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SEED HEALTH AND QUALITY STATUS OF MUSTARD SEED

PALASH GHOSH

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DEPARTMENT OF PLANT PATHOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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ix, 69p.

JUNE, 2009

SEED HEALTH AND QUALITY STATUS OF MUSTARD SEED

By

Palash Ghosh

Registration No. 01033

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE

IN

PLANT PATHOLOGY

SEMESTER: JANUARY - JUNE, 2009

Approved by:

Prof. Dr. Golam Ali Fakir
Adjunct Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Supervisor

Professor Mrs. Nasim Akhtar
Professor
Department of Plant pathology
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Co-supervisor

Dr. M. Salahuddin M. Chowdhury
Chairman
Examination Committee
Department of Plant pathology
Sher-e-Bangla Agricultural University

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

PABX: +88029144270-9
Fax: +88029112649
Web site: www.sau.edu.bd

Ref:

Dated: 30.06.2009

CERTIFICATE

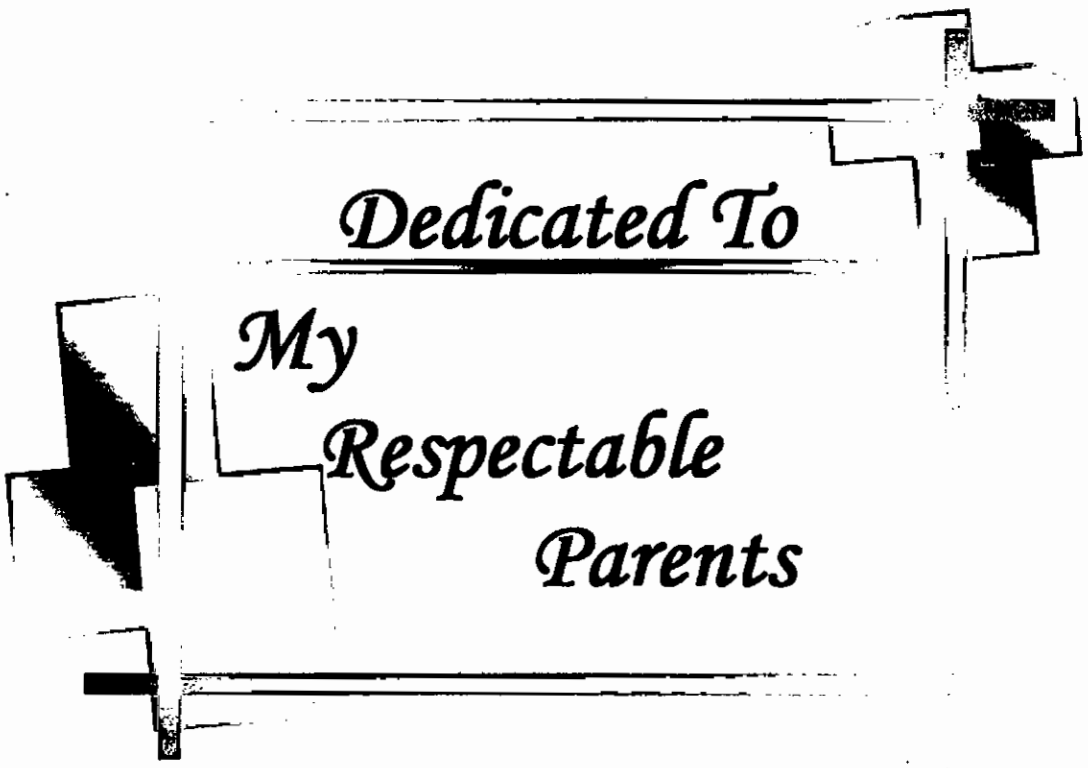
This is to certify that the thesis entitled, "**SEED HEALTH AND QUALITY STATUS OF MUSTARD SEED**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE IN PLANT PATHOLOGY*, embodies the result of a piece of bona fide research work carried out by *PALASH GHOSH, Registration No. 01033*, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma elsewhere.

I further certify that any help or source of information availed during the course of this inquire have been duly acknowledged and the contents and style of the thesis have been approved and recommended for submission.

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

Dated: 30.06.2009
Dhaka, Bangladesh

Prof. Dr. Golam Ali Fakir
Adjunct Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor


Dedicated To
My
Respectable
Parents

ACKNOWLEDGEMENTS

All praises to Almighty and Kindfull "God" who enabled me to pursue my higher study and to complete the research work as well as to submit the thesis for the degree of Master of Science (M.S.) in Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

The author avails the opportunity of conveying his heartfelt respect, deepest sense of gratitude, immense indebtedness and profound honour to his most reverend teacher and research supervisor, **Prof. Dr. Golam Ali Fakir,** adjunct Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University and vice-chancellor(in charge, Bangladesh University, Dhaka and Former V.C. Khulna University), Bangladesh for his scholastic guidance, valuable suggestions, constructive criticisms, continuous inspiration and constant encouragement during the entire period of the research work and in the preparation of the thesis.

The author wishes to express his sincere appreciation and extreme gratitude to his co-supervisor, **Mrs. Nasim Akhtar,** Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for her precious advices, instructions, inspirations and cordial help to complete the research work.

Cordial thanks and honors to **Dr. M. Salahuddin M. Chowdhury,** Chairman, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for her inspiration and co- operation throughout the period of the research work.

The author expresses heartfelt thanks and gratitude to his esteemed teachers, Nazneen Sultana Associate Professor and Khadija Akhter, Assistant Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for their inspiration and co- operation throughout the period of the research work.

The author expresses his sincere appreciation to Abu Noman Faruk Ahammed, Assistant Professor, Md. Belal Hossain, Assistant Professor, Fatema Begum, Assistant Professor, Nazmunnahar Tonu, Assistant Professor and Md. Tohidul Islam, Assistant Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for their inspiration and co- operation throughout the period of the research work.

Thanks are extended to Momin Uddin, Pritilata, Rehena Akhter and Khorshed Alam, Laboratory staff, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for their help and co-operation during the research work.

The author is also grateful to his friends Iqbal Hossen, Alaul,Somrat for their friendly co-operation.

Special thanks are extended to his junior brothers and sister Nasir, Pervez, Shohidul, Gazi, Salauddin, Hasan, Protap, Shuvo, Raju, Apu, Akbar, Fahim, Minhaj, Mizan, Rajib, Kumkum, Sukti, Shraboni, Zebin, Romana and Rubi for their help in compiling and analysis of data.

The author expresses his indebtedness to his senior brother Mintu, Emdad, Sobuj, Bimol. most loving younger sister Papri, Purobi and Munni for their inspiration to carry out higher study.

The Author

SEED HEALTH AND QUALITY STATUS OF MUSTARD SEED

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ABSTRACT

Quality and health status of nine improved varieties of breeder seed and farmer seed of mustard variety Tori-7 grown in 2007-2008 was determined by seed health and quality analysis in the Seed Health Laboratory, Department of Plant Pathology, SAU, Dhaka. Respectively, 14 seed samples of breeder tier and 40 from farmers representing four districts of Bangladesh were included in the present study. Quality analysis showed that the average moisture content of breeder seed was 6.9% and 5.6% collected from BARI, Gazipur and RARS, Ishurdi, respectively; whereas in farmer seed, the average moisture content was 8.0%. Three types of seed contaminants viz. inert matter, other crop seed and varietal mixture were recorded in farmer seed; while in breeder seed only inert matter was observed. Five types of abnormal seeds viz. discolored seed, shriveled seed, spotted seed, undersized seed and broken seed were encountered in farmer seed; whereas four types of abnormal seed except broken seed were found in breeder seed. The amount of abnormal seed and seed contaminants were higher in farmer seed than breeder seed. In an average, 93 and 60% 'best' or 'clean' seed were recovered from breeder and farmer seed, respectively by removing the seed contaminants and abnormal seed through manual seed cleaning. Occurrence of seed contaminants and abnormal seed was always higher in farmer seed compared to breeder seed. Seed health analysis revealed that 11 fungi were associated with mustard seeds. Of those, five fungi viz. *Alternaria brassicae, A. brassicicola, Fusarium solani, Aspergillus flavus* and *Penicillium sp.* were predominant, constituting 87.5% of the total seed-borne fungal infections. The fungi varied in prevalence with respect to seed tier, variety and sources of seed collection. Prevalence of the total as well as the individual predominant fungi were found always higher in unclean seed in comparison to clean seed at all the locations. Occurrence of the predominant fungi was higher in farmer seed compare to breeder seed. 'Clean' seed significantly gave higher percentage of normal seedlings and lesser number of abnormal seedlings and dead seeds over unclean seed both in breeder and farmer seed. Health and quality of farmer seed of mustard can be improved through manual seed cleaning.

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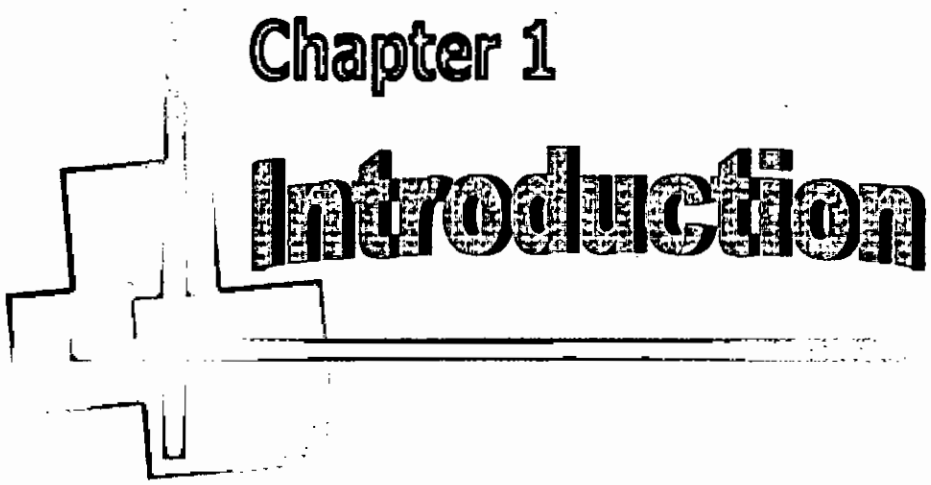
Chapter 1
Introduction

1. INTRODUCTION

Mustard (*Brassica spp.*) is the major oil seed crop of Bangladesh. At present 334000 metric tons of mustard are produced in 352000 ha of land in Bangladesh (BBS, 2005). The average yield of mustard in the country is low compared to other mustard growing countries of the world. The average yield of the crop is only 900 kg ha^{-1}. Among the various factors responsible for such low yield, diseases play an important role.

In Bangladesh, 16 different diseases are known to occur on mustard (Bakr *et al*, 2007; Meah *et al.*, 1985). Of these, six are seed borne (Fakir, 2000). Among all the seed borne diseases, Alternaria leaf blight caused by *Alternaria spp.* (*Alternaria brassicae* and *Alternaria brassicicola*) is the most devastating disease. Under favorable conditions the disease can break out in epidemic form resulting more than 70% yield loss. In an average, 25% yield can be reduced by the disease (Fakir, 2008; Bakr, 2007).

Seed is the most important input for crop production and quality healthy seed is the crying need of the day. Good or quality healthy seed means good crop. In Bangladesh, the total annual mustard seed requirement is 3520 tons. Out of this 3520 tons only 6% i.e., 214.7 tons good quality seed produced in the country by BADC, DAE and BARI. Thus 94% of total mustard seed required in the country is traditionally produced by the farmers. Obviously, these seeds are of poor quality. Of the different components of seed quality, health is vitally important. It has been reported that health of mustard seed may be affected due to infection by different fungal pathogens. As many as twelve different fungi have been

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found to infect the seeds of Tori and Rai varieties / lines of mustard at farmer's level and experimental research farm (Fakir, 1980; Dey, 1982). Infected mustard seeds fail to germinate or the young seedlings emerging from the infected seeds may die resulting post emergence death of seedlings and seedling blight. Dey (1982) detected 12 fungi in mustard seeds. Out of 12 fungi, six viz. *Alternaria brassicicola*, *Alternaria tenuis*, *Aspergillus flavus*, *Curvularia senegalensis*, *Fusarium equiseti* and *Fusarium oxysporum* were found pathogenic to germinating seeds and seedlings of mustard.

The study on seed borne fungi and their role on health of mustard seed conducted in the country (Dey 1982) were more than 25 years back. Further the study was limited to some strains / lines of mustard under trial and some old varieties like Tori and Rai sarisha (Mustard). In the mean time, a number of improved varieties of mustard have been released by BARI and other organizations. Also improved methods of cultivation technology have been adopted by the farmers. Thus, it is apprehended that seed health and quality scenario of mustard seed now in the country may be different.

In view of the above facts, the present study has been undertaken to determine the health and quality status of breeder seed of the improved selected varieties of mustard released by BARI and health and quality of seeds of the most commonly cultivated variety Tori-7 collected from four mustard growing districts of the country.

Chapter 2

Review of Literature

2. REVIEW OF LITERATURE

Seed health can be affected through direct infection by pathogens without showing any visible symptoms. Again infected seeds may be recognized by observing spots, lesions or different kinds of symptoms produced by the invading pathogens. Propagules of various pathogens present in dusts or soils, crop residues, weed or other crops seeds as contamination or concomitant contamination in a given seed lots, also indicate unhealthiness or ill seed health. Thus, like many crop seeds mustard seeds can be infected by pathogens or affected by contaminants and abnormal seeds as contamination or concomitant contamination. There are evidences that cleaning or removal of infected or abnormal seeds and seeds contaminants by manual or physical seed sorting can improve the health status of crop seeds. Therefore an attempt has been made here to collate the relevant literature on the health of mustard (crucifers) seeds infected by fungal pathogens as well as the seed health affected by the propagules of pathogens through contamination and concomitant contamination. Information available on seed health quality by seed cleaning through elimination of seed contaminants and abnormal seeds by physical seed sorting was also compiled.

Infection of Brassica and rape seeds by fungal pathogens:

While conducting an experiment at the National Biological Institute for Agriculture and Forestry, Pape (1940) found that *Alternaria brassicae* was transmitted through Rape (*Brassica sp.)* seeds.

Malone(1964) isolated 4 species of *Alternaria* viz. *A. brassicae, A. brassicicola, A. raphani and A. tenuis* from the low germination radish

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and *brassica* seeds grown in Michigan State, USA. Of them *A. raphani* was the most common and pathogenic to seedlings and growing plants. *A. brassicae* and *A. brassicicola* were found to be associated rarely with radish seeds and only of secondary importance in causing low seeds germination. *A. tenuis* was a common saprophyte in radish seed.

In studying the causes of grey discolouration of white mustard, Jorgensen(1966) from Denmark reported that *A. tenuis* was the most common fungus on normal and grey seeds followed by *A. brassicae* which was more frequent on the grey seeds. In France, Louvet (1968) found that *A. brassicae* causing heavy damage to seed crops of turnip rape was seed transmitted.

