Journal of Phytopathology and Pest Management

eISSN: 2356-6507

Volume (1), Issue (1)

2014

Effect of seed borne pathogens on germination of some vegetable seeds

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Abstract

Seed borne infection and germination of seeds of 7 vegetables viz. amaranth, red amaranth, spinach, okra, cucumber, tomato and eggplant were tested and 11 fungi were detected which were *Alternaria* spp., *Aspergillus flavus*, *Aspergillus niger*, *Phomopsis vexans*, *Curvularia* spp., *Fusarium* spp., *Penicillium* spp., *Rhizopus* spp., *Colletotrichum dematium*, *Macrophomina phaseolina* and *Cladosporium* spp. Six fungi were detected in amaranth, six fungi in red amaranth, four fungi in spinach, six fungi in okra, four fungi in cucumber, four fungi in tomato and five fungi in eggplant seeds. The highest total seed borne fungal infection was found in okra (26.75%), while the lowest was found in cucumber (13.50%). The highest percent germination was recorded in cucumber (87%), while the lowest in okra (49.5%). Maximum germination failure was recorded in okra (50.5%) and the lowest was recorded in cucumber (13%). Maximum normal seedlings were recorded in cucumber (77%) and the minimum was in okra (45%). The highest number of abnormal seedlings was found in okra (4%) and lowest in eggplant (2%). The highest number of diseased seedlings was found in okra (9%) and lowest in cucumber (2%). Maximum numbers of dead seeds were found in red amaranth (48%), while lowest in cucumber (18%). Among the vegetable seeds, highest seedling vigor index was encountered in cucumber (2150.5) and lowest in red amaranth (275.95).

Key words: Seed borne infection, germination failure, diseased seedlings

Introduction

In Bangladesh, agriculture accounts for 532,032 million taka of its gross domestic product (BBS 2013). Vegetables are a potential and important group of crops in Bangladesh. They are important for their low production cost, short production time period and high nutritive value. In 2010-2011 about 1115966 acres of land were under vegetable cultivation in Bangladesh and production was 3061840 metric tons (BBS, 2010). Seed is the vital input in agriculture. It may be called as the foundation of agriculture. Among the agricultural inputs, seed is the most important input for crop production. Quality and healthy seed is the crying need of the day. Healthy or pathogen free seeds are considered as the vital factor for desired plant population and good harvest. Health of seeds can be affected by direct infection by pathogens or through contamination of seeds by pathogenic proposals as contamination in, on or with the seeds or as concomitant contamination (Rashid *et al*. 2000). Infection of seed by a pathogenic organism and the presence of propagules of pathogens in a seed lot is vitally important because infected seeds/ seed lot may fail to germinate, cause infection to seedlings and growing plants. So, healthy seed is considered as an important factor for successful crop production.

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In the Bangladesh context where reducing of cultivable land, high population, low fertility, flood, drought, scanty of irrigation water and low yield are unavoidable hazards. Therefore, the yield of the crops is to be increased to feed the hungry people of the country. The successful crop production for ensuring food and elevating poverty is essential. The bumper crop production and use of healthy seed is unquestionably the most important basic input. The farmers must be aware of the consequences of the crop losses with low quality and unhealthy seeds. Although Bangladesh is an agro-based country only 18% certified seeds are produced by different seed organizations. The rest 82% seeds are produced by the farmers which are uncertified with unknown quality and out of the supervision of the Seed Certification Agency. In fact, this is actually an alarming situation in the country. The lack of high quality seeds and the prevalence of seed borne organisms are the main constraints in maintaining the crop production. Fakir (1998) estimated more than 400 seed borne diseases in 72 crops inflicting an estimated yield loss amounting to around Tk. 1000 million, i.e. 200 million US dollars annually. The per capita consumption of vegetables in Bangladesh is only 112g which is far below from the daily requirement of 400g/head (FAO 2012). The lack of high quality healthy seeds and the prevalence of seed borne diseases are among the main constraints for Bangladesh in maintaining the sustainability of vegetable crop production and per capita consumption.

Seeds of vegetables are more vulnerable to attack by pathogens and quickly deteriorate during storage. The germination potentiality of seeds cannot be assessed easily just from their external appearances. For a good crop, good seed germination is essential which indicates that the seed should be pure, viable and healthy. Use of good seeds can contribute to increase germination as well as vegetable yield as high as 30% remaining all other factors of production as content. Other hand, in Bangladesh amaranth, red amaranth, spinach, okra, cucumber, tomato and eggplant are commonly cultivated vegetables in the country. Considering the above facts, the present research has been undertaken to fulfill the following objectives:

i. To detect the prevalence of seed borne fungi in some vegetable seeds.
ii. To determine the effect of seed borne fungi on seed germination.

Materials and methods

Experimental site: The experiment was conducted at M.S. Laboratory, Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh.

Experimental period: The experiment was conducted during the period from September, 2012 to June, 2013.

Collection of seed samples: Vegetable seeds were collected from different shops of Mymensingh. The samples were brought directly to M. S. laboratory and kept in polythene bags and stored in the refrigerator, till the seeds were used for the subsequent studies.

Selected vegetables: Seeds of seven different vegetables were studied to know the effect of seed borne pathogens on germination. The selected vegetables were Amaranth, Red amaranth, Spinach, Okra, Cucumber (Shosha), Tomato and Eggplant. Common name, English name, scientific name and family name of vegetable seeds tested are given in Table 1.

Detection of seed borne fungi

Blotter method: To detect the seed borne pathogen associated with the seeds in samples, the blotter method was used following International Rules for Seed Testing Association (ISTA, 2001). In this method, two layers of blotter paper (Whatman No. 1) were soaked in distilled water and placed at the bottom of 9cm diameter plastic petri dish. Four hundred seeds were used for blotter test for detection of seed borne fungi. Depending on the size, seeds in different number were plated in single plastic petri dishes. In case of amaranth, red amaranth, spinach, okra, tomato and eggplant, 25 seeds per plate were placed. In case of cucumber (Shosha), 10 seeds were placed per plate. The petri dishes with seeds were then incubated for 12/12 hours alternating light and darkness in the incubation room of Seed Pathology Centre, Bangladesh Agricultural University, Mymenshingh for seven days at 20 ± 2 °C. Data were recorded after seven days. After incubation, fungi developed on each seed were examined under Stereo-binocular Microscope. Data were also recorded on seed germination (%), seed infection (%), and seed borne pathogens.

