 6 to 12 eggs.

Embryo development occurs at 5^0C degrees Celsius. The air temperature required for development of the first generation varies from 17-24^0C degrees Celsius. In the areas where the insect causes the greatest harm the intensive migration of aphids to cereals takes place at the end of May and in June. The borders of fields are populated at first and then the pest penetrates deep into the cereal field. The aphids infestation is very dangerous when the plants are in the phases of ear emergence, milk and dough development. The most favorable conditions for the insects are at temperatures of 16-20^{0}C degrees Celsius and a relative humidity of 65-80%. The greatest harm caused by this insect occurs after years with moderately warm and damp summers and also damp autumns. Within the territory of the Former Soviet Union the species produces 14-20 generations during a year.

9.1.3 Hosts

It has a broad host range, having been recorded from species of nearly 20 plant families. Major hosts are Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), triticale (*T. turgidum*), rye (*Secale cereale*), oat (*Avena sativa*) and grasses.

9.1.4 Distribution

Asia: Afghanistan, China, Georgia, India, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Lebanon, Myanmar, Pakistan, Saudi Arabia, Syria, Tajikistan, Thailand, Turkey, Turkmenistan, Uzbekistan, Yemen; **Africa:** Algeria, Burundi, Egypt, Ethiopia, Kenya, Libya, Morocco, Mozambique, South Africa, Tunisia, Zimbabwe; **Europe:** Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Former Czechoslovakia, Denmark, Finland, Former Yugoslavia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom; **North America:** Canada, Mexico, USA; **Central America:** Cuba; **South America:** Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay. **Absent in Australia.**

9.1.5 Hazard identification conclusion

Considering the facts that-

- *Sitobion avenae*is not known to be present in Bangladesh;
- is present in Canada, India, Mexico, Pakistan, Ukraine and USA from where wheat grains are imported to Bangladesh;
- cannot be carried on wheat grains;

*S. avenae*is not considered to be a potential hazard organism in this risk analysis.

9.2 *Eurygaster integriceps* (Sunn pest)

9.2.1 Hazard identification

Common name: Sunn pest, corn bug

Scientific name: *Eurygasterintegriceps* Puton

Synonames:
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Hemiptera
        - Family: Scutelleridae
          - Genus: Eurygaster
            - Species: *Eurygasterintegriceps*

Bangladesh status: Not present in Bangladesh.

Sunn pest or corn bug is a major pest of wheat, barley and oat. Spoilage of wheat kernel results in significant economic damage, reducing both quality and quantity of grain and impairs germination.

Young adult and nymphs move along with grain within the ear and continue to feed on ripened grain after harvest. It has high ecological plasticity which helps in its distribution.

9.2.2 Biology

Average life duration of sunn pest is 28-31 days and fertility 28-42 eggs/female, maximum 146-182/female. Eggs are located in two regular rows with 7 eggs in a row (2-3 batches on the average, maximum 13) on the lower side of leaves, on stalks, on weed vegetation, sometimes on ground lumps. Fertility depends both on abiotic conditions, and on phase of development of grain cereals during feeding. Oviposition lasts 30 to 50 days. Duration of egg development is 6 to 28 days. Development of 5 larval instars passes 20 to 45 days on grain crops, beginning from booting to the end of dough development. Air temperature 20-24^{0}C and precipitation about 25-35 mm per month are optimal for their development. 2nd-3rd-instar larvae have light abdomen and dark head and thorax. 4th-instar larvae have rudiments of forewings, and 5th-instar larvae have rudiments of hind wings.

It is univoltine species and its activity of imago starts when plant litter in woods and bushes where the insects winter begins warming up to 12-13^{0}C; flights in field begin at an average daily temperature of 12-14^{0}C. Summer flights usually coincide with dough development of host plant. If insect development is not finished before harvesting, then the larvae and young imagoes finish their feeding under windrows or on fallen ears and grain. After fattening, the bugs fly away and overwinter in plantations of trees; it is more rare that they overwinter among high weed vegetation along ditches, idle lands, and fields. They grow faster at an air temperature of 20–24°C (68–75°F).

9.2.3 Hosts

Pest of cereal crops especially wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), rye (*Secale cereal*e), sorghum (*Sorghum bicolor*), durum wheat (*Triticum turgidum*) oat (*Avena sativa*), and grasses.

9.2.4 Distribution

Afghanistan, Algeria, Armenia, Azerbaijan, Bulgaria, Cyprus, Georgia, Greece, Iran, Iraq, Israel, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Moldova, Pakistan, Romania, Russian Federation, Pakistan, Syria, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia. It is native to much of northern Africa, the Balkans and western and central Asia.

9.2.5 Hazard identification conclusion

Considering the facts that-

- *Eurygasterintegriceps*is not known to be present in Bangladesh;
- is present in Ukraine from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*E.integriceps*is considered to be a potential hazard organism in this risk analysis.

9.2.6 Risk assessment

9.2.6.1 Entry potential: Medium

The probability of entry for *E. integriceps* is rated as mediumas natural introduction is considered unlikely given the current world distribution. Incursions through importation of commodities or through non-commodity pathways is unlikely for *E. integriceps*, given current quarantine procedures and lack of recorded incursions. The most likely method of *E. integriceps* incursion into Australia is as a hitchhiker through the importation of commodities from the pest‟s host plants, and from regions in which *E. integriceps* is prevalent. The adults are relatively large and may be obvious in commodities. However, if individuals occur in low abundances in bulk cargo or bagged commodity, then detection may be difficult. Eggs and nymphs are much smaller and may escape unnoticed.

9.2.6.2 Establishment potential: Medium

The Bangladesh climate is suitable for *E. integriceps* establishment and would promote regular outbreaks particularly in the cereal production areas of the eastern and western Wheatbelts, as the climate is comparable to *E. integriceps* current distribution and an abundance of primary host plants are available. In other countries, *E. integriceps* has continuously expanded its distribution with the cultivation of cereals and the species has displayed some plasticity in its ecology to accommodate establishment in new regions. The probability of establishment for *E. integriceps* is therefore medium.

9.2.6.3 Spread potential: High

E. integriceps can migrate large distances as adults possess wings. One biotype of certain populations can migrate between 150 to 250 km (Brown, 1965). However, given its current Northern Hemisphere distribution, it is highly unlikely that *E. integriceps* will enter Australia by wind dispersal. It is not transported by birds. The climate of Australia is suitable for the spread of *E. integriceps* and coupled with the adults ability to fly, the probability of spread for *E. integriceps* is high.

9.2.7 Consequence assessment

9.2.7.1 Economic impact: High

The impact on yield and cost of protection for *E. integriceps* is rated as medium as, once established, *E. integriceps* may be impossible to eradicate and will require the implementation of Integrated Pest Management plans to contain outbreaks. The loss in yield of grain has been estimated at 50–90% in wheat and 20–30% in barley. While feeding, the sunn bugs inject proteolytic and amlolytic enzymes into the wheat causing breakdown of the gluten which reduces the quality of the flour resulting in the production of inferior dough. The initial economic outlay in research, trials and implementation will be high. During this time, the loss of yield in cereal production regions due to *E. integriceps* may also be high. Historically, chemical control of *E. integriceps* has been expensive.

9.2.7.2 Environmental impact: No environmental impact is reported.

9.2.8 Risk estimation: Medium

The overall risk is medium. Specific action is required, generic risk treatment plans should be adopted as soon as possible in the interim.

9.2.9 Risk management

- Pest management system in the field such as monitoring, filed sanitation, cultural, mechanical, chemical, and biological control methods should be implemented to reduce the pest population in field. Collection of grains from pest free zones reduces probability of pest occurance. After threshing all plant parts should be removed from the grain and grain should be dried properly to reduce the moisture level below 14%. Grain should be kept in dry condition for maintainting moisture level.

- Fumigation with aluminium phosphide tablets above 20^{0}C for 3 days or heat treatment at 60^{0}C for 3 minutes should be applied for disinfestation of grains.

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

9.3 *Nysius huttoni* (Wheat bug)

9.3.1 Hazard identification

Common name: Wheat bug

Scientific name: *Nysius huttoni* White

Synonyms:
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hemiptera
Family: Lygaeidae
Genus: *Nysius*
Species: *Nysius huttoni*

Bangladesh status: Not present in Bangladesh.

Nysius huttoni White commonly known as the Wheat Bug, this New Zealand endemic is a polyphagous pest of large number of weeds and crops. Currently on the **EPPO Alert List**, *N. huttoni* is established in parts of Northern Europe. This was the first discovery of this pest in the UK.

9.3.2 Biology

The eggs are creamy white when first laid but turn orange before hatching. There are five wingless nymphal instars. The first instar is approximately 0.5 mm long and pale to dark orange; later instars are grey or brown-grey and up to 2.5 mm long. The adults, which are 2.5-4 mm long are usually pale green when they emerge but quickly darken to brownish grey. The adults have a variegated outline with a conspicuous silvery triangle at the posterior end. The bug is distinguished from the six species of *Nysius* native to Britain by its conspicuous pubescence (hairiness). It has long erect hairs covering the pronotum, scutellum, clavus and corium and a distinctive double row of punctures along the claval suture. The bug is variable in form with three states of wing-development; during a survey in Belgium only 19.1% of the collected adults were macropterous (large winged) thus capable of flight.

In New Zealand mating takes place from early spring to late summer and up to 174 eggs can be laid, typically in cracks in the soil. Eggs hatch approximately 10 days after egg laying, and adults form 50- 65 days after hatching. Adults overwinter in decaying vegetable debris around the base of plants. In New Zealand, 2-4 generations per year have been recorded.

N. huttoni thrives best under hot, dry conditions and prefers sunny spots. The main feeding period is the middle of the day, and the bugs conceal themselves under debris on the ground as soon as the temperature drops in the evening, rain also inhibits activity. Nigel Cuming observed that the UK populations are very susceptible to changing weather conditions and he tended to see more on warm, sunny days, often as many as 80 to 100 individuals.

Laboratory studies on thermal requirements of *N. huttoni* concluded that the pest was probably able to establish in regions with mild to warm climates. Absent in importing countries.

9.3.3 Hosts

N. huttoni is a polyphagous species which feeds on a large number of weeds and crops. In New Zealand, it is mainly reported as a pest of wheat and Brassicaceae but it can also feed on many other plant species. It can attack; *Triticum aestivum* (wheat), *Hordeum sativum* (barley), *Avena sativa* (oat), *Secale cereale* (rye); *Brassica* spp.; *Medicago sativa* (lucerne); *Trifolium dubium*, *T. pretense, T. repens,* (clovers); *Bromus,* and *Lolium*. The following weeds have also been reported as hosts; *Anagallis arvensis, Calandrinia caulescens, Capsella bursa-pastoris, Cassinia leptophyla, Chenopodium album, Coronopus didymus, Hieracium, Polygonum aviculare, Rumex acetosella, Senecio inaequidens, Silene gallica, Soliva sessilis, Spergularia rubra,* and *Stellaria media*. There is evidence to suggest that the presence of mosses (e.g. *Ceratodon, Sphagnum, Polytrichum* spp.) may also be crucial for the overwintering period (Farrell and Stufkens, 1993; Wang and Shi, 2004; EPPO, 2006).

9.3.4 Distribution

New Zealand, Northern part of Netherlands and Belgium. Absent in Austarlia.

9.3.5 Hazard identification conclusion

Considering the facts that -

- *N. huttoni* is not known to be present in Bangladesh;
- Is not present inAustralia,Canada, India, Mexico, Pakistan, Ukraine and USA from where wheat grains are imported to Bangladesh;
- and can't be carried on wheat grains;

*N. huttoni*is not considered to be a potential hazard organism in this risk analysis.

9.4 *Haplothrips tritici* (Wheat thrips)

9.4.1 Hazard identification

Common name: Wheat thrips

Scientific name: *Haplothrips tritici (*Kurdjumov)

Synonames: *Anthothrips tritici* Kurdjumov, *Haplothrips paluster* Priesner, *Haplothrips cerealis* Priesner.

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Thysanoptera
        - Family: Phlaeothripidae
          - Genus: *Haplothrips*
            - Species:*Haplothrips tritici*

Bangladesh status: Not present in Bangladesh.

Most common economically important pest infesting wheat. Feeding results in brown spots on grain. Damage up to 5% reported in former USSR and yield losses averaged 8% along with other pests in Romania (Banita, 1987).

9.4.2 Biology

The body is elongated, thin and black-brown to black. Head is 1.1-1.2 times longer than wide. The eyes are dark-brown, almost black and large; 2nd antennal segment in apical part yellowish-brown; 3rd one yellow, blackened at apex, bearing two sensilla; 4th one yellowish at base and on each side; 5th segment yellowish-brown at the extreme base only. Fore tibia yellow except for the base and edges, fore tarsus yellow. Wings with 5-8 additional cilia, transparent, blackened at base. Female length is 1.5-2.2 mm and male length is 1.2-1.3 mm. Thelytoky (males occur rarely and do not participate much in reproduction) is registered in some regions, while in the others arrhenotoky (sex ratio near to 1:1) is common. Egg is pale-orange, oblong-oval, 0.5-0.6 mm long. Mature larva is bright red, with two setae at the end of abdomen. A single generation develops per year. Larvae over-winter underground and among stubble. In spring they rise to the surface where they pass through a complicated metamorphosis (pronymph, nymph I, nymph II, adult). Part of larvae metamorphosis occurs underground. Adult has immature ovaries and requires additional feeding. Female fecundity is estimated at 13-30 eggs. Eggs develop over a period of 6-11 days. First instar larva are greenish-yellow, becoming reddish after hours, and bright red after the first molt. The second molt occurs after wintering.

The spring emergence of larvae from wintering places usually starts at soil temperatures of 8°C and higher. The period of metamorphosis is strongly prolonged (about one month). Adults appear at the beginning of ear formation of winter cereals, usually in May-June. During development of cereals thrip adults invade winter rye at first, then winter wheat. The most intensive flight coincides with the beginning of ear formation of spring wheat where the great bulk of adults concentrate. Flying adults migrate by way of air streams at heights of 1.5-2 m. Most often they feed behind a sheath of penultimate leaf, sucking sap from the gentlest part of ear husk. Females lay their eggs in small groups containing 4-8 eggs each or, less frequently, one at a time, on the interior sides of ear scales and ear shank. The egg-laying period lasts 25-35 days. First larvae suck sap from ear scales and flower glumes, then from caryopsis. Larval peak density occurs during the milk development stage of seeds. During the stage of early dough development the larvae start to leave ears.

The main host plants are winter and spring wheat, rye, wheatgrass and some other gramineous plants; spring wheat is the most favorable for insect development. Dry and warm weather during ear emergence and flowering of wheat (the period of egg-laying and the beginning of larva feeding) promotes increased insect survival; prolonged air drought and cool rainy weather are both unfavorable for insect development. Hot dry weather at the end of summer may also be unfavorable for insect survival due to the promotion of fast grain ripening and corresponding shortening of the larva feeding period. In spring the larvae passing through metamorphosis perish because of heat and lack of moisture. In autumn and spring many larvae die during rainy weather which favors development of entomopathogenic fungi, namely *Entomophora* spp. and *Beauveria bassiana*. Predatory thrips, *Aelothrips* spp., as well as other predators such as bugs, ladybirds, lacewing larvae, ground beetles, staphilinids and robber flies are capable of causing a drop in thrip numbers. When preparing to hibernate the larvae can penetrate into soil to a depth of 10-20 cm or more (to 90 cm).

9.4.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), triticale (*T. turgidum*), rye (*Secale cereale*), oat (*Avena sativa*) and grasses.

9.4.4 Distribution

Afghanistan, Albania, Algeria, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, China, Czechoslovakia, India, Egypt, France, Germany, Georgia, Greece, Hungary, Iran, Iraq, Israel, Italy, Kazakhstan, Kyrgyzstan, Moldova, Mongolia, Morocco, Poland, Romania, Russian Federation, Spain, Syria, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan,.

9.4.5 Hazard identification conclusion

Considering the facts that-

- *Haplothrips tritici* is not known to be present in Bangladesh;
- present inIndia, and Ukraine from where wheat grains are imported to Bangladesh;
- and can be carried on wheat grains;

H. tritici is considered to be a potential hazard organism in this risk analysis.

9.5 *Limothrips cerealium* (Wheat thrips)

9.5.1 Hazard identification

Common name: Wheat thrips

Scientific name: *Limothrips cerealium* (Haliday)

Synonames: Corn thrips, grain thrips.
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Thysanopterea
Family: Thripidae
Genus: *Limothrips*
Species: *Limothrips cerealium*

Bangladesh status: Not present in Bangladesh.

May attack all cereals.Most common thrip pest of cereals in Britain (Empson, 1975). Larvae and adults cause internal feeding, grains discoloured, empty and shriveled. Vecotor of Tomato spotted wilt virus (Pherson *et al*. 1999). An alarming insect triggers smoke detectors, which cause unnecessary call-outs of fire services (Cuthbertson, 1989)

9.5.2 Biology

There is 1 generation per year in France, 2 in certain countries like Scotland, Germany, the Netherlands, and even sometimes a 3rd partial generation. Males emerge in early June, fertilizing the females and dying soon afterwards. After feeding for a while, females leave the host plant in late July (when the water content of ears drops below 45%) and fly to overwintering sites, forming exceptionally vast clouds. The fertilized female resumes activity in April and flies in search of a gramineous host. It feeds on the tenderest leaves, rasping them and sucking up cell contents. It deposits eggs at the base of leaves or inside the newest sheath. It then moves on to the ear when it is visible and lays eggs inside the glumes and in young ovaries. The female places its eggs under the plant's epidermis with its oviscapt. Nymph feeds in the sheaths or on the ears by biting the floral parts and developed seeds, once it has completed its development, the nymph "pupates" in the sheath or in the ear.

9.5.3 Hosts

Wheat (*Triticum aestivum*), rye (*Secale cereal*), maize (*Zea mays*), oat (*Avena sativa*), tobacco, cabbage, cotton.

9.5.4 Distribution

Australia, Austria, Belgium, Bulgaria, Canada, Chile, Cyprus, Czechoslovakia, Denmark, Egypt, Finland, France, Greece, Germany, Hungary, Ireland, Israel, Italy, Libya, Morocco, Netherlands, New Zealand, Portugal, South Africa, Spain, Sweden, Switzerland, Syria, Turkey, USA, Former USSR, Yugoslavia.

9.5.5 Hazard identification conclusion

Considering the facts that -

- *Limothrips cerealium*is not known to be present in Bangladesh;
- present inAustralia, Canada and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*L. cerealium*is considered to be a potential hazard organism in this risk analysis.

9.5.6 Risk assessment

9.5.6.1 Entry potential: Medium

Thrips can enter with seeds or as contaminant with soil, plant debris or propagating materials.

9.5.6.2 Establishment potential: Medium

It is medium, hot and dry weather in summer and heavy rainfall in rainy season reduced its population.

9.5.6.3 Spread potential: Low-medium

Thrips is a small insect, cannot fly long distance and its other hosts like cotton and tobacco are not available in Bangladesh.

9.5.7 Consequence assessment

9.5.7.1 Economic impact: High

Larvae and adults cause internal feeding, grains discoloured, empty and shriveled. The insect causes strong damage to wheat, especially to summer wheat, whose development is related most closely to the insect life cycle. To a lesser degree the pest harms winter rye, barley, and other cereals. Both adults and larvae are dangerous, but the latter are usually more noxious, invoking partial or complete white ear effect, drying of flag leaf, partial ear fertilization, and incomplete grain filling. During the pest outbreaks the larva density on sowing can reach 200 and more individuals per ear (Tanskii, 1962). According to Tanskii the weight losses can reach 5-7% in poorly damaged grain, but 15-31% and more in strongly damaged grain. Unlike the Sunn Pest, the flour-baking quality of grain damaged by thrips does not decrease, however the sowing quality of seeds drops notably.

9.5.7.2 Environmental impact: No environmental impact is reported.

9.5.8 Risk estimation: Medium.

The overall risk is medium

9.5.9 Risk management: Same as 9.2.9

9.6 Meromyza americana (Wheat stem maggot)

9.6.1 Hazard identification

Common name: Wheat stem maggot
Scientific name: *Meromyza americana* Fitch
Synonyms:
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Diptera
Family: Chloropidae
Genus: *Meromyza*
Species: *Meromyza americana*
Bangladesh status: Not present in Bangladesh.

*M. americana*infestations rarely affect more than 5% of heads and usually less than 2% (McBride *et al*, 1996. In California a reduction in the number of tillers causes the most damage, but significant damage does not occur and insecticide applications are not recommended (Strand *et al.*, 1990). Heavy infestations of wheat stands may kill a significant portion of the tillers. In South Dakota (USA) yield loss to *M. americana*was highest in spring wheat, followed in descending order by winter wheat, rye, and barley. No estimate of loss exceeded 9%, and most estimates in wheat and rye of between 1 and 3% (Kieckhefer and Morrill, 1970). In infested fields, 10-15% of plants may be injured. Damage can be severe in some years, but the insect seldom causes widespread damage.

9.6.2 Biology

Meromyza commonly completes two generations per year. Overwintering of wheat stem maggots occurs during the larval stage of the life cycle, where the insect resides inside the lower parts of grass stem. Larvae pupate in spring and adults typically emerge in late spring (May/June in China). Females lay up to 60 eggs on the leaves and stems of wheat and other hosts over a 2-3 week period.

Eggs hatch within 3-5 days of laying and the resulting larvae (maggots) enter the stem of the wheat or grass plant and burrow into the tender tissues inside. Larvae are 6-7 mm in length and pale-green or cream coloured and this stage lasts for approximately 20 days. These larvae consume the inside of the stem, killing the upper part of the stem and the head, resulting in “white head” or “silver head” typical of stem-boring insects. The larva pupates within a cigar-shaped, pale green puparium contained within the stem.

Adults emerging mid-summer typically lay eggs on wild grasses or volunteer grain. The resulting larvae overwinter in the stems of these plants and re-emerge in the following spring.

9.6.3 Hosts

Meromyza spp. preferentially attack wheat plants (*Triticum* spp.), but will also attack barley *(Hordeum vulgare*), rye (*Secale cereale*), oats (*Avena sativa*), bluegrass (*Poa* spp.), millet (*Pennisetum glucum*, *Setaria italica*, *Panicum miliaceum* and *Eleusine coracana*), quackgrass (*Elytrigia repens*), wild barley (*Hordeum spontaneum*) and timothy (*Phleum pratense*). Red fescue

(*Festuca rubra*) and smooth-stalked meadowgrass (*Poa pratensis*) also act as wild hosts for this pest. Other members of the Poaceae may also be hosts.

9.6.4 Distribution

North America, Russia, China, Mongolia, Siberia, Kazakhstan, throughout the European countries.Tropical Africa; Egypt, Israel, Yemen, India, China, Pakistan, Bhutan, USA, Mexico, Australia.

9.6.5 Hazard identification conclusion

Considering the facts that -

- *Meromyza americana*is not known to be present in Bangladesh;
- present inAustralia, India, Mexico, Pakistan and USA from where wheat grains are imported to Bangladesh;
- can't be carried on wheat grains;

*M. americana*is not considered to be a potential hazard organism in this risk analysis.

9.7 Sitodiplosis mosellana (Wheat midge)

9.7.1 Hazard identification

Common name: Wheat midge
Scientific name: *Sitodiplosis mosellana* (Géhin)
Synonyms: Orange wheat blossom midge, orange wheat gall midge, *Diplosis aurantiaca* Wagner.
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Diptera
Family: Cecidomyiidae
Genus: *Sitodiplosis*
Species: *Sitodiplosis mosellana*
Bangladesh status: Not present in Bangladesh.

The wheat midge is one of the most destructive pests of wheat. The first reference to a wheat midge larva in wheat was in 1741 in England, although researchers are uncertain if it is the same midge causing trouble today. Wheat midge originated in Europe, and the first record of its occurrence in North America was from Quebec in 1828. Since then, it has been recorded in various locations throughout the Old World and New World, especially in North America, Europe and China.

9.7.2 Biology

The wheat midge has only one generation per year and begins to emerge from the soil about the last week of June or first week of July. During the day, adults remain within the crop canopy where conditions are humid. Males emerge earlier than females and seek females on the first evening after hatching. After mating, females lay eggs on the newly emerged wheat heads in the evening. Oviposition begins on the second day after emergence, with the maximum number of eggs laid on the third day after emergence. Mated females deposit their eggs either individually or in groups of three to five underneath the glumes or the palea (small, chaffl ike bracts enclosing the flower of a grass) in florets of wheat heads primarily just before anthesis. However, eggs can be laid on almost any outer structure of the spikelet, including the rachis (main stem of an inflorescence).

Females live usually less than seven days and lay an average of 80 eggs. Eggs hatch in four to seven days, depending on the temperature.

Upon hatching, the larvae find their way to a developing kernel on which they feed. Larvae mature in about two to three weeks and remain quiescent, unsheathed in the second instar larval integument, and remain in this state until they are activated by rain or dew on the heads. Moisture causes them to drop to the soil surface, where they burrow in and form overwintering cocoons.

Wheat midge larvae break diapause and begin to emerge from the cocoons about the third week in May. Larvae move about in the soil and often are found on the soil surface. Pupation begins about mid-June and the first adults are observed during the last week of June or first week of July. Wheat midge larvae have an obligatory diapause, which can delay or even prevent emergence until the following year when soil conditions are dry.

Wheat midge adults emerge in late afternoon and early evening. They exhibit protandry, with males emerging up to three days earlier than females and one to two hours earlier than females on a given day. Environmental conditions play an important role in wheat midge activity and dispersal. Warm, calm, humid weather is ideal for fl ight and oviposition. Adults are not strong fliers, and cool temperatures (below 59^0F or 15^0C) and rainy, windy weather deter activities and between-field movements. Recent field reports suggest that wheat midge can be blown several miles on the wind, aiding dispersion.

9.7.3 Hosts

Wheat, *Triticum aestivum* L., is the primary host of the wheat midge throughout its modern distribution in Europe, Asia and North America. All 17 species in the genus *Triticum* are hosts for wheat midge. Other grass hosts include durum wheat (*Triticum durum*), occasionally rye (*Secale cereale*), Triticale (*T. tergidum*) and barley (*Hordeum vulgare*). Wheat midge also will deposit eggs on some grassy weeds, such as quackgrass (*Elymus repens* (L.) Gould), slender meadow foxtail, (*Alopecurus myosuroides* Huds.) and other grasses, but larval development on these grassy hosts is questionable.

9.7.4 Distribution

Europe (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Ireland, Luxemburg, Romania, Poland, Sweden, Switzerland, Yugoslavia, Russian Federation, UK), West Asia, North America (Canada, USA), China. **Originated in Europe**.

9.7.5 Hazard identification conclusion

Considering the facts that -

- *Sitodiplosis mosellana* is not known to be present in Bangladesh;
- present inCanada and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*S. mosellana*is considered to be a potential hazard organism in this risk analysis.

9.7.6 Risk assessment

9.7.6.1 Entry potential: Medium

It is transported with seeds

9.7.6.2 Establishment potential: Low

It is low in Bangladesh.

9.7.6.3 Spread potential: Medium

Wheat midge can be blown several miles on the wind, aiding dispersion. It is also transported via seed trade.

