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# Prevalence of Seed-borne Fungal Invasion on Tossa Jute (*Corchorus olitorius*) Seeds

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## To cite this article:

Fakhar Uddin Talukder, Mohammad Sohanur Rahman, Saleh Mohammad Ashraful Haque, Mohammad Mia Mukul. Prevalence of Seed-borne Fungal Invasion on Tossa Jute (*Corchorus olitorius*) Seeds. *Frontiers in Environmental Microbiology*. Vol. 7, No. 1, 2021, pp. 15-21. doi: 10.11648/j.fem.20210701.13

**Received:** December 30, 2020; **Accepted:** January 9, 2021; **Published:** March 12, 2021

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**Abstract:** Fungi of different kinds/races have been observed on Tossa jute seeds collected from different locations in Bangladesh. These fungi harm the quality of seeds and lessen germination percentage of the seeds. The aim of this research was to determine the seed-borne fungal pathogens on Tossa jute varieties collected from different locations in Bangladesh. The experiments were conducted following Completely Randomized Design (CRD) with four replications. Eight Tossa jute varieties are used in the present research. Seed sample of each and every variety collected from each of four different districts of Bangladesh. The predominant identified fungi were *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Aspergillus spp.*, *Fusarium spp.* and *Penicillium spp.* Kishoregonj District as well as O-72 variety is the most vulnerable in response of seed borne fungal infection, individually and simultaneously. Rangpur District as well as O-795 variety is the most secure in response of seed borne fungal infection, individually and simultaneously. No limitation has been found to conduct the experiment. Seed borne fungal pathogens are the extreme constraints which deadly influenced the healthy Tossa jute seed production. From the results obtained from this study, it will be easy to select the right variety and location for Tossa jute seed production in Bangladesh. And Farmers can be careful at the beginning of Tossa jute seed cultivation to get rid of the fungus which is more prevalent.

**Keywords:** Seed, Tossa Jute, Fungi

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## 1. Introduction

Tossa jute, (*Corchorus olitorius*), also called Jute mallow, nalta jute, or jew's mallow, annual herbaceous plant belongs to the mallow family (Malvaceae), mainly cultivated as like a source of jute fibre (natural bast fibre). Its juvenile stems and mucilaginous leaves are frequently eaten as a vegetable [1]. It is mostly grown in the tropical and South-East Asian countries particularly in Bangladesh and India. The fibre of jute produced in Bangladesh is frequently deliberated the best quality fibre in the world. Jute is recognized the "golden fiber" for its bright color as well as high cash value. The jute fibre comes from the ribbon (outer skin of main stem) of the jute plant. Among all the natural fibre production, it gains

position second to the cotton among all the natural fibre production [2]. Bangladesh supplies about 70% jute and related product to the global market [3]. Jute has considerable environmental, commercial and socio-economic importance having multifarious end users. One of the deadliest limiting factors in productivity improvement of this cash crop is the incidence of fungal diseases [4]. About 84% of world production of jute fibre is obtained in Bangladesh and India collectively [5]. Jute is a lingo-cellulose fiber which is absolutely biodegradable and eco-friendly [6]. As a whole, Jute and products invented from jute not only conserve green environment and atmosphere but also inhibit ecological degradation [7]. Total area under jute crop production has been anticipated at 7, 79, 658 hectares and total jute crop

