

PREVALENCE OF FUNGI ASSOCIATED WITH SOYBEAN SEEDS AND PATHOGENICITY TESTS OF THE MAJOR SEED-BORNE PATHOGENS

L.R. SHO VAN¹, M. K. A. BHUIYAN¹, N. SULTANA², J. A. BEGUM¹ AND Z. PERVEZ¹

¹Department of Plant Pathology, ²Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Accepted for publication: March 20, 2008

ABSTRACT

Shovan L.R., Bhuiyan M. K. A., Sultana N., Begum J. A. and Pervez Z. 2008. Prevalence of Fungi Associated with Soybean Seeds and Pathogenicity Tests of the Major Seed-Borne Pathogens. Int. J. Sustain. Crop Prod. 3(4):24-33

An investigation to detect the seed borne fungi of soybean and the pathogenicity tests of two major seed-borne fungal pathogens against soybean was conducted in the Microbiology Laboratory of Plant Pathology Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during 2005 to 2006. A total of 33 soybean seed samples were collected from four different locations namely Gazipur (BARI), Mymensingh (BAU), Meherpur (local farmer) and Noakhali (local farmer) representing three varieties and 16 genotypes. Blotter method was used for detection of the associated fungi of soybean seeds. Altogether, ten fungi comprising nine genera namely *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus niger*, *Chaetomium globosum*, *Colletotrichum dematium*, *Curvularia lunata*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Penicillium* sp. and *Rhizopus stolonifer* were found to be associated with the tested soybean seed samples. The germination of seed samples varied from 16-98 %. Germination of seeds was directly related to the prevalence of fungi associated with the seed. The pathogenicity test was performed with 25 isolates of *C. dematium* and 33 isolates of *F. oxysporum* against the variety Shohag in pot culture. All the tested isolates of both the pathogens were found to be pathogenic. Among the tested 25 isolates of *C. dematium* two isolates namely C19 and C20 collected from Noakhali district from variety Shohag were appeared to be virulent. Twelve were appeared to be moderately virulent while rest of the 11 isolates was found to be weak pathogen. Among the tested isolates of *F. oxysporum*, three isolates namely F21, F22 and F23 were appeared to be highly virulent. Seven isolates were found to be virulent, 13 isolates showed moderately virulence reaction and 10 isolates were appeared to be weak pathogens.

Key words: Pathogenicity, prevalence, seed-borne fungi, seed germination

INTRODUCTION

Soybean, (*Glycine max* (L) Merrill) is a world wide economic crop and the most important cultivated legume with hundreds of food, feed and industrial uses. It is an introduced crop in Bangladesh. The crop can be grown in tropical, sub-tropical as well as the temperate regions. It is a primary source of vegetable oil and protein concentrates (Anon. 1994). Soybean is an excellent source of major nutrients, about 40% of dry matter is protein and 20% fat (Cald Well 1973). As soybean acreage has expanded throughout the world, diseases have increased in number and severity. All parts of the soybean plant are susceptible to a number of pathogens which reduce the quality and/or quantity of seed yield. Soybean suffers from as many as 150 different diseases (Sinclair and Shurtleff 1975). Generally one or more diseases can be found in one field wherever soybeans are grown. A specific one may be very destructive in one season and difficult or impossible to find in the next season. Among the serious diseases of soybean, most of them are seed transmitted. In Bangladesh, only a limited study has been done on the prevalence of seed-borne fungi of soybean. In a preliminary report by Bhuiyan and Fakir (1982) on the important seed-borne fungi of soybean encountered were *Cercospora kikuchii*, *C. dematium* var. *truncatum*, *C. lindemuthianum*, *F. equiseti*, *F. oxysporum*, *F. solani*, *M. phaseolina*, *Myrothecium roridum* and *Phomopsis sojae*. They did not study the pathogenicity of the important seed-borne fungi of soybean. Although a lot of published reports on the seed-borne fungi of soybean are available in different soybean growing countries of the world but the information on the seed-borne fungi and their severity in causing diseases in Bangladesh is scanty. The present study has therefore been undertaken to detect the seed-borne fungi associated with soybean seeds and also to study the pathogenicity of the major seed-borne fungal pathogen causing serious diseases of soybean.

MATERIALS AND METHODS

The experiments on the prevalence of seed borne fungi of soybean and the pathogenicity of the major seed-borne fungal pathogens against soybean was conducted in the Microbiology Laboratory of Plant Pathology Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, during September, 2005 to March, 2006.