9.7.7 Consequence assessment

9.7.7.1 Economic impact: High

Sporadic outbreaks of S. mosellana have occurred in most parts of the northern hemisphere wheat belt over the past hundred years. Early attacks may prevent grain formation, in which case there may be some compensation from increased development of surviving grain but attacks generally result in loss of overall yield and quality of grain. Severe outbreaks over wide areas have often caused substantial losses. In Canada, an important outbreak began in 1983 when yield losses in north-eastern Saskatchewan were estimated at 30% (valued at 30 million dollars), and in 1984 some areas of north-western Manitoba reported grain losses as high as 26%. In the USA losses have generally been less marked, although a 40% loss of yield was reported on spring-sown wheat in the Pacific Northwest by Reeher in 1945.

9.7.7.2 Environmental impact: No environmental impact is reported**.**

9.7.8 Risk estimation: Low

The overall risk of wheat midge is low for Bangaldesh as it is a pest of temperate climate.

9.7.9 Risk management: Same as 9.2.9

9.8. *Mayetiola destructor* (Hessian fly)

9.8.1 Hazard identification

Common name: Hessian fly
Scientific name: *Mayetiola destructor* (Say)
Synonyms: *Cecidomyia destructor*, *Cecidomyia frumentaria* Rondani, *Chortomyia secalina* Loew, *Mayetiola mimeuri* Mesnil, *Mayetiola secalis* Bollow, *Phytophaga cerealis* Rondani, *Phytophaga destructor*.
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Diptera
        - Family: Cecidomyiidae
          - Genus: *Mayetiola*
            - Species: *Mayetiola destructor*

Bangladesh status: Not present in Bangladesh.

This is one of the most destructive insect pests on cereals. Widespread outbreaks have occurred and, in some locations (such as North Africa and the USA), the pest recurs annually. In 1836 a severe infestation of Hessian flies resulted in a crop shortage aggravating the financial problems of farmers leading up to the Panic of 1837.

Today, they are present in most wheat-growing areas of the United States, and can be found coast-to-coast.

9.8.2 Biology

Eggs are about 0.5 mm long, elongated with rounded ends, glossy red, darkening with age and are just visible on the upper surfaces of wheat leaves, where they are laid parallel with the veins. Foster and Hein (1998) compare their appearance as being "similar to a string of hot dogs" (when viewed with magnification").

A detailed description of the three larval instars is given by Gagné and Hatchett (1989). The first instar is 0.5-1.7 mm long, dorsoventrally flattened at first, but becoming cylindrical with age. The second instar is 1.7-4.0 mm long, unevenly cylindrical and with the posterior end variably tapered. The integument is almost uniformly covered with elongate spicules and the head is directed ventrally beneath the first thoracic segment. While feeding, this instar is white, but it subsequently turns brown and hard, and its shape may be modified by compression, especially when crowded. It becomes a puparium within which the third instar, pupa and adult will develop. The third instar develops within the second, is not visible, and does not feed. It is glistening white, dorsoventrally flattened, becoming cylindrical as the pupal tissues develop. The integument is completely covered with rounded verrucae, except on the anteroventral areas of the ventral segments, which have verrucae tipped with anteriorly directed points. A median, ventral, bifid sternal spatula is present on the prothorax.

The puparia, commonly known as 'flaxseeds', are 2-6 mm long, dark brown and slightly tapered anteriorly. Their shape may be modified by compression, especially when three or more puparia develop at the same feeding site. The pupae develop within the puparia and are not visible.

Adults are 2-4 mm long, resembling small mosquitoes. Females are generally larger than males. Both sexes have long antennae. In males the abdomen is elongate cylindrical, and in females the abdomen is heavier and markedly tapered, with a short terminal, partially retractile ovipositor.

Larval feeding on young plants stunts growth and the central shoots yellow and die. Severe infestations at this stage may kill plants, resulting in gaps in the crop. At later stages of crop growth the developing stems are weakened by larvae feeding at the nodes. This results in withering and lodging, which causes loss of yield since the earheads fail to develop.

9.8.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*),rye(*Secale cereal*), oat *(Avena sativa*), triticale (*Triticum tergidum*), wheat grass.

9.8.4 Distribution

This insect probably originated in the southern Caucasus region of Russia or Asia, and was accidentally introduced into North America when Hessian troops imported straw bedding during the American Revolutionary War. Hessian flies were first observed on Long Island, New York around 1779. It has also been classified as a worldwide pest as well. **Asia:** Iraq, Israel, Kazakhstan, Syria, Turkey**; Africa:** Algeria, Morocco, Tunisia; **Europe:** Austria, Belgium, Bulgaria, Cyprus, Czechoslovakia, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Netherlands, Norway, Poland, Portugal, Rumania, Russian Federation, Spain, Sweden, Switzerland, Ukraine, United Kingdom, USSR; **North America;** Canada, USA; **Oceania:** New Zealand. **Native to Asia.**

9.8.5 Hazard identification conclusion

Considering the facts that -

- *Mayetiola destructor* is not known to be present in Bangladesh;
- present inCanada, Ukraine and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*M. destructor*is considered to be a potential hazard organism in this risk analysis.

9.8.6 Risk assessment

9.8.6.1 Entry potential: Medium

Transport of diapausing larvae in wheat straw would certainly seem the most likely cause of long distance transfers and phytosanitary measures should be aimed at preventing this. It is also possible to transport flax-seed cocoons with grain and seed samples. Factors increasing the risk include the robust nature of the diapausing puparia, the increase in air travel and the proximity of the insect to Bangladesh. The probability of entry with wheat straw is less and with seed is high.

9.8.6.2 Establishment potential: Medium

Hosts are available in Bangladesh only in winter. So establishment potential is medium.

9.8.6.3 Spread potential: Medium

The pest is transported through stems (above ground)/ shoots/ trunks/ branches- larvae and pupae borne externally, which is visible to naked eye; through true seeds (including grain)- larvae and pupae borne externally visible to naked eye, and containers and packing straw (Barnes, 1956).

9.8.7 Consequence assessment

9.8.7.1 Economic impact: High

M. destructor was an important pest of wheat in the Soviet Union and Poland after 1918. Significant reduction in grain yields can occur and it is not uncommon for crops infested by Hessian fly to have 40-70 % of stems affected.

9.8.7.2 Environmental impact: No environmental impact is reported.

9.8.8 Risk estimation: Medium

The overall risk is medium in this PRA.

9.8.9 Risk management: Same as 9.2.9

9.9 *Cephus cinctus* (Wheat stem sawfly)

9.9.1 Hazard identification

Common name: Wheat stem sawfly
Scientific name: *Cephus cinctus* Norton
Taxonomic position
  Kingdom: Animalia
    Phylum: Arthropoda

Class: Insecta
Order: Hymenoptera
Family: Cephidae
Genus: *Cephus*
Species: *Cephus cinctus*

Bangladesh status: Not present in Bangladesh.

Sawfly can cause significant damage in some years, but infestations are usually discontinuous.

9.9.2 Biology

The wheat stem sawfly produces one generation per year. Adults emerge in late May or early June and are generally active when winds are calm and field temperatures are above 10°C or 50^0F. The adult wheat stem sawfly is about ¾ of an inch long with smoky-brown wings. It is wasplike in appearance, with a shiny black body with three yellow bands around the abdomen. When not in flight they often are found on wheat stems, positioned with the head pointed downward. Adults are active during warm conditions when temperatures exceed 16^0C or 62°F and wind speeds are minimal. Activity declines during cloudy, windy, or rainy conditions.

Females lay eggs immediately upon emergence and typically live about one week. The adult emergence and flight period continues for 3-6 weeks. They are not strong fliers and usually only fly until they find the nearest wheat field or other suitable host grasses. In wheat, this often results in more serious problems occurring at the field margins closest to the adult emergence site, which is the previous year's wheat field. They preferentially select the largest wheat stems available and insert eggs into the first available internode or when a stem is fully developed, below the uppermost node. If sawflies are abundant, eggs may be laid in smaller stems, and multiple eggs may be laid in a single stem. However, only one larva will survive in each stem due to cannibalism. Females lay an average of 30-50 eggs, depending on the size of available host stems. Eggs are difficult to detect because they occur inside the stem.

Sawfly larvae are always found within the stem and will assume an S-shaped position when taken out of the stem. They move slowly down the stem as they feed, for approximately 30 days. Sawfly larvaeare cream colored, have a broad head, and are ½ to ¾ of an inch in length when fully grown. When they are mature they move down towards soil level and cut a V-shaped notch around the interior of the stem. They then seal the interior of the stem just below the notch with frass and move down near the crown. The upper stem often breaks at this weakened notch just prior to harvest, and the remaining stem containing the overwintering chamber is referred to as the ‘stub’. The larvae overwinter in the stubs, slightly below soil level, before pupating in early spring. They produce a clear protective covering that protects them from excess moisture and moisture loss.

Summer and overwintering

The sawfly larva feeds within the stem and burrows down to or below ground level by the time the wheat heads begin to ripen. The larva then turns around, heads upwards and cuts most of the way through the stem at a point somewhere between soil level and about 2 cm above the ground, seals the end above itself, spins a cocoon in the stem and passes the winter as a larva in diapause (hibernation).

Spring appearance

Overwintering larvae pupate within their cocoons in May; adults begin to emerge in early summer from stubble fields and native grasses. As is common for many insects, males start to emerge first followed within a few days by females. In Alberta, sawfly adults appear from late June to early

July. They are rather inactive insects that drift from plant to plant and spend most of their time resting on grass stems.

9.9.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*),rye(*Secale cereal*), oat (*Avena sativa*), triticale (*Triticum tergidum*), wheat grass. Within the wheats, spring wheat is most heavily attacked in Alberta; winter wheat appears to have become a potential host in Alberta only within the last few years. In Montana, winter wheat has been severely infested and is arguably the major host there. Winter wheat is occasionally attacked in southern Alberta in counties bordering Montana. Durum is often severely attacked by wheat stem sawfly. Oats and broad-leaved crops are immune. Female sawfly will lay eggs in barley, but the larvae seldom cause yield losses. Plant age is important to egg-laying females. Plants that have not reached the jointing (stem elongation) stage is not acceptable to females.

9.9.4 Distribution

The wheat stem sawfly is a major problem in the Mediterranean Basin. North America (USA, Canada).

9.9.5 Hazard identification conclusion

Considering the facts that -

- *Cephus cinctus*is not known to be present in Bangladesh;
- present in(North America)Canada and USA from where wheat grains are imported to Bangladesh;
- can't be carried on wheat grains;

*C. cinctus*is not considered to be a potential hazard organism in this risk analysis.

9.10 *Cephus pygmeus* (European wheat stem saw fly)

9.10.1 Hazard identification

Common name: European wheat stem saw fly
Scientific name: *Cephus pygmeus* Linnaeus
Synonyms: *Status florialis* Klug, *Banchus spinipes* Panzer, *Banchus viridator* Fabricius, *Cephalus tanaiticus* Dovnar-Zapolskij, *Cephus atripes* Stephens, *Cephus clypealis* Costa, *Cephus flavisternus* Costa, *Cephus leskii* Lepeletier, *Cephus notatus* Kokujev, *Cephus pyramalus* Coaker, *Cephus subcylindricus* Gravenhorst, *Sirex pygmeus* Linnaeus, *Tenthredo longicornis* Geoffroy, *Tenthredo polygona* Gmelin.

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Hymenoptera
        - Family: Cephidae
          - Genus: *Cephus*
            - Species:*Cephus pygmeus*

Bangladesh status: Not present in Bangladesh.

9.10.2 Biology

Females lay eggs immediately upon emergence and typically live about one week. Eggs are laid, usually singly in mature internodes of the plant stem (the lower internodes of young plants and the upper internodes of older ones). The larva tunnels downwards in the stem and makes a wider overwintering chamber at the base; the stem usually breaks at this point, facilitating eventual emergence. Winter wheat is the preferred food-plant, followed by rye and barley; on oats infestation is relatively slight.

9.10.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*),rye(*Secale cereal*), oat *(Avena sativa*), triticale (*Triticum tergidum*), wheat grass.

9.10.4 Distribution

All over the Europe including Ukraine, UK, Russia; USA, Canada, Algeria, Mediterranean areas of Asia.

9.10.5 Hazard identification conclusion

Considering the facts that -

- *Cephus pygmeus*is not known to be present in Bangladesh;
- present inCanada, Ukraine and USA from where wheat grains are imported to Bangladesh;
- can't be carried on wheat grains;

*C.pygmeus*is not considered to be a potential hazard organism in this risk analysis.

9.11 *Petrobia latens* (Brown wheat mite)

9.11.1 Hazard identification

Common name: Brown wheat mite
Scientific name: *Petrobia latens* **(**Müller)
Synonyms:Legume mite, oxalis spider mite
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Arachnida
Order: Acarina
Family: Tetranychidae
Genus: *Petrobia*
Species:*Petrobia latens*
Bangladesh status: Not present in Bangladesh.

The brown wheat mite, Petrobia latens (Müller), is a common pest of dryland wheat in western Kansas that can be a problem as far east as Manhattan in dry years. It damages wheat plants by destroying plant cells as it feeds, causing a stippling of the leaves.

9.11.2 Biology

Brown wheat mites pass the summer as diapausing (resting) eggs in the soil. These eggs hatch in the fall as temperatures and moisture conditions become favorable. The brown wheat mite has a short life cycle and can produce multiple generations during the winter. One or two generations can develop in the fall and another two or three generations in the spring. Brown wheat mites feed in the daytime, with activity on the plants reaching a peak about mid-afternoon. They do not produce webbing. When disturbed, they run rapidly over the leaf surface or drop to the ground. At night they crawl down into the soil. They can survive cold temperatures without any problems, but their populations can be quickly reduced by a beating rain. The brown wheat mite historically has been a problem during drought cycles in western Kansas. It is generally only a pest on continuous wheat or where volunteer wheat was allowed to grow on summer fallow ground.

Brown wheat mite activity is highest in late fall and early spring, with populations usually peaking around mid-April. Outbreak potential is high because all adults are female, and each can produce 70 to 90 winter eggs in a three-week period. Later in spring, females begin laying small, white, oversummering eggs in the soil at the base of infested plants. This mite is not affected by cold temperatures, but populations are quickly reduced by driving rains of 10 mm or more.

9.11.3 Hosts

Wheat (*T. aestivum*), sorghum (*S. bicolor*), onions, fruit trees, carrots, cotton, garlic, asparagus, strawberries, cucumber, spice crops, lettuce, iris, alfalfa and clover.

9.11.4 Distribution

USA, Canada, China, India.

9.11.5 Hazard identification conclusion

Considering the facts that -

- *Petrobia latens*is not known to be present in Bangladesh;
- present inCanada, India and USA from where wheat grains are imported to Bangladesh;
- can't be carried on wheat grains;

*P. latens*is not considered to be a potential hazard organism in this risk analysis.

9.12 *Trogoderma inclusum* (Mottled dermastid beetle)

9.12.1 Hazard identification

Common name: Mottled dermastid beetle, mottled dermestid.
Scientific name: *Trogoderma inclusum* LeConte

Synonyms: *Trogoderma meridionalis* Kraatz; *Trogoderma flexuosa* Thomson, *Trogoderma testaceicorne* Perris, *Trogoderma hieroglyphica* Abbeille de Perrin, *Trogoderma tarsale*: Riley, *Trogoderma obsolescens* Casey, *Trogoderma advena* Casey, *Trogoderma nigrescans* Casey, *Trogoderma brunnescens* Casey, *Trogoderma frosti* Casey, *Trogoderma versicolor*: Mutchler & Weiss, *Trogoderma versicolor*: Beal, *Trogoderma inclusum*: Beal, *Trogoderma versicolor meridionale*: Mroczkowski, *Trogoderma testaceum* Kraatz, *Trogoderma inclus* Hua.

Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Family: Dermestidae
Genus: *Trogoderma*
Species:*Trogoderma inclusum*

Bangladesh status: Not present in Bangladesh.

9.12.2 Biology

T. inclusum can live in natural habitats such as bird and insect nests and these can actas a source of infestation. Adults are to 2-4 mm in length, with shining black cuticle and amoderate clothing of fine hairs on the dorsal surface. Larvae are hairy and light brown incolour. The adults are short lived and the females lay about 100 eggs. Development can takeplace between 20-40°C. Under favourable conditions the entire life cycle may take as little as50 days at 30°C and 70% R.H. *T. inclusum* is very tolerant of low relative humidities. Ifconditions are unfavourable larvae can enter diapause during which they can survive morethan a year without food.

9.12.3 Hosts

Cereals, wide range of stored products, including raw grains and processed foods, under bark, dead insects, bird and insect nests.

9.12.4 Distribution

Cosmopolitan, found in Canada, USA, Europe, Mediterranean region, former USSR, India.

9.12.5 Hazard identification conclusion

Considering the facts that -

- *T. inclusum*is not known to be present in Bangladesh;
- present inCanada, India and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*P. latens*isconsidered to be a potential hazard organism in this risk analysis.

9.12.6 Risk assessment

9.12.6.1 Entry potential: High

Larvae in particular often conceal themselves in cracks and crevices and can be difficult to detect. Risk of entry highest in mixed feeds, processed commodities or in grain (seed and stored products)in poor condition with significant admixture of other material.

9.12.6.2 Establishment potential: High

It can breed on a variety of stored foodstuffs and also capable of establishing in the natural environment.

9.12.6.3 Spread potential: High

Is can easily spread by movement of infested material in trade and adults can fly.

9.12.7 Consequence assessment

9.12.7.1 Economic impact: High

This species is the most frequently encountered species of *Trogoderma* infesting stored produce. Presence of any *Trogoderma* species can lead to trade difficulties in its own right or due to its close similarity to the khapra beetle *Trogoderma granarium.* It is a quarantine pest in Australia under existing legislation.

9.12.7.2 Environmental impact: No environmental impact is reported.

9.12.7.3 Health impact: Medium

Larval skins are highly allergenic.

9.12.8 Risk estimation: High

The overall risk is high.

9.12.9 Risk management

- Good store hygiene plays an important role in limiting infestation by stored grain pests. The removal of infested residues from the previous season's harvest is essential, as is general hygiene in stores; all spillage should be removed and all cracks and crevices filled. Grain should be kept in dry condition for maintainting moisture level. Before loading cargo should be cleaned and fumigated with alluminium phosphide or other fumigants for disinfestation.

- Fumigation with aluminium phosphide tablets above 25^0C for 7 days or heat treatment at 60^0C for 5 minutes should be applied for disinfestation of grains.

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

9.13 *Trogoderma varibile* (Grain dermestid beetle)

9.13.1 Hazard identification

Common name: Grain dermestid beetle
Scientific name: *Trogoderma varibile* Ballion
Synonames: Warehouse beetle, *T. parabile* Beal, *T. persica* Pic, *T. persicum* Chao & Lee.
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Family: Dermestidae
Genus: *Trogerma*
Species: *Trogerma varibile*
Bangladesh status: Not present in Bangladesh.

9.13.2 Biology

T. variabile can live in natural habitats such as bird and insect nests and these can actas a source of infestation. Adults are 2-4 mm in length, with weakly patterned brown cuticleand a moderate clothing of fine hairs on the dorsal surface. Larvae are hairy and light brownin colour. The adults are short lived and the females lay about 100+ eggs. Development cantake place between 17-37°C. Under favourable conditions the entire life cycle may take aslittle as 30 days at 30°C. *T. varibile* is very tolerant of low relative humidities. If conditionsare unfavourable larvae can enter diapause during which they can survive more than a yearwithout food.

9.13.3 Hosts

Wide range of stored products, including raw grains and processed foods, under bark, dead insects, bird and insect nests.Rice (*O. sativa*), wheat (*T. aestivum*), maize (*Z. mays*), sorghum (*S. bicolor*).

9.13.4 Distribution

Afghanistan, Australia, Canada, China, Finland, Kazakhstan, Mexico, Mongolia, Russian Federation, Saudi Arabia, South Africa, Tajikistan, UK, USA, Uzbekistan,

9.13.5 Hazard identification conclusion

Considering the facts that -

- *Trogoderma varibile* is not known to be present in Bangladesh;
- present in *Australia,* Canada, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*T. varibile*isconsidered to be a potential hazard organism in this risk analysis.

9.13.6 Risk assessment

9.13.6.1 Entry potential: High

Larvae in particular often conceal themselves in cracks and crevices and can be difficult to detect. Risk of entry highest in mixed feeds, processed commodities or in grain in poor condition with significant admixture of other material.

9.13.6.2 Establishment potential: High

T.varibile can breed on a variety of stored foodstuffs and also capable of establishing in the natural environment.

9.13.6.3 Spread potential: Medium

They can easily spread by movement of infested material (seed or stored products) in trade. Adults can fly.

9.13.7 Consequence assessment

9.13.7.1 Economic impact: Medium

A minor to important pest of a wide range of stored produce. A very persistent pest of storage structures once infested. It appears capable of breeding on clean well managed commodities. Presence of any *Trogoderma* species can lead to trade difficulties in its own right or due to its close similarity to the khapra beetle *Trogoderma granarium*.

9.13.7.2 Environmental impact: No environmental impact is reported**.**

9.13.7.3 Health impact: Medium

Larval skins are highly allergenic.

9.13.8 Risk estimation: Medium

The overall risk is medium.

9.13.9 Risk management: Same as 9.12.9

9.14 *Trogoderma glabrum* (Glaberous cabinet beetle)

9.14.1 Hazard identification

Common name: Glaberous cabinet beetle
Scientific name: *Trogoderma glabrum* (Herbst)
Synonames: *Anthrenus glaber* Herbst, *Trogoderma boron* Beal
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda

Class: Insecta
Order: Coleoptera
Family: Dermestidae
Genus: *Trogerma*
Species:*Trogoderma glabrum*

Bangladesh status: Not present in Bangladesh.

9.14.2 Biology

T. glabrum often lives in natural habitats such as bird and insect nests and these can act as a source of infestation. This species is however capable of developing on grain alone. Adults are to 24 mm in length, with shining black cuticle and a moderate clothing of fine hairs on the dorsal surface. Larvae are hairy and light brown in colour. The adults are short lived and the females lay between 60-80 eggs. Under favourable conditions the entire life cycle may take as little as 28–32 days at 32°C and 70% R.H. *T. glabrum* is very tolerant of low relative humidities.

9.14.3 Hosts

Wide range of stored products, including raw grains and processed foods, under bark, dead insects, bird and insect nests.

9.14.4 Distribution: USA, Mexico, Canada, Europe, Caucasus, Kazakhstan, S. Siberia**.**

9.14.5 Hazard identification conclusion

Considering the facts that -

- *Trogoderma glabrum* is not known to be present in Bangladesh;
- present inCanada, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*T. glabrum*is considered to be a potential hazard organism in this risk analysis.

9.14.6 Risk assessment

9.14.6.1 Entry potential: High

Larvae in particular often conceal themselves in cracks and crevices and can be difficult to detect. Risk of entry is the highest in mixed feeds, processed commodities or in grain (seeds and other dried plant and animal material)in poor condition with significant admixture of other material.

9.14.6.2 Establishment potential: High

The insect can breed on a variety of stored foodstuffs and also capable of establishing in the natural environment.

9.14.6.3 Spread potential: Low

It would be mostly dependant on movement of infested material in trade.

9.14.7 Consequence assessment:

9.14.7.1 Economic impact: Medium

It regarded as a minor pest of wheat. In the USA it is sometimes found infesting stored whole grains. It is best known as a pest of mixed animal feeds. Presence of any *Trogoderma* species can lead to trade difficulties in its own right or due to its close similarity to the khapra beetle

Trogoderma granarium. Presence of any *Trogoderma* species can lead to trade difficulties in its own right or due to its close similarity to the khapra beetle *Trogoderma granarium*.

9.14.7.2 Environmental impact: No environmental impact is reported.

9.14.7.3 Health impact: Medium

Larval skins are highly allergenic.

9.14.8 Risk estimation: Medium

The overall risk is medium.

9.14.9 Risk management: Same as 9.12.9

9.15 *Sitophilus granaries* (Granary weevil)

9.15.1 Hazard identification

Common name: Granary weevil
Scientific name: *Sitophilus granaries* Linnaeus
Synonames: Grain weevil, *Calandra granaria* Linnaeus, *Calendra granaria* Linnaeus, *Curculio granarius* Linnaeus.
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Coleoptera
        - Family: Curculionidae
          - Genus: *Sitophilus*
            - Species:*Sitophilus granaries*

Bangladesh status: Not present in Bangladesh.

9.15.2 Biology

The biology and behaviour of *S. granarius* is similar to the tropical species *S. oryzae* and *S. zeamais*, except that it cannot fly. Adults live for 7 to 8 months on average. Females usually lay around 150 eggs, and up to 300 eggs, throughout their lives. Eggs are laid individually in cavities that the female bores in the grain kernels. Cavities are sealed by a waxy egg plug, which the female secretes. Eggs incubate for about 4-14 days before hatching, depending on temperature and humidity. One larva develops in each infested kernel. Feeding larvae excavate a tunnel and may keep feeding until only the hull remains. There are four larval instars. Pupation occurs inside the grain. The newly emerged adult chews its way out of the grain, leaving a characteristic exit hole. In warm summer conditions the life cycle can be completed within 4 to 6 weeks, but can take as long as 17 to 21 weeks in the winter. Adults can survive for a month or more without food in cooler conditions.

Optimum conditions for development are similar to other tropical species of *Sitophilus*, about 30°C and 70% RH (Richards, 1947), but in tropical areas it is apparently not able to compete with *S. oryzae* and *S. zeamais*. It seems that its distribution is limited more by its commodity associations with cool climate crops (see Host Range) than by its direct response to temperature. However, it can develop at temperatures down to 11°C, and is therefore successful in temperate regions that are too cool for other *Sitophilus* species (Howe and Hole, 1968). Being flightless, *S. granarius* cannot usually infest crops in the field before harvest.

9.15.3 Hosts

It is a frequent pest of wheat (*T. aestivum*) and barley (*H. vulgare*). It can attack other cereals such as oat (*Avena sativa*), rye (*Secale cereale*), maize (*Zea mays*), sorghum (*Sorghum bicolor*) and rice (*Oryza sativa*).

9.15.4 Distribution

It is distributed throughout the temperate regions of the world. In tropical countries it is rare, being limited to cool upland areas. **Asia:** Afghanistan, India, Indonesia, Iran, Iraq, Israel, Japan, Malaysia, Saudi Arabia, Sri Lanka, Syria, Thailand, Turkey, Kazakhstan, Yemen (Hains 1981); **Africa:** Algeria, Cameroon, Egypt, Morocco South Africa, Swaziland; **North America:** USA, Mexico, Canada; **South America:** Argentina, Chile; **Europe:** Austria, Belgium, France, Italy, Spain, Denmark, Sweden, Poland, Germany, Greece, France, Hungary, Turkey, Czech Republic, Ireland, Croatia, Turkey, Italy, Spain, Poland, Portugal, Romani, UK, Ukraine, former USSR; **Oceania:** Australia.

9.15.5 Hazard identification conclusion

Considering the facts that *Sitophilus granaries* **-**

- is not known to be present in Bangladesh;
- present in Australia, Canada, India, Mexico, Ukraine and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*S. granaries*is considered to be a potential hazard organism in this risk analysis.

9.15.6 Risk assessment

9.15.6.1 Entry potential: High

Egg, larva, pupa and adult are transported with seeds and stored products but adult cannot fly.