Each individual incubated seed was observed under Stereo-microscope at 16x and 25x magnifications in order to record the incidence of seed borne fungi. Most of the associated pathogens were detected by observing their growth characters on the incubated seeds on Blotter paper following the keys outlined by Ramnath et al., (1970), Khan et al., (1975), and Kulshrestha et al., (1976).

Germination test: Germination test was conducted in the laboratory of Plant Pathology Department, Bangladesh Agricultural University, Mymenshingh to determine the effect of fungi on germination and incidence of seedling diseases or infection. The test carried out by sterilizing the sand in plastic trays. Sand was sterilized by 3% formaldehyde @ 200ml/cft. The sand was covered with polythene sheet for 24 hours. After 24 hours the polythene sheet was removed and the sand was spread and allowed to open for 7 days for evaporation of the formaldehyde gas. Thus, the sand was ready for sowing the seeds. The trays were then filled with sterilized sand and moistened with water. Four trays were used for each seed sample of amaranth, red amaranth, spinach, okra, eggplant, tomato and cucumber. Germination test was followed for seedling disease development. Data on percent normal seedlings, abnormal seedlings, diseased seedlings and dead seeds were recorded at 7 days, 14 days and 21 days after sowing. For proper identification of fungi temporary slides were prepared from the fungal colony and observed under compound microscope, and identified with the help of keys suggested by Malone and Muskette (1964), Booth (1971), Ellis (1971), Chidambaram and Mathur (1975) and Neergaard (1979).

Table1: List of different vegetable seeds

Common name	English name	Scientific name	Family
Data	Amaranth	*Amaranthus gangetica* L.	Amaranthaceae
Lal shak	Red Amaranth	*Amaranthus tricolor* L.	Amaranthaceae
Palong shak	Spinach	*Beta vulgaris* L. var. *bengalensis*	Chenopodiaceae
Dharosh	Okra	*Abelmoschus esculentus* L.	Malvaceae
Shosha	Cucumber	*Cucumis sativus* L.	Cucurbitaceae
Tomato	Tomato	*Lycopersicon esculentum* L.	Solanaceae
Begun	Eggplant	*Solanum melongena* L.	Solanaceae

Vigour test: The test was carried out following the same method as of germination test. For determination of seedling vigour of vegetables, 10 seedlings per replication were selected randomly and their individual shoot and root length were measured. The vigour of the seedlings was determined by the following formula:

Vigor Index = (Mean root length + Mean shoot length) x % seed germination

Water agar seedling symptoms test: The association of the pathogen with different category of seeds was also tested by the water agar seedling symptom test. Ten ml of 1% water agar was taken in each of 160×16 mm test tubes, autoclaved and allowed to solidify at an angle of 60^0. Hundred seeds each of the categorized were taken from the working sample. The seeds were sown at the rate of one seed per test tube and closed with a small piece of cotton plug. The cotton plug was removed after one week of sowing before the seedling reached up to the top. The test tubes were incubated in erect condition at 21^0C under 12 hours alternate daylight. Symptoms developed on the seedling were recorded after 14 days of incubation by examining the individual seedling under stereo binocular microscope.

Experimental design: The experiment was laid out in a completely randomized design (CRD) with four replications.

Data analysis: The collected data were analyzed by using statistical package program MSTAT-C. The level of significance and analysis of variance were done. The mean difference was judged by least significant difference test (LSD).

Results

Total seed borne fungal infections: A total of 565 seed borne fungal infections were recorded in 2800 seeds obtained from seven selected vegetables collected from different shops of Mymensingh. The total seed borne fungal infections varied in prevalence considerably depending on the vegetable seeds. The highest number of total seed borne fungal infection was recorded in Okra (26.75%), followed by Amaranth (23.75%), Red amaranth (23.25%), Tomato (19.00%), Spinach (18.25%) and eggplant (16.75%), while the lowest total fungal infection was observed in Cucumber (13.50%) as shown in Table 2.

Table 2: Prevalence of seed borne fungi in vegetable seeds (Blotter method)

Name of vegetables	Seed borne infections (%)											
	Alternaria spp.	*Aspergillus flavus*	*Aspergillus niger*	*Phomopsis vexans*	*Curvularia* spp.	*Fusarium* spp.	*Penicillium* spp.	*Rhizopus* spp.	*Colletotrichum dematium*	*Macrophomina phaseolina*	*Cladosporium* spp.	Total seed borne Pathogens
Amaranth	3.00 b	4.50 b	3.75 ab	0.0 b	3.50 ab	4.00 b	5.25 a	0.0 b	0.0 b	0.0 b	0.0 b	23.75
Red amaranth	2.50 b	4.25 bc	4.00 ab	0.0 b	0.0 d	4.50 ab	5.75 a	2.25 a	0.0 b	0.0 b	0.0 b	23.25
Spinach	5.25 a	0.0 d	0.0 d	0.0 b	3.25 b	5.50 ab	4.25 b	0.0 b	0.0 b	0.0 b	0.0 b	18.25
Okra	0.0 c	5.75 a	4.50 a	0.0 b	0.0 d	5.00 ab	3.00 c	0.0 b	4.75 a	3.75 a	0.0 b	26.75
Cucumber (Shosha)	3.00 b	0.0 d	0.0 d	0.0 b	3.75 a	4.75 ab	2.00 d	0.0 b	0.0 b	0.0 b	0.0 b	13.50
Tomato	0.0 c	4.75 ab	3.25 bc	0.0 b	0.0 d	5.75 a	0.0 e	0.0 b	0.0 b	0.0 b	5.25 a	19.00
Eggplant	0.0 c	3.25 c	2.25 c	3.75 a	2.75 c	4.75 ab	0.0 e	0.0 b	0.0 b	0.0 b	0.0 b	16.75
Total	13.75	22.5	17.75	3.75	13.25	34.25	20.25	2.25	4.75	3.75	5.25	141.75
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**
LSD(0.05)	0.941	1.128	1.208	0.166	0.293	1.705	0.954	0.055	0.055	0.055	0.055	
CV%	27.35	5.36	27.21	17.64	8.87	19.90	18.85	11.76	5.57	7.06	5.04	

400 seeds were used for each vegetable; In column, figures having same letter (s) do not differ statistically (as per LSD). Significance at 5% level of probability.