Collection of seed samples

A total of 33 seed samples of which 3, 16, 4 and 10 were collected from Gazipur (BARI), Mymensing (BAU),

Meherpur (local farmers) and Noakhali (local farmers), respectively during September 2005 to March 2006. Among the collected samples, 15 seed samples were variety Shohag, one variety BARI Soybean 4 and one variety BARI Soybean 5 and rest of the 16 seed samples collected from BAU were genotypes. All the seed samples collected from Meherpur and Noakhali were variety Shohag. The seeds were brought to the Plant Pathology Laboratory of BSMRAU and stored at room temperature for subsequent studies.

Detection and identification of fungi

Seed samples were analyzed for the detection of seed-borne fungi by blotter method following International Rules for Seed Health Testing (Anon. 1976) with some modifications. In this method three layers of blotter paper were soaked in sterilized water and placed at the bottom of the petridish. 100 seeds taken randomly from each sample and were placed in 10 petridishes (10 seeds per petridish). The petridishes with seeds were then incubated at room temperature for 7 days in the Laboratory. Germination and fungi associated with the seeds were also recorded during the incubation period. Each of the incubated seeds was examined under stereobinocular microscope to ascertain the presence of fungi. Sometimes fungi were not apparent even after seven days of the incubation. In such condition, the petridishes were allowed for further incubation. A temporary slide was prepared from each fungal colony, which could not be identified under stereobinocular microscope. Fungi were identified by preparing temporary slides and examining under the compound microscope. In fewer cases the fungi from the incubated seeds were transferred to PDA medium in petridishes aseptically and incubated under controlled temperature ($28\pm 1^\circ\text{C}$) for 3-10 days and then examined under compound microscope. Identification of fungi was confirmed observing their growth character on the slides under compound microscope by using a standard key as described by Rubert and Streets (1982).

Pathogenicity test of major seed-borne fungi on soybean plants

Based on the results of the prevalence study, two major fungal pathogens were found to be most predominant and selected for pathogenicity test against soybean plants.

Colletotrichum dematium

A total of 25 isolates of *C. dematium* was evaluated for the anthracnose symptom development on the leaf on soybean variety Shohag collected from Noakhali district (N-3). All the isolates were collected from the *C. dematium* infected seed samples analyzed for the prevalence of seed-borne fungi of soybean. Seven days old culture of *C. dematium* grown on PDA was flooded with 10 ml of sterilized distilled water. Acervuli and conidia along with mycelial mass were separated from the substratum by scrapping with a narrow edged sterilized glass slide. The suspension was sieved through double layer cheese cloth to discard acervuli and mycelial mass. The spore suspension was adjusted to 5×10^5 conidia ml^{-1} by adding sterilized distilled water and counting under stereo binocular microscope using counting slide haemocytometer.

The pathogenicity of *C. dematium* isolates was checked against soybean plants in a pot culture. Each earthen pot was filled with 1.0 kg sterilized soil. Three replicated pots were used for each isolate and 10 soybean seeds were sown in each pot. Inoculation was done when more than 80% seedling reached at 4-5 leaf stage. The inoculum suspension was sprayed in the evening on the soybean seedlings by using a Hand sprayer. The seedlings under control treatment were sprayed only with distilled water. After inoculation seedlings were covered with polythene bags moistened from time to time to ensure proper humidity. Polythene bags were removed from the inoculated seedlings 36 hours after inoculation. Anthracnose symptom development on the detached inoculated leaves was recorded 72 hours after inoculation. Based on the severity of the symptom appearance on the leaf, disease development was graded as +++++, +++, ++, + and – representing highly virulent, virulent, moderately virulent, weak pathogen and avirulent, respectively. Reisolation from the artificially inoculated leaves has been done to ensure the causal pathogen as *C. dematium*.