9.15.6.2 Establishment potential: Medium

In temperate climates it establishment potential is high but in tropical climate that is low due to competition withe *S. oryaze* and *S. zeamais*.

9.15.6.3 Spread potential: Medium

Adult *S. granarius* cannot disperse by flight, although they are very active walkers. They are transported within grain as eggs, larvae or pupae. They can readily spread in grain residues.

9.15.7 Consequence assessment

9.15.7.1 Economic impact: High

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

9.15.7.2 Environmental impact: No environmental impact is reported**.**

9.15.8 Risk estimation: High

The overall risk is high.

9.15.9 Risk management: Same as 9.12.9

9.16 *Tribolium confusum* (Confused flour beetle)

9.16.1 Hazard identification

Common name: Confused flour beetle
Scientific name: *Tribolium confusum* Jaquelin DuVal
Synonames: *Tribolium ferrugineum* Mulsant; *T.* (*Stene*) *confusum* Seidlitz.
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Coleoptera
        - Family: Tenebrionidae
          - Genus: *Tribolium*
            - Species: *Tribolium confusum*

Bangladesh status: Not present in Bangladesh.

Important pest of cereal grains and their products.

9.16.2 Biology

Adult is a small reddish-brown beetle, about 4 mm long and adult is easily confused with other *Tribolium* species. The female Confused Flour Beetle lays tiny white eggs and each female lays 200 to 700 eggs loosely in food. The larvae are slender and creamy yellow to light brown with two small pointed projections on the last body segment. Larvae are whitish with brown bands. Larvae reach a length of 8 mm prior to pupation. The pupae are white to yellowish. The life cycle takes from 40 to 90 days from egg to adult. Adult beetles can live for three years. Breeding takes place in a temperature range of 20^{o}C to 37^{o}C. Optimum development occurs in the range of 32^{o}C to 35^{o}C. Confused flour beetle has one of the highest rates of population growth for stored-product insects. The beetle is able to breed under cooler conditions than the red flour beetle.

The adults and larvae feed on cereals and their products. Infestation leads to persistent disagreeable odours in the commodity due to the secretion of benzoquinones from a pair of abdominal defence glands.

9.16.3 Hosts

All type of grains, cereal products, flour, animal feed, sunflower, millet; Starchy materials, beans, peas, spices, dried plant roots, dried, fruit, yeast, dried chocolate. Dead insects, herbarium specimens.The confused beetles cannot feed on whole undamaged grain.

9.16.4 Distribution

This insect has a worldwide distribution and is very abundant in the United States. The red flour beetle is of **Indo-Australian origin** and is found in **temperate areas**, but will survive the winter in protected places, especially where there is central heat (Tripathi *et al*. 2001). In the United States, it is found primarily in the southern states. The confused flour beetle, originally of **African origin**, has a different distribution in that it occurs worldwide in **cooler climates**. In the United States it is more abundant in the northern states.

9.16.5 Hazard identification conclusion

Considering the facts that *Tribolium confusum* -

- is not known to be present in Bangladesh;
- present in Australia and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;
- pest of cooler region (temperate climate);

T. confusum ***is*** considered to be a potential hazard organism in this risk analysis.

9.16.6 Risk assessment

9.16.6.1 Entry potential: Low

It is low in clean dry grain in good condition, risk increases with moisture content and quantity of admixture and damaged grains.

9.16.6.2 Establishment potential: Medium

T. confusum has a wide range of hosts and is able to colonise natural habitats.

9.16.6.3 Spread potential: Medium

Spread is dependent on passive transport in grain as the species does not appear to fly.

9.16.7 Consequence assessment

9.16.7.1 Economic impact: Medium

This species is usually seen in mills and places where milled products are used. It is probably the most common contaminant of flour, cereal, prepared flour mixes, dried fruits/nuts, and various spices.

9.16.7.2 Environmental impact: No environmental impact is reported**.**

9.16.8 Risk estimation: Low

The overall risk is low as it is a pest of cooler climate.

9.16.9 Risk management: Same as 9.12.9

9.17 *Tribolium destructor* (Large flour beetle)

9.17.1 Hazard identification

Common name: Large flour beetle
Scientific name: *Tribolium destructor* Uyttenboogaart.

Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Family: Tenebrionidae
Genus: *Tribolium*
Species:*Tribolium destructor*
Bangladesh status: Not present in Bangladesh.

9.17.2 Biology

A secondary pest of cereal grains. This species tends to be associated with poor storage conditions, especially inadequate hygiene and high commodity moisture content. It does not multiply rapidly on whole undamaged grain. Can be found living under bark of trees. Adults are 5-6 mm long and black to very dark brown in colour. The optimum temperature for development is 25°C and eggs do not hatch above 30°C. Recorded breeding at very low humidities of 10% R.H. The species does not tolerate very cold conditions of 5°C or less. Larvae and adults are general feeders being also cannibalistic and predatory. Eggs are laid at random, are sticky, and become coated with flour and other particles. Larvae are active and move through the food. Pupae are naked and found amongst the food.

The adults and larvae feed on cereals and their products. Infestation leads to persistent disagreeable odours in the commodity due to the secretion of benzoquinones from a pair of abdominal defence glands.

9.17.3 Hosts

Seeds, cereals, flour, stored grain, bran, dry bakery products, bird feed, dog food.

9.17.4 Distribution

Canada, USA, Asia, Europe, subtropical regions, cool areas in the tropics (Afghanistan, Ethiopia, Kenya). In Canada it is found ‘coast to coast’. Tropical (prob. African) origin.

9.17.5 Hazard identification conclusion

Considering the facts that *Tribolium destructor* -

- is not known to be present in Bangladesh;
- present inCanada and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

*T. destructor*is considered to be a potential hazard organism in this risk analysis.

9.17.6 Risk assessment

9.17.6.1 Entry potential: Low

It is low in clean dry grain in good condition, risk increases with moisture content and quantity of admixture and damaged grains.

9.17.6.2 Establishment potential: Medium

T. destructor has a wide range of hosts and is able to colonise natural habitats. It is mainly pest of cooler region.

9.17.6.3 Spread potential: Low

Spread is dependent on passive transport in grain as the species does not appear to fly.

9.17.7 Consequence assessment

9.17.7.1 Economic impact: Low

This species is usually seen in mills and places where milled products are used. In Canada it is sometimes as important as *Tribolium castaneum* and *T. confusum*.

9.17.7.2 Environmental impact: No environmental impact is reported.

9.17.8 Risk estimation: Low

The overall risk is low.

9.17.9 Risk management: Same as 9.12.9

9.18 *Prostephanus truncatus* (Larger grain borer)

9.18.1 Hazard identification

Common name: Larger grain borer, Greater grain borer, Scania beetle.
Scientific name: *Prostephanus truncatus* (Horn)
Synonames: *Dinoderus truncatus* Horn

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Coleoptera
        - Family: Bostrichidae
          - Genus: *Prostephanus*
            - Species: *Prostephanus truncatus*

Bangladesh status: Not present in Bangladesh.

9.18.2 Biology

Adult LGB eat into maize grains; females make small egg laying chambers at right angles to the main tunnels. Eggs are laid in batches of 20 and covered with finely chewed maize dust. The larvae hatch after about 3 days at 27°C and live on the maize dust produced by the adult's feeding activity. The last instar larva of LGB constructs a pupal case from frass stuck together with a larval secretion, either within the grain or in the surrounding dust. *Prostephanus truncatus* completes its life cycle in about 25-27 days at the optimum temperature of 32^0C and relative humidity of 70-80% under laboratory conditions on maize grain (Hodges, 1986; Subramanyan and Hagstrum, 1991). Adults disperse over short distances through flight. Females live longer (61 days) than males (45 days). Adults live for at least 4 months (Guntrip *et al*., 1996) excluding the effect of predators or other natural enemies and exogenous factors that can cause unpredicted death. The life-history of the Larger grain borer has been widely studied (Shires, 1980; Li, 1988). The capability of insects to disperse mainly by flight is generally determined by the success of their individual development and life-history trait adaptation to environmental conditions.

9.18.3 Hosts

LGB is a serious pest of stored maize and dried cassava roots, but will also attack maize in the field just before harvest. Wheat (*Triticum aestivum* Poaceae), rice *(Oryzae sativa* Poaceae), chickpea *Cicer arietinum* Fabaceae), sweet potatoes (*Solanum tuberosum* Solanaceae), sorghum *(Sorghum bicolor* Poaceae) and several leguminous crops are some commodities that can host *P. truncates* larvae and adults (Roux, 1999). However, it is not been found to be a pest of grains other than maize.

9.18.4 Distribution

P. truncatus is native to Central America, tropical South America, and the extreme south of the USA. It was introduced into Tanzania, probably in the late 1970s where it has become a serious pest of stored maize and dried cassava. It has since spread into Kenya, Uganda, Burundi, Rwanda, Malawi, Zambia, Mozambique, Namibia and South Africa, and is almost certainly present but unreported from several other countries in Africa. It was first found in West Africa in Togo in 1984 and it has since spread to Benin, Nigeria, Ghana, Niger and Burkina Faso. It is also present in Canada, China, India (Uttar Pradesh only), Iraq, Israel, Panama, Peru, Philippines, Mexico, Thailand, USA.

9.18.5 Hazard identification conclusion

Considering the facts that *Prostephanus truncates* -

- is not known to be present in Bangladesh;
- present inCanada, India, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains;

P. truncates is considered to be a potential hazard organism in this risk analysis.

9.18.6 Risk assessment

9.18.6.1 Entry potential: Low

They rarely attack wheat. Negligible on grain sourced / moved from and through areas where insect is not established. Risk increases if grain is sourced from areas where insect is found.

9.18.6.2 Establishment potential: High

High in areas which grow maize. They are also attacked wood trees and other cereals.

9.18.6.3 Spread potential: High

P. truncatus long distance dispersal has been attributed to transport and trade of commodities, particularly maize and dry cassava chips. They are long lived and are good fliers. They can also conceal themselves by boring into wooden structures. Native vegetation potentially offers a reservoir for this species. They are also strong fliers. Attempts to control this insect in Africa have at best only slowed its spread.

9.18.7 Consequence assessment

9.18.7.1 Economic impact: High

Weight loss up to 40% have been recorded in Nicaragua from maize cobs stored on the farm for 6 months (Giles and Leon, 1975). Losses up to 34% have been observed after 3 months storage on the farm with an average loss of 8.7% (Hodges *et al*., 1983) in Tanzania. Damage to maize stored on cob can be severe with weight losses as high as 34% observed after only 3-6 months storage. Losses in dried cassava after six months storage average between 19% to 30%. Presence of *P. truncatus* on grain, trade in commodities at risk could become difficult or badly disrupted as this pest is subject to official quarantine control in most countries.

9.18.7.2 Environmental impact: Medium

This insect is very likely capable of becoming an environmental pest in Australia. Native genera of woody shrubs and trees eg *Acacia* spp. appear at risk of being attacked.

9.18.8 Risk estimation: Low

The overall risk is low for Bangladesh in this pest risk analysis program.

9.18.9 Risk management: Same as 9.12.9

9.19 *Cryptolestes ferrugineus* (Rusty grain beetle)

9.19.1 Hazard identification

Common name: Rusty grain beetle/ Rust-red grain beetle
Scientific name: *Cryptolestes ferrugineus* (Stephens)
Synonyms: *Cucujus ferrugineus* Stephens, *Cucujus testaceus* Paykull, *Cucujus monilicornis* Stephens, *Laemophloeus concolor* Smith, *Laemophloeus obsoletus* Smith, *Laemophloeus carinulatus* Wollaston, *Laemophloeus emgei* Reitter, *Laemophloeus alluaudi* Grouvell.

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Coleptera
        - Family: Cucujidae
          - Genus: *Cryptolestes*
            - Species:*Cryptolestes ferrugineus*

Bangladesh status: Not present in Bangladesh.
It is common important pest of stored grain and grain products including flour and often overlooked because of very small size.

9.19.2 Biology

The eggs are placed in crevices within the grain or dropped loosely. Eggs are laid singly on or amongst the commodity. The elongate larva has pronounced tail-horns and feeds preferentially on the germ of the grain. It passes through four instars and pupates in a gelatinous cocoon which is usually covered in food particles. Cannibalism occurs under crowded conditions. After a pre-oviposition period of two or three days, the female lays approximately 400 eggs and lives for 6-9 months at 32°C and 70% R.H. The life-cycle can be completed over the range of 20°C to 42.5°C and the optimum for both development and population increase is about 35°C, when development is completed in 21 days (about 100 days at 20°C). Development is retarded and mortality increased at low humidities but the rate of population increase is still considerable at 40% R.H. This species is cold-tolerant and can overwinter without difficulty in very cold conditions. The adult flies actively at temperatures above 21°C and warm grain, i.e. above 30°C is preferred. It can survive in sub-zero temperature. (Lee *et al*., 1992).

9.19.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), oat (*Avena sativa*), rice (*Oryza sativa*), maize (*Zea mays*), tobacco (*Nicotiana tabacum*).

9.19.4 Distribution

Afghanistan, Albania, Australia, Armenia, Austria, Belarus, Belgium, China, Egypt, France, Germany, Greece, Hungary, Iran, Iraq, Israel, Italy, Kazakhstan, Moldova, Mongolia, Morocco, Poland, Rumania, Russian federation, Turkey, Ukraine, North America.

9.19.5 Hazard identification conclusion

Considering the facts that *Cryptolestes ferrugineus* -

- is not known to be present in Bangladesh;
- present in Australia,Canada, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed, stored products);

*C. ferrugineus*is considered to be a potential hazard organism in this risk analysis.

9.19.6 Risk assessment

Entry potential: Medium

It is medium in in clean dry grain in good condition, risk increases with moisture content and quantity of admixture and damaged grains. Its introduction pathways are seed and stored products.

Establishment potential: High

It is likely to be most serious a pest in temperate rather than tropical areas. It is a pest in areas with environmental conditions very similar to those present in Australia.

Spread potential: High

Cryptolestes species are commonly found associated with traded cereal grains and products made from them.

9.19.7 Consequence assessment

Economic impact: High
An important pest of flour and feed mills in temperate regions, most commonly found in flour residues associated with mill machinery. It is likely to remain undetected for a considerable period post establishment because of its close morphological similarity to *Cryptolestes* spp.

Environmental impact: No environmental impact is reported.

9.19.8 Risk estimation: Low

The overall risk is low for Bangladesh because it is mainly a serious pest of temperate region.

9.19.9 Risk management:Same as 9.12.9

9.20 *Typhaea stercorea* (Hairy fungus beetle)

9.20.1 Hazard identification

Common name: Hairy fungus beetle/ Fungus beetle
Scientific name: *Typhaea stercorea* (Linnaeus)
Synonyms: *Dermestes stercorea* Linnaeus; *Typhaea fumata* Linnaeus; *Dermestes stercoreus* Linnaeus; *Dermestes fumatus* Linnaeus
Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Coleptera
Family: Mycetophagidae
Genus: *Typhaea*
Species:*Typhaea stercorea*

Bangladesh status: Not present in Bangladesh.

Typhaea stercorea infests mouldy storage products, feeding mainly on the mould and often causing little damage to the products themselves. It is also reported as a pest in poultry houses.

9.20.2 Biology

In its natural environment, the adult hairy fungus beetles feed on molds growing on stored grains, where females deposit their eggs. The insects are frequently found in cornfields, where they are attracted to decaying kernels of exposed ears. Adults may also be introduced into grain bins on newly harvested grain. Very little information is available on the life cycle of this pest.

9.20.3 Hosts

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), maize (*Zea mays*), tobacco (*Nicotiana tabacum*).

9.20.4 Distribution

Africa, Australia, Central America, China, Germany, Indonesia, North America, Singapore, South America, USSR.

9.20.5 Hazard identification conclusion

Considering the facts that *Typhaea stercorea* -

- is not known to be present in Bangladesh;
- present in Australia,Canada, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed and stored products);

*T. stercorea*is considered to be a potential hazard organism in this risk analysis.

9.20.6 Risk assessment

9.20.6.1 Entry potential: Low

It is low in in clean dry grain in good condition, risk increases with moisture content and quantity of admixture and damaged grains. Its introduction pathways are seed and stored products.

9.20.6.2 Establishment potential: Low

It is not likely to be most serious a pest.

9.20.6.3 9.20.6.3 Spread potential: low

T. stercorea are rarely found associated with traded cereal grains and products made from them.

9.20.7 Consequence assessment

9.20.7.1 Economic impact: Low

It is a minor pest of stored grain, often present at harvest, will only persist in storage if grain remains slightly damp.

9.20.7.2 Environmental impact: No environmental impact is reported.

9.20.8 Risk estimation: Low

The overall risk is low for Bangladesh because it is a minor pest.

9.20.9 Risk management: Same as 9.12.9

9.21 *Plodia interpunctella* (Indian meal moth)

9.21.1 Hazard identification

Common name: Indian meal moth, mealworm moth, cloaked-not-horn moth
Scientific name: *Plodia interpunctella* (Hübner)
Synonyms: *Ephestia interpunctella* Hübner, *Tinea interpunctella* Hübner
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Lepidoptera
        - Family: Pyralidae
          - Genus: *Plodia*
            - Species: *Plodia interpunctella*

Bangladesh status: Not present in Bangladesh.

9.21.2 Biology

As long as the temperature within a grain bin or building where grain is stored remains above 50° F or 10^0C, the Indian meal moth can survive and reproduce. A typical life cycle (egg to adult) is completed in forth to fifty-five days. A potential for seven to nine generations per year exists; however, because of cool temperatures during the winter months fewer generations are usually completed. Under optimal conditions, the entire life cycle can be completed in approximately twenty-eight days.

A mature female lays 100 to 300 eggs on food material, either singularly or in groups of twelve to thirty. Larvae begin to hatch in two to fourteen days, depending on environmental conditions. Newly hatched larvae feed on fine materials within the grain and are small enough to pass through a sixty mesh screen. For this reason, it is difficult to exclude larvae from most packaged foods and grain.

However, larvae cannot chew through packages, so they must enter through a hole or at the seam. The larval stage lasts from two weeks to one year, and is responsible for grain losses. In grain, larval feeding is usually restricted to the top one to two inches. Large larvae feed on the grain germ. When mature, larvae spin a silken cocoon and transform into light-brown pupae. The cocoons and pupae can be seen on the grain surface and walls of grain bins. Adults emerge in four to thirty days, mate, and females lay the next generation of eggs. Adults live from five to twenty-five days.

9.21.3 Hosts

Wheat (*T. aestivum*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*) and other cereals, nuts and some pulses.

9.21.4 Distribution

Worldwide distribution; Australia, Austria, Bulgaria, China, India, Iran, Iraq, Israel, Vietnam, Egypt, South Africa, Malawi, Morocco, Lesotho, Mexico, USA, South America, Portugal, Spain, France, Greece, Germany, Italy, Switzerland, UK.

9.21.5 Hazard identification conclusion

Considering the facts that *Plodia interpunctella* -

- is not known to be present in Bangladesh;
- present in Australia,India, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed and stored products);

P. interpunctella is considered to be a potential hazard organism in this risk analysis.

9.21.6 Risk assessment

9.21.6.1 Entry potential: Medium

Egg, larvae and pupa are transported with seeds and other stored products. Adults are weak flier around the flour mill. The entry potential is medium.

9.21.6.2 Establishment potential: Medium

Hosts are available in Bangladesh, therefore it is medium for this pest.

9.21.6.3 Spread potential: Low

Moth activity was concentrated at or near the flour mill (Doud and Phillips, 2001).

9.21.7 Consequence assessment

9.21.7.1 Economic impact: Medium

Plodia interpunctella (Hübner), the Indian meal moth, is a world-wide insect pest of stored-products and processed food commodities. It can infest a variety of products and is perhaps the most economically important insect pest of processed food.

9.21.7.2 Environmental impact: No environmental is reported

9.21.8 Risk estimation: Medium

The overall risk is medium

9.21.9 Risk management: Same as 9.12.9

9.22 *Ephestia kuehniella* (Mediterranean flour moth)

9.22.1 Hazard identification

Common name: Mediterranean flour moth
Scientific name: *Ephestia kuehniella* (Zeller)
Synonyms: *Ephestia keuhniella* Zeller, *Ephestia fuscofasciella* Ragonot, *Ephestia gitonella* Druce, *Homoeosoma ischnomorpha* Meyrick.
Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Insecta
      - Order: Lepidoptera
        - Family: Pyralidae
          - Genus: *Ephestia*
            - Species: *Ephestia kuehniella*

Bangladesh status:Not present

9.22.2 Biology and Ecology

A virgin (or insufficiently fertilized) female adopts the calling position, extending her ovipositor and raising her abdomen. This position, which enables her to emit pheromones, can be taken up again over several days (Daumal, 1987). The males 'take to the air' to look for a mate and perform a courtship display. Mating takes place within a few seconds and usually lasts for 4-5 hours after dusk, but may continue for longer than this. Various abiotic factors may have caused sterility in the males, even if one or more spermatophores has been emitted (Daumal, 1987). The biotic potential of the females is not affected by the same factors. During mating the female's wings cover those of the male. When mating is complete the female no longer adopts the calling position, because a successful mating enables her to fulfil her entire reproductive potential, 6-10 hours after (or without) separation of the partners. The male, however, can fertilize five to six females during his life, although the later matings (over 6-8 days at 20°C) become increasingly less fertile.

During the day the adults remain immobile, with the antennae folded on the thorax, concealed under the wings, and the first pair of legs resting on the raised thorax (akinesis) . The moths fly after dusk, with nocturnal movements ceasing before dawn; males possess a peak in activity just prior to sunrise. The lifespan of the adults varies greatly. They can live for approximately 20 days if they do not find a mate, and for longer than this at low temperatures (10-18°C), providing that they have access to liquid feed sources (such as condensation, or fruit exudations). They tend to stay in shaded areas and almost always close to the highest thermal gradients (such as ceilings and flour-mill outlets). Emergence takes place from 17.00 to 22.00 h. Stretching and drying of the wings lasts for an average of 2 hours after the extension of the proboscis.

The females are stimulated by flour and other dusts, such as talcum powder. The female can gather heaps of dust into fissures and then place eggs on them. Firstly the tips of the antennae and simultaneously the ovipositor become active when inserted into fissures. The combination of these two stimuli leads her to slide particles into the fissures, using the setae on the papillae of the ovipositor and movements of the abdomen, before laying eggs in the fissures in rows. The eggs may, however, also be scattered apparently at random. This behaviour is not heritable for a given population. The females lay approximately 75% of their eggs in 48 hours, at 20-23°C. Females are deterred by high densities of larvae (Anderson and Löfqvist, 1996).

Most authors have noted the wide variation in biotic potential of this species: the number of offspring can range from 50 to 500. This variation may be attributable to genetic (Leibenguth and Russell, 1986) or epigenetic factors (Daumal and Pintureau, 1985; Daumal and Boinel, 1994). At emergence, females have eight ovarian sheaths, the content (chorionic oocytes during yolk formation, oogonia, atresia, the presence of corpora lutea) and length of each of which are a reflection of both the larval life of the female (quiescences, fasts, nutritional deficiencies, movements and competitiveness) and her genome. The pathogenic or physiological state of the male and female and conditions during mating will further affect the number of offspring. Male moths maintained under continuous illumination have a much lower reproductive capacity than males maintained under alternating light conditions.

The eggs (centrolecithal egg: 0.028 mg) are laid singly or close together. They adhere to the substrate because they are coated with secretions from the neck glands. Embryonic development takes 8 days at a constant 20°C. The lower heat threshold for development from primary division is 8°C (with 16 h light and 8 h dark cycle), and the upper heat threshold at this stage is 35°C (90% RH). These thresholds vary according to the developmental stage.

E. kuehniella has only a few hours of autonomy in its first stage after ingestion of the serous membrane. This is the most vulnerable stage (Daumal, 1987). Because development is heterogeneous, it is difficult to establish a precise duration: if a caterpillar deviates even slightly from the typical cycle described below, it may extend or even accelerate its development period. As an example, the complete cycle, from egg-laying to adult emergence, will take place within 60 days at 20°C for individuals fed exclusively on hard wheat semolina. Numerous studies have been carried out in this area, and all have demonstrated the plasticity of development of the five larval stages. This plasticity is due primarily to the polymorphism of the species, to the origin of the strain (Cox et al., 1981), and to a significant number of epigenetic factors which may or may not contribute to the expression of numerous pleiotropic genes.

From hatching to pupation, the caterpillar of E. kuehniella exhibits a stereotypical and completely solitary behavior. The first-instar larva immediately shows negative phototaxis and isolates itself in a woven network even before starting to feed. It only emerges to pick up dust particles of flour or semolina - which it incorporates into this network of silk threads. It takes its first feeds within this network, which it continuously adds to, thus forming its nutritional case. This behaviour continues throughout the four subsequent larval instars, during which the exterior of the case is extended and enriched with various types of food and non-food particles. The caterpillar remains in contact with the interior network by means of the setae on the cuticle. The hooks on the coronate legs stabilize the body during moulting.

Aerotaxis behaviour may be observed from the fourth instar: the caterpillar taking measurements of space by swinging and stretching its thoracic segments. This behaviour is clearly marked during the fifth instar: measurement-taking is accentuated after the caterpillar stops feeding and starts to construct the first pupation cocoon. The measurement enables the pest to establish the amount of space available above the cocoon: it will enable the imago to stretch its wings shortly after emerging from the second pupation cocoon (Daumal *et al*., 1985). This behaviour is exhibited on any ground-level area, but always occurs in the darkest part of the area. The study of this stereotypical behaviour has served as the basis for intensive breeding of E. kuehniella for production of biological control agents.

The dispersion of the different stages, and particularly of the fifth-instar larvae, which might appear to indicate negative geotaxis-type behaviour in warehouses or flour mills, is in fact only deterrence behaviour (when there is a high degree of competition in an area), or reactions to the discovery of a light and heat gradient.`Flight'-type behaviour is exhibited when the caterpillar is parasitized by a microbial agent or by an endoparasite which causes it to deviate from its normal behaviour. It should also be noted that the aggressive `cannibal' behaviour in situations where there is a high population density, described by various authors, is not a biological reality: the caterpillars competing for a case or a territory only `deter' each other by advancing and retreating, and following an excess of secretions from the mandibles some caterpillars abandon their territory. At high population densities (particularly in overcrowded laboratory production systems), an excess of secretions from older caterpillars can also lead to death by poisoning of younger first- and second-instar caterpillars. Nonetheless, particularly in flour mills, a series of cocoons may be discovered, in which fifth-instar larvae are living among fragments of parasitized or healthy pupae or pro-pupae which they have partially devoured while the pupae were in an inactive, immobile state. These fifth-instar larvae may, in their turn, be displaced by another healthy or parasitized specimen seeking to use their niche.

According to Cox *et al.* (1981) diapause in *E. kuehniella* is recognized as a delay in development between cessation of feeding and the start of pupation. Diapause is influenced by the strain and nutrition as well as by temperature and photoperiod (Cox, 1987). Diapause increased the tolerance of larvae to fumigants at low temperature. High temperature and darkness during larvae development, conditions common in flour mills, will result in a high number of diapausing larvae.

9.22.3 Host

Wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), maize (*Zea mays*), barley (*Hordeum vulgare*), rice (*Oryza sativa*), oat (*Avena sativa*), soybean (*Glycine max*), potato, cocoa, wheat flour, stored products.It also attacks nuts (e.g. almonds), date palms, carob pods, fruits and flowers, pollen, leaves, roots (dried), biscuits, human food and animal feed.