Prevalence of seed borne fungi and their occurrence: Prevalence of seed borne fungal infection varied depending on the seeds of different vegetables (Table 2). In case of *Alternaria* spp., maximum prevalence (5.25%) was recorded in seeds of Spinach, followed by amaranth (3.00%) and cucumber (3.00%) while the lowest prevalence was recorded in red amaranth (2.50%). Okra, tomato and eggplant were free from *Alternaria* spp. The maximum prevalence of *Aspergillus flavus* was recorded in okra (5.75%), followed by tomato (4.75%), amaranth (4.50%) and red amaranth (4.25%) while the lowest prevalence was recorded in eggplant (3.25%). Spinach and cucumber were free from *Aspergillus flavus*. The prevalence of *Aspergillus niger* was highest in okra (4.50%), followed by red amaranth (4.00%), amaranth (3.75%) and tomato (3.25%) while the lowest prevalence was recorded in eggplant (2.25%). Spinach and cucumber were free from *Aspergillus niger*. The fungi *Phomopsis vexans* was recorded only in seeds of eggplant (3.75%). In case of *Curvularia* spp. maximum prevalence (3.75%) was recorded in seeds of cucumber, followed by amaranth (3.50%) and spinach (3.25%) while the lowest prevalence was recorded in eggplant (2.75%). Red amaranth, okra and tomato were free from *Curvularia* spp. The maximum prevalence of *Fusarium* spp. was recorded in tomato (5.75%), followed by spinach (5.50%), okra (5.00%), cucumber (4.75%), eggplant (4.75%) and red amaranth (4.50%) while the lowest prevalence was recorded in amaranth (4.00%). In case of *Penicillium* spp., maximum prevalence (5.75%) was recorded in seeds of red amaranth, followed by amaranth (5.25%), spinach (4.25%) and okra (3.00%) while lowest prevalence was recorded in cucumber (2.00%). Tomato and eggplant were free from *Penicillium* spp. The fungi *Rhizopus* spp. was recorded only in seeds of red amaranth (2.25%). The prevalence of *Colletotrichum dematium* was recorded only in seeds of okra (4.75%), *Macrophomina phaseolina* was recorded only in seeds of okra (3.75%) and the highest prevalence of *Cladosporium* spp. was recorded in tomato (5.25%).

Table 3: Frequency of fungal occurrences recorded on seven different vegetable seeds

Name of vegetables	No. of fungal infection	% of infections	No. of infected seeds
Amaranth	95 b	23.75 b	93 a
Red amaranth	93 c	23.25 b	87 c
Spinach	73 e	18.25 d	71 e
Okra	107 a	26.75 a	89 b
Cucumber	54 g	13.50 f	53 g
Tomato	76 d	19.00 c	74 d
Eggplant	67 f	16.75 e	64 f
$LSD_{(0.05)}$	1.751	0.664	1.751
CV%	1.24	1.88	1.32

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

Frequency of fungal occurrences recorded on seven different vegetable seeds: In case of a number of fungal infections, highest number was recorded in okra (107) followed by amaranth (95), red amaranth (93), tomato (76), spinach (73) and eggplant (67). Lowest number of fungal infection was recorded in cucumber (54) (Table 3). Highest percent of infection was recorded in okra (26.75%) followed by amaranth (23.75%), red amaranth (23.25%), tomato

(19.0%), spinach (18.25%) and eggplant (16.75%). Lowest percent of infection was recorded in cucumber (13.5%) (Table 3). Highest number of infected seed was recorded in amaranth (93) followed by okra (89), red amaranth (87), tomato (74), spinach (71) and eggplant (64). Lowest number of infected seed was recorded in Cucumber (53) (Table 3).

Table 4: Frequency occurrence of seed borne fungi recorded on Amaranth

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Alternaria spp.	12 e	3.00 f	12 d
Aspergillus flavus	18 b	4.50 b	17 b
Aspergillus niger	15 cd	3.75 d	15 c
Curvularia spp.	14 d	3.50 e	13 d
Fusarium spp.	16 c	4.00 c	16 bc
Penicillium spp.	21 a	5.25 a	20 a
Total	95	23.75	93
$LSD_{(0.05)}$	1.779	0.1779	0.1779
CV%	6.25	2.50	6.52

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

Frequency of occurrence of seed borne fungi in individual vegetable seeds: In case of Amaranth the highest number of fungal infection was recorded in *Penicillium* spp. (21). The second number of fungal infection was recorded in *Aspergillus flavus* (18). Number of fungal infection of *Fusarium* spp. (16) and *Aspergillus niger* (15) were statistically similar but higher than that of *Curvularia* spp. (14). Lowest number of fungal infection was recorded in *Alternaria* spp. (Table 4). On the other hand the highest percent of infection was recorded by *Penicillium* spp. (5.25%) followed by *Aspergillus flavus*(4.50%), *Fusarium* spp.(4.00%), *Aspergillus niger* (3.75%) and *Curvularia* spp. (3.50%) the lowest percent infection was recorded by *Alternaria* spp. (3.00%) (Table 4). The highest number of seeds was infected by *Penicillium* spp. (20) followed by *Aspergillus flavus* (17), *Fusarium* spp. (16), *Aspergillus niger* (15), *Curvularia* spp. (13). The lowest number of seed sample was infected by *Alternaria* spp. (12) (Table 4).

Table 5: Frequency occurrence of seed borne fungi recorded on Red Amaranth

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Alternaria spp.	10 d	2.50 e	10 c
Aspergillus flavus	17 bc	4.25 c	17 b
Aspergillus niger	16 c	4.00 d	15 b
Fusarium spp.	18 b	4.50 b	15 b
Penicillium spp.	23 a	5.75 a	21 a
Rhizopus stolonifer	09 d	2.25 f	09 c
Total	93	23.25	87
$LSD_{(0.05)}$	1.779	0.052	3.843
CV%	6.45	0.26	14.90

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

In case of Red amaranth the highest number of fungal infection was recorded in *Penicillium* spp. (23). The second number of fungal infection was recorded in *Fusarium* spp. (18). Number of fungal infection of *Aspergillus flavus* (17) and *Aspergillus niger* (16) were statistically similar. Lowest number of fungal infection was recorded in *Alternaria* spp. (09) (Table 5). On the other hand, the highest percent of infection was recorded

in *Penicillium* spp. (5.75%) followed by *Fusarium* spp. (4.50%), *Aspergillus flavus* (4.25%), *Aspergillus niger* (4.00%) and *Alternaria* spp. (2.50%). The lowest percent infection was recorded in *Rhizopus stolonifer* (2.25%) (Table 5). The highest number of seeds were infected by *Penicillium* spp. (21) followed by *Aspergillus flavus* (17), *Fusarium* spp. (15), *Aspergillus niger* (15) and *Alternaria* spp.(10). The lowest number of seed sample was infected by *Rhizopus stolonifer* (09) (Table 5).