Nobel and Richardson (1968) listed 18 seed borne pathogens on *Brassica spp.* including mustard. Out of 18 seed-borne pathogens occurring on *Brassica*, only 6 were seed-borne in mustard. The important pathogens listed by them on mustard are *A. brassicae, A. brassicicola , Phoma lingum and Erysiphe sp.*

Investigating the seed-borne pathogens of *Brassica spp.* In Edinburgh, Scotland Richardson (1970) detected *Alternaria brassicicola, Alternaria brassicae* and *Phoma lingum* as the main seed-borne pathogens causing symptoms in a germination test of 157 seed samples. In this test 41, 10 and 4 seed samples yielded *A. brassicicola, A. brassicae* and *Phoma lingum,* respectively. According to him, *A. brassicae* was more pathogenic than *A. brassicicola.*

From Canada, Petric (1974) reported *A. brassicicola* as a serious crucifer pathogen which was detected in 21 seed samples of garden crucifers out

of 63 samples tested. According to him, commonly grown varieties of rape and mustard were highly susceptible to the fungus both at the seedling and mature stage of the plant.

Fakir (1976) detected 20 fungi, representing 14 genera in mustard (*Brassica campestris* var. *toria* and *B. juncea* var. *rai*) seeds in Bangladesh. The genera were *Alternaria, Aspergillus, Penicillium, Botrytis, Cephalosporium, Cladosporium, Drechslera, Epicoccum, Fusarium, Myrothecium, Nigrospora, Phoma, Rhizopus,* and *Verticillium.* He found 4 species of *Alternaria* namely- *A. brassicae, A. brassicicola, A. raphani and A. tenuis* and 4 species of *Fusarium* namely- *F. avenaceum, F. moniliformae, F. semitectum* and *F. solani* to be associated with mustard seeds.

While testing the health of 426 seed samples of white mustard at the State Seed Testing Station, Lyngby, Denmark, Jorgensen (1976) observed *Alternaria tenuis* in almost all seed samples. Whereas *A. brassicae* and *Penicillium spp.* occurred sporadically in the test seed samples depending on the environmental factors.

Petric (1978) found six fungal pathogens namely *A. brassicae, A. raphani, Fusarium roseum, Botrytis cinerea, Sclerotinia sclerotiorum* and *Albugo candida* to be associated with the seeds of Rape and Turnip grown in western Canada in 1976. He compared these results with those of an earlier study conducted in 1967-73, he observed the incidence of all the fungal pathogens, except *Alternaria brassicae* was higher in 1978 than 1967-73.

At the University of Alexandria, Egypt, Michail *et al.*, (1979) detected *A. brassicicola, A. raphani, Fusarium equiseti* and *Phoma oleracea* in seeds of cabbage, cauliflower and radish. According to them *A. brassicicola* and *A. raphani* were highly pathogenic to cabbage and radish(*Raphanus sativus*). In compiling the annotated list of seed borne diseases occurring in Bangladesh, Fakir (1980) listed 14 seed borne fungi on mustard (*Brassica spp.)* seed. According to him six fungi are of major importance.

Dey and Fakir (1982) detected twelve fungi representing eight genera in the seeds of two species of Mustard (*Brassica juncea* var. *Rai and Brassica campestris* var. *Toria*) seeds collected in 1981 from major mustard growing regions of Bangladesh. Among all of these fungi, the most devastating and pathogenic ones, in order of prevalence, were *Fusarium oxysporum, Alternaria brassicae, Alternaria tenuis, Aspergillus flavus* and *Fusarium equiseti.* These fungi varied in prevalence greatly with respect to location, month of recording, species and cultivars / strains of mustard. They observed that among all the twelve fungi, six- *Alternaria brassicicola, Alternaria tenuis, Aspergillus flavus, Curvularia senegalensis, Fusarium equiseti and Fusarium oxysporum* were found pathogenic to the germinating seeds and seedling of mustard.

Saleh *et al.*, (2003) studied the fungal flora of stored mustard seeds. He detected seven genera of fungi namely, *Alternaria, Fusarium, Aspergillus, Penicillium, Rhizopus, Chaetomium* and *Curvularia.* The incidence of fungal genera varied with location and duration of storage period. The highest seed borne infection of *Alternaria* was detected at Narshingdi (10.32%), followed by Munshiganj (10.06%), Manikganj (8.66%) and Mymensingh (6.03%). He also mentioned that with the increase of storage period, the frequency of *Alternaria* decreased; but

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Chowdhury (1999) found that cleaning of mustard seeds significantly increased the percent seed germination. The percent seed germination of cleaned seeds and unclean seeds were 93.04 and 62.31, respectively collected from healthy and infected pods (siliqua). On the other hand, percent seed germination of cleaned seeds and unclean seeds were 88.96 and 54.65, respectively from the infected pods.

In a study to evaluate the cleaning methods to improve the quality of farmers saved rice seeds, Rahman *et al.*, (2000) found reduced incidence of fungi in cleaned seeds compared to farmers original saved seeds. Seed cleaning also resulted significant increase in seedling growth and normal seedling and reduced number of diseased seedlings over the original farmer saved seeds.

Rahman (2000) obtained higher yield in Mustard by using clean or apparently healthy seeds mostly free from *Alternaria* infection.

Rahman *et al.*, (2000) reported that reduction of fungal infection was higher in cleaned seeds (var. BR-11) than that of uncleaned farmers saved rice seeds. They also found that cleaned seeds gave better seedling growth and lower disease incidence of seedling over the farmer saved seeds.

Hasan *et al.*, (2001) observed that use of cleaned rice seed resulted in lower fungal infection, higher germination and vigor index by 8.33% and 31.01%, respectively than that of farmer's uncleaned seed. The seedling emergence was also found to be higher. They also found that seedling stands was the highest when cleaned and washed seeds were used.

Hasan *et al.*, (2001) reported that prevalence of seed-borne pathogenic fungi was lower in manually clean rice seeds than farmers saved seeds. Germination test showed that manual seed cleaning and washing with water increased germination and vigor index by 8.33% and 31.01%, respectively. They also noted significantly higher (12.12%) seedling emergence in seed bed when farmer's seed were manually clean and washed. Number of diseased seedlings was significantly reduced in seed bed when clean and washed farmer's seed were used. The highest number of healthy seedlings (76.62%) was recorded where farmer's cleaned and washed seeds were sown.

Meah (2002) recorded higher speed and rate of germination as well as higher number of infection of *Phomopsis vexans* in sorted out apparently healthy egg plant seeds compared to uncleaned farmer seed.

Meah (2002) separated apparently healthy seeds from original farmer's seed and seeds from healthy fruits of eggplants. Apparently healthy clean seeds and seeds from healthy fruits showed higher speed and rate of germination and did not have infection of *Phomopsis vexans*.

Hawlader (2003) reported that form farmer's original seeds, sorted out apparently healthy and diseased seed gave 20-91%, 26-100% and 17-85% germination, respectively. Dead and rotten seeds were also lower in apparently healthy seed than that of farmer's original and diseased seeds. The highest percent of *Phomopsis vexans* infection was found in farmer's original diseased seed. The lowest seed infection of the pathogen was encountered in apparently healthy seeds. In net house experiment, the

highest seed germination (91%), no damping off and seedling blight was observed from apparently healthy seeds sown.

Siddique (2003) observed that apparently healthy or clean wheat seeds obtained by bamboo sieving showed better performance in respect of germination, seedling vigor and seed health compared to seeds that dropped under the sieve. Sieved apparently healthy seed had reduced infection of pathogens like *Bipolaris sorokiniana*, *Alternaria tenuis*, *Aspergillus spp.* and *Fusarium spp.*

Islam (2005) found that, infection of *Phomopsis vexans* was the lowest in apparently healthy seeds of egg plants among the three categories of manually sorted seeds viz. farmer's seed, apparently healthy seeds and diseased seed. According to him, seed cleaning was effective against damping off, tip over and seedling blight in the nursery bed of net house.

Kabir *et al.*, (2005) found that the population of seed borne fungal pathogens in farmers saved rice (BR-28) seed were lower when seeds cleaning by physical seed sorting was done. Percentage of germination and normal seedlings were higher in Vitavax treated seed, followed by cleaned washed seed over untreated farmer's seed.

Khokon *et al.*, (2005) reported that analysis of inert matter sorted out from wheat seeds (Cultivar- Khanchaan) yielded *Bipolaris sorokiniana*, *Fusarium moniliforme*, *Aspergillus spp.* and *Penicillium sp.* The original seed samples (from where the inert matter was sorted out) also yielded the similar fungal pathogens with higher frequencies. They also detected *B. oryzae*, *Alternaria padwikii*, *Fusarium spp. Aspergillus spp.* and Penicillium *sp.* in inert matter separated out of the rice seed samples of

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cultivar BR3, BR14 and BRRI dhan 29. The original rice seed samples also yielded the same fungi in different frequencies.

Chapter 3

Materials and Methods

3.MATERIALS AND METHODS

3.1. Experimental site:

The study on seed health and quality status of mustard seeds were studied in the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU). Sher-e-Bangla Nagar, Dhaka.

3.2. Experimental period

The experiments were carried out from March to December 2008.

3.3 Mustard varieties and seed tiers included:

Varieties included:

Breeder seed of nine improved varieties developed by BARI included in the study were as follows:

i) BARI Sharisa – 6
ii) BARI Sharisa – 9
iii) BARI Sharisa – 10
iv) BARI Sharisa – 11
v) BARI Sharisa – 12
vi) BARI Sharisa – 13
vii) BARI Sharisa – 14
viii) BARI Sharisa – 15
ix) Improved Tori – 7

Seeds of all these nine varieties were obtained from BARI head quarter Gazipur, whereas seeds of five varieties viz. BARI Sharisa – 9, BARI Sharisa – 11, BARI Sharisa – 13, BARI Sharisa – 14 and BARI Sharisa – 15 were collected from RARS, BARI, Ishurdi.

Traditional variety Tori – 7 produced by the farmer was also used for the study to compare the health of farmer seed with that of breeder seed of the improve varieties included.

3.4 Collection of Seed Samples:

One seed sample of the breeder seed tier for each of the selected improved mustard varieties were collected from the two selected research stations of BARI. Thus, 14 seeds samples were collected from breeder seed. Forty seed samples of farmer seed of variety Tori-7 were collected from farmers representing four mustard growing districts (Manikgonj, Naogaon, Tangail & Thakurgaon) of the country.

3.5 Preservation of seeds samples:

The collected seed samples were kept in polythene bag and stored immediately in a refrigerator in the laboratory until used for experiments.

3.6 Seed Quality Analysis:

3.6.1 Determination of moisture content:

The moisture content of the collected seed samples were determined using digital electric moisture meter and results were expressed in percentage on wet weight basis.

3.6.2 Sorting of 'Best' or 'clean' apparently healthy seeds:

'Best' or 'clean' (apparently healthy) seeds were sorted out from the original seeds samples by manual seed cleaning on a clean laboratory table. In this process, seed contaminants and abnormal seeds were separated from the collected seed samples. In doing so, 14 samples of

breeder seeds and 40 samples of farmers saved seeds were used for manual cleaning. Seeds contaminants and abnormal seeds separated and recorded from each sample were as follows:

Seed Contaminants

- Varietal mixture
- Other Crop seeds
- Inert matter (Crop residues, stones, soil and sand particles etc.)

Abnormal Seeds

- Broken seeds
- Discolored seeds
- Spotted seeds
- Shriveled seeds
- Undersized seeds

Best or clean apparently healthy) seeds were separated from each of the seed sample by removing or separating seed contaminants and abnormal seeds with the help of a spatula. Thus, the best looking seeds or apparently healthy seeds separated are termed as clean or best seed. Undersized seeds were considered those seeds which had comparatively less weight than the standard normal seed. The separation of contaminants and abnormal looking seeds were done manually with unaided eyes.

3.6.3 Seed health analysis:

Seed samples were analyzed for health to determine the seed-borne fungal infections. Two hundred seeds randomly taken from each working sample from both clean (apparently healthy) and unclean (farmer original seed) seed were used for detection of seed borne fungi prevalent in the collected samples. The fungi were detected by the blotter method (ISTA, 2001). In this method 25 seeds were plated on wet three layer filter paper (Whatman No. 1) soaked in water and were placed at the bottom of a 9 cm. diameter plastic Petridish. Distilled water was used for this purpose. The petridishes with seeds were than incubated at 20±2°C under 12/12 hours alternating cycles of Near Ultraviolet (NUV) light and darkness in the incubation room of the seed health laboratory of the department for seven days. After incubation, the seeds were examined for the prevalence at seed borne fungal infections. The fungi were detected by observing their growth characteristics on the incubated seeds under stereomicroscope at 25x magnification. The fungi, thus recorded were identified following the keys of Mathur and Kongsdal (2003). In doubtful cases; slides were prepared and observed under compound microscope for confirmation of identification of the fungi. Fungi thus, recorded and identified were expressed in percent seed-borne infection of the pahtogens. Of all the fungi detected in the mustard seed samples analyzed, five predominant pathogenic fungi viz. *Alternaria brassicicae, A brassicicola, Fusarium solani, Aspergillus flavus* and *penicillium sp.* were taken into consideration to interpret and explain the results. A fungus, which contributes at 5% of the total seed-borne fungal infections, was considered as the predominant one.

3.6.4 Determination of germination:

Germination of both clean and unclean seeds was determined in clean sand. Plastic trays were used for this purpose. Four hundred seeds in four replicates taken randomly from each seed sample were used for germination test. Hundred seeds were sown in each tray and the trays were kept on the laboratory table at room temperature for 14 days. Germination was recorded after 14 days at an interval of 2 days. Normal seedlings, abnormal seedlings and dead seeds were recorded separately following the International Rules for Seed Testing (ISTA, 2001). The results were expressed in percentages.

Normal seedlings were categorized by the following criteria:

i) Intact seedling with all essential structure well developed, complete in proportion and healthy.

Abnormal seedlings were categorized using following criteria:

i) Seminal roots missing/ stunted or broken and decayed due to primary infection.

ii) Shoot system deformed / decayed.

iii) Leaf missing / extending less than half way up to the shoot stunted or deformed.

iv) Seedling as a whole deformed spindly, discolored or decayed as a result of primary infection.

v) Blackened dead or decayed seed.

The number of seeds that produced normal seedlings were counted and the percentage calculated over the number of seeds placed for the test. Similarly, the data on abnormal seedlings and dead seeds were recorded.

3.7 Statistical analysis:

The recorded data were analyzed using MSTAT-C computer package program. The mean differences for efficiency of the treatments were judged by Least Significant Difference (LSD).

Chapter 4

Results

4. RESULTS

4.1 Moisture Content

4.1.1 Breeder seed

The moisture content of seeds collected from BARI Gazipur, varied from 5.7 -8.2%, the average being 6.9%. The maximum moisture content (8.2%) was found in seeds of variety BARI Sharisha-11 collected from BARI Gazipur. Whereas, the lowest moisture content (5.7%) in BARI Sharisha -6 (Fig. 1). The moisture content of seeds collected from RARS Ishurdi, varied from 5.2 - 6.0%. The average moisture content was 5.6%. The highest moisture content (6.0%) was found in BARI Sharisha-13 and the lowest (5.2%) in BARI Sharisha-15 (Fig. 2). The average moisture content of the breeder seed was 6.3%, seeds of Gazipur had higher moisture content than that of Ishurdi (Figs. 1-2).