Fusarium oxysporum

A total of 33 isolates of *F. oxysporum* was evaluated for the foot and root rot or wilting symptom development of soybean seedlings against soybean variety Shohag of Meherpur district (M-2). The selected isolates were also collected from the seed samples analyzed for the prevalence of seed-borne fungi of soybean. Wheat grains were used as substrates for the preparation of inoculum of the selected 33 isolates of *F. oxysporum*. Wheat grains soaked in water over night was taken in the 500 ml Erlenmeyer (Pyrex) flasks up to 1/3 from the bottom and autoclaved under 1.1 Kg/cm^2 pressure at 121°C for an hour. Separate flasks were used for the preparation of each isolate. Ten mycelial discs each of 5 mm diameter were cut from the edge of three days old PDA culture of petridishes and added into the flasks for each isolate. Flasks containing autoclaved wheat grain with the inoculum were then incubated at 25°C for 20 days. The incubated flasks were shaken by hand at 2-3 days

interval for even colonization. The colonized wheat grains were air dried for 2 weeks and stored at 10 °C for further use.

The pathogenicity of the selected 33 isolates of *F. oxysporum* was checked on soybean plants by inoculating pot soil and planting seeds before setting subsequent experiments in a pot culture. Each earthen pot was filled with 1.0 kg sterilized soil. Inocula of each isolate of *F. oxysporum* were thoroughly mixed with sterilized soil @ 20g/kg soil. Controls were prepared using sterilized soil only. Thirty seeds of soybean were sown for each isolate of *F. oxysporum* in three replicated pots. Foot rot and wilting were observed regularly and recorded at 10 and 20 days after planting. Plants infected from 80 to 100% were graded as highly virulent, 70 to 79% infection was graded as virulent, 50 to 69% infection was graded as moderately virulent and less than 50% infection was considered as weak pathogen. Re-isolation of the pathogen from the infected plants was also done to confirm the causal agent of foot rot and wilting. The disease development was expressed as % plant infected.

RESULTS AND DISCUSSION

Prevalence of seed borne fungi of soybean

Altogether ten fungi comprising nine genera namely *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus niger*, *Cheatomium globosum*, *Colletotrichum dematium*, *Curvularia lunata*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Penicillium* sp. and *Rhizopus stolonifer* were isolated from soybean seed samples (Table 1 and Figure 1). The fungal colony and the morphology of the isolated fungi are demonstrated in the Figure 2.

Among the isolated fungi *A. flavus* was most prevalent followed by *A. niger*, *F. oxysporum*, *C. dematium* and *Penicillium* sp ranged from 10-72%, 4-28%, 4-38%, 0-22%, 0-17%, respectively. The highest incidence of *A. flavus*, *F. oxysporum*, *A. niger*, *A. alternata*, *C. dematium*, *Penicillium* sp. *C. globosum*, *C. lunata* and *R. stolonifer* and *M. phaseolina* was 72%, 38%, 28%, 26%, 22%, 21%, 11%, 10% and 4%, respectively. These fungi were reported to seed borne in soybean by a number of other workers (Bhuiyan and Fakir 1993, Garcia *et al.* 1991, Gupta *et al.* 1993, Anwar *et al.* 1995). In blotter test, the germination of seed samples varied from 16-98 %. The highest germination of 98 % was recorded on seed sample N-10 variety Shohag from Noakhali district where the most pathogenic fungi *A. alternata*, *C. dematium*, *F. oxysporum* and *M. phaseolina* were either absent or present in a fewer number. The lowest germination was recorded in N-4 and also on variety from Noakhali district in which the incidences of these pathogenic fungi and *Aspergillus* spp. were present dominantly. It has been clearly evident that not only the pathogenic fungi but also the presence of the storage fungi like *Aspergillus* spp. caused lower the germination of the seeds. Where the prevalence of fungi was higher, germination percentage of the seed was lower. Similar observation was also reported by other investigators (Anwar *et al.* 1995).

Among the isolated fungi *F. oxysporum*, *C. dematium*, *A. alternata* and *M. phaseolina* were pathogenic on soybean but the other fungi are not reported as pathogenic rather those were reported as storage fungi on soybean (Gupta *et al.* 1993, and Anwar *et al.* 1995). The incidence of the pathogenic fungi *F. oxysporum* was observed on all the 33 tested varieties/lines and *C. dematium* was prevalent on 25 varieties/lines and also considered as the major pathogen of soybean. *M. phaseolina* causing charcoal rot of soybean was also a major disease but in this prevalence study the incidence of *M. phaseolina* as a seed-borne pathogen was found very negligible. Based on the prevalence of the pathogen associated with soybean seeds in the current study, *F. oxysporum* and *C. dematium* was selected for pathogenicity tests against soybean plants.