In case of spinach, the highest number of fungal infection was recorded in *Fusarium* spp. (22) followed by *Penicillium* spp. (17) and statistically similar with *Alternaria* spp. (21). Lowest number of fungal infection was recorded in *Curvularia* spp. (13) (Table 6). The highest percent of infection was recorded by *Fusarium* spp. (5.50%) followed by *Alternaria* spp. (5.25%) and *Penicillium* spp. (4.25%). The lowest percent infection was recorded in *Curvularia* spp. (3.25%) (Table 6). The highest number of seeds was infected by *Fusarium* spp. (22), followed by *Alternaria* spp. (21) and *Penicillium* spp. (16). The lowest number of seed sample was infected by *Curvularia* spp. (12) (Table 6).

Table 6: Frequency occurrence of seed borne fungi recorded on spinach

Name of the fungi	No. of fungal infection	% of infections	No. of infected seeds
Alternaria spp.	21 a	5.25 b	21 a
Curvularia spp.	13 c	3.25 d	12 c
Fusarium spp.	22 a	5.50 a	22 a
Penicillium spp.	17 b	4.25 c	16 b
Total	73	18.25	71
$LSD_{(0.05)}$	1.883	0.133	1.883
CV%	5.48	1.56	5.63

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

In case of okra, the highest number of fungal infection was recorded in *Aspergillus flavus* (23), followed by *Fusarium* spp. (20), *Colletotrichum dematium* (19), *Aspergillus niger* (18) and *Macrophomina phaseolina* (15). Lowest number of fungal infection was recorded in *Penicillium* spp. (12) (Table 7). The highest percent of infection was recorded in *Aspergillus flavus* (5.75%), followed by *Fusarium* spp. (5.0%), *Colletotrichum dematium* (4.75%), *Aspergillus niger* (4.5%), and *Macrophomina phaseolina* (3.75%). The lowest percent infection was recorded in *Aspergillus niger* (2.25%) (Table 10). The highest number of seeds was infected by *Fusarium* spp. (17) followed by *Phomopsis vexans* (14), *Aspergillus flavus* (13) and *Curvularia* spp. (11). The lowest number of seed sample was infected by *Penicillium* spp. (10) (Table 7).

Table 7: Frequency occurrence of seed borne fungi recorded on okra

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Colletotrichum dematium	19 b	4.75 abc	15 b
Macrophomina phaseolina	15 c	3.75 cd	12 c
Fusarium spp.	20 b	5.00 ab	17 ab
Aspergillus flavus	23 a	5.75 a	19 a
Aspergillus niger	18 b	4.50 bc	16 b
Penicillium spp.	12 d	3.00 d	10 c
Total	107	26.75	89
$LSD_{(0.05)}$	2.297	1.037	2.054
CV%	7.24	13.08	7.78

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

In case of cucumber, the highest number of fungal infection was recorded in *Fusarium* spp. (19), followed by *Curvularia* spp. (15) and *Alternaria* spp. (12). Lowest number of fungal infection was recorded in *Penicillium* spp. (8). (Table 8). The highest percent of infection was recorded in *Fusarium* spp. (4.75%) followed by *Curvularia* spp. (3.75%) and *Alternaria* spp. (3.0%). The lowest percent infection was recorded in *Penicillium* spp. (2.00%) (Table 8).The highest number of seeds was infected by *Fusarium* spp. (18), followed by *Curvularia* spp. (15) and *Alternaria* spp. (12). The lowest number of seed sample was infected by *Penicillium* spp. (08) (Table8)

Table 8: Frequency occurrence of seed borne fungi recorded on cucumber

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Alternaria spp.	12 c	3.00 bc	12 c
Curvularia spp.	15 b	3.75 ab	15 b
Fusarium spp.	19 a	4.75 a	18 a
Penicillium spp.	08 d	2.00 c	08 d
Total	54	13.50	53
$LSD_{(0.05)}$	1.883	1.372	2.824
CV%	7.41	21.60	11.32

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

In case of tomato, the highest number of fungal infection was recorded in *Fusarium* spp. (23), followed by *Cladosporium* spp. (21) and *Aspergillus flavus* (19). Lowest number of fungal infection was recorded in *Aspergillus niger* (13) (Table 9).The highest percent of infection was recorded in *Fusarium* spp. (5.75%) followed by *Cladosporium* spp. (5.25%) and *Aspergillus flavus* (4.75%). The lowest percent infection was recorded in *Aspergillus niger* (3.25%) (Table 9).The highest number of seeds was infected by *Fusarium* spp. (23), followed by *Cladosporium* spp. (20) and *Aspergillus flavus* (18). The lowest number of seed sample was infected by *Aspergillus niger* (13) (Table 9).

Table 9: Frequency occurrence of seed borne fungi recorded on Tomato

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Fusarium spp.	23 a	5.75 a	23 a
Cladosporium spp.	21 ab	5.25 ab	20 b
Aspergillus flavus	19 b	4.75 b	18 b
Aspergillus niger	13 c	3.25 c	13 c
Total	76	19.00	74
$LSD_{(0.05)}$	2.491	0.254	2.977
CV%	6.96	6.07	8.55

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

In case of eggplant the highest number of fungal infection was recorded in *Fusarium* spp. (19), followed by *Phomopsis vexans* (15), *Aspergillus flavus* (13) and *Curvularia* spp. (11). Lowest number of fungal infection was recorded in *Aspergillus niger* (09) (Table 10).The highest percent of infection was recorded in *Fusarium* spp. (4.75%), followed by *Phomopsis vexans* (3.75%), *Aspergillus flavus* (3.23%) and *Curvularia* spp. (2.75%). The lowest percent infection was recorded in *Aspergillus niger* (2.25%) (Table 10).The highest number of seeds was infected by *Fusarium* spp. (17) followed by *Phomopsis vexans* (14), *Aspergillus flavus* (13) and *Curvularia* spp. (11). The lowest number of seed sample was infected by *Aspergillus niger* (9) (Table 10).