9.22.4 Distribution

India, Turkey, Japan, Algeria, Egypt, Austria, Bulgaria, Denmark, Germany, France, Italy, Poland, Switzerland, North America, Australia.

9.22.5 Hazard identification conclusion

Considering the facts that *Ephestia kuehniella* -

- is not known to be present in Bangladesh;
- present in India,Canada, Mexico and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed and stored products);

E. kuehniella is considered to be a potential hazard organism in this risk analysis.

9.22.6 Risk assessment

9.22.6.1 Entry potential: High

It spreads all over the world by international trade with seed and stored products. Adults, eggs, larvae and pupae borne externally with true seeds.

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9.22.6.2 Establishment potential: High

Populations can quickly build up if there is opportunity for larval development and a lack of control measures Infestation. *E. kuehniella* are intensively bred as a basis for the commercial production of various parasitoids and predators.

9.22.6.3 Spread potential: Medium

It can spread with infested materials easily. The dispersion of the different stages, and particularly of the fifth-instar larvae, which might appear to indicate negative geotaxis-type behaviour in warehouses or flour mills, is in fact only deterrence behavior.

9.22.7 Consequence assessment

9.22.7.1 Economic impact: High

In an FAO survey of pests of stored products in 1972 it was given as a pest of major importance only in Czechoslovakia. Nevertheless, extensive resources are used to control this pest species in industrial flour mills.

9.22.7.2 Environmental impact: No environmental impact is reported**.**

9.22.8 Risk estimation: Medium

The overall risk is medium in this risk analysis.

9.22.9 Risk management: Same as 9.12.9

9.23 *Ephestia elutella* (Tobacco moth)

9.23.1 Hazard identification

Common name: Tobacco moth, warehouse moth, cocoa moth, chocolate moth, currant moth, red streaked knothorn, stored tobacco moth.

Scientific name: *Ephestia elutella* (Hubner)

Synonyms: *Tinea elutella* Hübner, *Phycis semirufa* Haworth, *Phycis rufa* Haworth, *Hyphantidium sericarium* Scott, *Ephestia roxburghi* Gregson, *Ephestia infumatella* Ragonot, *Homoeosoma affusella* Ragonot, *Ephestia icosiella* Ragonot, *Ephestia amarella* Dyar.

Taxonomic position
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Pyralidae
Genus: *Ephestia*
Species: *Ephestia elutella*
Bangladesh status: Not present in Bangladesh.
It is a common and important pest of mills and grain processors.

9.23.2 Biology

The adult *Ephestia elutella* has brownish grey forewings crossed with two light bands. The hind wings are paler and plain grey. The wingspan is 14-20 mm. Adults will emerge in the warmer months of April-October. Adult female lays 120-150 eggs on or near the products. Eggs hatch within 10-12 days. Life cycle takes 50 - 90 days under optimum temperature conditions. Young larvae are a creamy-white colour with dark spots on their sides. Larvae pass through 4-5 moults to attain full growth when they are 10-12 mm long. Larva is dark to start with, becoming yellow with a dark line down its back, and a dark brown head. The larvae go to diapauses stage throughout the winter before pupation. The pupae are light brown turning black before the adult emerges. Adults emerge in late spring.The duration of the egg, larval and nymphal stage at 26-30°C and 70-90% RH was 5-7, 29-50 and 6-18 days, respectively (Meng *et al.,* 1990).

9.23.3 Hosts

Wheat (*Triticum aestivum*), rye (*Secale cereale*), and other cereals, Coconut (*Cocos nucifera*), Tobacco (*Nicotiana tabacum*) etc.

9.23.4 Distribution

Afghanistan, Albania, Algeria, Argentina, Australia, Austria, Belgium, Bulgaria, Canada, China, Croatia, Cyprus, Denmark, Egypt, France, Germany, Greece, Italy, Iraq, Ireland, Israel, Japan, Korea, Central Asia, Russian Federation, Pakistan, New Zealand, Saudi Arabia, Spain, Sudan.

9.23.5 Hazard identification conclusion

Considering the facts that*Ephestia elutella* -

- is not known to be present in Bangladesh;
- presentin Australia, Canada and Pakistan from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed and dried stored products);

E. elutella isconsidered to be a potential hazard organism in this risk analysis.

9.23.6 Risk assessment

9.23.6.1 Entry potential: Medium

It is transported though seeds and dried stored products.

9.23.6.2 Establishment potential: Low

Widespread in temperate regions but rare in the tropics.

9.23.6.3 Spread potential: Medium

It is medium but increases with availability of hosts.

9.23.7 Consequence assessment

9.23.7.1 Economic impact: Medium

It is an important pest in factories and warehouses.Larvae foul the food/seed extensively with webbing and frass.

9.23.7.2 Environmental impact: No environmental impact is reported.

9.23.8 Risk estimation: Low

The overall risk is low.

9.23.9 Risk management: Same as 9.12.9

9.24 *Acarus siro* (Flour mite)

9.24.1 Hazard identification

Common name: Flour mite
Scientific name: *Acarus siro* Linneaus
Synonames: *Acarus siro* var, *farinae* Linnaeus, *Aleurobius farinae* Koch, *Tyroglyphus farina*e Latereille, *Tyroglyphus siro* Lat. Sensu Robin

Taxonomic position
- Kingdom: Animalia
  - Phylum: Arthropoda
    - Class: Arachnida
      - Order: Acarina
        - Family: Acaridae
          - Genus: *Acarus*
            - Species: *Acarus siro*

Bangladesh status: Not present in Bangladesh.

9.24.2 Biology

A flour mite doesn't live for long. Its life span can be as short as 9 days or as long as a month, depending upon various conditions. The life cycle starts with the egg. A female mite will lay up to 30 eggs per day for a period of several weeks. The maximum number of eggs a female will lay during her lifetime can approach 800. It is obvious then that even if these little bugs don't live long, a colony of them can grow to very large numbers and can be present in one location for a long time.

Once an egg has hatched, the flour mite enters its larval, or juvenile, stage. Most will eventually emerge from this stage as adults. A few however will develop small suction-like appendages, which allow them to hitch rides on pets, boxes, or whatever is moving by and thereby travel to another location. Most adults will stay put, as long as a food source is available.The development from egg to image dependents on the temperature and can vary from 17 to 140 days.

9.24.3 Hosts

Seed and stored products of wheat (*Triticum aestivum*), maize (*Zea mays*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), oat (*Avena sativa*), *Brassica napus*, *Camellia sinensis*, *Glycine max* and *Linum usitatissimum*.

9.24.4 Distribution

Canada, Chile, China, Czechoslovakia, New Zealand, Poland, Russian Federation, UK, USA.

9.24.5 Hazard identification conclusion

Considering the facts that*Acarus siro* -

- is not known to be present in Bangladesh;
- presentinCanada and USA from where wheat grains are imported to Bangladesh;
- can be carried on wheat grains (seed and stored products);

A. siro isconsidered to be a potential hazard organism in this risk analysis.

9.24.6 Risk assessment

9.24.6.1 Entry potential: Low

It is medium in clean dry grain in good condition, risk increases with moisture content.

9.24.6.2 Establishment potential: Medum

It is medium as it is pest of temperate regions.

9.24.6.3 Spread potential: Low-medium

It spreads with damp grains or products

9.24.7 Consequence assessment

9.24.7.1 Economic impact: Medium

Damages the germ, causing loss in germination and viability.Serious pest of foodstuff. Musty smell and large number of life and dead bodies render foodstuff unfit for sale and consumption.

9.24.7.2 Environmental impact: No environmental impact is reported**.**

9.24.8 Risk estimation: Low

The overall risk is low.

9.24.9 Risk management: Same as 9.12.9

Fungus

9.25 *Tilletia indica* (Karnal bunt)

9.25.1 Hazard Identification

Disease: Karnal bunt of wheat
Pathogen: *Tilletia indica* Mitra
Synonyms: Neovossia indica (Mitra) Mundk.
Common names: Karnal or partial bunt of wheat and other cereals
Taxonomic position:

Kingdom:	Fungi
Phylum:	Basidiomycota
Subphylum:	Ustilaginomycotina
Class:	Ustilaginomycetes
Order:	Tilletiales
Family:	Tilletiaceae
Genus:	Tilletia
Species:	*Tilletia indica*

Bangladesh Status: Not present in Bangladesh.

9.25.2 Biology

Tilletia indica survives upto a period of 5-years in the infested soil. Teliospores germinate at or near the soil surface in response to temperature and moisture, normally at temperatures between 20 and 25°C (Krishna and Singh, 1982). According to Sansford (1998) temperatures of 8–20°C and high humidity associated with light rain, showers and cloudy weather during heading to anthesis are considered favorable. Bonde *et al*. (1997), however, opined that there is some agreement that teliospores germinate well between 15–25°C over a pH range of 6.0–9.5. As with germination of teliospores, there is a range of opinions on the most favorable conditions for infection, but in general, temperatures of 8–25°C. In addition to temperature soil moisture and humidity are also important factors for teliospore germination. It has been reported that surface soil moisture >15% (Aujla *et al*. 1990) and >82% relative humidity (Bonde *et al*. 1997) is necessary for germination of teliospore. Karnal Bunt outbreaks are generally associated with average air temperatures ranging from 9.4 to 23.9º C, and optimal soil temperatures of between 17 and 21º C. Favorable conditions for disease development include cool, rainy weather or regular irrigation and high humidity at the time of heading.

Teliospores produce a promycelium bearing many filiform primary sporidia, which give rise to secondary sporidia, or hyphae that can also produce secondary sporidia. Dhaliwal and Singh (1989) found that two types of secondary sporidia are produced: allantoid sporidia and filiform sporidia, of which only the allantoid type is thought to be able to infect and cause the disease. Allantoid secondary sporidia are ballistospores (i.e. forcibly discharged). Bedi *et al*. (1990) studied conditions favorable for germination and production of sporidia. The optimum temperature and pH for germination and production of sporidia were 20 ± 1°C and 8.0, respectively. Primary and secondary sporidia are dispersed by wind or rainsplash to the wheat ears and act as the primary source of infection.

Infection of kernels is enhanced by high relative humidity or several rainy days during the 2–3 week period of thesis. Obviously, overhead irrigation of the cereal crop during heading and anthesis would also provide favorable conditions for infection. Conditions at one location in India that favored infection were: (i) maximum temperature of 22 ± 2°C; (ii) evening (2:30 pm) relative humidity > 48%; (iii) cloudiness for more than 3.5 hours per day during the first two weeks of anthesis; and (iv) number of rainy days more than 3 during the first week of anthesis (Mavi *et al*. 1992).

Survival and spread of the fungus can occur by transport of infested and infected seed. Recently, three distinct pathotypes of *T. indica*, which differed in virulence, were present in Punjab (Dhiman 1982). Aujla et al. (1987) reported pathotypes K1, K2, K3, and K4 in 21collections of *T. indica* from different regions of Punjab and Himachal Pradesh.

Seed- or soil-borne teliospores and their subsequent germination are believed to play only a starting role in Karnal bunt epidemics (Dhaliwal, 1989). According to Bains and Dhaliwal (1989), repeated cycles of sporidial production in the ears provide more inoculum than soil-borne teliospores of *T. indica.*

Primary and secondary sporidia are dispersed by wind or rainsplash to the wheat ears and act as the primary source of infection. Another factor regarding floral infection is the finding that sporidia develop on the outer glumes of florets, indicating that repeated cycles of sporidial production in spikes provide secondary inoculum (Bains and Dhaliwal, 1989). Sporidia also develop on leaves and other plant parts. According to Dhaliwal, the fungus colonizes the surfaces of lower plant leaves to produce more secondary sporidia. These are splashed or blown to higher leaves. In this way the pathogen moves in steps up the plant to infect the spike.

Seed-borne nature and seed transmission

This disease is wide spread in India and the seed infection by the pathogen is common. A survey of 2144 seed lots in Pakistan showed seed infection by *T. indica* in 28% of samples in 1983-84 (Shamshad Begum and Mathur, 1989). In India in 1986, bunt spores were detected in 52% of 100 wheat seed samples (Kailash Agrawal et al., 1986). *T. indica* is commonly found in wheat seeds in northern and central regions of India, Pakistan, Mexico, There is no direct evidence that *T. indica* can be transmitted from planted seeds to the plants grown from the seed. However, teliospores that heavily contaminate seeds do survive and germinate in the soil and are considered to be an important inoculum source of the pathogen (Bains and Dhaliwal, 1989).

Detection and inspection methods

A quarantine procedure for testing seeds of *Triticum* spp. for *T. indica* has been described by EPPO (OEPP/EPPO, 1991). Crops for seed should be inspected during the growing season. Field inspection should take place between heading and harvest. Any bunted seeds detected during the field inspections should be examined under the microscope for the characteristic teliospores of *T. indica*. For quarantine purposes, seed should be tested for the presence of the fungus by the washing test: about 400 seeds (eight replicates of 50) are placed in test tubes with sufficient water to submerge the seed; the test tubes are placed on a mechanical shaker for 10 min to obtain a spore suspension, then centrifuged for 20 min at 3000 revolutions per min; the sediment is examined under a compound microscope.

Direct visual observation for Karnal bunt (dry seed inspection) is regarded as insufficient for quarantine purposes since low levels of infection might pass undetected (Agrawal *et al*., 1986) and even minimal seed infections can substantially contaminate healthy seed lots (Aujla *et al*., 1988).

9.25.3 Hosts

Triticum aestivum (bread wheat) is the most common host of Tilletia indica, although the fungus also infects *Triticum durum* (durum wheat) and *X Triticosecale* sp. (triticale) and rye.

9.25.4 Geographical Distribution

Karnal bunt of wheat (*Tilletia indica*)has been reported from Asia: Afghanistan, India (Delhi, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Rajasthan, Madhya Pradesh, Jammu and Kashmir, West Bengal and Gujarat), Iran, Iraq, Nepal and Pakistan; Africa: South Africa; North America: Mexico, USA (in the states of Arizona, California, and Texas) and South America: Brazil.

9.25.5 Hazard Identification Conclusion

Considering the facts that:

- *Tilletia indica* is not known to be present in Bangladesh;
- is present in Afghanistan, India, Iran, Iraq, Nepal, Pakistan, South Africa, Mexico, Brazil and USA and can be carried with wheat seed or grain;

Tilletia indica is considered to be a potential hazard organism in this risk analysis.

9.25.6 Risk Assessment

9.25.6.1 Entry Assessment: High

Tilletia indica in wheat is listed as a I/AI quarantine pest for the European Union.The most likely pathway for *T. indica* to enter in the PRA area is via international trade in seed and grain of wheat that has been infected or contaminated with *T. indica.* At low level of infection in the field or infection of the ear at heading stage it is easily be overlooked and remain undetected. Therefore, the entry of the pathogen with the commodity may be as seed/grain infection or as contaminant. In 1996, *T. indica* was intercepted in Poland in grain of *T. aestivum* from India. Despite the existence of EC legislation and exporting country requirements since 1997, several interceptions of *T. indica* have been reported subsequently indicating that the disease in the field might have been remained undetected. Among the countries from where Bangladesh is importing huge quantity of wheat grain the diseases is present in India, Pakistan and USA andMexico from where seeds are imported, therefore the possibility of entry of the pathogen along with these pathways is high.

9.25.6.2 Exposure Assessment: High

Bangladesh is importing huge amount of wheat grain every year mostly from countries where the presence of *T. indica* has been reported. Similarly germplasms are imported from Mexico where the disease is present. After entry, wheat grains are transported to different parts of the country.During handling and transport operationsof the infected or contaminated grain in areas where wheat is grown, poses the highest risk, since the teliospores can be released and disseminated by wind. It is also likely that before milling the grains are generally cleaned and disposed the light weighted or broken grains along with dirt. Therefore, the probability of exposure of the pathogen to the environment of the PRA area is high.

9.25.6.3 Establishment Assessment: Medium

The hosts are available in Bangladesh, which could come in contact to the pathogen when entered with wheat seed or grain. Because of the longevity of teliospores, once introduced in the soil, these could be present for considerably longer than one cropping season and available to infect over a number of years during favourable climatic conditions. The favorable temperature for germination of teliospore and sporidia production is 15-25C and for seed infection during anthesis of wheat the favorable temperature is 22 ± 2C. The environmental factors in Bangladesh during wheat cultivation ismore or less close to those favor the pathogen. Therefore, the probability of establishment of *T. indica* in Bangladesh is high.

9.25.7 Consequence Assessment

9.25.7.1 Economic Impact: High

Yield losses resulting from KB are generally low. The disease appeared in the Punjab (India) in 1930 and reached to epidemic proportion in 1953-1954 (Agarwal et al., 1976). In 1974 and 1975, the disease was epidemic in other regions (Himachal Pradesh, Tarai areas of Uttar Pradesh and the Gurudaspur area of the Punjab) with 50% infection on the cultivar HD-2000. In 1976-1977, low levels of infection (up to 3%) were observed on cultivars HD-1553 and HD-1593 in Uttar Pradesh, Punjab, Haryana, Rajasthan and Madhya Pradesh. When infection is severe, yield, seed quality and germination are adversely affected. Food grain is unacceptable when infection exceeds 3% due to odor of rotten fish. Considering these facts it could be assumed that the economic impact of the disease under Bangladesh condition is high.

9.25.7.2 Long-term contamination of land

Spores of *T. indica*survive for up to 5 years in soil. Thus, once a field is infested, normal crop rotations do not control the disease. This contamination imposes the costs of control measures required for wheat crops.

9.25.7.3 Environmental Impact

There is no information on the direct impact of Karnal bunt on environment. However, the indirect negative impact on environment is that once the disease established it needs heavy sprays of chemicals to control the disease which leads to polluted environment.

9.25.7.4 Social impact

Karnal bunt is not toxic to humans, but infection by *T. indica*can affect the appearance and smell of grain products. Bunted grain smells like rotting fish due to the production of trimethylamine and unacceptable to the consumers.

9.25.8 Risk Estimation

The likelihood of entry and exposure of *T. indica* in Bangladesh is high and medium probability for establishment. This would bring negative economic and social impact. The risk estimate for *T. indica*is non negligible therefore this organism is classified as a hazard in this commodity and risk managemnet measures can be justified.

9.25.9 Risk Management

It has been reported (Warham, 1986) that all commercially available cultivars in India are susceptible to the pathogen. However, Gill et al. (1986a, b) reported two cultivars to be either tolerant or field resistant.

To prevent the spread of *T. indica* into previously unaffected areas, the use of disease-free seed is essential. The movement of farm machinery and soil from contaminated fields may also be restricted.

Chemical Control

Foliar sprays of fungicides may be used to control the airborne inoculum of primary and secondary sporidia. Propiconazole was shown to be effective against natural infection in India (Singh et al., 1989). CIMMYT (the International Wheat and Maize Research Programme) in Mexico also recommends the use of propiconazole (T1H 250 EC) at 0.5 l/ ha as a foliar spray. A first spraying is done at 25% heading and a second one 10 days later. In Pakistan, propiconazole and bitertanol reduced the disease by 79 and 67%, respectively (Chandhry and Khan, 1990). A foliar spray of triazole fungicides may be applied as a preventative measure in an area where Karnal Bunt is known to occur.

Phytosanitary Measures

Karnal Bunt is regarded as a serious disease of wheat and thus poses strict international quarantine status. Seeds orgrains should come from a pest-free area or from a pest-free place of production followed by testing of the harvested grain. CIMMYT (1989) uses the following procedures for germplasm material sent to other continents: production in areas free from *T. indica*; propiconazole sprays on seed-production plots; treatment of seed batches in a sodium hypochlorite bath; seed treatment with carboxin, captan and chlorothalonil.

9.26 UG99 of Puccinia graminis f.sp.tritici (Stem rust)

9.26.1 Hazard Identification

Disease: Stem rust or Black rust
Pathogen: UG99 of *Puccinia graminis f.sp. tritici* race UG99
Taxonomic position:

Kingdom:	Fungi
Phylum:	Basidiomycota
Sub-phylum:	Pucciniomycotina
Class:	Pucciniomycetes
Order:	Pucciniales
Family:	Pucciniaceae
Genus:	*Puccinia*
Species:	*Puccinia graminis*
Subspecies:	Puccinia graminis f. sp. tritici
Strain:	04KEN TTKSK 156/04 (Ug99)

Bangladesh Status: Not present in Bangladesh

9.26.2 Biology

Puccinia graminis f. sp. tritici is an obligate biotroph, a macrocyclic, heteroecious rust, with five distinct spore stages. It needs two different types of hosts- wheat and berberies to complete its life cycle. On wheat the uridinal stage is initiated by germination of urediniospore. Stem rust on wheat is characterized by the presence of uredinia on the plant, which are brick-red, elongated, blister-like pustules which are easily shaken off. They most frequently occur on the leaf sheaths, but are also found on stems, leaves, glumes and awns. On leaves they develop mostly on the underside but may penetrate to the upperside. On leaf sheaths and glumes pustules rupture the epidermis, giving a ragged appearance.Urediniospores are the only type of spores in the rust fungus life cycle which are capable of infecting the host on which they are produced, and this is therefore referred to as the 'repeating stage' of the life cycle. It is the spread of urediniospores which allows infection to spread from one cereal plant to another. This phase can rapidly spread the infection over a wide area by wind. The recycling of the uredinial stage is the major means whereby the fungus initiates and perpetuates an epidemic.

As the plant matures the production of urediniospore ceases and formation of black, thick-walled teliospore initiated and at this stage the symptom looks black. Teliospores are important because they are constitutionally dormant, enabling the fungus to survive severe cold or drought. The mature teliospore represents the only true diploid state of the fungus. Infected plants produce fewer tillers and set fewer seed, and in cases of severe infection the plant may die. Infection can reduce what is an apparently healthy crop about three weeks before harvest into a black tangle of broken stems and shriveled grains by harvest.The telia are firmly attached to the plant tissue.

Each teliospore undergoes karyogamy (fusion of nuclei) and meiosis to form four haploid spores called basidiospores. This is an important source of genetic recombination in the life cycle.Basidiospores are thin-walled and colourless. They cannot infect the cereal host, but can infect the alternative host (usually barberry). They are usually carried to the alternative host by wind.

Once basidiospores arrive on a leaf of the alternative host, they germinate to produce a haploid mycelium which directly penetrates the epidermis and colonises the leaf. Once inside the leaf the mycelium produces specialised infection structures called pycnia. The pycnia produce two types of haploid gametes, the pycniospores and the receptive hyphae. The pycniospores are produced in a sticky honeydew which attracts insects. The insects carry pycniospores from one leaf to another. Splashing raindrops can also spread pycniospores. A pycniospore can fertilise a receptive hypha of the opposite mating type, leading to the production of a dikaryotic mycelium. This is the sexual stage of the life cycle and cross-fertilisation provides an important source of genetic recombination.

This dikaryotic mycelium then forms structures called aecia, which produce a type of dikaryotic spores called aeciospores. These have a worty appearance and are formed in chains - unlike the urediniospores which are spiny and are produced on individual stalks. The chains of aeciospores are surrounded by a bell-like enclosure of fungal cells. The aeciospores are able to germinate on the cereal host but not on the alternative host (they are produced on the alternative host, which is usually barberry). They are carried by wind to the cereal host where they germinate and the germ tubes penetrate into the plant. The fungus grows inside the plant as a dikaryotic mycelium. Within 1–2 weeks the mycelium produces uredinia and the cycle is complete.

A new and devastating race of this pathogen has been detected in Uganda in 1998 and named as UG99. Most of the resistant varieties developed for the last 50 years showed susceptible to UG99. This race has created a threat to food security worldwide.

9.26.3 Hosts

Stem rust can affect wheat, barley, triticale, and many other related grasses; however, P.g. tritici can infect only wheat and related grasses. The alternate hosts are **Berberis** and **Mahonia** spp. Similar is the host range of UG99.

9.26.4 Geographical distribution

Stem rust disease of wheat is distributed worldwide. However, the devastating race of the pathogen-UG99, found in Uganda in 1999, which is considered as a threat for global food security, was observed for the first time in Uganda. Subsequently the ug99 has been detected in Uganda, Kenya, Ethiopea, Eritrea, Sudan, Yemen, Iran, Tanzania, Mozambique, Zinbabwe and South Africa.

9.26.5 Hazard Identification Conclusion

Considering the facts that:

- UG99 of *Puccinia gramis f.sp tritici* is not known to be present in Bangladesh;
- is present in some African countries,Yemen and Iran and can be carried with infected wheat plant parts and wind;

UG99 *is* considered to be a potential hazard organism in this risk analysis. So far, seven linease groups of UG99 have been identified.

9.26.6 Risk Assessment

9.26.6.1 Entry Assessment: High

The uredinia may occur on leaves, stems, leaf sheaths, spikes, glumes, awns and occasionally on grains. Therfore, the pathogen as urediniospore may enter through these pathways to Bangladesh as contaminant of wheat grain or seed. Under dry condition the spores could survive up to one month. Therefore, the probability of entry through this pathway is medium. Wind is the most important pathway for spreading rust fungi. This particular race has already reached to Iran from its initial place at Uganda. There is every possibility of entering this race to Bangladesh once it arrive to Pakistan and India. Yellow rust entered to this part of the world from Africa following the similar route. Therefore the probability of entry of UG99 in Bangladesh by wind is high.

9.26.6.2 Exposure Assessment: High

When the pathogen enter into Bangladesh either as infected plant parts along with grain/seed or by wind during the wheat growing season, there is high possibity of its exposureto the suitable hosts.

9.26.6.3 Establishment Assessment: High

The environmental condition of Bangladesh is conducive to establish stem rust pathogen and this disease is already present in Bangladesh although in a limited scale due to the cultivation of resistant varieties. Similar condition will also favor the establishment of the new race in Bangladesh condition and in such case the disease will spread rapidly by wind as most of the resistant varieties are susceptible to this race. Rust fungi have tremendous potential to spread once introduced, leading to epidemic out break.

9.26.7 Consecuence Assessment

9.26.7.1 Economic Impact: High

Wheat stem rust epidemics have the potential to cause large economic losses to the grains industry. For example, a single outbreak in south eastern Australia in 1973 caused $300 million in damage. If Ug99 were to become established, there would be an increase in the number of stem rust susceptible wheat varieties, increasing the likelihood of occurring new epidemics.

9.26.7.2 Environmental Impact

Once introduced, it will need a large amount of fungicide application in the field to control the disease. This will incur additional cost for wheat production and also contribute environmental pollution.

9.26.7.3 Social Impact

Increase food insecurity.

9.26.8 Risk estimation

Most of the varieties grown in Bangladesh are highly susceptible to UG99. Wind is the principal mode for spreading rust diseases and so is for stem rust (UG99). The migration of the new race from Uganda to Kenya in 2001, to Ethiopia in 2003, to Sudan and Yemen in 2006. It has also been reported from Iran. From its new position it has been predicted to spread to Pakistan, Afghanistan , India and Bangladesh. Therefore, Bangladesh is at the high risk zone for this race.

9.26.9 Risk management

The only effective management of rust caused by UG99 is the development and deployment of durable resistant varieties. An international initiative has been taken up under the coordination of Cornell University, USA and funded by Bill and Milinda Gate to screen varieties and germplasms of different wheat growing countries including Bangladesh againgt the devastating race in Kenya and Ethiopia. By this period, Bangladesh has developed three new varieties resistant to the variants of UG99.