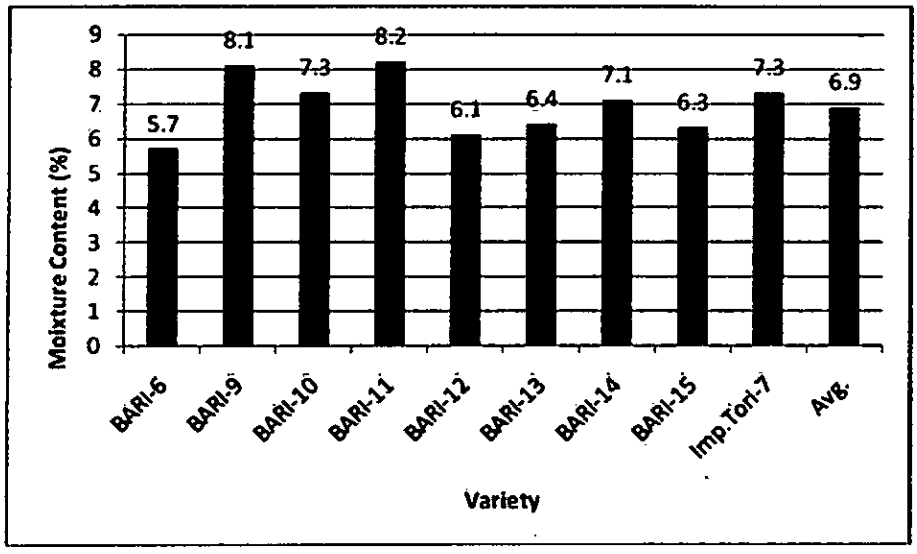

Fig 1. Moisture content of breeder seed of different mustard varieties collected from BARI Gazipur

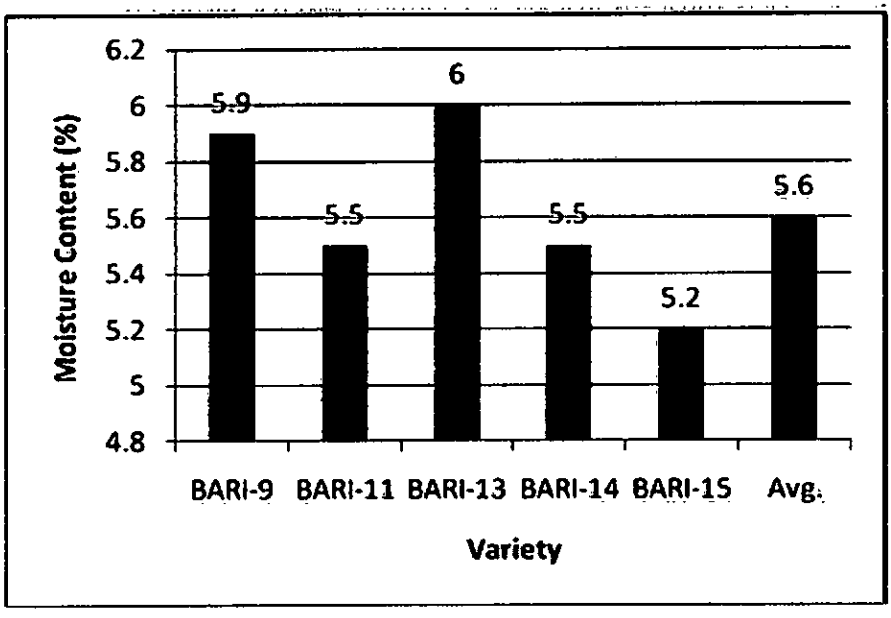

Fig 2. Moisture content of breeder seed of different mustard varieties collected from RARS, Ishurdi

4.1.2 Farmer seed:

The moisture content of farmer seed of variety Tori-7 collected from four districts of Bangladesh varied from 7.7-8.6 %. The average moisture content of farmer seed obtained from four districts was 8.0%. The maximum moisture content 8.6 % was recorded in seeds collected from Manikgonj, followed by Tangail (8.2 %) and Thakurgaon (7.8 %), while the lowest moisture content (7.7 %) was encountered at Naogaon (Fig. 3).

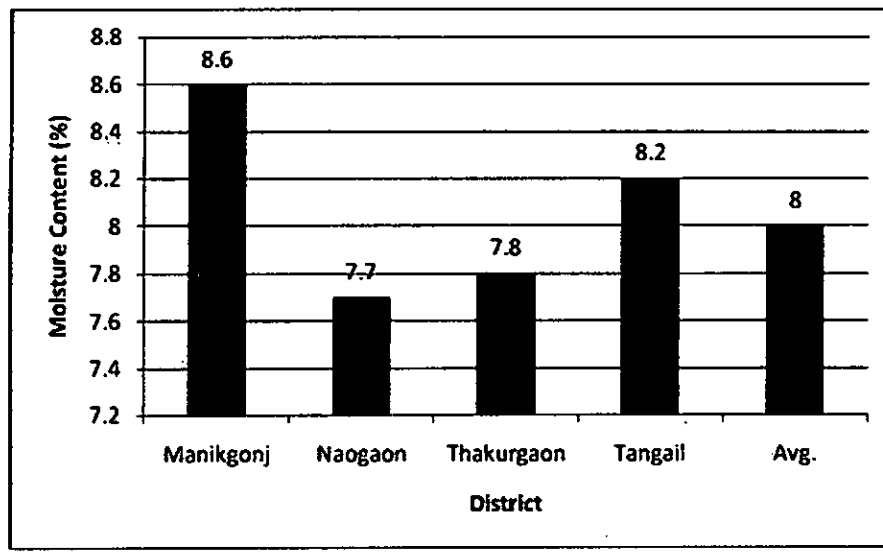

Fig 3. Moisture content of farmer seed collected from four districts of Bangladesh

4.2 Seed Contaminants

Seed contaminants and its frequency of occurrence in breeder seed and farmer seed are included in Tables 1-2. Altogether three types of seed contaminants were encountered in the present study. The contaminants were inert matter, other crop seed and varietal mixture. In breeder seed only inert matter was detected, while all the three contaminants were found in farmer seed.

4.2.1 Breeder seed:

Inert matter as seed contaminant and its frequency recorded in the breeder seeds obtained from two research stations - BARI, Gazipur and RARS, Ishurdi were presented in Table -1.The contaminants varied significantly from one another with respect to variety. The occurrence of inert matter detected at BARI, Gazipur varied from 0.04-0.17%.The highest(0.17%) percent of the contaminant was present in the variety BARI Sharisha - 11 and the lowest (0.04 %) percent encountered in the variety BARI Sharisha-6. Incase of Ishurdi, presence of inert matter ranged from 0.02-0.05% . The highest count (0.05%) was noted in BARI Sharisha -11, BARI Sharisha -13 and BARI Sharisha-15 and the lowest (0.02%) in BARI Sharisha -14.

Table 1. Inert matter detected in breeder seed collected from BARI, Gazipur and RARS, Ishurdi

Variety	Gazipur	Ishurdi
BARI sharisa-6	0.04 e	-
BARI sharisa - 9	0.08 bc	0.03 b
BARI sharisa - 10	0.04 e	-
BARI sharisa - 11	0.17 a	0.05 a
BARI sharisa - 12	0.09 b	-
BARI sharisa - 13	0.07 cd	0.05 a
BARI sharisa - 14	0.06 d	0.02 c
BARI sharisa - 15	0.09 b	0.05 a
Improved Tori -7	0.08 bc	-
LSD	0.012	0.006
CV%	25.37	30.78
Significance level	**	*

** significant at 1% level, *significant at 5% level.

(-) indicate that the varieties were not available.

4.2.2 Farmer seed:

Three different types of seed contaminants, viz. inert matter, varietal mixture and other crop seed were detected in farmer seed collected from four districts of Bangladesh. The individual contaminants varied significantly from one another with respect to location. The highest amount of total seed contaminants was recorded at Thakurgaon (8.85%), followed by Tangail (8.72%) and Naogaon (6.01%); whereas the lowest (5.40%) count was made at Manikgonj(Table - 2).

The percentage of inert matter ranged from 4.81-8.48%, the highest and the lowest being recorded at Thakurgaon (8.48%) and Manikgonj (4.81%) respectively. The highest occurrence of varietal mixture was recorded at Manikgonj (0.47%), followed by Naogaon (0.42%) and Thakurgaon (0.30%); while the lowest percent of varietal mixture was encountered at Tangail (0.16%). The occurrence of other crop seed varied from 0.08-0.18%. The highest count of other crop seed was found at Naogaon (0.18%), followed by Thakurgaon (0.14%) and Manikgonj (0.12%); while the lowest (0.08%) was observed at Tangail (Table - 2).

Table 2. Seed contaminants detected in Tori-7 collected from farmers of four districts of Bangladesh

Location	Seed Contaminants (%)			Total (%)
	Varietal mixture	Other crop seed	Inert matter	
Manikgonj	0.47 a	0.12 b	4.81 c	5.4
Naogaon	0.42 a	0.18 b	5.41 a	6.01
Tangail	0.16 c	0.08 a	8.48 d	8.72
Thakurgaon	0.30 b	0.14 a	8.41 b	8.85
LSD	0.109	0.894	0.0006	
CV%	17.14	5.19	6.59	
Significance level	**	**	**	

** significant at 1% level.

4.3 Abnormal Seeds

Abnormal seeds and its frequency of occurrence in breeder seed and farmer seed are presented in Tables 3-5. Altogether five types of abnormal seeds were recorded in the present study. The abnormal seeds were broken seed, discolored seed, shriveled seed, spotted seed and undersized seed. In breeder seed four types of abnormal seeds except broken seeds were detected (Tables 3-4), while in farmer seed all the five abnormal types of seeds were observed (Table - 5).

4.3.1 Breeder seed:

Four different types of abnormal seed viz. discolored seed, shriveled seed, spotted seed and undersized seed were detected in breeder seed collected from BARI, Gazipur and RARS, Ishurdi (Tables 3-4). The individual contaminants varied independently of each other with respect to variety.

4.3.1.1 BARI, Gazipur

The highest amount of total abnormal seed was recorded in BARI sharisha- 13 (1.48%), followed by BARI Sharisha -9 (0.81%); whereas the lowest count was made in improved Tori - 7 (0.26%). The highest occurrence of discolored seed was recorded in BARI Sharisha -13 (0.99%), followed by BARI Sharisha -6 (0.46%) and BARI Sharisha -14 (0.40%); while the lowest record of discolored seed was found in improved Tori -7 (0.09%); Prevalence of shriveled seed varied from 0.03-0.60%.The highest count of shriveled seed was made in BARI Sharisha-12(0.60%), whereas the lowest was encountered in BARI Sharisha-11(0.03%). The highest percent of spotted seed was observed in BARI

Sharisha -15 (0.06%), while the lowest was encountered in BARI Sharisha -6, improved Tori-7, BARI Sharisha -10, BARI Sharisha -12 & BARI Sharisha -14 (0.03%). The occurrence of undersized seed ranged from 0.03-0.08%. The highest and the lowest being recorded in BARI Sharisha -6 and BARI Sharisha -11, respectively (Table -3).

4.3.1.2 RARS, Ishudi

The highest amount of total abnormal seed was recorded at BARI Sharisha - 13 (0.71%), followed by BARI Sharisha -9 (0.57%) and BARI Sharisha -14 & BARI Sharisha -15 (0.55%); whereas the lowest count was obtained in BARI Sharisha -11 (0.40%). The highest occurrence of discolored seed was recorded in BARI Sharisha -15 (0.40%), followed by BARI Sharisha -9 (0.25%) and BARI Sharisha -14 (0.21%); while the lowest record of discolored seed was found in BARI Sharisha -13 (0.05%).The highest prevalence of shriveled seed was observed in BARI Sharisha -13 (0.40%), followed by BARI sharisha -9 (0.24%) and BARI Sharisha -11 (0.21%), while the lowest was encountered in BARI Sharisha -15 (0.05%). Highest percent of spotted seed was observed in BARI Sharisha -13 (0.06%), while the lowest was encountered in BARI Sharisha -9 & BARI Sharisha -11 (0.03%). The occurrence of undersized seed ranged from 0.05-0.24% the highest and the lowest being recorded in BARI Sharisha -13 and BARI Sharisha -11, respectively(Table- 4).

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Sharisha -15 (0.06%), while the lowest was encountered in BARI Sharisha -6, improved Tori-7, BARI Sharisha -10, BARI Sharisha -12 & BARI Sharisha -14 (0.03%). The occurrence of undersized seed ranged from 0.03-0.08%. The highest and the lowest being recorded in BARI Sharisha -6 and BARI Sharisha -11, respectively (Table -3).

4.3.1.2 RARS, Ishurdi

The highest amount of total abnormal seed was recorded at BARI Sharisha - 13 (0.71%), followed by BARI Sharisha -9 (0.57%) and BARI Sharisha -14 & BARI Sharisha -15 (0.55%); whereas the lowest count was obtained in BARI Sharisha -11 (0.40%). The highest occurrence of discolored seed was recorded in BARI Sharisha -15 (0.40%), followed by BARI Sharisha -9 (0.25%) and BARI Sharisha -14 (0.21%); while the lowest record of discolored seed was found in BARI Sharisha -13 (0.05%).The highest prevalence of shriveled seed was observed in BARI Sharisha -13 (0.40%), followed by BARI sharisha -9 (0.24%) and BARI Sharisha -11 (0.21%), while the lowest was encountered in BARI Sharisha -15 (0.05%). Highest percent of spotted seed was observed in BARI Sharisha -13 (0.06%), while the lowest was encountered in BARI Sharisha -9 & BARI Sharisha -11 (0.03%). The occurrence of undersized seed ranged from 0.05-0.24% the highest and the lowest being recorded in BARI Sharisha -13 and BARI Sharisha -15, respectively (Table- 4).