Table 10: Frequency occurrence of seed borne fungi recorded on eggplant

Name of fungi	No. of fungal infection	% of infections	No. of infected seeds
Phomopsis vexans	15 b	3.75 b	14 ab
Curvularia spp.	11 cd	2.75 d	11 bc
Fusarium spp.	19 a	4.75 a	17 a
Aspergillus flavus	13 bc	3.25 c	13 b
Aspergillus niger	09 d	2.25 e	09 c
Total	67	16.75	64
$LSD_{(0.05)}$	3.355	0.320	3.044
CV%	13.76	5.26	13.07

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

Germination test

Germination test of different vegetable seeds at 7 days after sowing: Germination test was followed for seedling disease development. Data on percent normal seedlings, abnormal seedlings, diseased seedlings and dead seeds were recorded at 7 days after sowing and shown in Figure 1. Normal seedlings ranged from 44 to 73% depending on seeds of different vegetables. The highest percent of normal seedlings was recorded in cucumber (73%) followed by eggplant (71%) and spinach (69%). The lowest percent of normal seedlings was recorded in okra (44%). In case of abnormal seedlings (2%) was recorded in red amaranth, spinach, okra, tomato and (1%) in amaranth, cucumber and eggplant. In case of diseased seedlings, very limited seedlings were found to be infected. In red amaranth (2%) and Tomato (2%) seedlings were found to be infected while (1%) infection occurs in amaranth, okra and eggplant; no infection occurs in spinach and cucumber. The maximum dead seeds were recorded in Okra (53%) and minimum dead seeds were recorded in cucumber (26%).

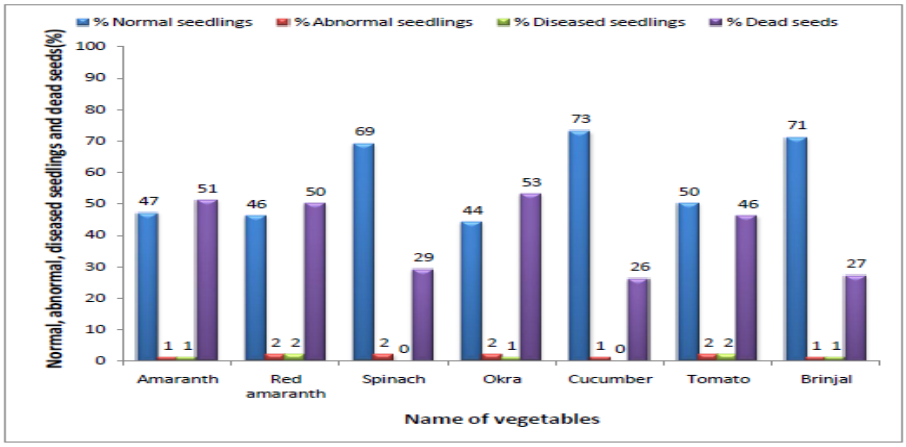

Figure 1. % Normal seedlings, abnormal seedlings,diseased seedlings and dead seeds of different vegetables (Germination test) at 7DAS

Germination test of different vegetable seeds at 14 days after sowing: Germination test was followed for seedling disease development. Data on percent normal seedlings, abnormal seedlings, diseased seedlings and dead seeds were recorded at

14 days after sowing and shown in Figure 2. Normal seedlings ranged from 46 to 77%, depending on seeds of different vegetables. The highest percent of normal seedlings was recorded in cucumber (77%) followed by eggplant (75%) and spinach (70%). The lowest percent of normal seedlings was recorded in Okra (46%) and Red amaranth (46%). In case of abnormal seedlings, highest percent was recorded in okra (4%). In case of diseased seedlings, very limited seedlings were found to be infected. The highest percent of diseased seedlings were recorded in okra (6%) and lowest percent was recorded in cucumber (1%). The maximum dead seeds were recorded in red amaranth (48%) and minimum dead seeds were recorded in cucumber (20%).

Germination test of different vegetable seeds at 21 days after sowing: Data on percent normal seedlings, abnormal seedlings, diseased seedlings and dead seeds were recorded at 21days after sowing and shown in Figure 3. Normal seedlings ranged from 45 to 77%, depending on seeds of different vegetables. The highest percent of normal seedlings was recorded in cucumber (77%) followed by eggplant (75%) and spinach (70%). The lowest percent of normal seedlings was recorded in okra (45%). In case of abnormal seedlings, highest percent was recorded in okra (4%) and amaranth (4%). The lowest percent of abnormal seedlings was recorded in eggplant (2%). The highest percent of diseased seedlings were recorded in okra (9%) and lowest percent was recorded in cucumber (2%). The maximum dead seeds were recorded in red amaranth (48%) and minimum dead seeds were recorded in cucumber (18%).

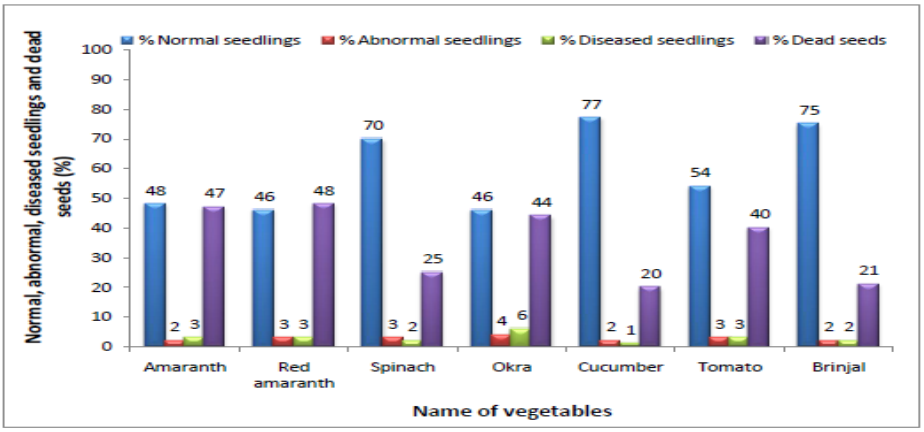

Figure 2. % Normal seedlings, abnormal seedlings,diseased seedlings and dead seeds of different vegetables (Germination test) at 14DAS

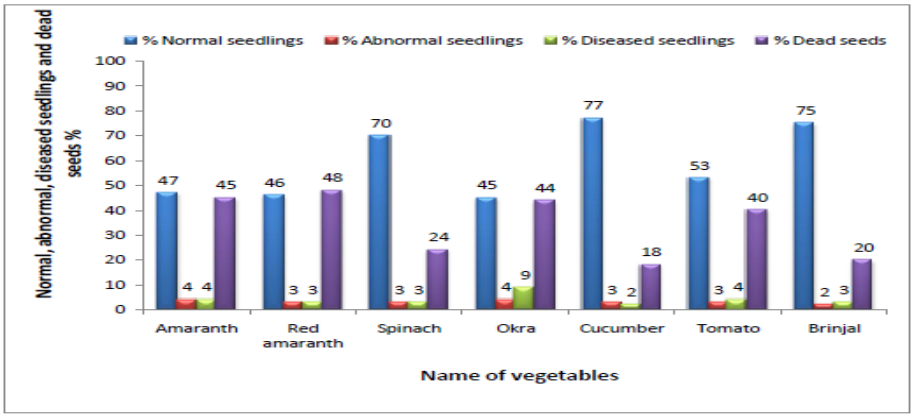

Figure 3. % Normal seedlings, abnormal seedlings,diseased seedlings and dead seeds of different vegetables (Growing on test) at 21DAS

Germination, germination failure and total seed borne infections (%) of different vegetables: Germination of vegetable seeds recorded in germination test varied significantly. The highest germination percent was recorded in cucumber (87%), while the lowest in okra (49.5%). Germination failure percent was higher compared to total seed borne infections percentage. Maximum germination failure percent was recorded in okra (50.5%) and lowest germination failure percent was recorded in cucumber (13%). The highest total seed borne fungal infections percent was found in okra (26.75%) and lowest in cucumber (13.5%) as shown in Figure 4.