Chemical control is possible only against small scale disease development but impossible in case of a massive epidemic out break of the disease.

Fungus

9.27 Tilletia laevis and Tilletia tritici (Common bunt)

9.27.1 Hazard Identification

Disease: Common bunt (CB), stinking bunt, covered smut, hill bunt, complete bunt, low bunt, high bunt
Pathogen: Two pathogen species,*Tilletia laevis* Kühn and *Tilletia tritici* (Bjerk.) Wint.are involved, and teliospores of both species are sometimes found in the same sorus.
Synonym: *T. foetida* (Wall.) Liro and *Tilletia caries* (DC.)Tul.
Taxonomic position:

Kingdom:	Fungi
Phylum:	Basidiomycota
Class:	Exobasidiomycetes
Subclass:	Exobasidiomycetidae
Order:	Tilletiales
Family:	Tilletiaceae
Genus:	*Tilletia*
Species:	*T. laevis caries* and *T. tritici*

Bangladesh Status: Not present in Bangladesh.

9.27.2 Biology

Tilletia laevis and *Tilletia tritici* (Bjerk.)Wint.are essentially identical except for differences in spore wall characteristics.Both fungi have similar life cycles and may occur together in the same infected plant. Natural morphological variants that have a full range of teliospore morphology between *T. tritici* and *T. laevis* have been observed. Several studies based on the biochemistry and molecular biology of the organisms have failed to differentiate them or have shown only slight differences. The close relatedness of these bunt fungi has led to the suggestion that they be treated as varieties of a single species (Holton and Kendrick 1956, Kawchuk et al.1988). The taxonomy and identification of *Tilletia* spp. on wheat and grasses are basedprimarily on teliospore morphology, but host range and the environment required for teliospore germination are also important.

The process of teliospore germination is similar in the CB fungi. The promycelium (basidium) grows through a hydrolyzed area of the spore wall and extends to a variable length depending on environment. On agar, the promycelium sometimes grows extensivelybefore producing primary sporidia, but onsoil, it is usually extremely short. Filiform primary sporidia (8-12) grow from the tip of the promycelium to form a compact bundle. Fused primary sporidiaproduce infection hyphae,vegetative hyphae, orsecondary sporidia. The allantoid secondarysporidia form on shortsterigmata and are forciblydischarged. Secondary sporidia mayproduce infection hyphae, vegetativehyphae, or additional allantoid or filiformsporidia.

Teliosporesgerminate most rapidly at 18-20^{0}C, butmost uniformly at 14-16^{0}C.Germinationoccurs after 4-5 days at 15^{0}C, and after10-14 days at 5^{0}C, under optimallaboratory conditions. Fewer primarysporidia are produced at 5^{0}C than at 15^{0}C. In soil under natural field conditions,teliospores of the CB fungi are viable forabout two years (Woolman and Humphrey1924). Infection occurs below the soilsurface, shortly after the seed germinatesand prior to emergence. Teliospores onseed or in the soil germinate andeventually produce infection hyphae thatpenetrate the coleoptile. Hyphae becomeestablished initially in both resistant andsusceptible cultivars (Hansen 1958,Swinburne 1963) but do not progress tothe apical meristem of resistant plants.Hyphae must inhabit apical meristemsbefore internode elongation or diseasedoes not develop. After penetrating thecoleoptile, hyphae enter the first leaf baseand then go through successive leafbases, or down the leaf base to the areadirectly beneath the apical meristem.Intercellular hyphae are present in theapical meristem by about the 5-leaf stage(Swinburne 1963).CB incidence is high when soil moistureranges from near the permanent wiltingpoint to field capacity, but is optimumwhen moisture is midway between fieldcapacity and the permanent wilting point(Purdy and Kendrick 1963). Infectionisoptimum at 5-10^{0}C soil temperature, andslight infection occurs at 22^{0}C (Purdy andKendrick 1963).

Symptoms of CB may not be apparent until after heading, when sporulation begins in the very young ovary. Immature infected spikes are usually darker green, and remain green longer, than healthy spikes. Mature infected spikes are usually slightly lighter in color and often have a slight bluish-gray color when compared to uninfected spikes. The pathogen grows within the terminal meristem, especially the flower primordia of the spike and completes its life cycle by transforming the ovaries into smut balls instead of kernels. The ovary wall is modified to become the exterior of the kernel-shaped sorus which remains intact until harvest.

Seed-borne nature, detection and inspection methods: Same as *T. indica*

9.27.3 Hosts

Secale cereale (rye), Triticale, *Triticum aestivum* (wheat), *Triticum dicoccum*, *Triticum spelta* (spelt), *Triticum turgidum* (durum wheat).

9.27.4 Geographical distribution

Tilletia laevis and *Tilletia tritici*have been reported from the following countries:

Asia: Afghanistan, Armenia, China, Cyprus,Georgia, India, Iran, Iraq, Israel, Greece Japan,Kazakhstan, Kyrgyzstan, Mongolia, North Korea, Nepal, Pakistan, Russia, South Korea, Syria, Tajikistan, Turkey, Turkmenistan, Uzbekistan.

Africa: Algeria, Angola, Lesotho, Libya, Egypt, Ethiopia, Kenya, Morocco, Somalia, South Africa, Tunisia, Zimbabwe.

Europe: Albania, Austria, Bulgaria, Croatia, Czech Republic, Denmark, France,Germany,Greece, Italy, Malta, Moldova, Montenegro, Netherlands, Norway,Poland, Portugal,Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Ukraine.

North America: Canada, Mexico, USA

South America: Argentina, Chile, Colombia, Peru, Uruguay, Venezuela

Oceania: Australia.

9.27.5 Hazard Identification Conclusion

Considering the facts that:

- *Tilletia laevis* and *Tilletia tritici*is not known to be present in Bangladesh;
- The fungi are primarily seed-borne;
- is present in Australia, Canada, China, India, Mexico, Pakistan, Russia and USA and can be carried with wheat seed or grain;

Tilletia laevis and *Tilletia tritici*are considered to be potential hazard organisms in this risk analysis.

9.27.6 Risk Assessment

9.27.6.1 Entry assessment: High

Tilletia laevis and *T. caries* are seed-borne in nature. Often it is difficult to distinguish diseased from healthy heads. Usually, all ovaries of the ear are affected, but not all heads on a plant may be infected. The entire kernel is replaced by bunt balls full of teliospores; however, some kernel may be only partially affected. At low level of infection the disease could be easily overlooked. However, during harvesting and threshing the teliospores are discharged and contaminate the grain/seed lot. Such teliospores could survive for several years under ambient condition in the vessel. Bangladesh generally import wheat grain in bulk from Australia, Canada, China, India, Pakistan, Ukraine and USA and germplasm from Mexico. Among these countries, common bunt (*T.* laevis&*T. caries*) is present in all the countries. Therefore, the probability of entering the pathogen in the PRA area through wheat grain or seed is high.

9.27.6.2 Exposure assessmen: High

Teliospores of the fungus *T. caries* and *T. tritici* are loosely attached with the seed/grain. During handling of the bulk grain for distribution the spores are exposed and dispersed by wind. After unloading from the carrier teliospores may remain in the carrier as contaminants and exposed to the environment. Similarly during loading-unloading and also during transporting to long distance some grains may fall to the ground and thus the spores may also be exposed to the environment of the PRA area. Therefore, the overall probability of exposure of *T. caries* and *T. tritici* to the environment of Bangladesh is high

9.27.6.3 Establishment assessment: Medium

The teliospores remain viable in the soil for about two years. In Bangladesh sowing of wheat seeds started from mid-November. The wether conditions during seed sowing period are more or less congenial for germination of teliospores of *T. tritici* and *T. caries*. The teliospores germinate most rapidly at 18-20^{0}C, but most uniformly at 14-16^{0}C and the germinating seeds get infected below soil surface and thelikelihood of its establishment under Bangladesh condition is medium.

9.27.7 Consequence assessment

9.27.7.1 Economic impact: Medium

Establishment of these two species of fungi would affect wheat production. Reported yield loss due to common bunt is 10-15%. Common bunt has a greater effect on the value of wheat because contaminated grain has an objectionable odour and become unacceptable. These quality effects justify the use of regulations designed to prevent the introduction of *T. tritici* and *T. caries* into Bangladesh.

9.27.7.2 Long-term contamination of land

Teliospores of *T. itritici* and *T. caries* survive for up to 2 years in soil. Thus, once a field is infested, normal crop rotations do not control the disease. This contamination imposes the costs of control measures required for wheat crops.

9.27.7.3 Environmental impact

There is no information on the negative impact of common bunt on environment.

9.27.7.4 Social impact

Common bunt infected grain is not toxic to humans, but infection by this diseasecan affect the appearance and smell of grain products. Bunted grain smells like rotting fish due to the production of trimethylamine and become socially unacceptable.

9.27.8 Risk estimation

The likelihood of entry and exposure of common bunt in Bangladesh is high and the probability for its establishment is medium. This would bring negative economic impact. The risk estimation for common buntis non negligible therefore this organism is classified as a hazard in this commodity and risk managemnet measures can be justified.

9.27.9 Risk management

Same as *T. indica*

Fungus

9.28 Claviceps purpurea (Ergot disease of wheat)

9.28.1 Hazard Identification

Disease: Ergot disease of wheat
Pathogen: *Claviceps purpurea* (Fr.) Tul.
Anamorph:*Sphacelia segetum* Lév.
Taxonomic position:

Kingdom:	Fungi
Division:	Ascomycota
Class:	Sordariomycetes
Order:	Hypocreales
Family:	Clavicipitaceae
Genus:	*Claviceps*
Species:	*Claviceps purpurea*

Bangladesh Status: Not present in Bangladesh

9.28.2 Biology

The first stage of ergot disease cycle occurs in the spring when ergot bodies germinate to produce tiny drumstick-shaped fruiting structures. Ergot bodies may be present in a field from a previous cereal crop, or from grasses along roadsides or neighbouring pastures. Ergot bodies may also be introduced into a field with planted seed. The conditions required for the germination of ergot sclerotia are a cold stratification period (winter), followed by prolonged wet soils in the spring. In the head, threadlike sexual spores form, which are ejected simultaneously when suitable hosts are at floweringstage.Ascospores from the perithecia comprise the primary inoculum and are spread by wind and splashing rain to host plant flowers. Ascospores germinate and invade the flower through the stigma to penetrate the ovary. This infection leads to the production of sticky exudate containing asexual conidia within 5 days.Insects are attracted to the sweet exudate, and carry conidia to healthy florets in the same spike or to adjacent spikes. Rainy or humid weather favors the production of exudate and spores. Hard, purple-black sclerotium, known as an ergotdevelops in each infected floret.Such ergots can be very large, up to 2 cm in length, and are very obvious in the standing crop and in contaminated grain samples. At or near to harvest, ergots fall to the ground where these fungal structures can survive in the soil from one season to the next, and under dry condition can remain viable for many years.

Favorable temperatures for growth are in the range of 18–30 °C. Temperatures above 37 °C cause rapid germination of conidia. Ergot is most prevalent in years when continuous moist conditions prevail during both stages of the disease cycle. First, moisture is needed at the soil surface during spring and early summer to promote germination of ergot bodies. Second, wet, cloudy and cool weather extends the period of flowering and increases the window of infection for spores to enter the florets. These weather conditions may also favour insect populations of aphids, thrips, midge and leaf hoppers, which serve as potential vectors of sticky spores.

Wet conditions during flowering and open flowers favor the disease. Susceptibility of different hosts relates to the length of time the flowers are open; hosts with longer flowering periods are more susceptible than those with shorter flowering periods.

Detection and inspection methods

Visual inspection of seed.

9.28.3 Hosts

Ergot has a wide host range of about 60 genera, all in the grass family. Rye and triticale are particularly susceptible, because they are open-pollinated, but wheat, barley, and many grasses (including weed grasses such as quack grass, meadow foxtail, wild oat, cheatgrass, hair grass, wild barley, annual bluegrass, and green foxtail) are among the hosts.

9.28.4 Geographical Distribution

Ergot disease of wheat (*Claviceps purpurea*) has been reported from the following 57 countries under Asia, Africa, Europe, North America, South America and Oceania. The countries are listed below.

Asia: Armenia, China, India, Iran, Israel, Japan, Kazakhstan, North Korea, South Korea, Nepal, Philippines, Russia,Turkey.

Africa: Algeria, Ethiopia, Guinea, Kenya, Malawi, Mauritania, Mauritius, Morocco, South Africa, Sudan, Tanzania, Zimbabwe.

Europe: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Guinea, Hungary, Iceland, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey, UK.

North America: Mexico, Canada, USA.

South America: Argentina, Brazil, Chile, Colombia,Peru, Uruguay.

Oceania: Australia, New Zealand.

9.28.5 Hazard Identification Conclusion

Considering the facts that:

- *Claviceps purpurea*is not known to be present in Bangladesh;
- is present in Australia, Canada, India, Mexico and USA and can be carried with imported wheat seed or grain from these countries;
- may be present with the seed/grain as concomitant contamination;

Claviceps purpureais considered to be a potential hazard organism in this risk analysis.

9.28.6 Risk Assessment

9.28.6.1 Entry Assessment: High

The most likely pathway for *Claviceps purpurea*to enter in Bangladesh is via international trade in seed and grain of wheat that has been contaminated with *C. purpurea.* Regarding the risk of entry of *C. purpurea*from imports of wheat seed as germplasm for variety development the probability of entry of this pathogen is nil because of low amount of such materials are generally imported. When bulk quantity of wheat grain is imported originating from countries where the disease is present there is possibility of undetected low level associationwith the lot and therefore, the probability of entry into Bangladesh with this commodity is high.

9.28.6.2 Exposure Assessment: Medium

Once the pathogen enters into Bangladesh along with wheat grains these are transported to different places of the country. During handling and processing of the wheat grains and transportation the sclerotia may be released and fall near the road side come in contact with the wheat field soil or near other grass hosts. It is also likely that before milling the grains are generally cleaned and disposed the light weighted or broken grains along with dirt. This is another way of exposure of the pathogen to the environment.The probability of exposure of *C. purpurea* in Bangladesh environment is medium.

9.28.6.3 Establishment Assessment: Medium

The released sclerotia under favorable condition germinate and produce ascospores which are spread to the flowers of wheat or grass host by wind. The conditions required for the germination of ergot sclerotia are a cold stratification period (winter), followed by prolonged wet soils in the spring. The secondary spread occurs by asexual spores produce on the infected flowers as exudates and spread by insects and/or rainsplash. The hosts are available in Bangladesh and the climatic condition of is more or less favorable for the germination of sclerotia and disease development. Wet, cloudy and cool weather extends the period of flowering and increases the chances of infectionare prevail in some years. These weather conditions may also favour populations of aphids, thrips, and leaf hoppers, which serve as potential vectors of sticky spores and are available in Bangladesh. Therefore, the probability of establishment of eargot in Bangladesh is medium.

9.28.7 Consequence Assessment

9.28.7.1 Economic Impact: Medium

Yield losses resulting from ergat is proportional to the number of kernel infected.In North Dakota, asmuch as 10 percent loss has been reported in wheat. In addition to yield loss ergot is considered as economically important diseases due to downgrading the grain quality. In the commercial grain trade, wheat or durum is graded as “ergoty” when it contains more than 0.05 percent by weight of the ergot sclerotia and triticale, oat, or barley are “ergoty” when they contain more than 0.1 percent. Most of the sclerotia can be removed from ergoty grain with modern cleaning machinery, unless broken pieces are present or the sclerotia are similar in size to the grain. However, it is costly and often difficult to remove enough sclerotia to meet the legal standards.

9.28.7.2 Impact on human and animal health: High

The ergot sclerotium contains high concentrations (up to 2% of dry mass) of the alkaloidergotamine, a complex molecule consisting of a tripeptide-derived cyclol-lactam ring connected via amide linkage to a lysergic acid (ergoline) moiety, and other alkaloids of the ergoline group that are biosynthesized by the fungus. Ergot alkaloids have a wide range of biological activities including effects on circulation and neurotransmission.Ergotism is the name for sometimes severe pathological syndromes affecting humans or other animals that have ingested plant material containing ergot alkaloid, such as ergot-contaminated grains.

9.28.8 Risk Estimation

The likelihood of entry of ergot in Bangladesh is high with medium exposure and establishment probability. This would bring negative economic and health impact. The risk estimate for ergot is non negligible therefore this organism is classified as a hazard in this commodity and risk managemnet measures can be justified.

9.28.9 Risk Management

Use seed from healthy crop. The sclerotia could be removed from the seed but cleaning can be expensive. For small or expensive seed lots such as forage grasses, a flotation method can be used. Soak the seed in a 20 per cent salt solution and stir.

Wheat cultivars whose florets remain open for short periods of time may escape infection, but sanitation measures are the most important way of controlling ergot. Remove sclerotia from seed by screening or by brine flotation. In addition, seeding deeper than 3 inches buries sclerotia and eliminates primary inoculum by preventing emergence of perithecial stroma. Alternate-year rotations allow time for sclerotial disintegration and reduce the amount of inoculum in the soil. Destroy stands of ergoted grass near seed or grain fields.

Fungus

9.29 Phaeosphaeria nodorum (Glume blotch)

9.29.1 Hazard Identification

Disease name: Glume blotch
Name of Pathogen:*Phaeosphaeria nodorum* (Müll.) Hedjar.(Teleomorph)
Synonym:*Leptosphaeria nodorum E. Muell.*
Anamorph: S*tagonospora nodorum*(Berk.) Castell.et Germano
Synomyms: Septoria nodorum (Berk.) Berk; Castell.and Germano, Hendersonia nodorum (Berk.) Petr.S. glumarum Pass.
Taxonomic position:

Kingdom:	Fungi
Phylum:	Ascomycota
Syb- phylum:	Euascomycota
Class:	Dothideomycetes
Order:	Pleosporales
Family:	Phaeosphaeriaceae
Genus:	Phaeosphaeria
Species:	Phaeosphaeria *nodorum*

Bangladesh Status: Not present in Bangladesh

9.29.2 Biology

All overground parts of plants may be infected by the pathogen *S. nodorum*. On leaves S. nodorum forms numerous small, irregular, oblong, dark brown flecks or spots with chlorotic border. Spherical, dark-brown semisubmerged, scattered or allocated linearly pycnidia are visible on leaf surface. On stems lesions are dark brown, indistinct, gradually decolorized; pycnidia develop rarely. On wheat heads the lesions begin as dark brownish spots on the glumes; then the lesions enlarge, the centers turn grayish-white in color, and pycnidia develop there. The disease can infect wheat seeds but without visible symptoms. S*tagonospora nodorum* survives as dormant mycelium, and as pycnidia and pseudothecia on seed, stubble and debris of crops and volunteers. In the absence of crop debris, initial infections in the autumn or spring may result from wind-borne ascospores released from pseudothecia long distances away. Pycnidiospores are produced from the pycnidia as temperature rises and humidity increases. These are splash-dispersed up the infected plant and from plant to plant. Temperatures of 20-27°C, together with 100% relative humidity, are optimal for spore production and germination and a period of rain is essential for spore dispersal. The disease cycle can be completed in 10-14 days during such conditions. Spores produced from pseudothecia and pycnidia, which develop on the flag leaf and ear at the end of the season, can initiate infection in early autumn-sown crops and volunteers and may also remain dormant for the winter. Glume blotch infection of the ear can lead to infection of the seed. While trash-borne inoculums is usually more important in initiating the later phases of the disease (leaf and glume blotch), fungus carried on the seed is more likely to be responsible for septoria seedling blight. The pathogen has the potentiality to cause 20-60% yield loss.

9.29.3 Host

The disease mainly attacts wheat, but other species also recorded as susceptible hosts are *Agropyron* sp., *Bromus* intermis, *Cynodon dactylon, Hordeum vulgare*, *Lolium perenne, Secale cereale*, Triticale, *Triticum aestivum* and wilds cereals.

9.29.4 Distribution

Asia: Azerbaijan, China, Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Russia, Siberia, Syria,

Africa: South Africa

Europe: Denmark, Moldova, Sweden, Switzerland, Ukraine, UK

North America: USA

Oceania: Australia

9.29.5 Hazard Indentification Conclusion

Considering the facts that:

- S*tagonospora nodorum* is not known to be present in Bangladesh;
- is present in Australia, Canada, Ukraine and USA from where wheat grains are imported to Bangladesh;
- and can be carried on wheat grains;

S*tagonospora nodorum* is considered to be a potential hazard organism in this risk analysis.

9.29.6 Risk Assessment

9.29.6.1 Entry Assessment: High

This disease is present in Australia, Canada, Ukrane and USA from where wheat grain is imported to Bangladesh. The pathway of entry of S*tagonospora nodorum*may be through infected or contaminated grain or through plant debris. Wheat germplasms are imported only from CYMMIT, Mexico where glume blotch disease caused by *S. nodorum* is absent. If the grains are adequately cleaned before shipment then the probability of entry through plant debris is low. However, the probability of its entry into Bangladesh with wheat grainis high.

9.29.6.2 Exposure Assessment: Medium

Along with wheat grains, the pathogen enters into Bangladesh,may be carried to different places of the country. During loading and unloading of the wheat grains at different locations the infected grain or plant debris may be exposed to the environment. It is also likely that before milling the grains are generally cleaned and disposed the light weighted or broken grains along with dirt, which might have infection with *S, nodorum* that may be carriedto the natural hosts. Therefore,the probability of exposure of *S. nodorum*in Bangladesh environment is medium.

9.29.6.3 Establishment Assessment: High

The main host wheat plants are available in most of the places in Bangladesh and the grass hosts especially *Cynodon dactylon* is presents almost every where in the country. Therefore, there will be no problems for the pathogen to find a suitable host. The optimum temperature for germination of *S. nodorum spores* is 20-27^{0}C. Rainfall during vegetative stage of the host plants favors disease development. Such conditions are available in Bangladesh. Therefore, the probability of establishment of the pathogen in the PRA area is high.

9.29.7 Consequence Assessment

9.29.7.1 Economic Impact: High

S. nodorum was once the most serious pathogen on cereals in the UK, although it now rarely causes significant losses except in wet seasons in the south west of England. Yield losses up to 50% have been reported in trials although average annual losses in the UK probably do not exceed 3%. Losses caused by septoria seedling blight are generally not significant. In Poland in the epidemic year yield losses was as high as 50-60%.

Infected seeds are the sources of infection causing yield decrease in the next growing season. Germination of infected seeds decreases by 9.5 to 12% (the infection in middle and strong extent). Therefore, once the pathogen is established in Bangladesh the probability of causing economic damage to the crop is high.

9.29.7.2 Impact on Environment

Regarding the impact on environment, no information is available.

9.29.8 Risk Estimation

The probability of entry of the hazard in Bangladesh with grain has been assessyed as high and through plant debris is low but non negligible. The exposure and establishment probability under Bangladesh condition is medium and high respectively. The economic impact of the disease is also high. Considering all these *S. nodorum* has been classified as a risk organism for Bangladesh and justify the risk management.

9.29.9 Risk Management

The pathogen *Stagonospora nodorum* may carry with the grain/seed and also infected plant parts. Therefore, grain/seeds to be cleaned properly to remove debris or plant parts associated.

The seeds/grains to be collected from the wheat crops grown in disease-free area to avoid the pathogen and seed infectionto be confirmend followed by seed health testing to ascertain the health status of the lot.

Adequate amounts of N, P, and K should be applied at planting to insure good seedling growth but excessively high rates of nitrogen will make the field prone to damage by Stagonospora blotch. Avoid high rates of nitrogen that would increase the potential for lodging.

Chemical control of Stagonospora leaf blotch may be necessary when environmental conditions favor epidemics.

Nematode

9.30 Anguina tritici*(Seed-gall nematode)*

9.30.1 Hazard Identification

Disease name: Ear-cockle nematode orSeed-gall nematode
Name of pathogen: Anguina tritici (Steinbuch, 1799) Chitwood, 1935
Taxonomic position:

Kingdom:	Animalia
Phylum:	Nematoda
Class:	Chromodorea
Order:	Tylenchida
Family:	Anguinidae
Genus:	Anguina
Species:	*Anguinia tritici*

Bangladesh Status: Not present in Bangladesh

9.30.2 Biology

Anguina tritici is a large nematode, ranging from 3–5 mm in length. It is an ectoparasite that becomes endoparasitic invading inflorescence and developing seeds. The nematode is spread in galled or 'cockled' seeds when infected seed is sown. A single gall may contain over 10,000 dormant juveniles. Once the galls take up water, the juveniles emerge, find host and move up the plant in a film of water and remain between the leaves of the growing plant. The primary leaves become twisted and distorted, and the plant may die from a heavy attack. In growing seedlings, the juveniles are carried upward towards the growing point of the plant, and when the ear is formed, the flower head is invaded by the juveniles. As a result, the ovules and other flowering parts of the plant are transformed into galls or cockles. Compared to normal wheat seeds, galls are smaller in size, lighter, and their color ranges from light brown to black. In the developing seed they molt, become adults, mate, and reproduce. Females lay thousands of eggs from which the juveniles hatch within the seed gall where they desiccate and remain dormant in the seed. Dormant J2 overwinter in the seed galls until spring. They are released when galls come in contact with moist soil and hydrate. The nematode is favoured by wet and cool weather. Total life cycle is completed in 113 days. Under dry conditions, the juveniles may survive for decades.

9.30.3 Hosts

Emmer (Triticum monococcum), rye (Secale cereale), spelt (T. spelta), and wheat (T. aestivum) are the main hosts of A. tritici. But this has also been reported to infect barley (Hordeum vulgare) and related grasses, however, barley is less attacked in India (Paruthi and Gupta, 1987).

9.30.4 Geographical Distribution

Seed gall nematode (*Anguina tritici*) has been reported from Afghanistan, Australia, Brazil, Bulgaria, China, Egypt, Ethiopia, Hungary, India, Iran, Iraq, Israel, Lithuania, New Zealand, Pakistan, Poland, Romania, Russian Federation, Russian Far East, Syria, Switzerland, Turkey, and Yugoslavia. Early records of nematode detection in the US include California, Georgia, Maryland, New York, North and South Carolina, Virginia and West Virginia. Recent surveys of the wheat seed gal nematode in stored grain harvested from states with records of this nematode have not provided any evidence that nematodes are still occurring in the US (CAB International, 2001).

9.30.5 Hazard Identification Conclusion

Considering the facts that:

- *Anguina tritici*is not known to be present in Bangladesh;
- is present in some Australia, Canada, European countries, India, Japan and USA;
- and can be carried on wheat grains;

*Anguina tritici*is considered to be a potential hazard organism in this risk analysis.

9.30.6 Risk Assessment of Ear-cockle

9.30.6.1 Entry Assessment: High

The nematode is spread in galled or 'cockled' seeds when infected seed is sown. A single gall may contain over 10,000 dormant juveniles. Under dry conditions, the juveniles may survive for decades. The potential pathway that *A. tritici*may enter into Bangladesh is through admixture of gall with the seed lots. Probability of entry through this pathway is high.

9.30.6.2 Exposure Assessment: Medium

During loading and unloading of wheat grain some may be dropped. Secondly, before crushing these are generally cleaned. The galls are light weight and smaller in size and easily separated out, which are discarded on anywhere into the environmenteven in the remote rural areas. The probability of coming in contact with wheat is medium.