Pathogenicity test of *C. dematium* and *F. oxysporum* on soybean plants

The results of pathogenicity test of selected 25 isolates of *C. dematium* against soybean seedlings are presented in the Table 2. The symptoms of anthracnose appeared on soybean plants are shown in the Figure 3. Two isolates namely C19 and C20 collected from Noakhali district of variety Shohag appeared as virulent. Twelve isolates including C4, C5, C8, C10, C12, C15, C17, C18, C21, C22, C23 and C25 were appeared as moderately virulent while rest of the 11 isolates were found to be weak pathogen developing minute and minimum anthracnose spots on the inoculated leaf surface. Among the tested isolates of *F. oxysporum* only three isolates namely F21, F22 and F23 were highly virulent. Isolates F15, F18, F25, F26, F28, F29 and F32 were virulent and the isolates F1, F2, F4, F5, F7, F10, F13, F16, F17, F20, F24, F27 and F31 were moderately virulent and rest of the isolates F3, F6, F8, F9, F11, F12, F14, F19, F30 and F33 were appeared to be weak pathogens (Table 3 and Figure 3). The highest 93.33% plants showed foot and root rot or wilting symptom by the isolate F21, 86.67% by the isolate F22 and 83.33% by the isolate F23 on the variety Shohag M-2, M-3 and M-4 collected from Meherpur, respectively.

In fact, it is difficult to conclude about the degree of virulence as only single method of inoculation has been used and observation was also done for shorter period in pot culture. In the field condition with different methods of inoculation the degree of virulence of the isolates may be varied greatly. The results of the present study of the pathogenicity are in agreement with several investigators who also reported that *C. dematium* and *F. oxysporum* were highly pathogenic causing anthracnose and foot and root rot or wilt diseases of soybean, respectively (Roy 1982, Shchelko et al. 1982, Skripka et al. 1989 and Johansen et al. 1994).

Table 1. Prevalence of different seed-borne fungi associated with soybean seeds

Seed Samples	% prevalence of fungi										%Germination
	<i>Fusarium oxysporum</i>	<i>Alternaria alternata</i>	<i>Colletotrichum dematium</i>	<i>Curvularia lunata</i>	<i>Macrophomin a phaseolina</i>	<i>Chaetomium globosum</i>	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>	<i>Penicillium sp.</i>	<i>Rhizopus stolonifer</i>	
Shohag	24	4	3	2	0	4	27	12	7	0	63
Soybean-4	12	3	7	0	0	2	22	13	6	0	70
Soybean-5	16	2	5	4	0	2	28	7	7	0	80
AGS-120	20	0	9	0	2	0	19	20	11	4	75
Asset-93	10	5	11	0	0	0	12	16	11	3	74
G-2261	4	0	0	5	0	3	17	9	13	6	94
BAU-20	26	4	4	2	0	11	23	12	17	5	71
BAU-5	7	0	7	0	0	0	20	15	12	8	87
G-2120	4	0	0	0	0	5	30	4	21	4	92
ACC-1222	20	2	8	3	0	4	20	4	12	10	58
AGS-95	5	0	0	0	0	6	31	14	11	3	90
Gaurab	8	7	9	0	0	5	27	16	16	9	84
MTD	15	2	12	0	0	3	24	14	10	4	59
JS-5	4	0	3	0	0	0	10	17	8	7	85
Colombus	20	5	11	0	0	0	33	15	12	0	75
G-10180	9	6	4	0	2	0	17	28	13	6	74
AGS-91	11	0	0	3	0	5	16	14	12	2	70
BAU-6	22	0	6	0	0	3	34	28	3	0	81
AGS-302	4	2	9	6	4	0	16	13	17	0	82
M-1	28	11	0	2	0	0	18	18	13	7	40
M-2	38	13	10	10	0	0	19	12	10	6	22
M-3	32	22	0	0	0	0	48	18	3	2	24
M-4	28	26	11	0	0	0	21	7	2	4	35
N-1	24	2	0	5	0	2	42	23	5	2	52
N-2	23	5	7	2	0	6	47	26	2	0	60
N-3	21	2	22	0	0	2	40	20	0	3	25
N-4	20	4	16	3	0	0	72	21	0	2	16
N-5	22	0	10	2	0	3	68	20	0	0	50
N-6	26	4	12	6	0	2	30	11	7	0	30
N-7	9	3	15	0	0	0	39	25	4	0	67
N-8	22	6	8	4	0	0	35	16	5	0	61
N-9	26	4	16	5	0	0	31	8	2	4	35
N-10	4	0	0	2	0	0	20	4	0	3	98
Mean	17.09	4.36	7.12	2.00	0.24	2.06	28.97	15.15	8.24	3.15	