Vigour Test: Seedlings vigour of different vegetables seeds in vigour test are presented in Table 11. Vigour index ranged from 272.95 to 2150.5. Vigour index was highest in cucumber (2150.5) and lowest in red amaranth (272.95). The highest germination percentage was recorded in cucumber (85%) and lowest in okra (48.5%). Shoot length was highest in cucumber (18.4) and lowest in red amaranth (3.9). Root length was highest in cucumber (6.9) and lowest in red amaranth (1.25). There was difference among the seeds of different vegetables in respect of % germination, shoot length, root length and vigour index.

Table11: Germination and seedling vigour test of different vegetable seeds

Name of vegetables	Germination (%)	Mean Shoot length (cm)	Mean Root length (cm)	Vigour index
Amaranth	50.5 f	4.05 f	1.5 e	330.77 f
Red amaranth	53.0 e	3.9 f	1.25 f	272.95 g
Spinach	77.5 c	8.85 c	3.1 c	926.12 c
Okra	48.5 g	14.65 b	5.65 b	984.55 b
Cucumber	85.0 a	18.4 a	6.9 a	2150.5 a
Tomato	59.5 d	7.1 d	3.2 c	612.85 d
Eggplant	79.5 b	4.5 e	2.6 d	564.45 e
$LSD_{(0.05)}$	0.947	0.166	0.175	0.175
CV%	0.84	1.06	2.89	0.01

In column, figures having same letter(s) do not differ statistically (as per LSD), at 5% level of significance.

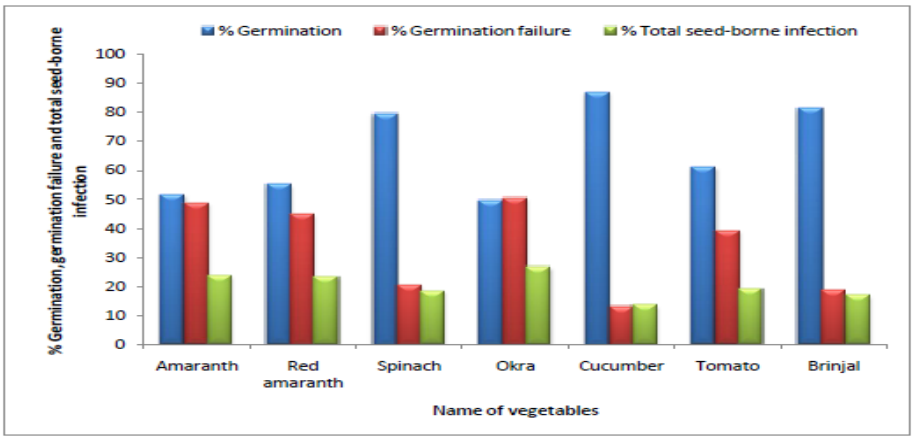

Figure 4. Germination, Germination failure and total seed borne infections (%) of different vegetables

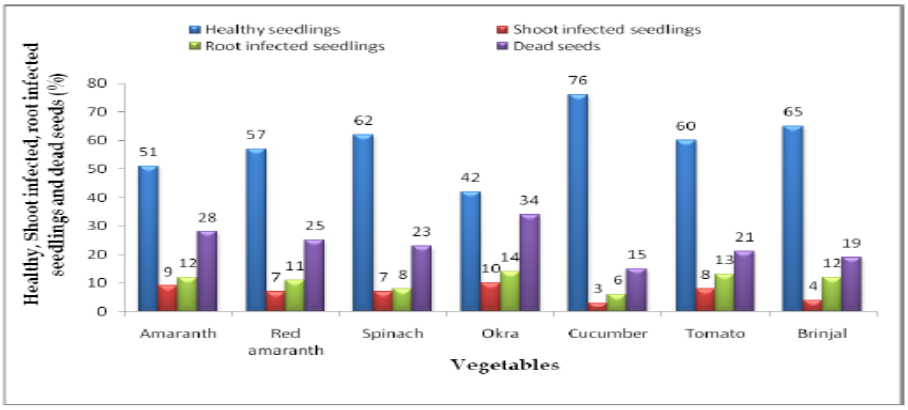

Figure 5. Healthy seedlings, shoot infected seedlings, root infected seedlings dead seeds (%)

Water agar seedling symptoms test: Healthy seedlings, shoot infected seedlings, root infected seedlings and dead seeds recorded in water agar seedling symptoms test. The highest healthy seedlings percent were recorded in cucumber (76%) and lowest in okra (42%). The highest shoot infected seedlings were recorded in okra (10%) while lowest recorded in cucumber (3%). Root infected seedlings were highest in okra (14%) and lowest in cucumber (6%). The highest dead seeds were recorded in okra (34%) while lowest recorded in cucumber (15%) as shown in Figure 5.

Discussion

Altogether ten genera of seed borne fungal pathogens viz. *Alternaria*, *Aspergillus*, *Phomopsis*, *Curvularia*, *Fusarium*, *Penicillium*, *Rhizopus*, *Colletotrichum*, *Macrophomina and Cladosporium* were recorded in 7 vegetable seeds viz. amaranth, red amaranth, spinach, okra, cucumber, tomato and eggplant collected from different shops of Mymensingh sadar.

The present investigation revealed that altogether six different fungi viz. *Alternaria* spp., *Aspergillus flavus*, *Aspergillus niger*,

Curvularia spp., *Fusa*rium spp. and *Penicillium* spp. were found to be associated with amaranth seeds. A considerable number of seed borne fungal pathogens belonging to the genera *Aspergillus*, *Curvularia*, *Fusarium* and *Penicillum* had been detected in Amaranth seeds (Begum, 2012). The present findings clearly showed that *Alternaria* spp., *Aspergillus flavus, Aspergillus niger, Curvularia* spp., *Fusa*rium spp. and *Penicillium* spp. were associated with the tested seed samples of amaranth significantly reduced percent germination. Similar result was reported by earlier worker (Islam, 2005).