Table 3. Abnormal seeds detected in nine different varieties of breeder seed collected from BARI, Gazipur

Variety	Abnormal seed (%)				Total (%)
	Discolored	Shriveled	Spotted	Undersized	
BARI Sharisa -6	0.46 b	0.10 f	0.03 c	0.03 h	0.62
BARI Sharisa - 9	0.25 f	0.47 b	0.04 bc	0.05 d	0.81
BARI Sharisa - 10	0.22 g	0.17 e	0.03 c	0.05 e	0.47
BARI Sharisa - 11	0.39 d	0.03 g	0.05 ab	0.08 a	0.55
BARI Sharisa - 12	0.10 h	0.60 a	0.03 c	0.06 b	0.79
BARI Sharisa - 13	0.99 a	0.40 c	0.05 ab	0.04 g	1.48
BARI Sharisa - 14	0.40 c	0.24 d	0.03 c	0.04 f	0.71
BARI Sharisa - 15	0.33 e	0.10 f	0.06 a	0.04 f	0.53
ImprovedTori -7	0.09 i	0.08 f	0.03 c	0.06 c	0.26
LSD	0.008	0.026	0.019	0.002	
CV%	4.36	7.83	26.44	14.26	
Significance level	**	**	**	*	

** significant at 1% level, *significant at 5% level.

Table 4. Abnormal seed detected in five different varieties of breeder seed collected from RARS, Ishurdi

Variety	Abnormal seed (%)				Total (%)
	Discolored	Shriveled	Spotted	Undersized	
BARI Sharisa -9	0.24 b	0.24 b	0.03 d	0.06 c	0.57
BARI Sharisa -11	0.11 c	0.21 c	0.03 d	0.05 d	0.40
BARI Sharisa -13	0.05 d	0.40 a	0.06 a	0.24 a	0.76
BARI Sharisa -14	0.21 b	0.15 d	0.04 c	0.15 b	0.55
BARI Sharisa -15	0.40 a	0.05 e	0.05 b	0.05 c	0.55
LSD	0.059	0.002	0.002	0.006	
CV%	12.37	9.91	30.12	12.13	
Significance level	**	**	ns	**	

** significant at 1% level, ns= not significant.

4.3.2 Farmer seed:

Five different types of abnormal seed viz. broken seed, discolored seed, shriveled seed, spotted seed and undersized seed were detected in farmers seed collected from four districts of Bangladesh. The individual types of abnormal seeds varied independently from each other with respect to location. The highest amount of total abnormal seed was recorded at Naogaon (37.92%), followed by Thakurgaon (36.42%) and Manikgonj (32.78%); whereas the lowest was observed at Tangail (22.88%). The highest occurrence of discolored seed was recorded at Manikgonj (12.00%), followed by Thakurgoan (11.60%) and Naogaon (11.24%); while the lowest record of discolored seed was encountered at Tangail (4.74%). Prevalence of shriveled seed varied from 10.05 - 14.04%. The highest count of shriveled seed was observed at Naogaon

(14.04%), followed by Thakurgoan (13.45%) and Manikgonj (10.49%); while the lowest was encountered at Tangail (10.05%). The occurrence of undersized seed in farmer seed varied from 6.62-10.96% with respect to source of seed collection. The highest count of undersized seed was found at Naogaon (10.96%), followed by Thakurgaon (10.30%) and Manikgonj (9.52%); while the lowest (6.62%) was recorded at Tangail. The occurrence of spotted and broken seed as abnormal seed in farmer seed was found in low quantity at all the locations with some exceptions. Spotted seed was present at all the locations of seed collection. It varied from 0.24-0.34% depending on the seed sources. Broken seed was also occurred at all the locations ranging from 0.53-1.34 %. Maximum association of broken seed was found at Naogaon (1.34%) and the minimum was encountered at Manikgonj (0.53%) (Table-5).

Table 5. Abnormal seed detected in variety Tori - 7 Collected from farmers of four districts of Bangladesh

Location	Abnormal Seed (%)					Total (%)
	Discolored	Shriveled	Undersized	Spotted	Broken	
Manikgonj	12.00 a	10.49	9.52 a	0.24	0.53 b	32.78
Naogaon	11.24 a	14.04	10.96 a	0.34	1.34 a	37.92
Tangail	4.74 b	10.05	6.62 b	0.30	1.17 a	22.88
Thakurgaon	11.60 a	13.45	10.30 a	0.30	0.77 b	36.42
LSD	1.938	5.422	2.243	0.126	0.303	
CV%	9.8	22.6	12.01	21.64	16.08	
Significance level	**	Ns	*	Ns	**	

** significant at 1% level, *significant at 5% level, ns= not significant

4.4 Best/Clean Seed Recovered

Best or clean seed and its frequency of occurrence in breeder seed and farmer seed are presented in (Tables 6-7). In breeder seed, best or clean seed recovered from BARI, Gazipur and RARS, Ishurdi ranged from 84.47-96.57 % and 92.10-95.47 %, respectively. Incase of farmer seed, it was 54.73-68.40%. The highest amount of recovery of best seed varied significantly depending on the variety. In general, higher quantity of best/clean seed was recovered from breeder seed in compared to farmer seed.

4.4.1 Breeder seed:

Percentage of clean/best seed recovered from BARI, Gazipur ranged between 84.47-96.57. The average percentage recovery of best or clean seed from BARI, Gazipur was 92.26. The maximum percentage of best/clean seed recovered from the seed of variety improved Tori-7 (96.57%), followed by BARI Sharisha -10 (94.90%) and BARI Sharisha - 15 (93.77%); whereas the lowest was in BARI Sharisha -13 (84.47%). Percentage of best or clean seed recovered from RARS, Ishurdi ranged from 92.10-95.47. On the other hand, average percentage recovery of best or clean seed from RARS, Ishurdi was 93.96. Incase of RARS, Ishurdi the highest (95.47%) percentage of best or clean seed was recovered from the seeds of variety BARI Sharisha -11 and lowest (92.10%) percentage in BARI Sharisha -13.The average percentage of best or clean seed recovered from two research stations was 93.11(Table-6).

Table 6. Best or clean (Percent of apparently healthy seed) recovered from breeder seed collected from BARI, Gazipur and RARS Ishurdi

Variety	Location	
	BARI, Gazipur	RARS, Ishurdi
BARI Sharisa -6	93.47 a	-
BARI Sharisa -9	91.10 a	93.97 ab
BARI Sharisa -10	94.90 a	-
BARI Sharisa -11	92.73 a	95.47 a
BARI Sharisa -12	91.17 a	-
BARI Sharisa -13	84.47 b	92.10 b
BARI Sharisa -14	92.20 a	94.37 a
BARI Sharisa -15	93.77 a	93.90 ab
Improved Tori -7	96.57 a	-
Average	92.26	93.96
LSD	5.339	2.029
CV%	3.34	1.15
Significance level	*	*

*significant at 5% level,

(-) Indicate that varieties were not available.

4.4.2 Farmer seed:

Percentage of best or clean seed sorted out manually from farmer seed ranged from 54.73- 68.40 %. The occurrence varied with respect to locations of seed collection. The average percentage of best or clean seed recovered from farmer seed was 60.26. Out of the four locations, two had more than 60.00% best or clean seed. The two locations were Manikgonj (61.83%) and Tangail (68.40%). And rest of the two locations had less than 60.00% best or clean seed. The two locations were Naogaon (56.07%) and Thakurgaon (54.73%). On an average, 60.26% best seed was recovered from farmer seed by manual seed cleaning (Table - 7).

Table 7. Best or clean seed recovered from farmers level

Location	% best or clean seed
Manikgonj	61.83 b
Naogaon	56.07 bc
Tangail	68.40 a
Thakurgaon	54.73 c
Range	54.73-68.40
LSD	6.397
CV%	5.31%
Significance level	**

** significant at 1% level.

4.5 Prevalence of Fungi

Altogether 11 species of fungi representing six genera were detected in breeder and farmer seed of mustard studied in the present investigation. Eleven fungi identified were – *Alternaria brassicae*, *A. brassicicola*, *A.tenuis*, *Aspergillus flavus*, *Aspergillus niger*, *Chaetomium sp.*, *Fusarium moniliformae*, *Fusarium oxysporum*, *Fusarium solani*, *Penicillium sp.* and *Phoma lingum*. Of all these, five predominant fungi, in order of prevalence, were *Aspergillus flavus* (28.3%), *Fusarium solani* (25.4%), *Penicillium sp.* (14.7%), *Alternaria brassicae* (9.9%) and *Alternaria brassicicola* (7.4%). These five predominant fungi[1] constituted 85.7% of the total seed borne fungal infections and at least 2.7% of the seeds yielded each of these fungi (Table - 8).

[1]Predominant fungus one which constitutes at least 5% of the total seed borne fungal infections and at least 2.7% of the seeds yielded it.

Table 8. Frequency of occurrence of various fungi recorded in breeder and farmer seed of mustard collected from different research stations and locations of Bangladesh

Fungi	Total no. of fungal infection	% infection of total infected seeds [a]	% infection of total seeds [b]
Alternaria brassicae	790	9.9	3.7
Alternaria brassicicola	592	7.4	2.7
Alternaria tenuis	246	3.1	1.1
Aspergillus flavus	2266	28.3	10.5
Aspergillus niger	274	3.4	1.3
Chaetomium sp.	31	0.4	0.1
Fusarium moniliformae	207	2.6	1.0
Fusarium oxysporum	221	2.8	1.0
Fusarium solani	2033	25.4	9.4
Penicillium sp.	1178	14.7	5.5
Phoma lingum	166	2.1	0.8

Where

[a] Total number of fungal infection was 8004.

[b] Percentage of seeds yielding different fungal organisms was calculated on the basis of 21600 seeds.

4.5.1 Prevalence of Individual Fungi:

The prevalence of individual fungi varied with respect to variety, seed tier, location of seed collection and seed cleanliness. Of the total eleven individual fungi detected in mustard seeds, all were detected in unclean seed, while only eight were found in clean seed. Occurrence of the five predominant fungi was always higher in unclean seed compared to clean seed in all the varieties of the two tiers and at all the locations (Tables 9-15).

Table 9. Occurrence of various fungi detected in unclean and clean mustard seed collected from breeder and farmers level

Sl. No.	Fungi detected in	
	Unclean	**Clean**
01.	*Alternaria brassicae*	*Alternaria brassicae*
02.	*Alternaria brassicicola*	*Alternaria brassicicola*
03.	*Alternaria tenuis*	*Alternaria tenuis*
04.	*Aspergillus flavus*	*Aspergillus flavus*
05.	*Aspergillus niger*	*Aspergillus niger*
06.	*Chaetomium sp.*	-
07.	*Fusarium moniliformae*	-
08.	*Fusarium oxysporum*	-
09.	*Fusarium solani*	*Fusarium solani*
10.	*Penicillium sp.*	*Penicillium sp.*
11.	*Phoma lingum*	*Phoma lingum*

(-) indicates that the fungus was not present.

4.5.2 Predominant Fungi in Breeder Seed

4.5.2.1 BARI, Gazipur (Unclean seed):

The prevalence of predominant fungi observed in unclean seed varied significantly with each other depending on the variety. Of the five predominant fungal pathogens, *Aspergillus flavus* was the most predominant fungus in unclean seed. The incidence of the fungus ranged between 4.94-24.67%. The highest occurrence of *Aspergillus flavus* was recorded from BARI Sharisha-10 (24.68 %) and the lowest was encountered in BARI Sharisha -11(4.94%). The highest count of *Alternaria brassicae* was recorded in BARI Sharisha-9 (7.13%), while the lowest was encountered in BARI Sharisha-6 (2.74%). The highest and lowest prevalence of *Alternaria brassicicola* was observed in BARI Sharisha-12 (6.58%) and BARI Sharisha-15 (1.09%), respectively. The highest seed borne infection of *Fusarium solani* was found in BARI Sharisha-12 (7.68%), while the lowest was detected in BARI Sharisha-13(1.65%). The occurrence of *Penicillium sp.* ranged from 4.94% in BARI Sharisha-10 & BARI Sharisha-12 to 12.61% in BARI Sharisha-14(Table- 10).

Table 10. Percent seed-borne infection of the five predominant fungi detected in unclean breeder seed at BARI, Gazipur

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
BARI Sharisa -6	2.74 f	2.19 g	6.03 c	18.64 b	9.32 d
BARI Sharisa -9	7.13 a	6.03 b	3.29 g	15.35 d	8.23 e
BARI Sharisa -10	3.29 e	3.84 d	4.94 d	24.68 a	4.94 f
BARI Sharisa -11	3.29 e	3.84 d	6.58 b	4.94 h	9.87 c
BARI Sharisa -12	4.94 c	6.58 a	7.68 a	7.13 g	4.94 f
BARI Sharisa -13	4.39 d	4.39 c	1.65 h	8.77 f	9.87 c
BARI Sharisa -14	4.94 c	2.74 f	4.39 e	7.13 g	12.61 a
BARI Sharisa -15	5.48 b	1.09 h	4.94 d	17.00 c	9.87 c
Improved Tori-7	5.48 b	3.29 e	3.84 f	10.42 e	10.42 b
LSD	0.189	0.239	0.274	0.908	0.346
CV%	2.37	3.68	3.43	4.14	2.26
Significance level	**	**	**	**	**

** significant at 1% level.

Table 10. Percent seed-borne infection of the five predominant fungi detected in unclean breeder seed at BARI, Gazipur

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Penicillium* sp.
BARI Sharisa -6	2.74 f	2.19 g	6.03 c	18.64 b	9.32 d
BARI Sharisa -9	7.13 a	6.03 b	3.29 g	15.35 d	8.23 e
BARI Sharisa -10	3.29 e	3.84 d	4.94 d	24.68 a	4.94 f
BARI Sharisa -11	3.29 e	3.84 d	6.58 b	4.94 h	9.87 c
BARI Sharisa -12	4.94 c	6.58 a	7.68 a	7.13 g	4.94 f
BARI Sharisa -13	4.39 d	4.39 c	1.65 h	8.77 f	9.87 c
BARI Sharisa -14	4.94 c	2.74 f	4.39 e	7.13 g	12.61 a
BARI Sharisa -15	5.48 b	1.09 h	4.94 d	17.00 c	9.87 c
Improved Tori-7	5.48 b	3.29 e	3.84 f	10.42 e	10.42 b
LSD	0.189	0.239	0.274	0.908	0.346
CV%	2.37	3.68	3.43	4.14	2.26
Significance level	**	**	**	**	**

** significant at 1% level.

4.5.2.2 BARI,Gazipur (Clean seed):

The prevalence of predominant fungi encountered in clean seed differed significantly from one another with respect to variety. The highest occurrence of *Aspergillus flavus* in clean seed was recorded from BARI Sharisha-15 (11.52%) and the lowest was encountered in BARI Sharisha -11(2.19%). In case of *Alternaria brassicae* the highest (2.74%) record of the fungus was observed in BARI Sharisha-11 and the lowest (1.09%) in BARI Sharisha-6, BARI Sharisha-10 and BARI Sharisha-14. The maximum incidence of *Alternaria brassicicola* was recorded in BARI Sharisha-12 (4.39%) and the minimum in BARI Sharisha-15(0.55%). The highest and the lowest occurrence of the pathogen *Fusarium solani* was encountered in BARI Sharisha-12 (5.48%) and BARI Sharisha-13 (0.55%), respectively. In case of *Penicillium sp.*, the lowest percent (3.29%) of infection was observed in BARI Sharisha-12 and the highest (8.23%) in BARI Sharisha-15(Table-11).