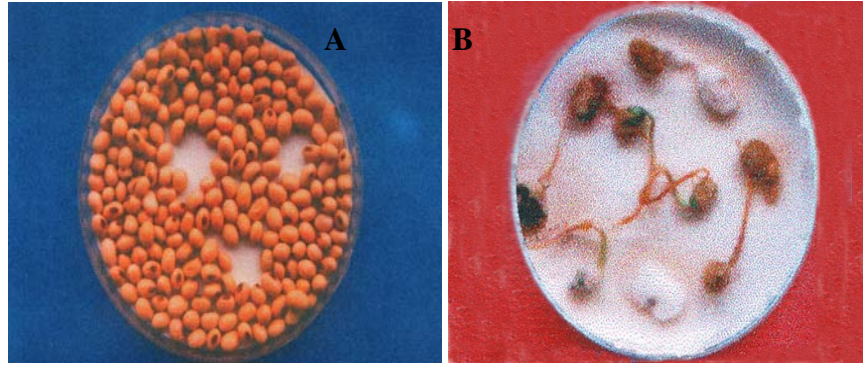


Figure 1. A. Healthy soybean seeds and B. Seed-borne fungi infected soybean seeds seven days after incubation on blotter.

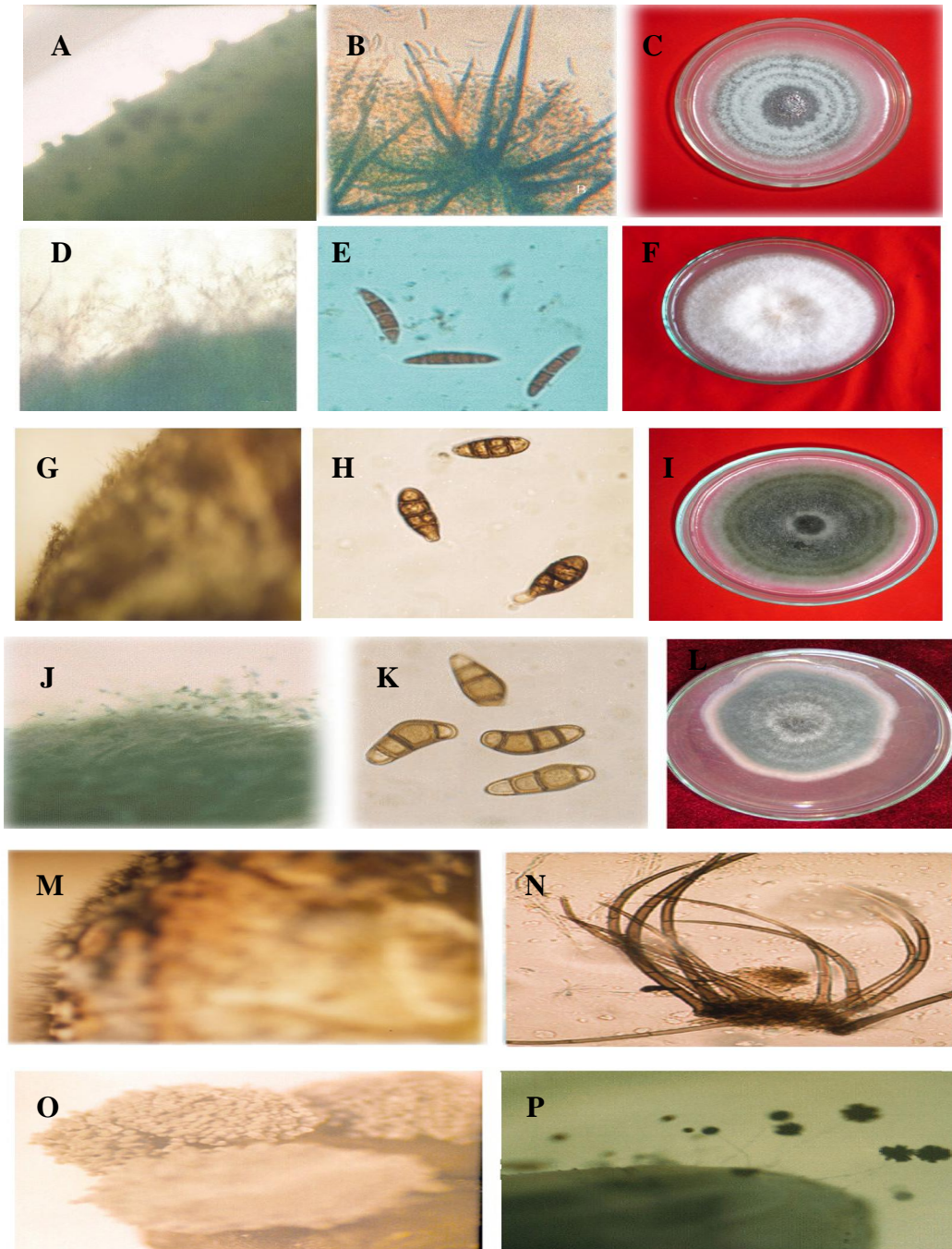


Figure 2. Fungi isolated from soybean seeds [A,B,C *Colletotrichum dematium*; D,E,F *Fusarium oxysporum*; G,H,I *Alternaria alternata* J,K,L *Curvularia lunata*; M,N *Chaetomium globosum* O. *Aspergillus flavus*; P. *Aspergillus niger*.]

Table 2. Pathogenicity test of *Colletotrichum dematium* isolates against soybean variety Shohag collected from Noakhali district seed sample N-3 with their origin and locations.

Isolates of <i>C. dematium</i>	Variety/ Genotype	Designation of seed sample	Location	Degree of virulence
C1	Shohag	Shohag	BARI, Joydebpur	+
C2	Soybean-4	Soybean-4	BARI, Joydebpur	+
C3	Soybean-5	Soybean-5	BARI, Joydebpur	+
C4	AGS-120	AGS-120	BAU, Mymensingh	++
C5	Asset-93	Asset-93	BAU, Mymensingh	++
C6	BAU-20	BAU-20	BAU, Mymensingh	+
C7	BAU-5	BAU-5	BAU, Mymensingh	+