In red amaranth, six different fungi *Alternaria* spp., *Aspergillus flavus, Aspergillus niger, Fusarium* spp., *Penicillium* spp. and *Rhizopus* spp. were detected where as Khanom (2011) detected *Alternaria* spp., *Aspergillus flavus, Aspergillus niger, Curvularia* spp., *Fusarium* spp., *Phoma* spp., *Penicillum* spp. and *Rhizopus* spp. in leafy vegetables. Richardson (1990) reported only one fungal species *Alternaria amaranthi* in the seeds of *Amaranthus* spp.The present results clearly showed that *Aspergillus flavus, Aspergillus niger, Fusarium* spp., *Penicillium* spp. and *Rhizopus* spp. associated with the tested seed samples significantly reduced percent germination. Similar result was also reported by earlier worker (Islam, 2006).

In case of spinach seeds, four different fungi viz. *Alternaria* spp., *Curvularia* spp., *Fusa*rium spp. and *Penicillium* spp. were found to be associated.

A considerable number of seed borne fungal pathogens belonging to the genera *Alternaria*, *Curvularia*, *Fusa*rium and *Penicillium* had been detected in spinach seeds by many researchers (Begum, 2012; Khanom, 2011). The present findings clearly showed that *Alternaria* spp., *Curvularia* spp., *Fusarium* spp. and *P*
enicillium spp. were associated with the tested seed samples significantly reduced percent germination. Similar result was reported by earlier worker (Islam, 2005).

The present investigation revealed that altogether six different fungi viz. *Aspergillus flavus, Aspergillus niger, Fusarium* spp., *Penicillium* spp., *Colletotrichum dematium* and *Macrophomina phaseolina* were found to be associated with okra seeds. A considerable number of seed borne fungal pathogens belonging to the genera *Aspergillus, Fusarium, Penicillium, Colletotrichum* and *Macrophomina* had been detected in okra seeds by many researchers (Sultana, 2009; Akter, 2008; Alam, 2001; Jamadar *et al*. 2001; Fakir, 2000). The present findings clearly showed that *Aspergillus flavus, Aspergillus niger, Fusarium* spp., *Penicillium* spp., *Colletotrichum dematium* and *Macrophomina phaseolina* were associated with the tested seed samples significantly reduced percent germination. A similar result was reported by some earlier workers (Jamadar *et al*. 2001; Gupta *et al.* 1989; Adisa and Aborisade, 1987; Neergaard, 1979).

In case of cucumber seeds, four different fungi viz. *Alternaria* spp., *Curvularia* spp., *Fusarium* spp. and *Penicillium* spp. were recorded. A considerable number of seed borne fungal pathogens belonging to the genera *Alternaria*, *Curvularia*, *Fusa*rium and *Penicillium* had been detected in cucumber seeds by many researchers (Chowdhury *et al.* 2005; Alimova *et al.* 2002; Nasreen and Sultana, 2000; Puspa *et al.* 1999).The present findings clearly

showed that *Alternaria* spp., *Curvularia* spp., *Fusarium* spp. and *Penicillium* spp. were associated with the tested seed samples significantly reduced percent germination. A similar result was reported by some earlier workers (Begum and Momin, 2000; Alimova *et al.* 2002; Islam, 2005).

In tomato seeds, four different fungi viz. *Aspergillus flavus, Aspergillus niger, Fusarium* spp. and *Cladosporium* spp. were found to be associated with Tomato seeds. *Aspergillus flavus, Aspergillus niger, Fusarium* spp. and *Cladosporium* had been detected in tomato seeds by many researchers (Sultana, 2009; Alam, 2002; Shome, 2002; Delwal and Prasad, 1970). The present findings clearly showed that *Aspergillus flavus, Aspergillus niger, Fusarium* spp. and *Cladosporium* were associated with the tested seed samples significantly reduced percent germination. Similar result was reported by some earlier workers (Delwal and Prasad, 1970; Lorenz and Maynard, 1980).

The present investigation revealed that altogether five different fungi viz. *Aspergillus flavus, Aspergillus niger, Curvularia* spp., *Phomopsis vexans* and *Fusarium* spp. were found to be associated with eggplant seeds. *Aspergillus flavus, Aspergillus niger, Curvularia* spp., *Phomopsis vexans* and *Fusarium* spp. had been detected in eggplant seeds by many researchers (Habib *et al.* 2007; Sarker *et al.*2006; Basak *et al.*1989. The present findings clearly showed that *Aspergillus flavus, Aspergillus niger, Curvularia* spp., *Phomopsis vexans* and *Fusarium* spp. were associated with the tested seed samples significantly reduced percent germination. Similar result was reported by earlier worker (Habib *et al.* 2007).

Germination of vegetable seeds recorded by growing on test varied significantly. Germination failure was highest in okra (50.5%) and lowest in cucumber (13%). There was a highly positive relationship between germination failure and prevalence of seed borne fungal infection. In the present study, germination categories of seeds of 7 vegetables were recorded. Normal seedlings, abnormal seedlings, diseased seedlings and dead seeds were the categories. Normal seedlings ranged from 45 to 77% in 7 vegetables. Normal seedlings were found high in cucumber 77(%), whereas abnormal seedlings were found to be ranged from (2-9%) in seeds of 7 vegetables. The notorious fungi, *Fusarium* spp. cause seedlings infection or foot and root rot disease. *Fusarium* spp. is an established seed borne pathogen capable of causing germination failure/ seed rot, damping-off, root rot and wilts etc in many crops (Mathur *et al.*1975; Richardson, 1990). Non germinated or dead seeds were also encountered in this experiment that varied from (18 to 48%) in germination test. The cause of non-germination was pathogenic infection and sometimes it was physiological cause. Among the 7 vegetable seeds the vigour index was ranged from 272.95 to 2150.5.

The above study revealed very good relationship between seed borne infections and germination failure of vegetable seeds existed. Therefore, further studies with more representative seed samples from different agro-ecological zones of the country should be undertaken in order to reveal the exact picture regarding the prevalence of seed borne fungi and the role they do play on seed germination.

References

Adisa VA, Aborisade AT, 1987. Seed borne mycoflora of two okra cultivars and their effects on seed quality. Journal of Fitopathologia Brasilera **l2**: 388-390.

Akter N, 2008. Effect of plant extract on the management of seed borne fungal diseases of okra, MS Thesis, Department of Plant Pathology, BAU, Mymensingh. 36 and 74 pp.