9.30.6.3 Establishment Assessment: High

The host is available in the PRA area. Some of the dropped or discarded grains may germinate and the nematodes released from the gall have the possibility to come in contact with the volunteer seedlings or grass hosts and cause infection. The nemadore can move through water and crawl the seedlings or wheat plants under wet condition. In Bangladesh wheat seedling become wet due to low temperature and remain for few hours in the morning. This condition is favorable for the nematode to crawl to the growing point and establish their. The probability of establighment of *A. tritici* in the PRA area is high.

9.30.7 Consequence Assessment

9.30.7.1 Economic Impact: High

Worldwide, wheat, barley and rye are commonly attacked, but barley is less attacked in India (Paruthi and Gupta, 1987). In Iraq, seed gall is an important pest on wheat with infection ranging from 0.03 to 22.9 percent and causing yield losses up to 30 percent (Stephan, 1988). Barley is also attacked in Iraq but with an isolate that does not affect wheat (Al-Tabib *et al*., 1986).

In Pakistan, seed gall is a known pest on wheat and barley and is found in nearly all parts of the country, causing yield losses of 2 to 3 percent; association with the bacterium produces serious yield losses on wheat (Maqbool, 1988). In China, Chu (1945) found yield losses between 10 and 30 percent on wheat.Yield losesin subtropical and tropical environment yield reduction of 30-70% has been reported.

The nematodes causes severe crop losses to rye (35- 65%) and wheat (20-50%) (Anwar *et al*, 2001; Leukel, 1929, 1957) in 3rd world countries, where poor agricultural practices, monoculture, and the use of poor quality seeds are widespread. In spite of the insignificant damage caused by the nematode in modern agricultural production systems of developed countries, their ability to export grains in the international markets is severely hampered if historical records still exist of the presence of this pest in grain production areas due to the quarantines imposed by many countries because of this pest.

In India, theeffects of contamination of seed galls on grain and flourmarketing prices resulted in reductions between 22.8 and48.1% in marketing prices (Paruthi and Bhatti, 1988).In Turkey the price of durum wheat per tonne was reduced from 335 to 297 USD$ with increasing *A. tritici* contamination (from 5 to 20%).

Earlier information indicated the high economic significance of seed gall nematode. The environmental conditions would be favorable for the development of this disease and there is high possibility of causing similar economic impact.

9.30.7.2 Environmental Impact

There is no information on the direct impact of *A. tritici* on environment.

9.30.8 Risk Estimation

The likelihood of entry and exposure of *A. tritici* in Bangladesh is high and medium probability for exposure. This would bring negative economic impact. The estimated risk for *A. tritici* is non negligible therefore this organism is classified as a hazard in this commodity and risk managemnet measures can be justified.

9.30.9 Risk Management

Seed gall can easily be controlled through seed hygiene: sowing clean, non-infected seed obtained by using certified seed or by cleaning infected seed either with modern seed cleaning techniques or by sieving and freshwater flotation (Singh and Agrawal, 1987). Although seed gall has been eradicated from the Western Hemisphere through the adoption of this approach, it remains a problem on the Indian subcontinent, in West Asia and to some extent in China (Swarup and Sosa-Moss, 1990).

For countries where hygiene practices are difficult to implement, host resistance and crop rotation offer some control of seed gall. Resistance to *A. tritici* has been identified in Iraq in both wheat and barley (Saleh and Fattah, 1990) and in Pakistan (Shahina *et al*., 1989) and is currently being sought in India (Swarup and Sosa-Moss, 1990). In Iraq, laboratory screening has identified sources of resistance in both wheat and barley (Stephan, 1988). Oat, maize and sorghum are considered to be non-hosts (Limber, 1976; Paruthi and Gupta, 1987), and while they may offer some option for reducing populations by rotation, the disease is not completely controlled.

Virus

9.31 *Barley stripe mosaic virus* (Barley stripe mosaic disease)

9.31.1 Hazard Identification

Disease name: Barley stripe mosaic disease
Name of Pathogen: *Barley stripe mosaic virus*
Taxonomic position:
Group: Group IV ((+)ssRNA)
Family: Virgaviridae
Genus: Hordeivirus
Species: Barley stripe mosaic virus
Bangladesh Status: Not present in Bangladesh

9.31.2 Biology

Barley stripe mosaic virus (BSMV) is confined to only plant tissues, within the mesophyll and epidermal cells. This virus is known to be aggregated in the seed and transmissible through infected seed. The rate of seed transmission of BSMV is very high. It has been demonstrated that seed to seed transmission rate is about 10%. In the field the virus could potentially spread over long distances as the virus could be spread to seed by infected pollen grains. However, an infected ovule is a more important factor for the spread of this disease. The disease is more likely to spread when an infected ovule produces progeny with infected pollen, with a 70% transmission rate. When an infected ovule is pollinated by uninfected pollen there is only about a 66% transmission rate. In an uninfected ovule that is pollinated by infected pollen there is only about a 3% transmission rate to the subsequent seedlings. The main way the virus perpetuates itself is growth from an infected seed. The infection can persist for years inside the seed. Barley stripe mosaic virus is not known to be transmitted through any vectors.

For spreading and developing the disease in the infected plant the critical factor is temperature. When an infected plant placed at 7^0C it took about 30 days to express the symptom but there is no secondary infection from this source. At higher temperature of 13-18^0C, symptom developed in 7-8 days and there were secondary spread of the virus from such source. Another study revealed that the levels of virus present remained relatively constant over a range of 13°C-25°C and that the amount of virus present was related only to the age of the hosts and length of time that they were infected. It has been observed that the severity of symptoms do not always correlate with the amount of the virus present. Disease symptoms express rapidly under light compared to shade. Severity of the disease, however depends on the susceptibility of the host.

9.31.3 Host

Barley and wheat are the main hosts of BSMV, however it can also be seen on wild oats, rye, maize, rice, sorghum and millets under natural condition.

9.31.4 Geographic Distribution

Argentina, Australia, Brazil, Bulgaria, Canada, China, Cyprus, Czech Republic, Denmark, Egypt, France, Germany, Greece, Hungary, Israel, Japan, Jordan, Korea, Lebanon, Mexico, Moldova, New Zealand, Norway, Pakistan, Peru, Poland, Portugal, Romania. Russian Federation, Slovakia, Slovenia, South Africa, Switzerland, Syria, Tunisia, Turkey, Ukraine, UK, USA, Yugoslavia (erstwhile).

9.31.5 Hazard Identification Conclusion

Considering the facts that:

- Barley stripe mosaic virus is not known to be present in Bangladesh;
- is present in some Australia, Canada, European countries, mexico, Pakistan, Ukraine and USA;
- can cause high rate of seed infection
- and the rate of seed transmission is also high;

Barley stripe mosaic virus is considered to be a potential hazard organism in this risk analysis.

9.31.6 Risk Assessment

9.31.6.1 Entry Assessment: High

This disease is present in Mexico. Bangladesh is importing germplasms from CIMMYT, Mexico for the development of wheat variety. Huse amount of wheat grains are also imported from the countries from where the disease is present namely, Australia, Pakistan, Ukraine and USA. Barley stripe mosaic virus is a seed-borne disease. The rate of seed infection is quite high. If the seed or grain is collected from infected field or from near any infected field there is high possibility of seed infection because, the virus is transmitted from infected seed to the plants grown from it and also to the seed of that plant. It cian also cause seed infection through infected pollen to a considerably long distance. Therefore, seed/grain is the pathway of entry of this virus in Bangladesh and the probability of entry of this hazard is high.

9.31.6.2 Exposure Assessment: High

Once the virus is entered to the PRA area through seed or grain, the seed will be used as planting material and some of the infected grains may be dropped during handling and transporting. Moreover, before crushing some more will be exposed to the environment during cleaning. Considering all these it is assumed that the probability of exposure of BSMV in Bangladesh environment is high.

9.31.6.3 Establishment Assessment: High

The rate of seed transmission of Barley stripe mosaic virus is very high. Assessment of the entry and exposure indicated that the probability of both entry and exposure of this organism is high. The hosts are available in the country. The primary source is the infected seed and from where the secondary spread of the virus in the field is by infected pollen. The environmental condition such as temperature during the reproduction of wheat under Bangladesh condition is congenial for rapid development of the disease. Therefore, the probability of establishment of this disease in the PRA area is also high.

9.31.7 Consequence Assessment

9.31.7.1 Economic Cosequence: High

Barley Stripe Mosaic Virus is one of the very few viruses that is transmitted through seeds for small grain cereals. BSMV mostly affects regions in Montana and North Dakota and have reduced yields by up to 25%. Shortly after its discovery, BSMV was found to be present in 97% of barley fields in North Dakota in 1954. From the earlier information it could be assumed that once established in Bangladesh the disease can cause significant yield loss and it would be an additional threat for wheat cultivation in Bangladesh. Moreover, the rate of spread of this disease is also very high as the disease is spread by pollen, therefore, the disease could be readily spread over wheat growing areas and cause serious economic consequence.

9.31.7.2 Environmental Consequence

No information is available.

9.31.8 Risk Estimation

Wheat seed or grain is the pathway of entering BSMV in Bangadesh. The entry assessment indicated that the probability of entry of BSMV in Bangladesh is high. Similarly the exposure and establishment probability is also high. It has the potentiality to spread quickly and cause significant yield loss, it is considered as a risk organism for Bangladesh and justify the risk management.

9.31.9 Risk Management

Use of resistant variety is the best option for management of BSMV. The seed or grain should not be collected from areas where the disease is present. Standard seed health test should be conducted before shipment of the seed/grain. The recommended method of testing is enzyme linked immunosorbent assay (ELISA).

Virus

9.32 *Wheat streak mosaic virus* (Wheat streak mosaic disease)

9.32.1 Hazard Indetification

Disease name: Wheat streak mosaicdisease
Name of Pathogen: Wheat streak mosaicvirus
Taxonomic position:

Group:	Group IV ((+)ssRNA)
Family:	Potyviridae
Genus:	Tritimovirus
Species:	Wheat streak mosaic virus

Bangladesh Status: Not present in Bangladesh

9.32.2 Biology

General appearance of Wheat streak mosaicvirus(WSMV) disease is yellowing and stunting of infected plants. On leaves the initial symptoms appear as discontinuous yellow streak parallel to the veins. Severity of the diseases is depends on the stage of plant infection, earlier the infection more stunting of the plants occur. As the disease progresses, many leaves may become mottled in appearance, and eventually the yellowed leaves turn brown and die. Symptom become more visible and develop rapidly when temperature over 26.6^{0}C prevails for several days The disease often appearsfirst at theedge of the field or in patches. In the field the disease is spread primarily by the wheat curl mite, *Aceria tosichella*carried by wind. Although mites can be spread up to several miles, crops within one-half mile of a severely infected field are at the highest risk. The disease may spread through rubbing of the infected leaf with healthy ones. The virus is seed-borne but the rate of seed transmission is low- 0.2 to 1.5%.

The life cycle of the mite, from egg to adult, is completed in seven to 10 days. The mite requiresgreen plants for feeding and reproduction. The mites reproduce most rapidly from 23.9 to 26.6C. Reproduction stops at temperatures near freezing. At 23.9^{0}C, the mitescan survive only for about eight hours without foodor water. The mites overwinter as eggs, nymphs or adults in the living winter wheat crown or crown of other perennial grass hosts.

Newly hatched mites pick up the virus in their feeding on infected plants. Infection of winter wheat may occur in the fall if green plants infected with the virus and infested with mites are present at seedling emergence. Early seeding of winter wheat favors WSMV epidemics. At early seeding, air temperatures are generally warm, and the mites reproduce rapidly and have a longer time to build up on the emerged wheat seedlings prior to cold or freezing temperatures.

9.32.3 Hosts

Wheat is very susceptible to the virus among the cereal crops. Barley, rye, corn, sorghum and oats are also susceptible to the virus. However, among the cereals, only wheat is the good host for survival and multiplication of the mite. Sorghum is poor-good, corn is poor-fair, barley and rye are the poor host for mite. Among the grass-hosts, Barnyard grass, Cheat, Japanese brome, Field sandbur, Jointed goatgrass, Foxtail (green), Wild oat, Witchgrass are susceptible and good hosts of the virus. However, for the mite Cheat and Field sandbur are the good hosts.

9.32.4 Geographic Distribution

Wheat streak mosaic virus disease of wheat has been reported from the following countries:

Asia: China, Iran, Jordan, Kazakhstan, Russia, Syria, Turkey, Uzbekistan

Africa: Zimbabwe

Europe: Bulgaria, Croatia, Czech Republic, Germany, Italy, Moldova, Poland, Romania, Serbia, Slovakia, Ukraine

North America: Canada, Mexico, USA

South America: Argentina

Oceania: Australia, New Zealand.

9.32.5 Hazard Indentification Conclusion

Considering the facts that:

- WSMV is not known to be present in Bangladesh;
- is present in Australia, Canada, Mexico and USA;
- can cause economic damage to the crop
- and the virus is seed-borne in wheat; and thus

Wheat streak mosaic virus is considered to be a potential hazard organism in this risk analysis.

9.32.6 Risk Assessment

9.32.6.1 Entry Assessment: High

Seed or grain is the pathway for wheat streak mosaic virus as this is a seed-borne virus.No report was available on the rate of seed infection however; the seed transmission rate has been demonstrated as 0.5 to 1.5%. There is no visible symptom on seed due to infection by this virus. Therefore, the probability of entry of WSMV along with wheat grain/seed is high.

9.32.6.2 Exposure Assessment: High

Post entry handling i.e., loading, unloading and transporting may cuse dropping of some grains or some half filled or broken grains are discarded during cleaning before crushing and thrown anywhere and exposed to the environment. Some of such infected grains if germinated act as a source of the virus and transmitted to the nearby wheat field by wheat curl mite. When the seed is imported from areas where the disease is present then the virus may enter through this pathway and transmit to the seedlings. Considering these facts the probability of exposure has been fixed as high.

9.32.6.3 Establishment Assessment: Medium

The entry and exposure assessment of the virus through this commodity is high and medium respectively. The primary source of this virus is self-sown infected seeds. Some of the seedlings grown from the infected seeds may act as the primary source of the virus from where it may be spread to the nearby wheat field or other hosts including grass hosts by wheat curl mite. The environmental condition of the PRA area is similar to those required for the development and multiplication of the mite during the wheat growing season in Bangladesh (Temperature 23.9 to 26.7^{0}C) and therefore the possibility of its establishment in the PRA area is medium.

9.32.7 Consequence Assessment

9.32.7.1 Economic Consequence: High

Once the disease is established in the PRA area it would be spread by the wheat curl mite (*Aceria tosichella*) in the field. Earlier report indicated that yield loss because of Wheat streak mosaic virus infections can surpass 60%, and it can also cause 100% crop mortality.The environmental condition in the PRA area is more or less similar to those favor the development of the disease and also multiplication of the vector. Therefore, once the disease is established in the country it would cause serious economic consequences and a significant negative impact on wheat cultivation.

9.32.7.2 Environmental Consequence

As the virus has a wide host range it may bring negative impact on the biodiversity of the PRA area.

9.32.8 Risk Estimation

Assessment of the hazard showed that probability of entry into Bangladesh and its exposure to the environment is high and the probability of establishment is medium. This disease has high potentiality of yield reduction and significant negative impact on wheat cultivation. Considering all these WSMVhas been classified as a risk organism for Bangladesh and risk management is justified.

9.32.9 Risk Management

The disease is managed by breakingthe “green bridge” necessary for thelife cycle of the wheat curl mite through destroying all volunteer wheat plantsand grassy weed hosts two weeksbefore planting the new wheat.

Plant at the recommendedseeding dates of Wheat.

Use healthy seed for planting.

Phytosanitary Measures

Seeds or grains should come from a pest-free country or from a pest-free place of production followed by testing of the harvested grain following ELISA..

9.33 Weeds

9.33.1 Hazard Identification

Name of weed: *Amaranthus blitoides* S. Wats.
Common name: Matweed, Mat amaranth, Spreading amaranth, Creeping or Prostrate pigweed

Taxonomy:

Kingdom:	Plantae
Division:	Magnoliophyta – Flowering plants
Class:	Magnoliopsida – Dicotyledons
Subclass:	Caryophyllidae
Order:	Caryophyllales
Family:	Amaranthaceae – Amaranth family
Genus:	AmaranthusL. – pigweed
Species:	Amaranthus blitoidesS. Watson – mat amaranth

Bangladesh Status: Not present in Bangladesh

9.33.2 Biology

Stem is mostly prostrate, ramified from the base, albescent, hairless or with short hairs at the top, quite leafy, height 15-50 cm; leaves are obovate or spathulate, to lanceolate-oblong; with a thin thorn to 1 mm long at the top, tapered gradually into petiole toward the base, leaf margins have light border. Flowers are glomerated in axils; hypocotyls are lanceolate, shorter than perianths; perianth is tetramerous (sometimes there are flowers with a pentamerous perianth on the same plant); perianth leaflets of staminate flowers are lanceolate, shortly pointed, pestillate flowers have lanceolate-oblong perianth leaflets unequal in length, with a gristly bulge at the base; boll is rounded elliptic, shorter than the longest perianth leaflet (it is 2-2.5 mm long), opens across with a mostly redish cover; seed is 1.3-1.5 mm, rounded obovate, black, not very glossy. The mass of 1000 seeds is 0.5-0.6 g. The maximum fruitfulness of one plant is about 700,000 seeds. Seeds emerge from the depth not more than 8 cm and they maintain the ability to germinate in soil up to 40 years. Xeromesophyte, do not stand floods. Found most frequently in steppe zones. Shoots emerge at the minimal temperature +7-+8°C, with optimal temperature of +30 - +36°C.

9.33.3 Hosts

Glycine max,Gossypium hirsutum,Heliathus annuus, Lycopersicon esculentum, Medicago sativa, Olea europapea sub. Sp. Europaea, Phaseolus vulgaris, Pisum sativum, ***Triticum aestivum****, Zea mays*

9.33.4 Geographic Distribution

Asia: Iran Iraq, Israel, Jordan, Lebanon, Russian Federation.

Africa: Morocco, South Africa, Spain.

North America: Canada, Mexico, USA.

Europe: Albania, Austria, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, Spain.

Oceania: Australia, New Zealand.

9.33.5 Hazard Indentification Conclusion

Considering the facts that:

- *Amaranthus blitoides* is not known to be present in Bangladesh;
- is present in Australia, Canada, Mexico and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

The weed *Amaranthus blitoides* is considered to be a potential hazard organism in this risk analysis.

9.33.6 Risk Assessment

9.33.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Mexico and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.33.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.33.6.3 Establishment Assessment: High

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. The minimum temperature required for germination and growth is 12 to 15°C and for growth optimum temperature is 30-36 C. Therefore the probability of establishment in the PRA area is high.

9.33.7 Consequence Assessment

9.33.7.1 Economic Consequence

This weed is found to have allelopathic effect on wheat and reduced germination, coleoptile length, root length and root dry weight of wheat seedlings. It also causes significant yield losses in different crops including wheat.

9.33.7.2 Environmental Consequence

Not yet known.

9.33.7.3 Impact on health

When grown on nitrogen-rich soils they are known to concentrate nitrates in the leaves. This is especially noticeable on land where chemical fertilizers are used. Nitrates are implicated in stomach cancers, blue babies and some other health problems if consume alsocan cause poisoning in pigs and cattle.

9.33.8 Risk Estimation

The likelihood of entry of *A. blitoides* in Bangladesh is medium with high exposure and establishment probability. This would bring negative economic and health impact. The risk estimate for *A. blitoides* is non negligible therefore this organism is classified as a hazard in this commodity and risk managemnet measures can be justified.

9.33.9 Risk Managementas

Wheat grain/ seed should be imported from areas where *A. blitoides* is absent. Seed cleanibg using strainer effectively removes the weed seed as the size of seed is very small. This weed may be controlled readily by severing, uprooting, burial, or heat at the seedling stage and also by use of chemical herbicide. In Florida, cowpea, sunnhemp, or velvetbean cover crops seeded at high rates reduced but did not eliminate smooth pigweed growth.

9.34 Weed

9.34.1 Hazard Identification

Name of weed:*Ambrosea artimisiifolia* L.

Common name: Matweed, Mat amaranth, Creeping or Prostrate pigweed

Taxonomy:

Kingdom:	Plantae
Phylum:	Spermatophyta
Subphylum:	Angiospermae
Class:	Dicotyledonae
Order:	Asterales
Family:	Asteraceae
Genus:	Ambrosia
Species:	*Ambrosia artemisiifolia*

Native to North America.

Bangladesh Status: Not present in Bangladesh

9.34.2 Biology

Ambrosia artemisiifolia completes its life cycle in 115 to 183 days. Photoperiod, fluctuating soil temperature and low carbon dioxide levels favour seed germination. It is one of the earliest emerging summer annual weed species and may germinate once soil temperatures reach 11-13°C. In the autumn, ploughing generally favours establishment of this weed.

Ambrosea artemisiifolia is wind pollinated. Flowering is initiated approximately 119 days after germination. Long days favour male flowers, whereas female flowers are favoured as the days shorten. Peak pollen production often occurs from mid-August to mid-September. The production of male flowers has been related to the relative height of neighbouring plants.

This weed is susceptible to frost and is commonly found between 30 and 50° C at both north and south latitudes in diverse settings. *Ambrosea artemisiifolia* grows in clay or sandy soils, but grows well on wet, heavy soils at pH 6.0 to 7.0.

A study in the USA, using plants originating from Indiana, Michigan, Ohio and Wisconsin suggested the existence of common ragweed ecotypes based on origin of the seeds. Seeds have a low germination at maturityand usually require winter stratification before germination; however, seeds may undergo secondary dormancy. Burial of seeds increased the non-dormant seed population of *A. artemisiifolia* by 0.5 to 7.1%.One plant may produce 3000-4000 seeds; however, up to 32,000 seeds have been produced by a single plant.*A. artemisiifolia* seeds may survive up to 40 years.

9.34.3 Hosts

Allium cepa, Arachis hypogaea, Capsicum annuum, C. frutescens, Glycine max, Helianthus annuus, Lycopersicon esculentum, Nicotiana tabacum, Phaseolus vulgaris, Pinus taeda, Populus spp., Solanum tuberosum, Sorghum bicolor, ***Triticum aestivum****, Zea mays.*

9.34.4 Geographic Distribution

Asia: Azerbaijan, China, Georgia, India, Japan, Korea (Republic), Taiwan, Turkey.

Africa: Mauritius,

North America: Canada, Bermuda, Mexico, USA

South/Central America: Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Guadeloupe, Guatemala, Jamaica, Martinique, Paraguay, Peru.

Europe: Austria, Belgium, Croatia, Czech Republic, France, Germany, Hungary, Italy, Lithuania, Luxembourg, Macedonia, Moldova, Netherlands, Poland, Portugal, Romania, Russian Federation, Slovakia, Spain, Sweden, Switzerland, UK, Ukraine.

Oceania: Australia, New Zealand.

9.34.5 Hazard Indentification Conclusion

Considering the facts that:

- *Ambrosea artimisiifolia* is not known to be present in Bangladesh;
- is present in Australia, Canada, India, Mexico, Ukraine and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

*Ambrosea artimisiifolia*is considered to be a potential hazard organism in this risk analysis.

9.34.6 Risk Assessment

9.34.6.1 Entry Assessment: Medium

There is every possibility of mixing the weed seed with wheat grain during harvesting and threshing if the weeds in the wheat field are not cleaned before seed formation. These seeds may remain associated with wheat grain if not cleaned properly. Therefore the probability of entry of this weed seed with wheat grain is medium.

9.34.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.34.6.3 Establishment Assessment: High

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. The weed grows well in temperature between 30 and 50°C in clay or sandy soils, but grows well on wet, heavy soils at pH 6.0 to 7.0. Therefore the probability of establishment in the PRA area is high.

9.34.7 Consequence Assessment

9.34.7.1 Economic Consequence

Ambroseaartemisiifolia is an aggressive and competitive weed in several crops, but its effect on crop yield depends on emergence relative to the crop, weed free periods, and implemented control measures. As sunflower (*Helianthus annuus*) and *A. artemisiifolia* are in the same family, producers in France ranked it as one of the worst weeds because of the absence of selective herbicides for control. A. artemisiifolia was the fourth worst agronomic weed in Ohio, USA. Common ragweed is one of the more competitive weeds in groundnut and a potential economic threat to groundnut growers.In Hungary,it caused up to 69-73% yield loss in maize. Similar yield may be attributed by this weed in Bangladesh also.

9.34.7.2 Environmental Impact

Ragweed is biological air pollutant due to very high volume of pollen release to the air.

9.34.7.3 Social Impact

Pollen produced by *A. artemisiifolia* is one of the most common seasonal sources of aeroallergens which commonly causes allergic rhinitis (hay fever). It is also a source of contact dermatitis and has been described as a substance harmful to human health.

9.34.8 Risk Estimation

*Ambrosea artimisiifolia*has high reproductive potential, can remain viable for more than one year and highly adaptable to different environments. It has medium probability to enter into Bangladesh and high probability to expose in nature and also high probability of establishment under Bangladesh condition. It has negative economic, environmental and social impact. The risk estimate for *A. artimisifolia*is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.34.9 Risk Management

Ambrosea artemisiifolia is a major problem in crop production. Several weed management systems including cultural, biological and chemical control methods have been implemented to reduce the impact of this weed.

Cultural Control

A combination of mechanical and banded chemical control of *A. artemisiifolia* has helped reduce herbicide application use by up to 67%. Mechanical cutting can reduce *A. artemisiifolia* seed production by up to 74% depending on the number and timing of cuttings (Guan et al., 1991). Planting red clover as a cover crop in established winter wheat reduced common ragweed biomass.

Chemical Control

The use of chemicals has effectively controlled *A. artemisiifolia*. Pre- and post emergence herbicides has been effectively used to control this weed in different crops. Pre-emergence treatments of strip-tillage groundnut diclosulam controlled common ragweed by 100%.

9.35 Weed

9.35.1 Hazard Identification

Name of weed:*Cardaria draba* (L.) Desv.

Synonym*: Lepidium draba* L.

Common name: Heart- podded, hoary cress, thanet cress, white top, white weed, perennial peppergrass

Taxonomy:

Kingdom:	Plantae
Order:	Brassicales
Family:	Brassicaceae
Genus:	*Cardaria*
Species:	*Cardaria draba* L.

Bangladesh Status: Not present in Bangladesh

9.35.2 Biology

Perennial with a spreading root system from which many aerial shoots are produced; stem stoutish, 30-60 cm, erect to occasionally nearly procumbent' glabrous to nearly so above, slightly to densely pubescent below; basal leaves with scattered to dense pubscence, irregularly toothed to entire, narrowed to a petiole; middle and upper leaves sparsely pubescent to glabrous, obovate, elliptic-oblong or lanceolate, irregularly toothed to nearly en tire, clasping the stem with cordate-sagittatebases, to 9 cm long and 4 cm broad; fruiting inflorescence usually of elongated racemes; petals white, 3-4 mm long; sepals glabrous, white-margined, 1.5-2.0 mm long; pedicels slender, to 1.5 cm long; silicles cordate, glabrous, inflated, usually constricted at septum, broader than long, 3.0-5.0 mm broad, 2.5-3.5 mm long, indehiscent with one ovary in each locule; mature silicles usually with two seeds; style 0.8-1.6 mm long; seeds oval,slightly compressed, red-brown, 1"5 X 2.0 mm; cotyledons incumbent (Mulligan and Frankton 1962).Reproduces both by seeds and vegetatively. Hoary cress spreads vigorously by creeping roots (FEIS 1998). Within three weeks of germination, a seedling root can begin producing buds (FEIS 1998). One plant can eventually result in a large colony and push out other vegetation to form a monoculture.One plant can produce from 1,200-4,800 seeds. Buried seeds can remain viable for three years in the soil (Sheley and Stivers 1999).