C8	ACC-1222	ACC-1222	BAU, Mymensingh	++
C9	Gaurab	Gaurab	BAU, Mymensingh	+
C10	MTD	MTD	BAU, Mymensingh	++
C11	JS-5	JS-5	BAU, Mymensingh	+
C12	Colombus	Colombus	BAU, Mymensingh	++
C13	G-10180	G-10180	BAU, Mymensingh	+
C14	BAU-6	BAU-6	BAU, Mymensingh	+
C15	AGS-302	AGS-302	BAU, Mymensingh	++
C16	Shohag	M-2	Meherpur	+
C17	Shohag	M-4	Meherpur	++
C18	Shohag	N-2	Noakhali	++
C19	Shohag	N-3	Noakhali	+++
C20	Shohag	N-4	Noakhali	+++
C21	Shohag	N-5	Noakhali	++
C22	Shohag	N-6	Noakhali	++
C23	Shohag	N-7	Noakhali	++
C24	Shohag	N-8	Noakhali	+
C25	Shohag	N-9	Noakhali	++



Figure 3. Pathogenicity of *C. dematium* and *F. oxysporum* [A: Anthracnose symptoms on soybean leaf; B: *F. oxysporum* infected seedlings; C: Healthy soybean seedling; D: *F. oxysporum* infected soybean seedling's roots; E: Healthy soybean seedling's roots]

Table 3. Pathogenicity test of *Fusarium oxysporum* isolates against soybean variety Shohag collected from Meherpur district seed sample M-2 with their origin and locations.