production has been anticipated at 85, 76, 0.087 bales in 2018-19 year. Average yield rate has been anticipated at 11.440 bales per hectares [8]. Seed is a fundamental input for any crop production project, but Bangladesh has been facing a severe shortage of good quality jute seed each year [9]. One of the main reasons for not getting high quality jute seeds is the presence of various harmful fungi in jute seeds. Jute crop suffers from over 13 different diseases and among them 10 diseases are seed borne [10]. Rahsid *et al.*, (2007) stated that jute crop suffers from not less than 12 different diseases of which 10 are seed borne [11]. In Bangladesh, the humid and hot environment and moist soil in early growth stage of jute seed production are vastly favorable for fungal growth and infestation. Germination of seeds lessens with exacerbates of the seed borne fungal infection. Sowing of infected seeds (e.g. jute seed) may cause the seedlings death and habitually plants escaping early infection surrender to death due to different diseases. Highly seed-borne infected seeds result to extensively higher extent of disease expansion in the field. But the rate of transmission of all these pathogens from infected seeds to the growing plants and lastly to the harvested seeds was comparatively low [12]. The seed-borne fungal disease e.g. stem-rot caused by *Macrophomina phaseolina* (Tassi) Goid and black-band caused by *Botryodiplodia theobromae* are often transmitted through jute seeds [13, 14]. *Corchorus olitorius* appeared immune to the anthracnose disease caused by *Colletotrichum corchori* [15]. The fungal pathogens resembling *Fusarium* spp. (*Fusarium oxysporum* and *Fusarium semitectum*), is responsible for causing seed rot and germination failure [16]. *Macrophomina phaseolina* individually can cause up to 10% yield loss of jute [17]. Seed discolouration also occurred by various fungi. The disease is soil, air or seed borne in nature which constantly harms the crop beginning from germination to maturity in both fiber as well as seed crops [18]. Seed is a key source of primary inoculum followed by infection throughout soil. The occurrence of fungal disease like stem rot epidemic can be gauged from primary infection, while secondary infection is generally 4 times of the primary infection [19]. Seedlings of jute or young growing plants created from the infected seeds may escape early infection but may frequently be infected at the afterward stages of their growth by the initial seed borne inocula that grown as well as multiplied on the infected deceased seeds along with seedlings. Afterward, those inocula may possibly be transmitted to the vigorous growing plants of the same plant or adjacent plants or even nearby fields consequential to disease outburst, May often in epidemic outline. Seed borne pathogens in jute causes mainly fungal diseases on the growing jute plants, quite frequently attack the pods or capsules and consequently contaminate the seed, ensuing to production of either unhealthy or infected seeds. Taking into account the above facts, the present exploration was conducted with the objective was to find out the availability of different seed borne pathogens in various Tossa jute varieties which are collected different locations of Bangladesh.

## 2. Materials and Method

The experiment was carried out in February, 2020 at plant pathology laboratory, Bangladesh Jute Research Institute to attain related information easily about the jute seeds' health status. Eight varieties of Tossa jute (*Corchorus olitorius*) were selected for this experiment.

### 2.1. Collection of Jute Seed Samples

A total of 32 seed samples (TLS) of Tossa jute (*Corchorus olitorius*) were collected from four different districts of Bangladesh (Manikgonj, Rangpur, Cumilla, Kishoregonj). Each sample was collected from intensively cultivated jute plot. The size of each sample was 250 g (approx.). In the Seed Store of the Plant Pathology Laboratory-BJRI, the seeds were stored in polythene bags at 5-7°C, until these seeds were used for the successive exploration.

Used Varieties:

- (i) V<sub>1</sub>=O-4
- (ii) V<sub>2</sub>=O-9897
- (iii) V<sub>3</sub>=BJRI TOSSA PAT 3 (OM-1)
- (iv) V<sub>4</sub>=BJRI TOSSA PAT 4 (O-72)
- (v) V<sub>5</sub>=BJRI TOSSA PAT 5 (O-795)
- (vi) V<sub>6</sub>=BJRI TOSSA PAT 6 (O-3820)
- (vii) V<sub>7</sub>=JRO-524
- (viii) V<sub>8</sub>=BJRI TOSSA PAT 8 (Robi -1)

### 2.2. Identification of Seed-Borne Fungi Associated with Jute Seeds

All the tossa jute seed samples were tested for the incidence of fungal pathogens imitates by the Blotter Method following the International Rules for Seed Testing Association [20].