Table 11. Percent seed-borne infection of the five predominant fungi detected in clean breeder seed at BARI, Gazipur

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
BARI Sharisa -6	1.09 d	1.09 e	2.19 c	9.87 b	4.94 d
BARI Sharisa -9	2.19 b	3.84 b	1.65 d	3.84 f	4.39 e
BARI Sharisa -10	1.09 d	2.19 c	1.09 e	9.32 c	3.84 f
BARI Sharisa -11	2.74 a	1.09 e	4.39 b	2.19 h	7.68 b
BARI Sharisa -12	1.65 c	4.39 a	5.48 a	4.39 e	3.29 g
BARI Sharisa -13	2.74 a	1.65 d	0.55 f	3.84 f	7.13 c
BARI Sharisa -14	1.09 d	1.09 e	1.65 d	3.29 g	8.23 a
BARI Sharisa 15	2.19 b	0.55 f	2.19 c	11.52 a	3.84 f
Improved Tori-7	1.66 c	1.65 d	2.19 c	7.68 d	7.13 c
LSD	0.095	0.182	0.226	0.471	0.263
CV%	2.96	5.38	5.10	4.37	2.72
Significance level	**	**	**	**	**

** significant at 1% level.

4.5.2.3 RARS, Ishurdi (Unclean seed):

The occurrence of predominant fungi varied significantly from one another depending on the variety. Of the five predominant fungi, *Aspergillus flavus* was the most predominant fungus in unclean seed. The incidence of the fungus ranged between 7.79-25.05%. The highest and the lowest occurrence of *Aspergillus flavus* was recorded in BARI Sharisha-15 (25.05%) and in BARI Sharisha-11(7 .79%).The highest count of *Alternaria brassicae* was recorded in BARI Sharisha-13 (6.13%), while the lowest count was made in BARI Sharisha-9 (2.79%).

The highest and the lowest prevalence of *Alternaria brassicicola* was observed in BARI Sharisha-13 (24.49%) and BARI Sharisha-15 (4.45%), respectively. The highest seed borne infection of *Fusarium solani* was found in BARI Sharisha-13 (16.70%), while the lowest (6.13%) was detected in BARI Sharisha-9. The occurrence of *Penicillium sp.* ranged from 9.47% in BARI Sharisha-9 to 22.83% in BARI Sharisha-14(Table-12).

Table 12. Percent seed-borne infection of the five predominant fungi detected in uncleaan breeder seed at RARS, Ishurdi

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
BARI Sharisa -9	2.79 d	11.13 c	6.13 d	8.35 c	9.47 e
BARI Sharisa -11	3.90 c	15.03 b	15.59 b	7.79 c	20.04 b
BARI Sharisa -13	6.13 a	24.49 a	16.70 a	18.37 b	16.15 d
BARI Sharisa -14	3.90 c	11.69 c	9.47 c	18.37 b	22.83 a
BARI Sharisa -15	5.01 b	4.45 d	10.02 c	25.05 a	18.37 c
LSD	0.246	1.423	0.863	1.438	0.982
CV%	3.02	5.65	4.96	4.90	3.00
Significance level	**	**	**	**	**

** significant at 1% level.

4.5.2.4 RARS, Ishurdi (Clean seed):

The occurrence of predominant fungi also differed significantly from one another with respect to variety. Of the five predominant fungi, *Aspergillus flavus* was the most predominant fungus in clean seed. The incidence of the fungus ranged between 4.45-18.37%. The highest and the lowest occurrence of *Aspergillus flavus* was recorded in BARI Sharisha-15 (18.37%) and BARI Sharisha –11(4.45%). The highest and

the lowest record of the fungus *Alternaria brassicae* was noted in BARI Sharisha-15 (2.79%) and BARI Sharisha-14 (0.56%). The maximum incidence of the pathogen *Alternaria brassicicola* was recorded in BARI Sharisha-14 (9.47%) and the minimum in BARI Sharisha-15(2.79%). In case of *Fusarium solani*, the highest and the lowest occurrence of the pathogen were encountered in BARI Sharisha-11 (8.91%) and BARI Sharisha-9 (2.23%), respectively. In case of *Penicillium sp.*, the lowest (5.01%) incidence of seed borne infection was observed in BARI Sharisha-9 and the highest (15.03%) incidence in BARI Sharisha-14 (Table -13).

Table 13. Percent seed-borne infection of the five predominant fungi detected in clean breeder seed at RARS, Ishurdi

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
BARI Sharisa -9	1.67 c	6.68 c	2.23 e	5.57 c	5.01 e
BARI Sharisa -11	1.11 d	5.01 d	8.91 a	4.45 c	12.81 b
BARI Sharisa -13	2.23 b	7.24 b	7.24 b	17.26 a	10.02 d
BARI Sharisa -14	0.56 e	9.47 a	4.45 c	15.59 b	15.03 a
BARI Sharisa -15	2.79 a	2.79 e	3.90 d	18.37 a	11.69 c
LSD	0.168	0.487	0.523	1.303	0.734
CV%	5.44	4.14	5.20	5.65	3.57
Significance level	**	**	**	**	**

** significant at 1% level.

the lowest record of the fungus *Alternaria brassicae* was noted in BARI Sharisha-15 (2.79%) and BARI Sharisha-14 (0.56%). The maximum incidence of the pathogen *Alternaria brassicicola* was recorded in BARI Sharisha-14 (9.47%) and the minimum in BARI Sharisha-15(2.79%). In case of *Fusarium solani*, the highest and the lowest occurrence of the pathogen were encountered in BARI Sharisha-11 (8.91%) and BARI Sharisha-9 (2.23%), respectively. In case of *Penicillium sp.*, the lowest (5.01%) incidence of seed borne infection was observed in BARI Sharisha-9 and the highest (15.03%) incidence in BARI Sharisha-14 (Table -13).

Table 13. Percent seed-borne infection of the five predominant fungi detected in clean breeder seed at RARS, Ishurdi

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium* sp.
BARI Sharisa -9	1.67 c	6.68 c	2.23 e	5.57 c	5.01 c
BARI Sharisa -11	1.11 d	5.01 d	8.91 a	4.45 c	12.81 b
BARI Sharisa -13	2.23 b	7.24 b	7.24 b	17.26 a	10.02 d
BARI Sharisa -14	0.56 e	9.47 a	4.45 c	15.59 b	15.03 a
BARI Sharisa -15	2.79 a	2.79 e	3.90 d	18.37 a	11.69 c
LSD	0.168	0.487	0.523	1.303	0.734
CV%	5.44	4.14	5.20	5.65	3.57
Significance level	**	**	**	**	**

** significant at 1% level.

4.5.3 Prevalence of Predominant Fungi in Farmer Seed:

The frequency of occurrence of the five predominant fungi varied significantly with respect to location and seed cleanliness. Occurrence of the five predominant fungi were always higher in unclean seed compared to clean seed at all the four locations (Table 14-15).

4.5.3.1 Unclean seed:

In unclean seed, the highest count of *Alternaria brassicae* was recorded at Naogaon (13.32%), followed by Tangail (9.32%) and Manikgonj (3.1%); while the lowest was encountered at Thakurgaon (2.88%). The highest occurrence of *Alternaria brassicicola* was recorded at Tangail (12.22%) and the lowest at Thakurgaon (5.1%). The highest seed borne infection of *Fusarium solani* was found at Tangail (36.18%), while the lowest was detected at Thakurgaon (24.86%). The highest and the lowest prevalence of *Aspergillus flavus* was observed at Thakurgaon (36.62%) and Tangail (18.64%), respectively. The occurrence of *Penicillium sp.* ranged from 3.34% at Naogoan to 22.64% at Thakurgaon(Table - 14).

Table 14. Prevalence of five predominant fungi detected in farmer unclean mustard seed of variety Tori-7 collected from four districts of Bangladesh

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
Manikgonj	3.10 c	9.10 b	33.74 b	18.88 c	8.44 c
Naogaon	13.32 a	11.98 a	30.20 c	23.54 b	3.34 d
Tangail	9.32 b	12.22 a	36.18 a	18.64 c	19.32 b
Thakurgaon	2.88 c	5.10 c	24.86 d	36.62 a	22.64 a
lsd	0.549	0.357	0.5359	1.656	0.980
CV%	8.13	3.95	1.82	6.31	7.75
Significance level	**	**	**	**	**

** significant at 1% level.

4.5.3.2 Clean seed

The highest and the lowest occurrence of the predominant fungus, *Alternaria brassicae* were recorded in clean seed at Naogaon (10.22%) and Thakurgaon (2.0%), respectively. The highest frequency of occurrence of *Alternaria brassicicola* was observed at Naogaon (7.23%) followed by Tangail (4.66%), Manikgonj(3.98%) and Thakurgaon (3.56%).The highest observation of the fungus *Fusarium solani* was noted at Manikgonj (20.64%), while the lowest was detected at Thakurgaon (13.32%). The maximum incidence of the pathogen *Aspergillus flavus* was recorded at Thakurgaon (30.20%) and the minimum at Naogoan (8.66%). In case of *Penicillium sp.* the maximum occurrence of the pathogen was counted at Thakurgaon (8.66%) and the lowest was found at Naogoan (1.34%), (Table-15).

Table 15. Prevalence of five predominant fungi detected in farmers clean mustard seed of variety Tori-7 collected from four districts of Bangladesh

Variety	*Alternaria brassicae*	*Alternaria brassicicola*	*Fusarium solani*	*Aspergillus flavus*	*Pencillium sp.*
Manikgonj	2.22 c	3.98 c	20.64 a	17.1 b	4.88 c
Naogaon	10.22 a	7.32 a	19.32 b	8.66 d	1.34 d
Tangail	5.1 b	4.66 b	17.1 c	11.32 c	7.54 b
Thakurgaon	2.00 c	3.56 d	13.32 d	30.20 a	8.66 a
lsd	0.413	0.188	0.347	1.035	0.357
CV%	8.97	4.04	2.11	6.54	6.73
Significance level	**	**	**	**	**

** significant at 1% level.

4.6 Germination

Percentage of normal seedling, abnormal seedling and dead seed recorded in unclean and clean seeds in the germination test varied significantly with respect to variety, location and seed cleanliness. In general, higher percentage of normal seedlings and lower percentage of abnormal seedlings and dead seeds were observed in clean seed compared to unclean seed in all the varieties of breeder and farmer seed at all the locations (Figs. 4-12).

4.6.1 Breeder seed (BARI, Gazipur)

Percentage of normal seedling, abnormal seedling and dead seed recorded in unclean and clean breeder seed collected from BARI, Gazipur are presented in Figs. 4-6.

4.6.1.1 Normal seedling

In case of unclean seed the highest count of normal seedlings was obtained in BARI Sharisha-15 (92%), followed by BARI Sharisha-6 & 11 (90.75%); whereas the lowest incidence of normal seedlings was observed in unclean seed of BARI Sharisha-9 (86%). On the other hand, highest count of normal seedlings in clean seed was recorded in BARI Sharisha-12 (95.25%), followed by improved Tori-7 (94.25%), while the lowest count (90%) of normal seedlings was found in BARI Sharisha-9 (Fig. 4).

4.6.1.2 Abnormal seedling

The highest count of abnormal seedlings was found in unclean seed of BARI Sharisha-14 (4.25%), followed by BARI Sharisha-10 (4%);

whereas the lowest (2.75%) incidence of abnormal seedlings was observed in BARI Sharisha-12 & 13. In case of clean seed, the highest count of abnormal seedlings was obtained in BARI Sharisha-10 (3.5%), followed by BARI Sharisha-9 & 14 (3%); while the lowest incidence (2%) of abnormal seedlings were recorded in BARI Sharisha-11 and BARI Sharisha-15 (Fig 5).

4.6.1.3 Dead seed

The highest count of dead seed was found in unclean seed of BARI Sharisha-9 (10.5%), while the lowest incidence of dead seed was encountered in improved Tori-7 (4.75%). In case of clean seed the highest incidence was obtained in BARI Sharisha-9 (7%), followed by BARI Sharisha-10 (5.75%); while the minimum percentage of dead seed (2.5%) was recorded in BARI Sharisha-12 (Fig. 6).

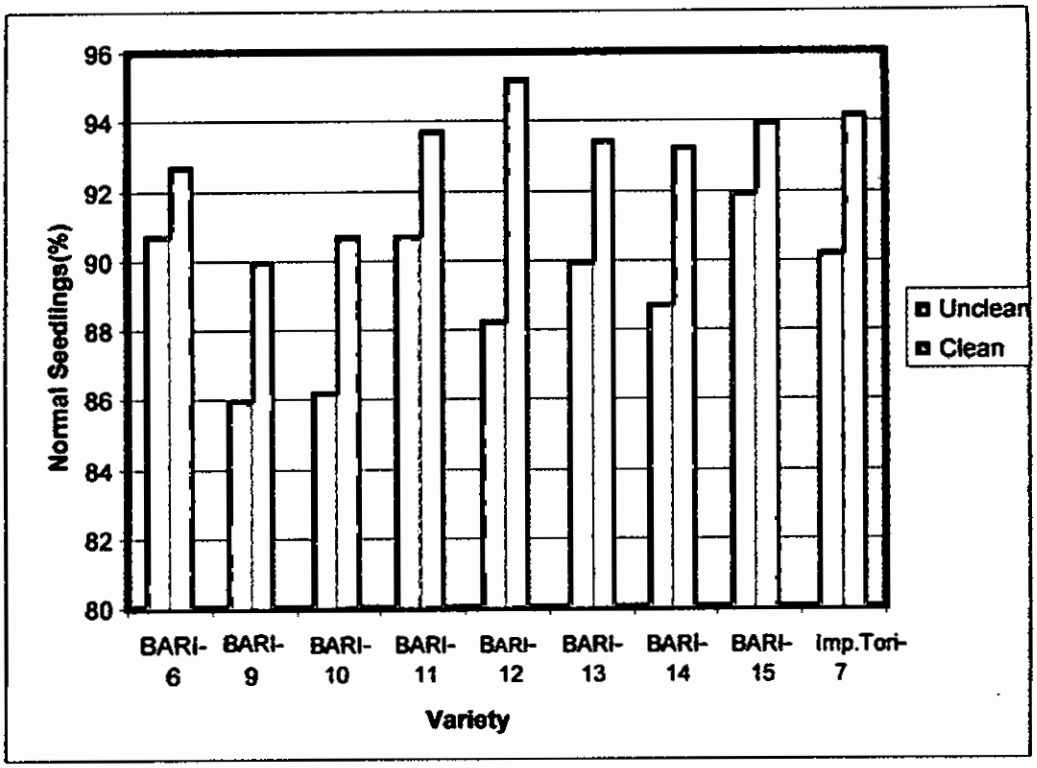

Fig 4. Normal seedling recorded in unclean and clean breeder seed of mustard collected from BARI, Gazipur