9.35.3 Hosts

Avena sativa, Beta vulgaris, Citrus spp., Fragaria ananassa, Gossypium hirsutum, Helianthus annus, Hordeum vulgaris, Lens culinaris, Medicago sativa, Nicotiana tabacum, Pyrus communis, Quercus spp., Secale cereale, *Solanum tuberosum,* ***Triticum aestivum****, Vitis vinifera, Zea mays*

9.35.4 Geographic Distribution

Asia: Afghanistan, Argentina, Iran, Iraq, Israel, Jordan, Lebanon, Pakistan, Russia Federation, Saudi Arabia, Spain, Syria, Turkey,

Africa: Egypt, South Africa, Tunisia, Zimbabwe.

North America: Canada, Mexico, USA

Central and Caribbean: Guatemala.

South America: Chile.

Europe: Bulgaria, Czech republic, France, Germany,Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, UK.

Oceania: Australia, New Zealand

9.35.5 Hazard Indentification Conclusion

Considering the facts that:

- *Cardaria draba* (L.) Desv. is not known to be present in Bangladesh;
- is present in Australia, Canada, Mexico, Pakistan and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

*Cardaria draba*is considered to be a potential hazard organism in this risk analysis.

9.35.6 Risk Assessment

9.35.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Mexico, Pakistan and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.35.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.35.6.3 Establishment Assessment: High

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

9.35.7 Consequence Assessment

9.35.7.1 Economic Consequence

Heart-podded hoary cress is the least weedy of the three hoary cresses in Canada. It is most troublesome in the Prairie Provinces, particularly in southern Manitoba and southern Alberta, and is probably the weediest hoary cress found in the United States. In Australia it causes considerable economic loss and has seriously reduced the value of high-priced wheat lands.
Cereal crops may experience significant yield losses where dense infestations of hoary cressare present. Pasture quality is degraded, and fodder and small seed products (egg Lucerne and clover) may be contaminated by hoary cress seed.
It has the allelopathic potential and reduces germination of wheat and some other crop seed.

9.35.7.2 Environmental Consequence

No information is available.

9.35.8 Risk Estimation

This weed is present in some countries from where wheat is imported to Bangladesh. The entry of this weed seed as contaminant to wheat or other crop species is estimated as medium probability. However, the exposure and establishment probabilities are high. It has negative economic, environmental and social impact. The risk estimate for *C. draba*is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.35.9 Risk Management

Cost effective herbicide regimes are available for the short term control of hoary cress. Long term eradication is often cost prohibitive, and technically difficult. A combination of cultural,herbicidal and mechanical measures may be required to reduce the impacts of hoary cresson production, which may become expensive.

Management of hoary cress is most commonly achieved through a combination of herbicidesand introduction or encouragement of competitive species.

9.36 Weed

9.36.1 Hazard Identification

Name of weed:*Fumaria officinalis* L.

Common name: Common furnetory

Taxonomy:

Kingdom:	Plantae
Class:	Dicotyledonae
Order:	Papaverales
Family:	Papaveraceae
Genus:	*Fumaria*
Species:	*Fumaria officinalis* L.

Bangladesh Status: Not present in Bangladesh

9.36.2 Biology

Fumaria officinalis is an herbaceous annual plant. Plant is blue-green, covered with a layer of wax, with taproot. Stem is hairless, prostrate, ascending or erect, ramified, up to 30 cm in height, somewhat grooved, sometimes reddish tinged. Cotyledons are slender, linear, long, acuminate; hypocotyl light red. Leaves are tender, petiolate, pinnate, pinnae palmatified and also petiolate. Flowers are zygomorphic, oblong, 7-9 mm long, narrow, rose-violet; corolla tip dark red to black; flowers aggregated in erect heavily-blossomed racemes. Fruit is one-seeded nutlet about 2 mm in diameter, rounded, heavily bulged-in at the top, from straw-yellow and greenish-gray to grayish-brown and brown, dull. Seeds are ovate, rugged, reddish-brown. Flowering period is May-June, fruiting period is July-August. The maximal fruitfulness of one plant is 15,000 seeds. Seeds maintain germinability in soil for 3-5 years. Prefers friable, nutrient-rich loams, usually low in lime.Optimum temperature for emergence of seeds is 18-20°C.

9.36.3 Hosts

Allium cepa, Avena sativa, Beta vulgaris, Brassica napus var. napus, B. rapa subspp. oleifera, Daucus carota, Hordeum distichicon, H. vulgaris, Linum usitatissimum, Pisum sativum, Secale cereale, *Solanum tuberosum,* ***Triticum aestivum****, Zea mays.*

9.36.4 Geographic Distribution

Asia: Iran, Iraq, Israel, Jordan, Lebanon, Pakistan, Sudan, Turkey,

Africa: Algeria, Egypt, Mauritius, Morocco, South Africa,

North America: Canada, USA.

South America: Argentina, Uruguay,

Europe:Albania, Austria, Belgium, Bulgaria, Chile, Czech republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, , Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Russia Federation, Spain, Sweden, Switzerland,

Oceania: Australia, New Zealand.

9.36.5 Hazard Indentification Conclusion

Considering the facts that:

- *Fumaria officinalis* L. is not known to be present in Bangladesh;
- is present in Australia, Canada, Pakistan and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

Fumaria officinalis is considered to be a potential hazard organism in this risk analysis.

9.36.6 Risk Assessment

9.36.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Pakistan and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.36.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.36.6.3 Establishment Assessment: High

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

9.36.7 Consequence Assessment

9.36.7.1 Economic Consequence

Infests grain and mainly tilled crops, fodder grasses, flax; occurs in kitchen gardens, orchards, near habitations, on fallow lands, along roads, railway embankments.

9.36.7.2 Environmental Consequence

Not available

9.36.8 Risk Estimation

This weed is present in some countries from where wheat is imported to Bangladesh. The entry of this weed seed as contaminant to wheat or other crop species is estimated as medium probability. However, the exposure and establishment probabilities are high. It has negative economic impact. The risk estimate for *F. officinalis*is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.36.9 Risk Management

Wheat grain/ seed should be imported from areas where *A. blitoides* is absent. Seed cleanibg using strainer effectively removes the weed seed as the size of seed is very small.Field trials in Scotland in winter wheat showed that high cereal crop ground cover, achieved with cultivars such as Apollo, was very important in limiting the growth of *Fumaria officinalis*.

9.37 Weed

9.37.1 Hazard Identification

Name of weed:***Papaver rhoeas* L.**

Synonym: Synonyms: *Papaver commutatum* Fisch. and C.A. May., *P. insignitum* Jord., *P. roubiaei* Vig., *P. strigosum* (Boenn.) Schur.,*P. tenuissimum* Fedde, *P. trilobum* Wall.

Common name: Common poppy, corn poppy, field poppy

Taxonomy:

Kingdom:	Plantae
Phylum:	Spermatophyta
Class:	Dicotyledonae
Order:	Papaverales
Family:	Papaveraceae
Genus:	Papaver
Species:	*Papaver rhoeas* L.

9.37.2 Biology

Papaver rhoeas is a variable, erect annual, forming a long-lived soil seed bank that can germinate when the soil is disturbed. In the northern hemisphere it generally flowers in late spring, but if the weather is warm enough other flowers frequently appear at the beginning of autumn. It grows up to about 70 cm in height. The flowers are large and showy, 50 to 100mm across, with four petals that are vivid red, most commonly with a black spot at their base. The flower stem is usually covered with coarse hairs that are held at right angles to the surface. Each plant is able to produce around

17, 000 seeds, common poppy has seeds that can lie dormant in the soil for over 80 years. Seed germination is dependent on climate and should occur between 4 and 25 days. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It cannot grow in the shade. It prefers moist soil. The optimum temperature required for germination and growth is 5 to 25°C.

9.37.3 Hosts

Allium cepa, Avena sativa, Beta vulgaris, Brassica napus var. napus, Daucus carota, Helianthus annuus, Hordeum vulgaris, Lens culinaris subsp. culinaris, Linum usitatissimum, Medicago sativa, Panicum miliaceum, Phaseolus sp., Secale cereale, *Solanum tuberosum,* ***Triticum aestivum****, T. turgidum, Vicia faba, Vitis vinifera, Zea mays.*

9.37.4 Geographic Distribution

Afghanistan, Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Canada, Chile, China, Colombia, Czech republic, Denmark, Egypt, Finland, Georgia, Germany, Greece, Hungary, Iceland, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Latvia, Lebanon, Libya, Lithuania, Morocco, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Romania, Russia Federation, South Africa, Spain, Sweden, Switzerland, Syria, Tunisia, Turkey, Ukraine. UK, USA.

9.37.5 Hazard Indentification Conclusion

Considering the facts that:

- *Papaver rhoeas* L.is not known to be present in Bangladesh;
- is present in Australia, Canada, Pakistan, Ukraine and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

Papaver rhoeas is considered to be a potential hazard organism in this risk analysis.

9.37.6 Risk Assessment

9.37.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Pakistan, Ukraine and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.37.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.37.6.3 Establishment Assessment: High

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. Seed germination is dependent on climate and should occur between 4 and 25 days.The optimum temperature required for germination and growth is 5 to 25°C. Therefore the probability of establishment in the PRA area is high.

9.37.7 Consequence Assessment

9.37.7.1 Economic Consequence

P. rhoeas is the only one regarded as being among the most serious weeds on a global scale.

9.37.7.2 Environmental Consequence

Various alkaloids are present in all parts of the plant; potentially poisonous to horses, cattle and sheep if eaten in large quantities, but unlikely to cause human poisoning.

9.37.8 Risk Estimation

This weed is present in some countries from where wheat is imported to Bangladesh. The entry of this weed seed as contaminant to wheat or other crop species is estimated as medium probability. However, the exposure and establishment probabilities are high. It has negative economic impact. The risk estimate for *F. officinalis* is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.37.9 Risk Management

Cultural, manual and herbicidal control approach should be taken as an integrated manner.

9.38 Weed

9.38.1 Hazard Identification

Name of weed:*Parthenium hysterophorus L.*

Common name: Carrot grass, bitter weed, star weed, white top, congress weed

Taxonomy:

Kingdom:	Plantae
Order:	Asterales
Family:	Asteraceae
Genus:	*Parthenium*
Species:	*Parthenium hysterophorus* L.

Bangladesh Status: Not present in Bangladesh

9.38.2 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 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.

9.38.3 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*

9.38.4 Geographic Distribution

Asia: Bangladesh, China, India, Nepal, Pakistan, Sri Lanka

Africa: Ethiopia,Kenya, Madagascar, Somalia,South Africa, Uganda

Central/ Caribbean America: Barbados, Curacao, Dominica, Guadeloupe, Jamaica, Martinique, Puerto Rico, Tobago, Trinidad, Virgin Islands,

North America: Mexico, USA

South America: Argentina, Brazil, Venezuela

Oceania: Australia

9.38.5 Hazard Indentification Conclusion

Considering the facts that:

- *Parthenium hysterophorus L.*is known to be present in Bangladesh in limited scale;
- is also present in Australia, India, Mexico, Pakistan and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

Parthenium hysterophorus is considered to be a potential hazard organism in this risk analysis.

9.38.6 Risk Assessment

9.38.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Mexico, Pakistan and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.38.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.38.6.3 Establishment Assessment: High

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

9.38.7 Consequence Assessment

9.38.7.1 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.

9.38.7.2 Environmental Consequence

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

9.38.8 Risk Estimation

The probability of entry of *Parthenium hysterophorus* weed seed as contaminant along with wheat or other crop species is estimated as medium. However, the exposure and establishment probabilities are high. It has negative economic and environmental impact. The risk estimate for *P. hysterophorus*is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.38.9 Risk Management

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.

9.39 Weed

9.39.1 Hazard Identification

Name of weed:*Phalaris minor* Retz.

Common name: Little seed canarygrass

Taxonomy:

Kingdom: Plantae
Order: Poales
Family: Poaceae
Genus: *Phalaris*
Species: *Phalaris minor*Retz.
Bangladesh Status: Not present in Bangladesh

9.39.2 Biology

Phalaris minor is a winter annual propagated by seeds. It is erect or decumbent, caespitose, more-or-less slender with stems up to 90 cm tall. Leaves long, linear, acuminate; sheath smooth; ligule an oblong hyaline membrane, about 5 mm long. Panicle more-or-less protruding or entirely protruding from the uppermost swollen leaf sheath, ovate to oblong, 5-8 cm long, green; spikelets green, broadly lanceolate on short pedicels, shining, not as conspicuously striped as in P. brachystachys, 4-5 mm long, strongly laterally compressed. Glumes 4-6 mm long, fertile lemma lanceolate about 3 mm long, more or less lustrous; sterile lemma solitary, about 1 mm long.

Glumes acute, but not mucronate, with a minutely toothed wing.Hermaphrodite florets with palea villous with applied hairs, and with very small filiform residue of a neutral floret at the base.

9.39.3 Hosts

Allium cepa (onion), Brassica juncea var. juncea (Indian mustard), *Cicer arietinum* (chickpea), *Hordeum vulgare* (barley), *Lens culinaris* subsp. *culinaris* (lentil), *Linum usitatissimum* (flax), *Pisum sativum* (pea), *Solanum tuberosum* (potato), *Trifolium alexandrinum* (Berseem clover), *Triticum aestivum* (wheat)

9.39.4 Geographic Distribution

Asia: Afghanistan, Bhutan, India, Indonesia, Iran, Iraq, Israel, Jordan, Lebanon, Saudia Arabia, Pakistan,

North America: Mexico, USA

Africa: Egypt, Morocco, South Africa, Zimbabwe

Central/Caribbean: Bolivia, El-Salvador,

South America: Argentina, Brazil, Equador, Colombia. Uruguay.

Europe: Spain, Italy, Portugal, France, Greece, UK

Oceania: Australia.

9.39.5 Hazard Indentification Conclusion

Considering the facts that:

- *Phalaris minor* Retz. is not known to be present in Bangladesh;
- is present in Australia, India, Mexico, Pakistan and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

*Phalaris minor*is considered to be a potential hazard organism in this risk analysis.

9.39.6 Risk Assessment

9.39.6.1 Entry Assessment: Medium

The weed is reported from Australia, India, Mexico, Pakistan, and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.39.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.39.6.3 Establishment Assessment: High

The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas.

Seed can germination in a wide range of environmental conditions. The environmental condition in Bangladesh is favorable for it growth. Therefore the probability of establishment in the PRA area is high.

9.39.7 Consequence Assessment

9.39.7.1 Economic Consequence

Phalaris minor is a very competitive weed in several winter crops in many Mediterranean countries, the Middle East, Asia, Australia and South Africa. Yield losses vary depending on crop, climate and management practices. The losses are maximum in crops of short stature. In India, yield losses in wheat due to this weed ranging from 15-50% (Gill et al., 1978). Cudney and Hill (1979) recorded 40-60% reduction in wheat yield

9.39.7.2 Environmental Consequence

Not known

9.39.8 Risk Estimation

This weed is present in Australia, India, Mexico and USA from where wheat is imported to Bangladesh. The entry of this weed seed as contaminant to wheat or other crop species is estimated as medium probability. However, the exposure and establishment probabilities are high. It has negative economic impact. The risk estimate for *Phalaris minor*is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.39.9 Risk Management

Mechanical removal is very effective and useful if done during the initial growth stages of the crop. However, this is not always practical because of the morphological similarities of P. minor to wheat, in which it is a major weed. The stale seed-bed technique involves encouraging emergence of P. minor by irrigating the field, then later eliminating the weed either by shallow cultivation or by use of non-residual foliage-acting herbicides. Competitive crops such as rape, mustard, barley, etc. are useful. Rotations with fodder crops such as oats or berseem (Trifolium alexandrinum) and cultivation of sugarcane have been found to be effective in checking weed growth. Phalaris minor is highly sensitive to phenylureas. Clorotoluron, isoproturon, methabenzthiazuron and metoxuron have been widely used in India, Pakistan and the Mediterranean countries.

9.40 Weed

9.40.1 Hazard Identification

Name of weed:*Thlaspi arvense* L.

Common name: Pennycress, field pennycress, bastardcress, fan weed, stink weed

Taxonomy:

Kingdom:	Plantae
Class:	Dicotyledonae
Order:	Capparidales
Family:	Brassicaceae
Genus:	Thlaspi
Species:	Thlaspi arvense

9.40.2 Biology

Thlaspi arvense is an annual or winter annual. The entire plant is glabrous and bright green, with an unpleasant odour when bruised. Stems are erect, 18 to 80 cm tall, simple or branched above. The leaves are alternate, with basal leaves narrowly obovate, petioled and soon withering, the middle and upper leaves are oblong, entire or irregularly toothed and clasp the stem by two ear-lobes, 1 to 1.5 mm long. The flowers are initially in a small, flat cluster at the top of the leafy stem with racemes becoming elongated when in fruit, perfect, regular with four sepals, four white petals, 3 to 4 mm long; six stamens, two shorter than others. The silicule is pod-like, borne on slender, upward curving stalks, bright green to yellowish to greenish-orange. As the seeds ripen they are easily seen in crop fields, almost circular, 1.25 cm across, strongly flattened and winged. The very short style persists in a deep, narrow notch at the top of the wings, dehiscent, the two-winged locules each with 4 to 16 seeds. The seeds are ovoid, 1.2 to 2.3 mm long and 1 to 1.5 mm wide, reddish or purplish-brown to black, unsymmetrically oval in outline, somewhat flattened with several concentric ridges resembling a finger print, each face with a narrow groove extending from the hilum to the centre of the seed.T. arvense is a prolific seed producer, with yields as high as 20,000 seeds/plant and seed germinate well at 10-25°C.

9.40.3 Hosts

Allium cepa, A. porrum, Asparagus officinalis, Avena sativa, Beta vulgaris, Brassica napus var. napus, Carthamus tinctorius, Cicer arietinum, Daucus carota, Glycine max, Gossypium spp., *Helianthus annuus, Hordeum vulgaris, Lens culinaris, Linum usitatissimum, Medicago sativa, Oryza sativa, Phaseolus* spp., *Pisym sativum, Solanum tuberosum,* ***Triticum aestivum****, Visia fabam Zea mays.*

9.40.4 Geographic Distribution

Asia: Afghanistan, Argentina, Armenia, Bhutan Azerbaijan, China, Colombia, Georgia, Iran, Ireland, Israel, Italy, Japan, Jordan, Korea (DPR), Korea (Republic), Pakistan, Russia Federation, Tajikistan, Turkey, Turkmenistan.

Africa: Spain, South Africa, Tunisia.

America: Canada, Greenland, USA

Europe: Austria, Albania, Belarus, Belgium, , Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Latvia, Lebanon, Lithuania, Luxembourg, Mongolia, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland, UK.

Oceania: Australia, New Zealand.

9.40.5 Hazard Indentification Conclusion

Considering the facts that:

- *Thlaspi arvense* L. is not known to be present in Bangladesh;
- is present in Australia, Canada, Pakistan and USA;
- can cause economic damage to the crop
- and the weed seed may be present with grains or seeds of wheat or other host species as contaminant; and thus

Thlaspi arvense is considered to be a potential hazard organism in this risk analysis.

9.40.6 Risk Assessment

9.40.6.1 Entry Assessment: Medium

The weed is reported from Australia, Canada, Pakistan and USA from where Bangladesh is importing wheat. If the weed is not cleaned properly before seed formation, there is every possibility of becoming mixed with wheat grain during harvesting with combiner. Therefore the probability of entry into Bangladesh is considered medium.

9.40.6.2 Exposure Assessment: High

Once the weed seed entered into Bangladesh it becomes exposed to the nature while transporting. It is also likely that 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.

9.40.6.3 Establishment Assessment: High

The environmental condition in Bangladesh Is suitable for the growth of *T. arvense.*The released weed seeds under favorable condition germinate and grow to produce seed, which may be dispersed to other areas through soil or irrigation or rain water and establish in new areas. The seeds are winged and wind dispersal may carry the seed for distances of up to 1 km or more. Therefore the probability of establishment in the PRA area is high.

9.40.7 Consequence Assessment

9.40.7.1 Economic Consequence

Thlaspi arvense is a weed of 30 crops in 45 countries and is classified as a serious or principal weed in 12 countries. In Canada, it has been shown that a light infestation can reduce wheat yields by 35% and a heavy infestation by 50%.

9.40.7.2 Environmental Consequence

Thlaspi arvense acts as an alternative host to a range of crop pests and diseases and may be toxic to cattle.

9.40.8 Risk Estimation

The probability of entry of seeds of*Thlaspi arvense* as contaminant along with wheat or other crop species is estimated as medium. However, the exposure and establishment probabilities are high. It has negative economic and environmental impact. The risk estimate for *T. arvense* is non negligible therefore this organism is classified as a hazard in this commodity and risk management measures can be justified.

9.40.9 Risk Management

T. arvense was one of the most resilient weeds, and harrowing achieved only 0-34% control, compared with 100% for herbicide treatments. T. arvense is a poor competitor with certain forage crops, including Agropyron cristatum and Bromus inermis. Densities of this weed could be reduced from 2000 plants/m² at 24 days after emergence to none at 82 days after emergence when grown with these crops. A number of herbicides are effective for controlling T. arvense.

REFERENCES

Agrawal K, Yadav V, Singh T, Singh D, 1986. Occurrence and detection of Karnal bunt in wheat seed in Rajasthan. *Indian Journal of Mycology and Plant Pathology*.**16**:290-291.

Ahmed, H.U. 1986. Prevailing Wheat Diseases in Bangladesh.*In*: Anonymous (ed.), Third National Wheat Training Workshop. Wheat Research Centre, BARI, Joydebpur, Gazipur. pp 124-134.

Alam, K.B., Shaheed, M.A. Ahmed A.U. and Malaker.P.K. 1994. Bipolaris leaf blight (spot blotch) of wheat in Bangladesh. *In*: D.A. Saunders and G.P. Hettel (eds.), Wheat in Heat-stressed Environments: Irrigated, Dry Areas and Rice-Wheat Farming Systems. Mexico, D.F.: CIMMYT. pp 339-342.

Albasser, G. 1992. Ragweed pollen sampling in Gallarate (north-west of Milan) during four years (1987-1990). Aerobiologia, 8(1):31-33

Altieri, M.A., Liebman, M. 1988. Weed management in agroecosytems: ecological approaches. Boca Raton, Florida, USA: CRC Press, Inc., viii + 354 pp.

Anderson, P. and Lofqvist, J. 1996. Asymmetric oviposition behaviour and the influence of larval competition in the two pyralid moths Ephestia kuehniella and Plodia interpunctella.*Oikos*.**76**(1):47-56.

Anwar, S.A., McKenry, M.V. Riaz, A. and Khan, M.S.A. 2001.Evaluation of wheat cultivars for *Anguina tritici* resistance, development and influence of nematode on wheat growth.*International Journal of Nematology*.**11**:150-156.

Atkinson, R.E. 1945. Mosaic of wheat in the Carolinas. Plant Dis. Reptr. 29: 86.

Aujla, S.S, Sharma I, Gill, K.S, Grewal A.S. 1986. Additional hosts of Neovossia indica (Mitra) Mundkur. *Indian Journal of Plant Pathology.***4**(1):87-88.

Aujla, S.S., Sharma, I. and Gill, K.S. 1990. Effect of soil moisture and temperature on teliospore germination of *Neovossia indica*.*Indian Phytopathology.***43:** 223–225.

Aujla, S.S., Sharma, I. and Singh.B.B. 1987.Physiologic specialization of Karnal Bunt of wheat.*Indian Phytopatholo*gy.**40**:333-336.

Bains, S.S. and Dhaliwal H.S. 1989.Release of secondary sporidia of Neovossia indica from inoculated wheat spikes.*Plant and Soil*.**115**(1):83-87

Barnes, H.F. 1956. Gall midges of economic importance. Vol. VII: *Gall midges of cereal crops.* London, UK: Crosby Lockwood.

Bassett, I. J, Crompton, C.W. 1975. The biology of Canadian weeds. 11. Ambrosia artemisiifolia L. and A. psilostachya DC. Canadian Journal of Plant Science, 55(2):463-476

Bedi, P.S., Singh, S. and Singh, P.P. 1990. Effect of some physical factors on germination and sporidial potential index of teliospores of Neovossia indica, the pathogen of Karnal bunt of wheat. Plant Disease Research 5: 38–46.

Bennett, M.D., Rao, M.K., Smith, J.B. and Bayliss, M.W.1973. Cell development in the anther, the ovule, and the young seed of *Triticum aestivum* L. var. Chinese Spring.*Phil.Trans. Royal Soc., Lond. B*. **66**: 39-81.

Beres, I. 1994. New investigations on the biology of Ambrosia artemisiifolia L. 46th International Symposium on Crop Protection, 59:1295-1297.

Beres, I., Kazinczi, G., Narwal, S.S. 2002. Allelopathic plants. 4. Common ragweed (Ambrosia elatior L. Syn A. artemisiifolia). Allelopathy Journal, 9(1):27-34; 41 ref.

Bertrand, P. and Maupas, E. 1996. Ragweed, invasive and allergenic!. Phytoma, No. 484:25-26.

Bidwell, J. 1860. Trans. 1860: 325 (From Neergaard, Paul. 1979. Seed Pathology. The MacMillan Press Ltd.).

Blamey, M.; Fitter, R.; Fitter, A (2003).*Wild flowers of Britain and Ireland: The Complete Guide to the British and Irish Flora*. London: A & C Black. p. 32.ISBN 978-1408179505

Bonde, M.R., Peterson, G.L., Schaad, N.W. and Smilanick, J.L. 1997. Karnal bunt of wheat.*Plant Disease*.**81**: 1370–1377.

Borlaug, N.E., Harrar, J.G and Stakman, E.C. 1946. Flag smut og wheat in Mexico. *Phytopathology*.**36**: 479.

Brakke, I.L. Estes, K.A.P. and Shuster, M.L. 1965. Fenne, S. 3. and C.W. Roane. 1952. Wheat mosaic in Virginia. *Plant Disease Report*.**36**: 212

Brakke, IL. K., Estes, A.P. and Shuster, M.L. 1965. Transmission of soil-borne whe~-t mosaic virus.Phytopathology.**55**: 79-86.

Brown, E.S. 1965. Notes on the migration and directions of flight of *Eurygaster* and *Aelia* species (Hemiptera, Pentatomoidea) and their possible bearing of the invasion of cereal crops.The Journal of Animal Ecology.**34**(1): 93-107.

CABI.2001. *Anguina tritici in*: Crop protection compendium, global module, 3rd edition. CAB International, Wallingford, UK.

CABI.2008. Crop Protection Compendium. CAB International. CAB International, UK,Wallingford. http://www.cabicompendium.org/cpc/home.asp

CABI.2012. Crop Protection Compendium. CAB International, Wallingford, UK.