### 2.3. Blotter Method for Evaluating Seed Health Status of Jute Seed

The status of Seed health was explored by Blotter method to identify the seed borne fungal pathogens associated with the seed samples. In this way, from each sample one hundred seeds were randomly taken. In plastic petridishes the seeds were planted on three layered water soaked Whatman No. 1 filter paper. 25 jute seeds were plated maintaining equal distance in each Petridis. All petridishes were incubated at 20°C±2°C under 12 hrs, alternate cycle of Near Ultra Violet (NUV) light and darkness [21]. After 7 days of incubation, petridishes containing incubated seeds were observed under stereomicroscope for identifying seed borne fungal pathogens on Tossa jute seeds' surface under stereomicroscope at 25× magnification. Where identification or detection of pathogens was doubtful or difficult under the stereomicroscope, temporary slide was prepared and examined under the compound microscope and identified with the help of expert consultation and literature review. The seed-borne fungi was recorded after seven days of incubation. The results showed the number of fungi present in 25 seeds.

## 2.4. Identification of Seed-borne Fungi

After 7 days of incubation of tossa jute seeds on wet blotting paper the yielded fungi were detected and identified. The fungi yielded were *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Aspergillus spp.*, *Fusarium spp.*, *Penicillium spp.*, *Curvularia spp.*, *Chaetomium spp.*, *Alternaria spp.* A wide range of fungi is observed on the seeds. Among them only the major ones were taken into account in this experiment. Identification of isolated fungi was made on the basis of culture character, sporulation and conidial characters [22].

## 2.5. Analysis of Data

Analysis of variance was done and the mean differences in

the efficacy of the treatments were judged by Duncan's Multiple Range Test (DMRT).

## 3. Results

Fungal pathogens e.g. *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Aspergillus spp.*, *Fusarium spp.*, *Penicillium spp.*, *Curvularia spp.*, *Alternaria spp.*, and *Chaetomium spp.* had been found mostly. The incidence of fungi was observed the maximum at the seed sample collected Kishoregonj district. Minimal pathogen incidence was observed at the seed sample collected from Rangpur district. It is sure that climate has played a significant role in the spread and circumference of fungal pathogens.

**Table 1.** Availability of seed borne fungi at tossa jute seeds collected from different locations of Bangladesh.

Location	Availability of seed borne fungi in 25 seeds							
	MP	BT	Asp	Fus	Pen	Cur	Alt	Cha
Manikgonj	2.28 bc	2.59 a	3.22 a	2.97 b	2.19 a	1.69 b	1.88 b	0.78 c
Rangpur	1.63 c	1.69 b	1.72 b	1.72 c	1.34 b	0.00 c	0.00 c	0.00 d
Cumilla	3.13 ab	3.28 a	4.03 a	3.44 ab	2.72 a	2.22 ab	2.50 ab	1.47 b
Kishoregonj	3.38 a	3.38 a	4.13 a	3.97 a	2.88 a	2.38 a	2.84 a	2.06 a
SE	0.51	0.42	0.54	0.46	0.41	0.31	0.37	0.30
LSD (0.05)	1.01	0.83	1.07	0.91	0.81	0.62	0.73	0.59

BJRI Tossa Pat 5 (O-795) was found the most protective against fungal pathogens. BJRI Tossa Pat 4 (O-72) was found the most vulnerable against fungal pathogens. The incidence of *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Aspergillus spp.* and *Fusarium spp.* are excessive in comparison to *Curvularia spp.*, *Alternaria spp.*, and *Chaetomium spp.* And O-9897 and BJRI Tossa Pat 8 (Robi -1) also performed better in respect to fungal pathogen invasion.