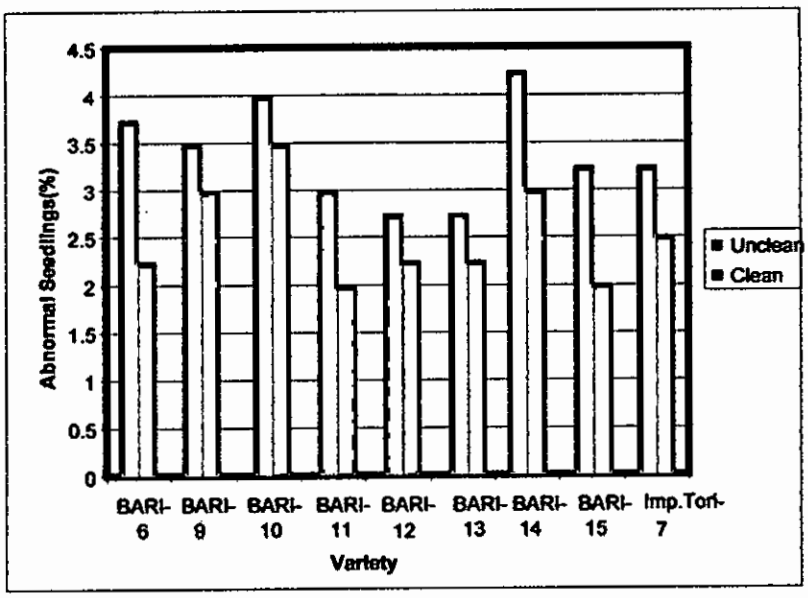

Fig 5. Abnormal seedling recorded in unclean and clean breeder seed of mustard collected from BARI, Gazipur

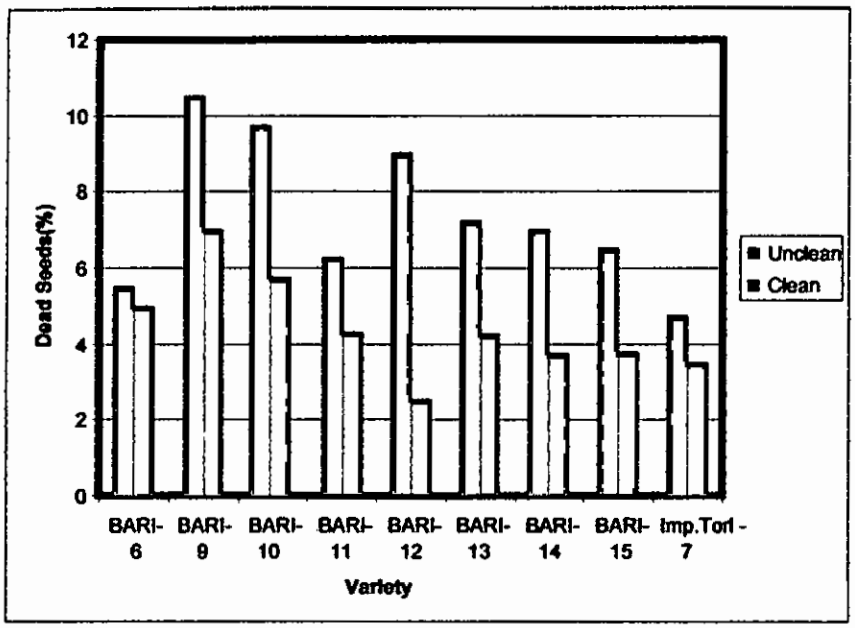

Fig 6. Dead seed recorded in unclean and clean breeder seed of mustard collected from BARI, Gazipur

4.6.2 Breeder seed (RARS, Ishurdi)

Percentage of normal seedling, abnormal seedling and dead seed recoded in unclean and clean breeder seed collected from RARS, Ishurdi are included in Figs.7-9.

4.6.2.1 Normal seedling

The highest count of normal seedlings was obtained in unclean seed in BARI Sharisha-13 (89.25%), followed by BARI Sharisha-9 and BARI Sharisha-15 (87.25%); whereas the lowest (84.75%) incidence of normal seedlings was observed in unclean seed in BARI Sharisha-14. On the other hand, highest count of normal seedlings in clean seed was recorded in BARI Sharisha-13 (94.25%), followed by BARI Sharisha-15 (93%)

in BARI Sharisha-13 (94.25%), followed by BARI Sharisha-15 (93%) and BARI Sharisha-9 (92.75%); while the lowest count (90%) of normal seedlings was found in BARI Sharisha-11 (Fig. 7).

4.6.2.2 Abnormal seedling

The highest occurrence of abnormal seedlings was noted in unclean seed of BARI Sharisha-15 (5%), followed by BARI Sharisha-14 (4.25%); whereas the lowest (3.5%) incidence of abnormal seedlings was observed in BARI Sharisha-9 & 11. In case of clean seed, the highest count of abnormal seedlings were obtained in BARI Sharisha-15 (4.75%), followed by BARI Sharisha-14 (4.5%); while the lowest incidence (2.25%) of abnormal seedlings was recorded in BARI Sharisha-13 (Fig. 8).

4.6.2.3 Dead seed

The highest prevalence incidence of dead seed was found in unclean seed of BARI Sharisha-14 (11.0%), while the lowest occurrence of dead seeds was encountered in BARI Sharisha-13 (7%). In case of clean seed, highest count of dead seed was obtained in BARI Sharisha-11 (7.5%), followed by BARI Sharisha-14 (4.75%); while the minimum percentage of dead seed (2.25%) was recorded in BARI Sharisha-15 (Fig. 9).

in BARI Sharisha-13 (94.25%), followed by BARI Sharisha-15 (93%) and BARI Sharisha-9 (92.75%) while the lowest count (90%) of normal seedlings was found in BARI Sharisha-11 (Fig. 7).

4.6.2.2 Abnormal seedling

The highest occurrence of abnormal seedlings was noted in unclean seed of BARI Sharisha-15 (5%), followed by BARI Sharisha-14 (4.25%), whereas the lowest (3.5%) incidence of abnormal seedlings was observed in BARI Sharisha-9 & 11. In case of clean seed, the highest count of abnormal seedlings were obtained in BARI Sharisha-15 (4.75%), followed by BARI Sharisha-14 (4.5%); while the lowest incidence (2.25%) of abnormal seedlings was recorded in BARI Sharisha-13 (Fig. 8).

4.6.2.3 Dead seed

The highest prevalence incidence of dead seed was found in unclean seed of BARI Sharisha-14 (11.0%), while the lowest occurrence of dead seeds was encountered in BARI Sharisha-13 (7%). In case of clean seed, highest count of dead seed was obtained in BARI Sharisha-11 (7.5%), followed by BARI Sharisha-14 (4.75%); while the minimum percentage of dead seed (2.25%) was recorded in BARI Sharisha-15 (Fig. 9).

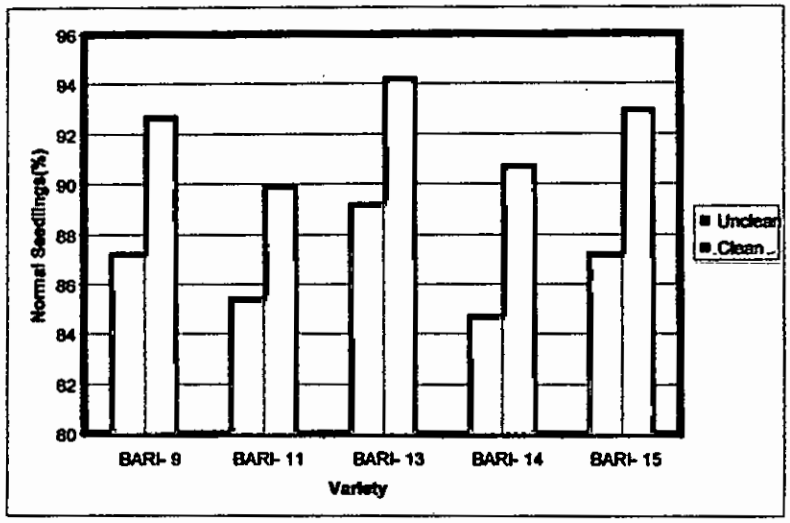

Fig 7: Normal seedling recorded in unclean and clean breeder seed of mustard collected from RARS, Ishurdi

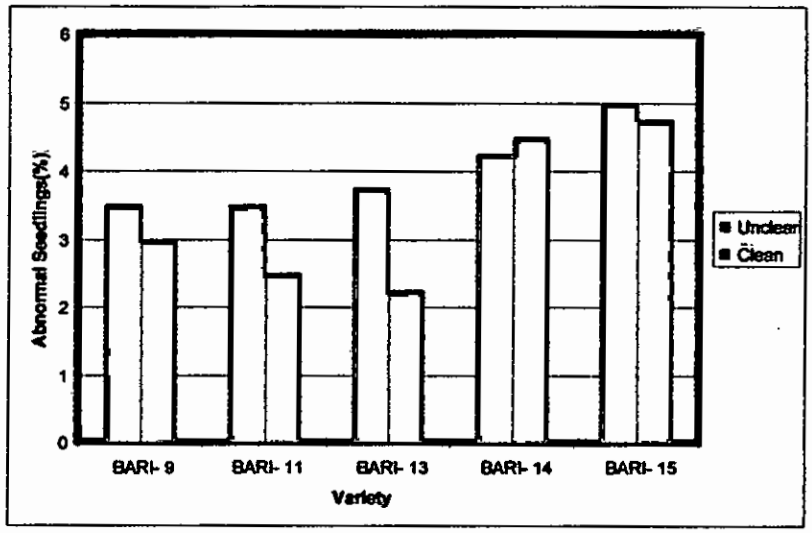

Fig 8. Abnormal seedling recorded in unclean and clean breeder seed of mustard collected from RARS, Ishurdi

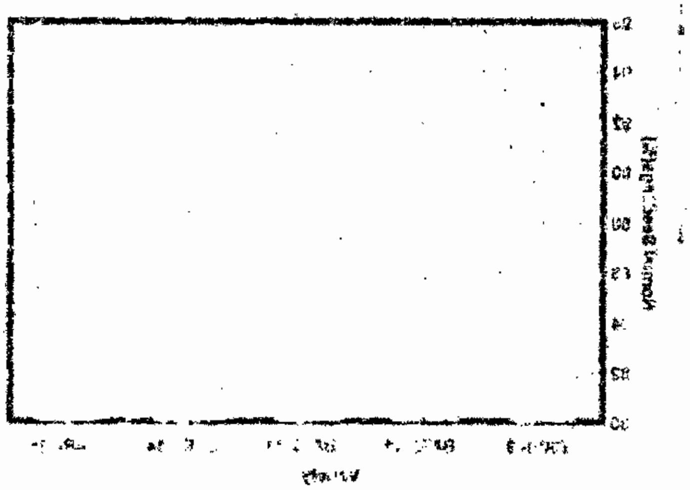

Fig 7: Normal seedling record.d in unclean and clean breeder seed of mustard collected from RARS. Ishurdi

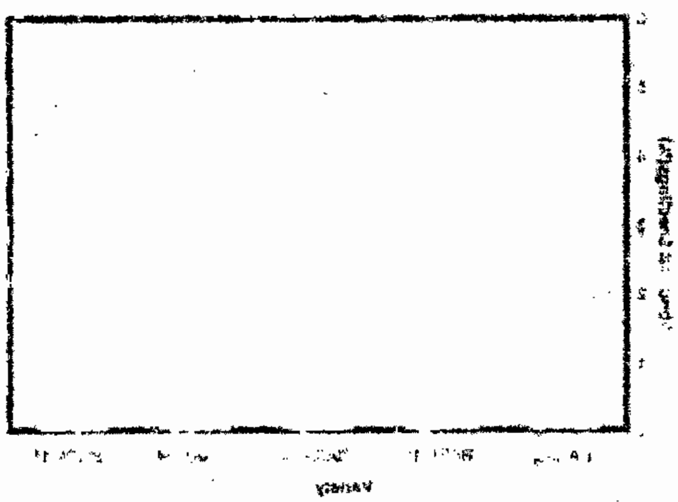

Fig 8. Abnormal seedling recorded in unclean and clean breeder seed of mustard collected from RARS. Ishurdi

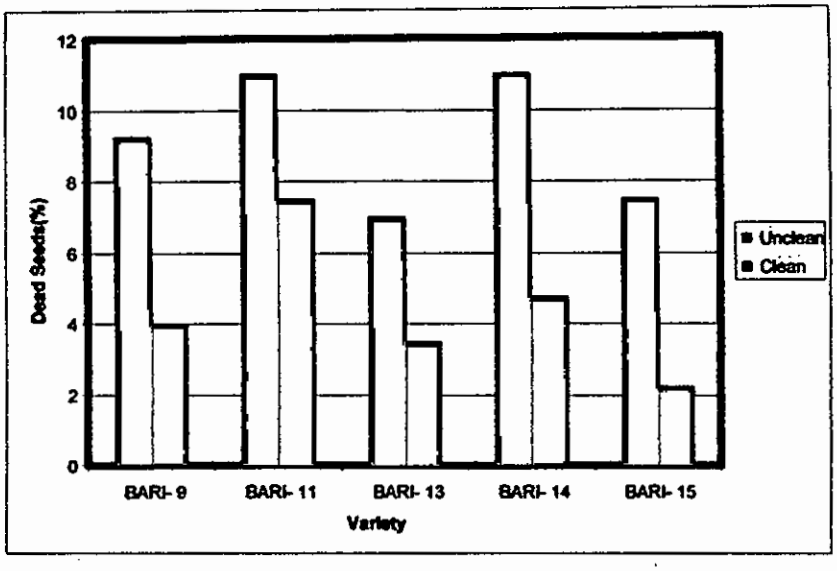

Fig 9. Dead seed recorded in unclean and clean breeder seed of mustard collected from RARS, Ishurdi

4.6.3 Farmer seed

Occurrence of normal seedling, abnormal seedling and dead seed recoded in unclean and clean farmer seed collected from four districts of Bangladesh are presented in Figs. 10-12.

4.6.3.1 Normal seedling

The highest count of normal seedlings was obtained in unclean seed at Naogaon (74.03%), followed by Manikgonj (71.15%) and Thakurgaon (69.95%); whereas the lowest (68.45%) incidence of normal seedlings was observed in unclean seed at Tangail. On the other hand, highest count of normal seedlings in clean seed was recorded at Tangail (88.23%), followed by Thakurgaon (87.58%) and Naogaon (87.05%); while the lowest count (85.7%) of normal seedlings was found at Manikgonj (Fig 10).

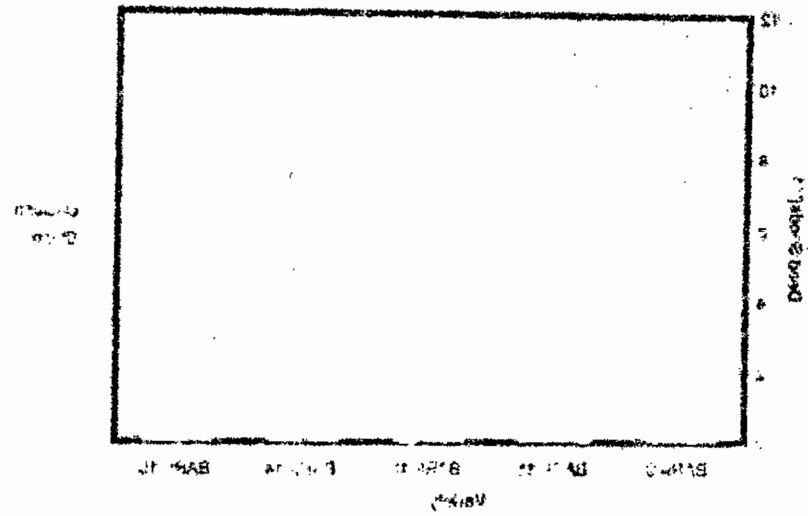

Fig 9. Dead seed recorded in unclean and clean breeder seed of mustard collected from RARS, Ishurdi

4.6.3 Farmer seed

Occurrence of normal seedling, abnormal seedling and dead seed recoded in unclean and clean farmer seed collected from four districts of Bangladesh are presented in Figs. 10-12.