Alam AKMA, 2001. Studies on the quality of vegetable seeds available in the market, MS thesis, Department of Horticulture, BAU, Mymensingh. 90 pp.

Alam MM, 2002. Studies on the health of some vegetable seeds collected from different sources, MS Thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 49 pp.

Alimova FK, Zakharova NG, Asghar MG, Fattahkova AN, Garusov, AV, 2002. The quarantine control and the methods of disinfection of tomato and cucumber seeds in different regions of Russian Federation. Pakistan journal of Scientific and Industrial Resesrch **45**: 196.

Basak AB, Mridha MAU, Shamina S, 1989. Mycoflora associated with different cultivar of brinjal seeds collected from Chittagong. Journal of Seed Research **17**: 93-95.

BBS 2010. Monthly Statistical Bulletin, January, Ministry of Planing, Govenrment of the People's Republic of Bangladesh, Dhaka, 67.

BBS 2013. GDP of Bangladesh at 2012-2013, Ministry of Planing, Govenrment of the People's Republic of Bangladesh.

Begum HA, Momin A, 2000. Comparison between two detection techniques of seed borne pathogen in cucurbits in Bangladesh. Pakistan Journal of Scientific and Industrial Research **43**: 244-248.

Begum N, 2012. Assessment of health and quality of some vegetables seeds of Saidpur, MS Thesis, Department of plant pathology, BAU, Mymensingh. 36 pp.

Booth C, 1971. The genus *Fusarium*. Commonwealth Mycological Institute, Kew, Surey, England. 236 pp.

Chidambaram PS, Mathur BS, 1975. Production of pycnidia by *Macrophomina phaseolina*. Journal of Transactions of British Mycology Society **64**: 24-25.

Chowdhury Z, Monjil MS, Chowdhury MFI, Hossain MM, 2005. Seed borne fungi in Cucumber *(Cucumis sativa L.)* and musk-melon *(Cucumis melo L.)* of Mymensingh, Bangladesh. Journal of Seed Science & Technology **9**: 105-109.

Delwal GL, Prasad R, 1970. Seed Mycroflora of Cucumber (*Cucumis sativus*). Journal of Indian phytopathology **XXIII**: 105-110.

Fakir GA, 1998, Health Status of Farmer's Jute seeds, Progress and prospects of seed pathological research in Bangladesh. Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 17-18 pp.

Fakir GA, 2000. An annotated list of seed borne diseases in Bangladesh. Seed Pathology Laboratory, Department of Plant pathology, Bangladesh Agricultural University Mymensingh. 20 pp.

FAO 2012. World agriculture towards 2015/2030, Summary report, Rome, Food and Agriculture Organization of the United Nations.

Gupta k, Sindu IR, Nazz S, 1989. Seed mycoflora of *Abelmoschus esculentus* (L.) Moench: A Survey and

enumeration. Journal of Acta Botanica Indica **17**: 200-206.

Habib A, Sahi ST, Ghazanfar MU, All S, 2007. Location of Seed borne Mycoflora of Eggplant *(Solanum melongena* L.) in different Seed Components and Impact on Seed Germinability, Department of Plant Pathology, University of Agriculture, Faisalabad-38040, Pakistan. International Journal of Agriculture and Biology **9**: 3.

Islam MR, 2005. Studies on the health and seedling diseases of some leafy vegetables, MS Thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 67 pp.

Islam MS, 2006. Study on the seed health status of selected vegetable crops, MS Thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 47 pp.

ISTA 2001. International Rules for Seed Testing, Rules amendments. Journal of Seed Science and Technology **29**: 1-12

Jamadar MM, Ashok S, Shamrao J, Sajjan A, Jahangidar S, 2001. Studies on seed mycoflora and their effect on germination of colour graded okra [*Abelmoschus esculentus* (L.) Moench]. Journal of Crop Research **22**: 479-484.

Khan AZMNA, Islam S, 1975. *Colletotrichum lindemuthianum* of *Dolichos lablab* from Bangladesh. Bangladesh Journal of Botany **4**: 121-123.

Khanom D, 2011. Assessment of health and quality of some vegetables seeds of Mymensingh, MS Thesis, Department of plant pathology, BAU, Mymensingh. 28 pp.

Kulshrestha DD, Mathur SB, Neergaard P, 1976. Identification of Seed borne species of *Colletotrichum.* Journal of Danish Seed Health Centre freesia **11**: 116-125

Lorenz OA, Maynard DN, 1980. Knott's Handbook for Vegetable Growers. 2nd edition, John Wiley and Sons, New York.

Malone GP, Muskette AE, 1964. Seed borne fungi, Description of 77 fungal species. Proceedings of the International Seed testing Association **29**: 180-183.

Mathur SK, Mathur SB, Neergaard P, 1975. Detection of seed borne fungi in sorghum and location of *Fusarium moniliforme* in the seed. Journal of Seed Science and Technology **3**: 683-690.

Nasreen S, Sultana N, 2000. Seed health testing of Cucumber *(Cucumis sativus* L). Pakistan Journal of scientific and industrial Research **43**: 127-129.

Neergaard P, 1979. Seed Pathology, Volume l. The MacMillan press Limited, London. 839 pp.

Puspa K, Borkar GM, Patil DV, 1999. Studies on seed borne pathogens of pumpkin, cucumber, watermelon and muskmelon. Journal of Soils and Crops **9**: 234-238.

Ramnath, Neergaard P, Mathur SB, 1970. Identification of *Fusarium* spp. on seeds as they occur in blotter test. Proceedings of the International Seed Testing Association **35**: 121-144.

Rashid AQMB, Fakir GA, 2000. Impact of seed health on sustainable crop production in Bangladesh. Co-operation, Yearly Journal Published by Cooperative Department of Samabaya Sadan, 9/D, Motijheel Commercial Area, Dhaka-l000, Bangladesh. 24-36 pp.

Richardson MJ, 1990. An annotated list of seed borne diseases. 4th edition, The International Seed Testing Association, Switzerland. 338 pp.

Sarkar ABMM, Alam KH, Miah MK, Khatun MJM, Rashid AQMB, 2006. Effect of seed borne fungal pathogens on the planting value of brinjal seeds of different sources. International Journal of Sustainable Agriculture Technology **2**: 22-27.

Shome AK, 2002. Studies on the quality of tomato, brinjal and onion seeds available in the market, MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. 54 pp.

Sultana L, 2009. Assessment of health status of TLS of Bean, Tomato, Okra and Cowpea seeds in the markets of Bangladesh, MS Thesis, Department of Plant Pathology, BAU, Mymensingh. 39 pp.