Chaudhuri, S. Maiti S.S. and Saha P, 1976.Leaf blight of triticale caused by *Alternaria triticina*.*Plant Disease Report*.**60**(2):133-134.

Chng, S.F., Cromey, M.G. and Butler, R.C. 2005.Evaluation of the susceptibility of various grass species to *Gaeumannomyces graminis* var*.tritici.New Zealand Plant Protection.***58**:261-267.

Clewis, S.B., Askew, S.D. and Wilcut, J.W. 2002.Common ragweed interference in peanut. Weed-Science, 49(6):768-772.

Collins, A. S., Chase, C. A., Stall, W. M. and Hutchinson, C. M. 2008. Optimum densities of three leguminous cover crops for suppression of smooth pigweed (**Amaranthus hybridus**). Weed Science 56: 753–761. (Available online at: http://dx.doi.org/10.1614/WS-07-101.1) (verified 10 Sept 2012).

Costea, M. and Tardif, F. J. 2003.The biology of Canadian weeds. 126. *Amaranthus albus* L., *A. blitoides* S.Watson and *A. blitum* L. Canadian journal of plant science Downloaded from pubs.aic.ca by 58.97.150.33

Cox, P.D. 1987. Cold tolerance and factors affecting the duration of diapause in Ephestia kuehniella Zeller (Lepidoptera: Pyralidae). *Journal of Stored Products Research*.**23**(3):163-168.

Cox, P.D., Mfon, M., Parkin, S. and Seaman, J.E. 1981.Diapause in a Glasgow strain of the flour moth, Ephestia kuehniella.*Physiological Entomology*.**6**(4):349-356.

Crous, P.W., Jaarsveld, Castlebury, L.A., Carris, L.M., Frederick R.D. and Pretorius, Z.A. 2001. Karnal bunt of wheat newly reported from the African continent. *Plant Disease*.**85**(5):561

Daumal, J. 1987. Contribution à l'étude de la biologie d'Ephestia kuehniella Zeller (Lepidoptera: Pyralidae - Phycitinae). Application aux élevages intensifs. [Contribution to the study of the biology of Ephestia kuehniella Zeller (Lepidoptera: Pyralidae - Phycitinae). Application to intensive production.].PhD Dissertation. Aix-Marseille, France: St Jérôme University.

Daumal, J. and Boinel, H. 1994. Variability in fecundity and plasticity of oviposition behaviour in Anagasta kuehniella (Lepidoptera: Pyralidae). *Annals of the Entomological Society of America*.**87**(2):250-256.

Daumal, J. and Pintureau, B. 1985.Study of the variability of the duration of development in Ephestia kuehniella Zeller (Lep.Pyralidae).*Acta Oecologica, Oecologia Applicata*. **6**(4):367-380.

Daumal, J., Marconi, D. and Chassain, C. 1985. Small-scale automated rearing of Ephestia kuehniella Zeller (Lepidoptera- Pyralidae). *Bulletin de la Societe Linneenne de Lyon*.**54**(1):7-12.

Dewey, W.G. and Hoffmann, J.A., 1975. Susceptibility of barley to *Tilletia controversa*.*Phytopathology*.**65**(6): 654-657

Dhaliwal, H.S. 1989. Multiplication of secondary sporidia of Tilletia indica on soil and wheat leaves and spikes and incidence of Karnal bunt. *Canadian Journal of Botany*.**67**(8): 2387-2390.

Dhaliwal, H.S. and Singh, D.V. 1989.Up-to-date life cycle of Neovossia indica (Mitra) Mundkur.*Current Science*.**57**(12):675-677

Dhiman, J.S. 1982. Epidemiology of Karnal bunt of wheat in Punjab.Ph.D.Thesis, Punjab Agricultural University, Ludhiana, India.

Doud, C. W. and Phillips, T. 2001. Activity of Plodia interpunctella (Lepidoptera: Pyralidae) in and Around Flour Mills. Journal of Economic Entomology. 93(6): 1872-1877.

EPPO, (2014).PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm.

EPPO, 1991.*Tilletia indica* occurrence in Mexico.EPPO Reporting Service No. 513/06. Paris, France: EPPO.

EPPO, 2013.PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

EPPO. 2006. Alert: *Nysius huttoni* (Heteroptera: Lygaeidae) wheat bug. http://www.eppo.org./QUARANTINE/Alert List/Insects/nysius.htm.

EPPO. 2013. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Esser, R.P., O'Bannon, J.H., and Clark R.A. 1991. Procedures to detect wheat seed gall nematode (Anguina tritici) should an infestation appear in Florida. Nematology Circular No. 186.Fla dept. Agric. and Consumer Serv.

Farrell, J.A. and Stufkens, M.W. (1993) Phenology, diapauses, and overwintering of the wheat bug, Nysius huttoni (Hemipetera: Lygaeidae), in Canterbury, New Zealand. *New Zealand Journal of Crop and Horticultural Science.***21**: 123-131.

FEIS - Fire Effects Information System [Online] (1996, September).Prescribed Fire and Fire Effects Research Work Unit, Rocky Mountain Research Station (producer), US Forest Service. Available: www.fs.fed.us/database/feis/ [1998,March 12]

Fellows, H., Sill, Jr. W.H. and King. C.L. 1953.The 1952 epihytotic of a soil-borne wheat mosaic in Kansas.*Plant Disease Report*.**37**: 287-289.

Forcella, F., Wilson, R.G., Dekker, J., Kremer, R.J., Cardina, J., Anderson, R.L., Alm, D., Renner, K.A., Harvey, R.G., Clay, S., Buhler, D.D. 1997. Weed seed bank emergence across the Corn Belt. Weed Science, 45(1):67-76; 35 ref.

Foster, J.E. 1977. Suppression of a field population of the Hessian fly by releases of the dominant avirulent Great Plains biotype.*Journal of Economic Entomology*.**70**(6):775-778.

Gagné, R.J. and Hatchett, J.H. 1989. Instars of the Hessian fly (Diptera: Cecidomyiidae). *Annals of the Entomological Society of America*.**82**:73-79.

Gill, K.S., Dhaliwal H.S., Randhawa, A.S., Sharma, S.K., Karam, C., 1986b.PBW 138 variety of bread wheat (*Triticum aestivum* L.).*Journal of Research of the Punjab Agricultural University*.**23**:162.

Gill, K.S., Dhaliwal, H.S., Randhawa, A.S., Sharma, S.K., Aujla, S.S. and Karam, C., 1986a. PBW 120 variety of bread wheat (*Triticum aestivum*).*Journal of Research of the Punjab Agricultural University*.**23**:161-167.

Goodwin, M. 2005. Crop profile for wheat in Canada.Agriculture and Agri-Food Canada, 960 Carling Avenue, Ottawa, Ontario, Canada. 33p.

Gorkovenko, V.S. 2001. Causal agents of leaf spot of winter wheat. *Zashchita i Karantin Rastenii*.**5**:33.

Guan, G.Q., Li, S., Gao, D.C., Zhai, Q., Wan, F.H., Wang,R.and Liu, W.Q. 1991. Effect of defoliation on growth and fruiting of ragweed. Chinese Journal of Applied Ecology, 2(4):292-297

Guntrip, J., Sibly, R.M. and Smith, R.H. 1996. A phenotypic and genetic comparison of egg to adult life-history traits between and within to strains of the larger grain borer, *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). *Journal of Stored Products Research*.**32**: 213-223.

Haines, C.P. 1981. Insects and arachnids from stored products: a report on specimens received by the Tropical Stored Products Centre 1973-77. Report of the Tropical Products Institute.L 54.73 pp.

Hansen, F. 1958. Anatomical investigations on the penetration and extension of *Tilletia* species in cereals in relation to the stage of development of the host plant.*Phytopatholgy*.**34**:169-208.

Hardison, J.R., Meiners, J.P., Hoffmann J.A. and Waldher, J.T. 1959.Susceptibility of Graminae to *Tilletia contraversa*.*Mycologica*.**51**:656-664.

Hill, D.S. (1990). Pests of stored products and their control.Belvan Press, 25, Floral Street, London. 274p.

Hodges, R.J. 1986. The biology and control of *Prostephanus truncatus:* A destructive pest with an increasing range. *Journal of Stored Products* Research.**22**:1-14.

Holton, C.S. and Kendrick, E.L. 1956. Problems on the delimitation of species of Tilletia occurring on wheat. Res. Stud. State Coll. Washinton. **24**:318-325.

Howe, R.W. and Hole, B.D. 1968. The susceptibility of developmental stages of *Sitophilus granarius* (L.) (Coleoptera, Curculionidae) to moderately low temperatures. *Journal of Stored Products Research.***4**:147-156.

Howlader, A.J. and Matin, A.S.M.A. 1988.Observations on the pre-harvest infestation of paddy by stored grain pests in Bangladesh.*Journal of Stored Products Research*.**24**(4): 229-231.

http://www.cabicompendium.org/

Humphrey, H.B. and Johnson, A.G. 1919. Take-all and flag smut, two wheat diseases new to the united states. Fmrs' Bull. 1063. U.S. Department of Agriculture. 8p.

Irfan, O., Sirac, Y., Abuzer, Y., Mehmet K. and Julie, M.N. 2011. The impact of seed gall nematode on grain yield, quality and marketing prices on durum wheat in Anatolia, Turkey. *African Journal of Agricultural Research.***6**(16): 3891-3896.

ISPM-11. 2004. Pest risk analysis for quarantine pestsincluding analysis of environmentalrisks and living modified organisms.

ISPM-14. 2002. The use of integrated measures in a systemsapproach for pest risk management. Produced by the Secretariat of the International Plant Protection Convention.

ISPM-2. 2007. Framework for pest risk analysis. Produced by the Secretariat of the International Plant Protection Convention.

ISPM-5. 2007. Glossary of phytosanitary terms. Produced by the Secretariat of the International Plant Protection Convention.

Kailash, A. Veena, Y., Tribhuwan, S. and Singh, D. 1986. Occurrence and detection of Karnal bunt in wheat seed in Rajasthan. *Indian Journal of Mycology and Plant Pathology*.**16**(3): 290-291

Kawchuk, L.M., Kim, W.K. and Nielsen. J. 1988. A comparison of polypeptides from the wheat bunt fungi *Tilletia laevis*, *T. tritici*, and *T. controversa*. *Canadian Journal of Botany*. **66**:2367-2376.

Kieckhefer, R.W. and Morrill, W.L. 1970. Estimates of loss of yield caused by the wheat stem maggot to South Dakota cereal crops. *Journal of Economic Entomology.***63**:1426-1429.

King, L.J. 1966. Weeds of the World.Biology and Control. New York, USA: Interscience Publ.

Kort, J. 1972. Nematode diseases of cereals of temperate climates.*In* J.M. Webster, ed. *Economic nematology*, p. 97-126.New York, NY, USA, Academic.

Koseinan, J.G., McKinney, H.H. and Roane.W.W. 1954.Reaction of wheat varieties and selection to the soil-borne viruses in southern United States.*Plant Disease Report*. 38: 19-24.

Krishna, A., Singh, R.A., 1982.Effect of physical factors and chemicals on the teliospore germination of Neovossia indica. *Indian Phytopathology*.**35**(3):448-455

Kulshrestha, V.P., and Rao, M.V. 1976. Genetics of resistance to an isolate of Alternaria triticina causing leaf blight of wheat. *Euphytica*.**25**(3):769-775.

Kumar, V.R., Kumar, A., Arya, H.C. 1974. Chemical nature of disease resistance and susceptibility in leaf blight of wheat caused by *Alternaria triticina*.I*ndian Journal of Mycology and Plant Pathology*.**4**(2):203-204.

Lambat, A.K., Nath, R., Mukewar, P.M., Majumdar, A., Rani,I., Kaur, P., Varshney, J.L., Agarwal, P.C., Khetarpal, R.K. and Dev, U. 1983.*International spread of Karnal bunt of wheat. Phytopathologia Mediterranea*. **22**(3):213-214.

Lee, R.E. Jr, Strong-Gunderson, J.M., Lee, M.R. and Davidson, E.C. 1992.Ice-nucleating active bacteriadecrease the cold-hardiness of stored grain insects.*Journal of Economic Entomology*.**85***:* 371-374.

Leif, J.W., Vollmer, J.L., Hartberg, T.J., Ballard, T.O. 2000. Growth and response of common ragweed (*Ambrosia artemisiifolia*) ecotypes to imazethapyr. Weed Technology, 14(1):150-155; 18 ref.

Lelchers, L.E. 1931. Wheat mosaic in Egypt.*Science*.**73**: 95-96.

Leukel, R.W. 1929. The nematode disease of wheat and rye. US Department of Agriculture Farmers' Bulletin 1607.

Leukel, R.W. 1957. The nematode disease of wheat and rye.U.S.Department of Agriculture Farmers' Bulletin 1607.

Li, L. 1988. Behavioral ecology and life history evolution in the larger grain borer *Prostephanus truncatus* (Horn).PhD. thesis, University of Reading. Great Britain.

Li, S., Dongchang, G., Guangqing, G. 1989.A study on the phenology of common ragweed and great ragweed. Journal of Shenyang Agricu.ltural University, 20(3):344-250

Limber, D. 1976. Artificial infection of sweet corn seedlings wheat *A.tritici* Stein buch(1799) Chitwood, 1935. Proceedings of the Helminthological Society of Washington.**43**: 201-203.

Logrieco A, Bottalico A, Solfrizzo, M., Mule, G. 1990.Incidence of Alternaria species in grains from Mediterranean countries and their ability to produce mycotoxins.*Mycologia*.**82**(4):501-505.

Loux, M.M. and Berry, M.A. 1991. Use of a grower survey for estimating weed problems. Weed Technology, 5(2):460-466; 11 ref.

Luc , M. Sikora, R.A. and Bridge, J. 1990. Plant parasitic nematodes in subtropical and tropical agriculture.CABI Publisihing, Wallingford, UK.

Lundholm, J.T., Aarssen, L.W. 1994. Neighbour effects on gender variation in Ambrosia artemisiifolia. Canadian Journal of Botany, 72(6):794-800

Malaker, P.K., Ahmed, M.U. and Reza, M.M.A. 2007.Research on cereal disease management at Bangladesh Agricultural Research Institute.*In*: M.A. Bakr, H.U. Ahmed and M.A. Wadud Mian (eds.), Advances in Plant Pathological Research in Bangladesh. Plant Pathology Division, BARI, Joydebpur, Gazipur. pp 3-20.

Mavi, H.S., Jhorar, O.P., Sharma, I., Singh, G., Mahi, G.S., Mathauda, S.S. and Aujla, S.S. 1992. Forecasting Karnal bunt disease of wheat - a meteorological method.*Journal of Washington Academic Science.***34**: 322, 1944.

McBride, D.K., Kopp, D.D. and Nyegaard, C.W. 1996. Wheat stem insect pests and management practices accessed. 21 May 2009 at www.ag.ndsu.edu/pubs/plantsci/smgrains/e680w.htm.

McLean, J. Schaff, A. and Servant, V. 2007.Pest control in stored grain.Lakeland College, Vermillon, Alberta, Canada.

Mehiar, F.F., Wasfy, E.H., El-Samra, I.A. 1976. New leaf diseases of barley in Egypt. *Zentralblatt fur Bakteriologie, Parasitenkunde, Infektions-krankheiten und Hygiene.***131**(8):757-759.

Meng, G.L., Gong, X.W., Gui, L.Y. and Chen, B. 1990. Observations on *Ephestia elutella* (Hubner).*Insect Knowledge*.**27**(1): 16-18.

Mitra, M., 1931.A new bunt on wheat in India.Annals of Applied Biology.**18**:178-179.

Mulligan, Gerald, A. and Findlay, Judy N. 1974.The biology of Canadian weeds. 3. *Cardaria draba, C. chalepensis* and *C. pubescens*. Can. J. of Plant Sci. 54:149-160.

OEPP/EPPO. 1991. Quarantine procedure No. 37.*Tilletia indica*.Inspection and test methods for wheat seeds.*Bulletin OEPP/EPPO Bulletin.* **21**: 265-266.

Partridge, J. E. 2000.Stem Rust of Wheat. Online: University of Nebraska-Lincoln. Department of Plant Pathology.Paulsen, *Phytopathology*.**60**: 1307- 1315.

Paruthi, I.J. and Gupta, D.C.1987. Incidence of tundu in barley and kanki in wheat field infested with *Anguina tritici*. *Harayana Agric. Univ. J. Res.***17**: 78-79.

Percival, J. 1921. *The wheat plant.A monograph*. London, Duckworth.

Prasada, R. and Prabhu, A.S 1964.Leaf blight of wheat.FAO Plant Protection Bulletin.**12**:117.

Price, A.J., Wilcut, J.W. and Cranmer, J.R. 2002. Flumioxazin preplant burndown weed management in strip-tillage cotton (Gossypium hirsutum) planted into wheat (Triticum aestivum). Weed Technology, 16(4):762-767; 30 ref.

Purdy, L.H., and E.L. Kendrick. 1963. Influence of environmental factors on the development of wheat bunt in the Pacific Northwest. IV. Effect of soil temperature and moisture on infection by soil spores. Phytopathology 53:416-418.

Ragunathan, V. Integrted Pest Management Package for Wheat. Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture, Government of India, 33p.

Reddy, D.B. 1970.Loose smut of wheat (in Laos).FAO Plant Protection Bulletine.**18**: 147p.

Richards, O.W. 1947. Observations on grain weevils, Calandra (Coleoptera: Curculionidae). In: General biology and oviposition. Proceedings of the Zoological Society of London.**117**: 1-43.

Roger, A.C., Coutts, B.A.,Mackie,A.E. and Dwyer, G.I. 2005. Seed transmissionof wheat streak mosaic virus shownunequivocally in wheat.Plant Disease **89**: 1048-1050.

Roux, P.W.J. (1999). Larger grain borer: further developments. Plant Protection News (South Africa).Plant protection Research Institute.**55**: 3-4.

Royer M.H., Rytter, J. 1988. Comparison of host ranges of *Tilletia indica* and *T. barclayana*. *Plant Disease.***72**(2):133-136.

Sahoo, U.K. 1998. Effect of depth and duration of burial on seed viability and dormancy of four annual weeds. Annals of Agricultural Research, 19(3):304-310; 19 ref.

Saleh, H.M. and Fattah, F.A. 1990. Studies on the wheat seed gall nematodes. *Nematologia Mediterranea*. **18**: 59-62.

Sansford, C.E. 1998. An assessment of the significance of the initial detection of *Tilletia indica* Mitra in the USA in early 1996 and the potential risk to the United Kingdom (and the European Union). In Bunts and Smuts of Wheat: An International Symposium. (Eds V.S. Malik and D.E. Mathre), pp. 273–302. North American Plant Protection Organization, Ottawa, Canada.

Shahina, F., Abit, M. and Maqbool, M.A.1989.Screening for resistance in corn cultivars against *Heterodera Zea*.*Pakistan Journal of Nematology*.**7**: 75-79.

Shamshad Begum, Mathur SB, 1989. Karnal bunt and loose smut in wheat seed lots in Pakistan. *FAO Plant Protection Bulletin*.**37**(4):165-173.

Sheley, R.L. and J. Stivers. 1999. Whitetop. In: Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis. pg. 401-407.

Shires, S.W. 1980. Life story of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) at optimum conditions of temperature and humidity. *Journal of Stored Products Research*.**16**:147-150.

Singh A.K., Sinha, A.K. and Taiyab, M. 1990.Studies on varietal stability in spring wheat for responses to *Alternaria* blight and brown rust in Bihar.*Indian Journal of Genetics and Plant Breeding*.**50**(1):91-92

Singh, D. and Agrawal, K. 1987. Ear cockle disease (*A. tritici* (Steinbuch) Flipjev) of wheat in Rajastan, India.*Seed Science Technology*.**15**: 777-784.

Singh, D.V., Srivastava, K.D. and Joshi, L.M. 1985. Present status of Karnal bunt of wheat in relation to its distribution and varietal susceptibility. *Indian Phytopathology*.**38**(3):507-515.

Steckel, L. E., Sprague, C. L., Stoller, E. W. and Wax, L. M. 2004. Temperature effects on germination of nine **Amaranthus** species. Weed Science 52: 217–221. (Available online at: http://dx.doi.org/10.1614/WS-03-012R) (verified 10 Sept 2012).

Stephan, Z.A. 1988. Plant parasitic nematodes on cereals and legumes in Iraq. In: Saxena, M.C., Sikora R.A. and Srivastava, J.P (eds) Nematodes parasitic to cereals and legumes in temperate semi arid regions, Aleppo, Syria ICARDA. pp. 155-159.

Strand, L. 1990. Integrated pest management for small grains. Oakland: University of California Division of Agriculture and Natural Resources Publication 3333.

Subramanyam, B.M. and Hagstrum, D.W. 1991.Quantitative analysis of temperature, relative humidity and diet influencing development of the larger grain borer *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). *Tropical Pest Management*.**37**:195-202.

Swarup, G. and Sosa-Moss, C.1990.Nematode parasites of cereals.*In* M. Luc, Sikora, R.A. and Bridge, J. (eds.) Plant parasitic nematodes in subtropical and tropical agriculture, Wallingford, UK, CAB International. pp. 109-136.

Swinburne, T.R. 1963. Infection of wheat by *Tilletia caries*, the causal organism of bunt. Trans Britain Mycological Society. **46**:145-156.

Tanskii V.I. 1961. Formation of thrips (Thysanoptera) fauna of wheat sowings on new lands of North Kazakhstan.*Entomol.Obozr.***40**(4): 785-793.

Taylor, R.W.D. and Halliday, D. 1986. The geographical spread of resistance to phosphine by coleopterous pests of stored products.1986 British Crop Protection Conference.Pests and diseases.Vol. 2. Proceedings of a conference held at Brighton Metropole, England, November 17-20, 1986 Thornton Heath, UK; British Crop Protection Council, 607-613.

Turkington, T.K., Petran, A., Yonow, T, and Kriticos, D.J. 2014.*Fusarium graminearum*.HarvestChoice Pest Geography. St. Paul, MN: InSTePP-HarvestChoice.

Vadworth, D.and Young. H.C. 1953.A soil-borne wheat mosaic vims in Oklahoma. Plant Disease Report.**37**: 27-29.

Varga, P., BTres, I. and Reisinger, P. 2002. The competitive effect of three dangerous weeds on the yields of maize in different years. No^umlaut~ve^acute~nyve^acute~delem, 38(5):219-226; 21 ref.

Wada, S, and H. Hukano. 1937. On the difference and discrimination of wheat mosaic in Japan. *Review of Applied Mycology*.**16**: 665-670.

Wang, Q. and Shi, G.L. 2004. Mating frequency, duration and circadian mating rhythm of New Zealand wheat bug *Nysius huttoni* White (Heteroptera: Lygaeidae). *New Zealand Entomologist*.**27**: 113-117.

Warham, E.J. 1986. Karnal bunt disease of wheat: a literature review. *Tropical Pest Management*.**32**(3):229-242

Wiese, M.V. 1987. Compendium of Wheat Diseases.The American Phytopathological Society.

Wilcoxson, R.D., and Saari, E.E. 1996. Bunt and Smut Diseases of Wheat: Concepts and Methods of Disease Management. Mexico, D.F., CIMMYT.

Williams, R.F.1975. *The shoot apex and leaf growth: a study in quantitative biology*. Cambridge, CUP.

Woolman, H.M., and H.B. Humphrey. 1924. Summary of literature on bunt, or stinking smut, of wheat. U.S.D.A. Bulletin No. 1210. pp. 1-44.

WRC. 2014. Annual Report 2013-14. Wheat Research Centre, BARI, Nashipur, Dinajpur.

Zashurillo, V. K. and Sitnikova. G. M. 1940. Mosaic of winter wheat .*Review of Applied Mycology*. **19**: 268-275.

Zeiss, M.L., Brandenburg, R.L. andVan Duyn. J.W. 1993. Effect of disk harrowing on subsequent emergence of Hessian fly (Diptera: Cecidomyiidae) adults from wheat stubble. *Journal of Entomological Science*.**28**: 8-15.

http://agrihunt.com/crop-diseases/360-ear-cockle-disease-of-wheat.html

http://archive.hgca.com/minisite_manager.output/3610/3610/Cereal%20Disease%20Encyclopedia/Diseases/Ergot.mspx?minisiteId=26

http://archive.hgca.com/minisite_manager.output/3614/3614/Cereal%20Disease%20Encyclopedia/Diseases/Leaf%20and%20Glume%20Blotch.mspx?minisiteId=26

http://en.wikipedia.org/wiki/Agriculture_in_Canada

http://en.wikipedia.org/wiki/Agriculture_in_Mexico

http://en.wikipedia.org/wiki/Anguina_tritici

http://en.wikipedia.org/wiki/Ergot

http://en.wikipedia.org/wiki/Geography_of_Canada

http://en.wikipedia.org/wiki/Wheat_production_in_the_United_States

http://extension.udel.edu/kentagextension/tag/stagonospora-leaf-and-glume-blotch/

http://link.springer.com/article/10.1071/APP9870034

http://nematode.unl.edu/hetaven.htm

http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7348.1990.tb06636.x/abstract

http://plpnemweb.ucdavis.edu/nemaplex/taxadata/G060S1.HTM

http://thecanadianencyclopedia.com/en/article/wheat/

http://www.agroatlas.ru/en/content/diseases/Tritici/Tritici_Septoria_nodorum/

http://www.albertawheat.com/about-wheat/canada/

http://www.aphis.usda.gov/plant_health/plant_pest_info/kb/index.shtml).

http://www.fao.org/docrep/006/Y4011E/y4011e0j.htm#TopOfPage

http://www.gain.fas.usda.gov/...Dhaka_*Bangladesh*_3-28-2013.pdf

http://www.ianr.unl.edu/nu-distance/socrates/disease/agron/wheat/WhStRst.html.

http://www.mapsofindia.com/top-ten/india-crops/wheat.html

http://www.nationsencyclopedia.com/economies/Europe/Ukraine-AGRICULTURE.html

http://www.pakissan.com/english/advisory/wheat.cultivation.in.rain.fed.areas.shtml

http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=53923

http://www.plantwise.org/knowledgebank/pwmap.aspx?speciesid=21712&loc=global

http://www.plantwise.org/knowledgebank/pwmap.aspx?speciesid=28320&loc=global

http://www.rochedalss.eq.edu.au/wheat.htm

http://www.thecropsite.com/reports/?id=1829

http://www.thecropsite.com/reports/?id=1829#sthash.jOWLwmq9.dpuf

http://www.tryukraine.com/info/nature.shtml

http://www.digital.csic.es/bitstream/10261/11604/1/*Heterodera*%20Nemat.%20Medt.pdf

http://www.agroatlas.ru/en/content/weeds/Amaranthus_blitoides/

http://dx.doi.org/10.1614/0890-037X(2002)016[0231:HCCDRE]2.0.CO;2

http://www.pfaf.org/user/Plant.aspx?LatinName=Papaver+rhoeas

http://www.arkive.org/common-poppy/papaver-rhoeas/

http://www.agmrc.org/media/cms/thlaspi_arvense_0df0842489133.pdf

http://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Thlaspi-arvense.pdf

http://pubs.aic.ca/doi/abs/10.4141/cjps75-039