4.6.3.1 Normal seedling

The highest count of normal seedlings was obtained in unclean seed at Naogaon (74.03%), followed by Manikgonj (71.15%) and Thakurgaon (69.95%); whereas the lowest (68.45%) incidence of normal seedlings was observed in unclean seed at Tangail. On the other hand, highest count of normal seedlings in clean seed was recorded at Tangail (88.23%), followed by Thakurgaon (87.58%) and Naogaon (87.05%); while the lowest count (85.7%) of normal seedlings was found at Manikgonj (Fig 10).

4.6.3.2 Abnormal seedling

The highest count of abnormal seedlings was marked in unclean seed at Tangail (14.65%), followed by Thakurgaon (13.93%) and Naogaon (13.48%); whereas the lowest (13.03%) incidence of abnormal seedlings was observed at Manikgonj. In case of clean seed, the highest count of abnormal seedlings was obtained at Thakurgaon (6.65%), followed by Tangail (6.5%) and Manikgonj (6.45%); while the lowest incidence (5.5%) of abnormal seedlings was recorded at Naogaon (Fig 11).

4.6.3.3 Dead seed

In unclean seed, the highest occurrence of dead seed was found at Tangail (16.9%); while the lowest incidence of dead seeds was encountered at Naogaon (12.2%). In case of clean seed, the highest count of dead seed was obtained at Manikgonj (7.85%), followed by Naogaon (7.45%) and Thakurgaon (5.78%); while the minimum percentage of dead seed (5.28%) was recorded at Tangail (Fig 12).

4.6.3.2 Abnormal seedling

The highest count of abnormal seedlings was marked in unclean seed at Tangail (14.65%), followed by Thakurgaon (13.93%) and Naogaon (13.48%); whereas the lowest (13.03%) incidence of abnormal seedlings was observed at Manikgonj. In case of clean seed, the highest count of abnormal seedlings was obtained at Thakurgaon (6.65%), followed by Tangail (6.5%) and Manikgonj (6.45%); while the lowest incidence (5.5%) of abnormal seedlings was recorded at Naogaon (Fig 11).

4.6.3.3 Dead seed

In unclean seed, the highest occurrence of dead seed was found at Tangail (16.9%); while the lowest incidence of dead seeds was encountered at Naogaon (12.2%). In case of clean seed, the highest count of dead seed was obtained at Manikgonj (7.85%), followed by Naogaon (7.45%) and Thakurgaon (5.78%); while the minimum percentage of dead seed (5.28%) was recorded at Tangail (Fig 12).

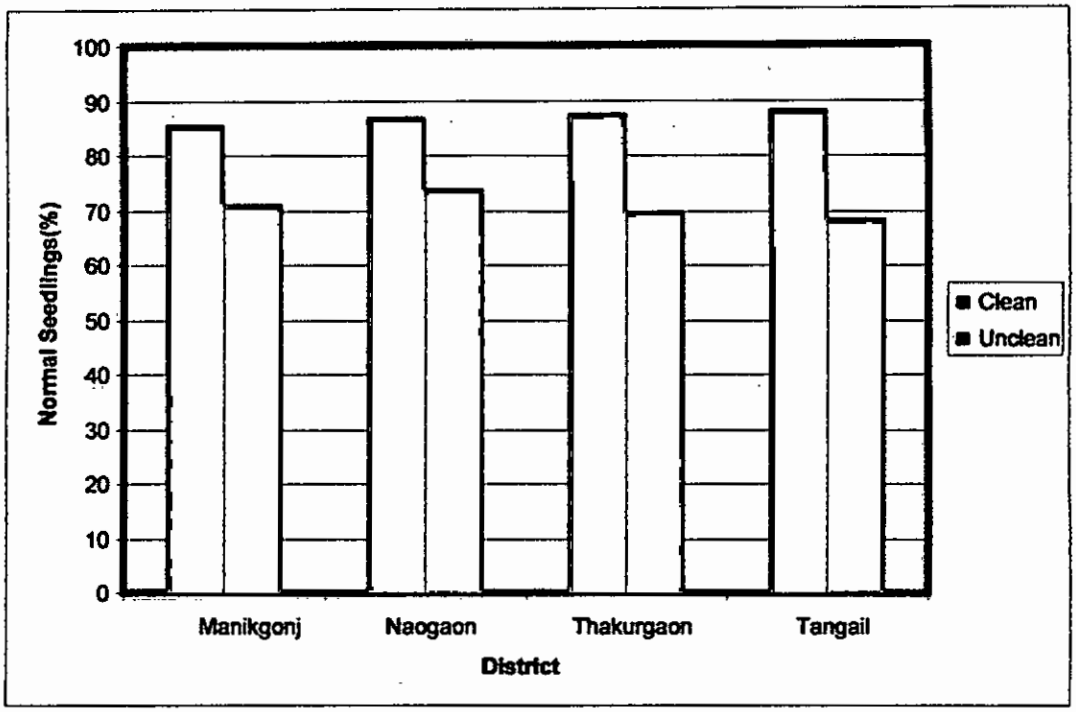

Fig 10: Normal seedling recorded in unclean and clean mustard seed of Tori-7 collected from four districts of Bangladesh

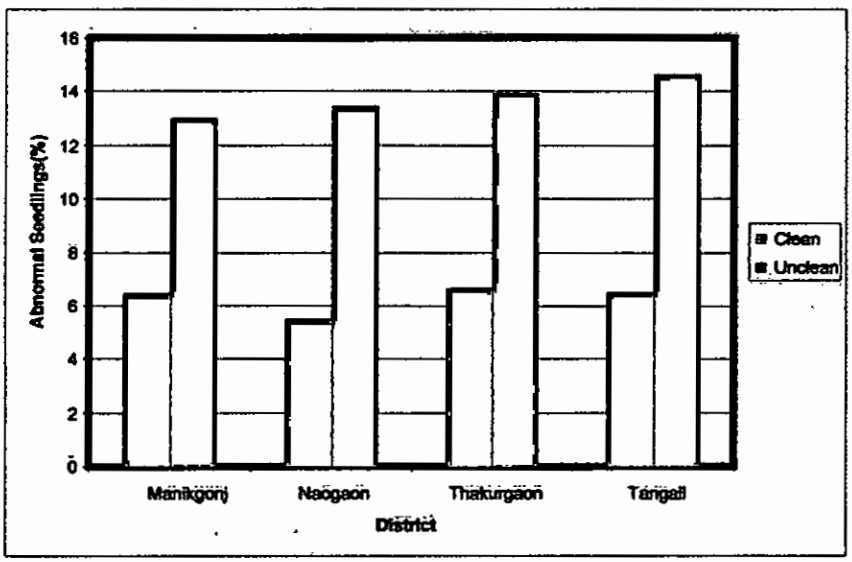

Fig 11. Abnormal seedling recorded in unclean and clean mustard seed of Tori-7 collected from four districts of Bangladesh

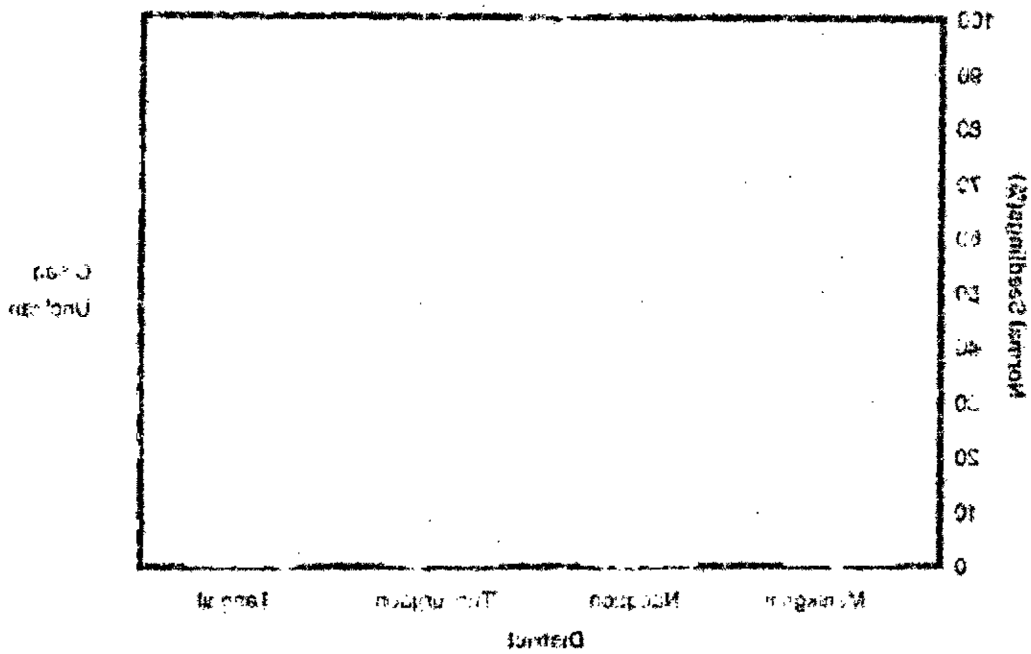

Fig 10: Normal seedling recorded in unclean and clean mustard seed of Tori-7 collected from four districts of Bangladesh

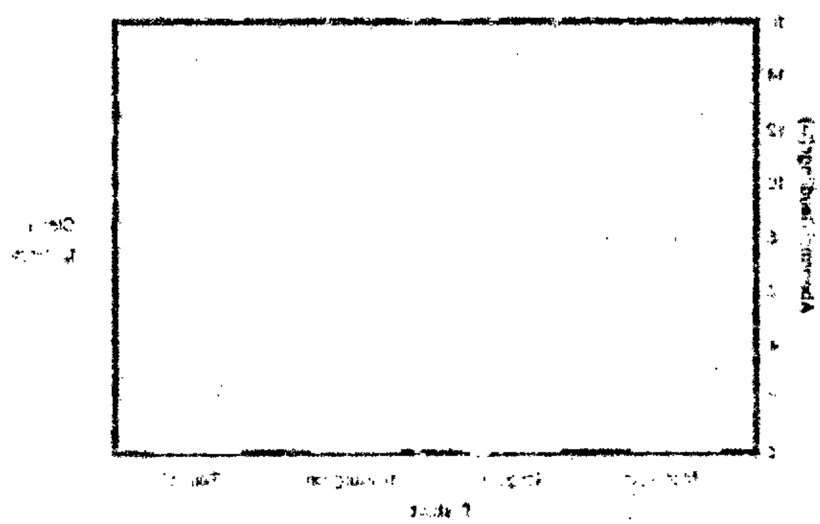

Fig 11: Abnormal seedling recorded in unclean and clean mustard seed of Tori-7 collected from four districts of Bangladesh

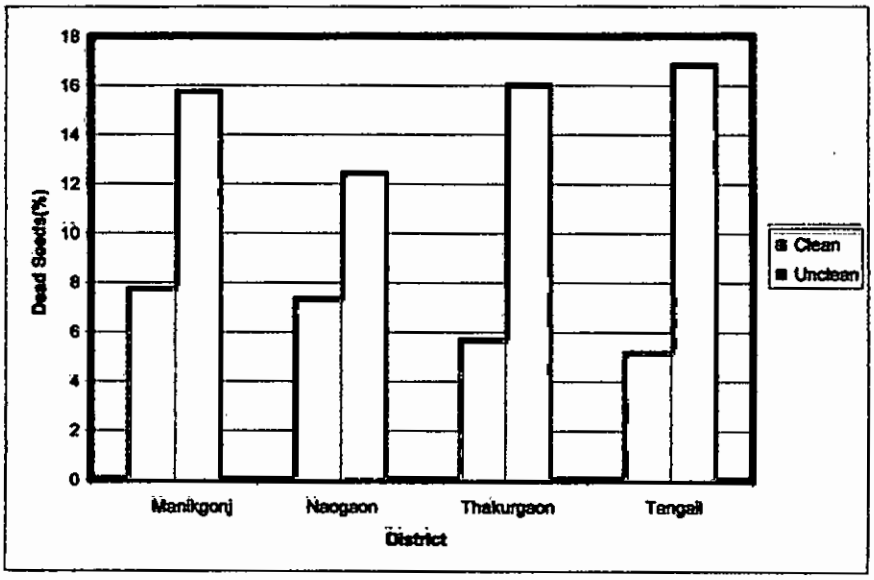

Fig 12. Dead seed recorded in unclean and clean mustard seed of Tori-7 collected from four districts of Bangladesh

Chapter 5

Discussion

5. Discussion.

From the results of seed quality analysis, it is found that the average moisture content of farmer's mustard seed was 8.0%, whereas breeder seed were 6.9% and 5.6% collected from BARI,Gazipur and RARS, Ishurdi respectively. Variation in moisture content of the seeds of farmer's seed and breeder seed observed probably due to the differences in the degree of drying of seeds. Again the difference in farmer seed could be due to the ignorance of the farmers about the deleterious effect of high moisture content in seeds. Or, it could be due to the exposure of seeds to foggy weather when mustard crop was harvested and processed. National standard for moisture content of mustard seed is 6%, but the moisture content data found in the present study indicated that some seed samples of farmer seed had higher moisture content than the national standard. Seed with high moisture content before storage is not safe for health of stored seed. Because mustard seed stored with higher moisture content is favourable to the attack of storage fungi and stored grain insects which sometimes cause marked losses through reduction in germination. (Christensen and Kaufmann, 1965; Islam *et al.*, 1991).

Seed contaminants viz. varietal mixture, other crop seed and inert matter occurred in most of the samples of farmer's seed collected from different districts, whereas only inert matter was found in breeder seed. These contaminants occurred in trace to appreciable extent depending on the type of contaminant, mustard variety and location of seed collection. This situation indicates that the farmer's mustard seed is not of good quality. Because, varietal mixture and other crop seed present in farmers seed sample may carry inocula of fungal pathogens like *Alternaria brassicae,*

A. brassicicola, Fusarium solani etc. The presence of seeds of other mustard varieties as well as the seeds of other crops in a given seed lot may affect the health of the seed lot, through mixture of seeds of susceptible varieties/crops with the saved seeds of a resistant variety.