Isolates of <i>F. oxysporum</i>	Variety/Genotype	Designation of seed sample	Location	% plant infected
F1	Shohag	Shohag	BARI	60.00
F2	Soybean-4	Soybean-4	BARI	53.33
F3	Soybean-5	Soybean-5	BARI	46.67
F4	AGS-120	AGS-120	BAU, Mymensingh	66.67
F5	Asset- 93	Asset- 93	BAU, Mymensingh	60.00
F6	G – 2261	G – 2261	BAU, Mymensingh	43.33
F7	BAU-20	BAU-20	BAU, Mymensingh	63.33
F8	BAU-5	BAU-5	BAU, Mymensingh	40.00
F9	G-2120	G-2120	BAU, Mymensingh	33.33
F10	ACC-1222	ACC-1222	BAU, Mymensingh	66.67
F11	AGS-95	AGS-95	BAU, Mymensingh	40.00
F12	Gaurab	Gaurab	BAU, Mymensingh	33.33
F13	MTD	MTD	BAU, Mymensingh	56.67
F14	JS-5	JS-5	BAU, Mymensingh	33.33
F15	Colombus	Colombus	BAU, Mymensingh	70.00
F16	G-10180	G-10180	BAU, Mymensingh	60.00
F17	AGS-91	AGS-91	BAU, Mymensingh	60.00
F18	BAU-6	BAU-6	BAU, Mymensingh	76.67
F19	AGS-302	AGS-302	BAU, Mymensingh	36.67
F20	Shohag	M-1	Meherpur	63.33
F21	Shohag	M-2	Meherpur	93.33
F22	Shohag	M-3	Meherpur	86.67
F23	Shohag	M-4	Meherpur	83.33
F24	Shohag	N-1	Noakhali	53.33
F25	Shohag	N-2	Noakhali	76.67
F26	Shohag	N-3	Noakhali	73.33
F27	Shohag	N-4	Noakhali	66.67
F28	Shohag	N-5	Noakhali	70.00
F29	Shohag	N-6	Noakhali	73.33
F30	Shohag	N-7	Noakhali	40.00
F31	Shohag	N-8	Noakhali	66.67
F32	Shohag	N-9	Noakhali	70.00
F33	Shohag	N-10	Noakhali	33.33

REFERENCES

Anonymous 1976. International Rules for Seed Testing. International Seed Testing Association (ISTA). Seed Sci. Tech. 24 (supplement): 29-72

Anonymous 1994. Tropical Soybean Improvement and Production. Published by FAO. Rome, 1994. ISBN 92-5-103312-4, FAO code: 11.pp 1-5

Anwar, S.A., Abbas, S.F.Gill, M.M., Rauf, C.A., Mahmood, S. and Bhutta, A.R. 1995. Seed borne fungi of soybean and their effect on seed germination. Pakistan Journal of Phytopathology 7(2):184-190

Bhuiyan, K.A. and Fakir, G. A. 1982. Control of two major seed-borne pathogens of soybean with seed dressing fungicides. Proc. 6th and 7th Bangladesh Ann. Sci. Conf. Abs. Section-1: 69 p

- Bhuiyan, K.A. and Fakir, G. A. 1993. Prevalence of seed-borne infection of *Colletotrichum dematium* var. *truncatum* on soybean and its control both in *vitro* and *in vivo* with different seed dressing fungicides. Thai J. Agric. Sci. 26: 1-10
- Cald Well, B.E. 1973. Soybean: Improvement production and use. Medison Univ. American Soc. For Agronomy, pp. 1-10, 17-22
- Garcia, J. L., Diaz Carrasco, H. and Gonzales, L.A.1991. Major pathogens observed in soybean seeds. Soybean Abstract 1993. 16(4)
- Gupta, I.J., Schmitthenner, A.F. and McDonald, M.B. 1993. Effect of storage fungi on seed vigour of soybean. Seed science and Technology 21(3):581-591
- Johansen, O., Stolen, O. and Pooldakdi A. 1994. Seed, seedling and adult plant resistance of soybean to *Colletotrichum truncatum* in Thailand. World Soybean Research Conference V. 11p. Abstract, held in Chiang Mai. Thailand on 20-26 February, 194.11p
- Roy, K.W. 1982. Seedling diseases caused in soybean by species of *Colletotrichum* and *Glomerella*. Phytopathology 72 (8): 1093-1096
- Shchelko, L.G., Prostakoua, H.J. and Nikitina, K.V. 1982. Species composition of fungus and bacterial diseases of soybean seeds. Trudy po prikladnoi Botanike, Genetike; Seleksii 72(1):111-116
- Sinclair, J.B. and Shurtleff, M.C. 1975. Compendium of soybean diseases. American Phytopathological Society 69 pp
- Skripka, O.V., Sizova, T.P. and Bab'eva, E.N. 1989. Fungi on soybean seeds in Abkhazia. Mikologiya i Fitopatologiya 20(4) 306-308.