Mustard seed with inert matter present in all the samples of farmer's seed and breeder seed analyzed may carry invisible spores of seed borne pathogenic fungi attacking mustard seed. This has not been investigated in mustard seed earlier or in the present study. But there is evidence that inert matter present in rice seed produced by the farmers of Bangladesh can carry propagules of *Bipolaris oryzae, Alternaria padwickii, Fusarium spp., Aspergillus spp.* and *Penicillium sp.* (Khokon *et al.*, 2005). Thus, the presence of inert matter in farmer's seed as well as breeder seed poses risk as regard to contamination of seed lot by the propagules of pathogenic fungi. Farmer's seed carries more risk in this regard as it contains larger quantity of inert matter compared to breeder seed. Therefore, studies need to be undertaken on the role of inert matter present in mustard seed in carrying pathogenic fungi.

The five types of abnormal seeds viz. discolored seed, undersized seed, shriveled seed, spotted seed and broken seed were present in farmer seed, whereas the breeder seeds contain all the type of abnormal seeds except broken one. The presence of broken seed in farmer seed could be due to careless threshing and processing operations of seed. Occurrence of abnormal seeds like undersized seed, discolored seed, shriveled seed, spotted seed and broken seed poses threat of carrying pathogens like *Alternaria spp.* which are responsible for causing leaf blight disease in the field. Similar result was found in wheat seed by Agarwal *et al.*, (1993).

On an average, approximately 93% best or clean seed could be recovered from the breeder seed, while in case of farmer seed it was approximately 60%. Thus, the study shows that almost 40% of the mustard seed produced by the farmers is discarded due to presence of abnormal seeds and seed contaminants. This shows that the farmer's seed is of poor quality in comparison with breeder seed. This is an alarming situation in mustard seed production for Bangladesh. This situation demands more careful attention to seed crop management and processing of seeds after harvest specially during cleaning operations.

Ten fungi were detected in unclean breeder seed, while 8 fungi, except *Fusarium moniliformae* and *Fusarium oxysporum* were encountered in the manually sorted out best or clean seed. In case of farmer's unclean seed a total number of eleven fungi were detected, while 8 fungi, except *Fusarium moriliformae*, *Fusanum oxysparum* and *Chaetomium sp.* were encountered in the manually sorted out best or clean seed. The cause of absence of those fungi in clean seed was probably due to the fact that seed cleaning processes might have eliminated them from the uncleaned seed.

Occurrence of the five predominant pathogenic fungi varied independently and significantly from one another with respect to variety, seed tier and location of seed collection. Variation in the prevalence of seed borne fungi with regard to geographic locations has been demonstrated earlier in a number of crops like rice, kaon, mustard, blackgram, wheat, jute, chili, zinnia, maize, barley, sorghum and cheena by different research workers in Bangladesh (Hossain *et al.*, 1977; Barma and Fakir, 1981; Dey and Fakir, 1988; Kabir and Fakir, 1988; Rahman *et*

On an average, approximately 93% best or clean seed could be recovered from the breeder seed, while in case of farmer seed it was approximately 60%. Thus, the study shows that almost 40% of the mustard seed produced by the farmers is discarded due to presence of abnormal seeds and seed contaminants. This shows that the farmer's seed is of poor quality in comparison with breeder seed. This is an alarming situation in mustard seed production for Bangladesh. This situation demands more careful attention to seed crop management and processing of seeds after harvest specially during cleaning operations.

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al., 1988; Fakir and Islam, 1990; Basak *et al.*, 1991; Fakir and Halder, 1993; Sultana, 2004; Fakir and Mia, 2004; Karim, 2005; Islam, 2005).

In most of the cases population of each of the five predominant fungi was found to be reduced in clean seed in comparison with unclean seed in both breeder and farmer seed. This indicates that manual seed cleaning has significant impact on the reduction of the pathogenic fungi in farmer's mustard seed. Such reduction in population of pathogenic fungi through manual seed cleaning has been observed in Rice (Hossain and Doullah, 1998; Rahman, 2000; Kabir *et al.*, 2005; Khokon *et al.*, 2005), eggplant (Miah, 2002; Hawlader, 2003 and Islam, 2005), Mustard (Chowdhary, 1999) and Jute (Fakir *et al.*, 1990). Reduced population of pathogenic fungi has also been encountered in apparently healthy wheat seed obtained through sieving (Siddique, 2003) and by seed cleaning (Tonu, 2005).

Presence of seed borne infection of the five predominant pathogenic fungi- *A. brassicae, A. brassicicola, Fusarium solani, Aspergillus flavus* and *Penicillium sp.* in the test seed samples depict that no way the health status of farmer's mustard seed samples tested is satisfactory in comparison to breeder seed. Farmer's mustard seed carrying high amount of inocula of the three pathogenic field fungi *A. brassicae, A. brassicicola* and *Fusarium solani* as observed in the present analysis, if transmitted to the field, may create alarming disease outbreaks in the fields resulting heavy yield losses to the crop as well as hampering quality seed production. Breeder seed has also been found to carry these three pathogens. So more critical attentions also need to be paid for production and processing of healthy breeder seed of mustard.

Occurrence of the dangerous storage fungi, *A. flavus* and *Penicillium sp.* in the test seed samples also questions the keeping of farmer's mustard seed in storage as these two pathogens are known to cause germination loss of stored seeds in many crops (Christensen and Kaufmann, 1965; Fakir *et al.*, 1971; Miah and Fakir, 1998; Fakir and Mia, 2004). The above mentioned facts can be supported from the germination test record in the present study, where original farmer seed had always poor germination, produced much lesser number of normal seedlings and resulted higher number of dead seed, abnormal or diseased seedlings (Figs. 10-12). On the contrary, best seeds obtained from breeder seed and farmer seed through physical cleaning by separation or removal of seed contaminants and abnormal seeds, had low seed borne infections of pathogenic fungi (Tables 11, 13 & 15). Best seeds in the germination test also resulted markedly higher percentage of normal seedlings, lesser percentage of dead seeds and abnormal seedlings including diseased seedlings. Similar benefits of manual seed cleaning have been obtained in Jute (Fakir *et al.*, 1990), Mustard (Chowdhury, 1999), Rice (Fakir and Mia, 2004) and Egg plant (Islam, 2005).

From the foregoing discussions, it is clearly evident that the health status of farmer's seed of mustard is poor in comparison with breeder seed. It is, therefore, suggested to provide proper training to the farmers for better seed crop management, seed processing and proper storage of mustard seed. This will help improve the seed health quality of mustard seed at farmer's level and contribute to higher yield of the crop.

Chapter 6
Summary and Conclusion

6. Summary and Conclusion

Health and quality of breeder seed and farmer seed of mustard grown in 2007-2008 was determined by seed health and quality analysis. Fourteen breeder seed samples of nine improved mustard varieties used in the study were collected from two locations- BARI, Gazipur and RARS, Ishurdi. Forty seed samples of the traditional variety Tori-7 included in the present study were collected from 40 different farmers representing four mustard growing districts- Manikgonj, Naogaon, Thakurgaon and Tangail. The study was carried out in the Seed Health Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka.

Seed samples were tested for moisture content by electronic digital moisture meter. Best or clean (apparently healthy) seed was sorted out from the original seed sample through elimination of seed contaminants and abnormal seeds by manual seed cleaning. Germination test was conducted on sand in plastic trays to record the normal seedlings, abnormal seedlings and dead seeds following the International Rules for Seed Testing. Health analysis was carried out to detect seed borne fungal infections by blotter method.

Seed quality analysis revealed that the average moisture content of breeder seed were 6.9% and 5.6% collected from BARI, Gazipur and RARS, Ishurdi, respectively; whereas in farmer seed the average moisture content was 8.0%.

Three types of seed contaminants viz. varietal mixture, other crop seed and inert matter were recorded from breeder and farmer seed of mustard.

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Seed quality analysis revealed that the average moisture content of breeder seed were 6.9% and 5.6% collected from BARI, Gazipur and RARS, Ishurdi, respectively; whereas in farmer seed the average moisture content was 8.0%.

Three types of seed contaminants viz. varietal mixture, other crop seed and inert matter were recorded from breeder and farmer seed of mustard.

The seed contaminants varied independently depending on the seed tier and source of seed collection. All the seed contaminants were recorded in farmer seed, while only inert matter was found in breeder seed. Five types of abnormal seeds viz. discolored seed, shriveled seed, spotted seed, undersized seed and broken seed were recorded in mustard seed under the present investigation. All the five types of abnormal seeds except broken seed were found in breeder seed. The seed contaminants as well as the abnormal seed encountered in mustard seed varied significantly with respect to seed tier, variety and sources of seed collection.

Amount of best or clean seed recovered through manual seed cleaning varied significantly with respect to variety and sources of seed collection. Average percentage of 'best' or 'clean' seed recovered from breeder and farmer seed were approximately 93 and 60, respectively.

Eleven fungi namely- *Alternaria brassicae*, *Alterraria brassicicola*, *Alternaria tenuis*, *Aspergillus flavus*, *Aspergilles niger*, *Chaetomium sp.*, *Fusarium monliformae*, *Fusarium oxysporum*, *Fusarium solani*, *Penicillium sp.* and *Phoma lingum* were detected both in breeder and farmer's mustard seed collected from two research stations and four different districts of Bangladesh. Out of 11 fungi, five predominant fungi viz. *Alternaria brassicae*, *Alternaria brassicicola*, *Fusarium solani*, *Aspergillus flavus* and *Penicillium sp.* detected in the present study, varied in prevalence, with respect to seed tier, variety and location of seed collection. Occurrence of all the five predominant fungi were found always higher in unclean seed compared to clean seed at all the locations. Among the five predominant fungi, three were field fungi and two were storage fungi. The field fungi were *Alternaria brassicae*, *Alternaria*

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brassicicola and *Fusarium solani* and two storage fungi were *Aspergillus flavus* and *Penicillium sp.*

Normal seedlings, abnormal seedlings and dead seeds recorded in the germination test varied significantly depending on the location and cleanliness of seed. Higher percentage of normal seedlings and lower percentage of abnormal seedlings and dead seed were always observed in clean seed compared to unclean seed at all the locations. Higher percentage of germination was found in breeder seed compared to farmer seed.

Based on the present study the following conclusions may be drawn:

(1) Quality and health status of farmer seed of mustard in Bangladesh is poor compared to breeder seed. Farmer seed contains more moisture content, greater quantity of seed contaminants, abnormal seeds and higher percentage of seed borne infection of dangerous pathogenic fungi compared to breeder seed.

(2) Approximately 93% best or clean seed can be recovered through manual seed cleaning from breeder seed, while only 60% best or clean seed can be obtained from farmer seed.

(3) Best or clean seed gives higher counts of normal seedling and lesser parentage of abnormal seedlings and dead seeds compared to unclean seed both in breeder and farmer seeds of mustard.

(4) Health and quality of farmer mustard seed can be improved markedly by manual seed cleaning.

Chapter 7
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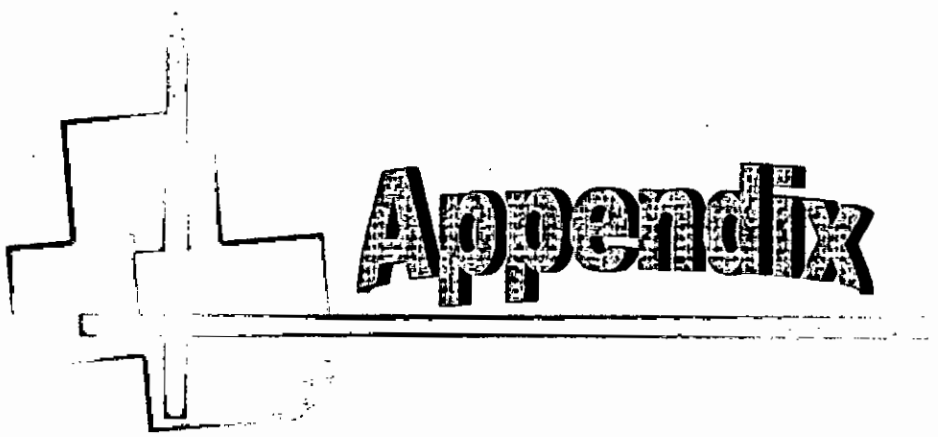
Appendix

APPENDIX

Appendix 1. List of farmers along with their address from where mustard seeds (Tori-7) were collected

Sample No.	Farmers Name	Address
01.	Md. Hossain Ali	Vatnagar, Manikgonj Sadar
02.	Md. Lal Mia	Vatnagar, Manikgonj Sadar
03.	Md. Billal Hossain	Vatnagar, Manikgonj Sadar
04.	Shahabuddin Ahammed	Vatnagar, Manikgonj Sadar
05.	Md. Ansar Uddin	Vatnagar, Manikgonj Sadar
06.	Md. Abdul Jalil	Uchutia Manikgonj Sadar
07.	Abdur Razzak	Chhuti Vatkaur, Manikgonj Sadar
08.	Qazimuddin	Chhuti Vatkaur, Manikgonj Sadar
09.	Md. Based Mia	Chhuti Vatkaur, Manikgonj Sadar
10.	Md. Azizul Haque	Uchutia Manikgonj Sadar
11.	Md. Alam	Bhabanipur, Atrai, Naogaon
12.	Subodh Ghosh	Mirjapur, Atrai, Naogaon
13.	Subodh Sarker	Mirjapur, Atrai, Naogaon
14.	Komol Ray	Shahagola, Atrai, Naogaon
15.	Somir Sarker	Shahagola, Atrai, Naogaon
16.	Dr. Gopal Chandra Pramanik	Shahagola, Atrai, Naogaon
17.	Uzzal Ghosh	Raypur, Atrai, Naogaon
18.	Haren Ghosh	Raypur, Atrai, Naogaon
19.	Milon Ghosh	Raypur, Atrai, Naogaon
20.	Biplob Ghosh	Mirjapur, Atrai, Naogaon
21.	Md. Abdus Samad	Tangail Sadar
22.	Md. Alauddin	Tangail Sadar
23.	Abu Bakkar Khan	Tangail Sadar
24.	Md. Abul Mia	Tangail Sadar
25.	Md. Shahajahan	Tangail Sadar
26.	Md. Arfan Ali	Tangail Sadar
27.	Muhit	Tangail Sadar
28.	Md. Moin Uddin	Tangail Sadar
29.	Khodeja Begum	Tangail Sadar
30.	Morsheda Parvin	Tangail Sadar
31.	Dabesh	Jagannathpur, Thakurgaon Sadar
32.	Durjamohon	Jagannathpur, Thakurgaon Sadar
33.	Md. Abdul Baki	Akcha, Thakurgaon Sadar
34.	Md. Shahjahan	Akcha Thakurgaon Sadar
35.	Tarani Kanta Ray	Akcha Thakurgaon Sadar
36.	Shahidul Haque	Salondar, Thakurgaon Sadar
37.	Jageswar	Jagannathpur, Thakurgaon Sadar
38.	Tamiz Uddin	Salondar, Thakurgaon Sadar
39.	Moni Pada Barmon	Salondar, Thakurgaon Sadar
40.	Toiabur Rahman	Salondar, Thakurgaon Sadar

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