**Table 2.** Availability of seed borne fungi at different varieties of tossa jute seeds.

Variety	Availability of seed borne fungi in 25 seeds							
	MP	BT	Asp	Fus	Pen	Cur	Alt	Cha
V <sub>1</sub>	3.13 b	3.94 a	4.06 b	3.69 b	3.63 a	2.63 a	2.94 a	2.00 a
V <sub>2</sub>	1.81 bc	1.81 cd	1.56 c	1.31 d	1.25 c	0.88 b	0.94 b	0.81 bc
V <sub>3</sub>	2.81 b	3.25 ab	3.31 b	3.44 b	3.13 ab	2.13 a	3.50 a	1.31 a-c
V <sub>4</sub>	4.56 a	4.38 a	5.63 a	5.69 a	3.19 ab	2.38 a	2.94 a	1.56 ab
V <sub>5</sub>	1.19 c	1.31 d	1.56 c	1.06 d	1.25 c	0.69 b	0.94 b	0.50 c
V <sub>6</sub>	2.56 bc	2.50 bc	3.31 b	3.50 b	1.75 c	0.75 b	1.19 b	0.88 bc
V <sub>7</sub>	2.56 bc	2.13 b-d	4.06 b	3.38 bc	2.13 bc	2.19 a	0.88 b	0.88 bc
V <sub>8</sub>	2.19 bc	2.56 bc	2.69 bc	2.13 cd	1.94 c	0.94 b	1.13 b	0.69 c
SE	0.72	0.59	0.76	0.65	0.58	0.44	0.52	0.42
LSD (0.05)	1.43	1.18	1.51	1.29	1.15	0.87	1.03	0.83

Seeds of all varieties collected from Rangpur district are free from *Curvularia spp.*, *Alternaria spp.*, and *Chaetomium spp.* On an average 7.75 *Fusarium spp.* per 25 seeds had been found in BJRI Tossa Pat 4 (O-72) variety. BJRI Tossa Pat 5

(O-795) collected from Rangpur district had been found absolutely pathogen free. Highest amount of *Macrophomina phaseolina* and *Aspergillus spp.* (6.00) per 25 seed had been found in BJRI Tossa Pat 4 (O-72) variety.

**Table 3.** Availability of seed borne fungi at different varieties of tossa jute seeds collected from different locations of Bangladesh.

Loc.	Var.	Availability of seed borne fungi in 25 seeds							
		MP	BT	Asp	Fus	Pen	Cur	Alt	Cha
Manikgonj	V <sub>1</sub>	3.50 a-c	4.50 ab	4.00 a-h	3.75 b-f	3.25 a-e	3.00 a-d	2.75 c-f	1.75 b-e
	V <sub>2</sub>	1.25 c-e	1.50 d-i	1.00 h-k	1.25 f-j	1.00 e-g	0.75 f-h	0.75 fg	0.25 ef
	V <sub>3</sub>	2.75 b-e	3.5 a-e	4.00 a-h	3.50 c-g	2.75 a-f	2.75 a-e	4.50 a-c	1.50 b-f
	V <sub>4</sub>	4.00 a-c	4.25 a-c	5.25 a-c	5.25 a-c	3.50 a-d	2.75 a-e	3.25 b-e	1.00 c-f
	V <sub>5</sub>	0.50 de	0.50 hi	0.75 i-k	0.50 ij	1.25 d-g	0.50 gh	0.75 fg	0.00 f
	V <sub>6</sub>	2.75 b-e	2.00 c-i	4.00 a-h	3.75 b-f	1.75 c-g	0.75 f-h	1.25 e-g	1.00 c-f
	V <sub>7</sub>	1.75 c-e	2.00 c-i	4.25 a-g	3.50 c-g	1.75 c-g	2.25 b-f	0.75 fg	0.25 ef
	V <sub>8</sub>	1.75 c-e	2.50 a-h	2.50 c-k	2.25 e-j	2.25 a-g	0.75 f-h	1.00 fg	0.50 ef

Loc.	Var.	Availability of seed borne fungi in 25 seeds							
		MP	BT	Asp	Fus	Pen	Cur	Alt	Cha
Rangpur	V <sub>1</sub>	2.25 c-e	2.75 a-h	2.50 c-k	1.75 e-j	3.50 a-d	0.00 h	0.00 g	0.00 f
	V <sub>2</sub>	0.50 de	0.75 g-i	0.50 jk	1.00 g-j	0.75 fg	0.00 h	0.00 g	0.00 f
	V <sub>3</sub>	2.50 b-e	2.50 a-h	2.00 d-k	3.25 c-h	2.25 a-g	0.00 h	0.00 g	0.00 f
	V <sub>4</sub>	3.00 b-d	3.75 a-d	4.50 a-f	3.50 c-g	0.75 fg	0.00 h	0.00 g	0.00 f
	V <sub>5</sub>	0.00 e	0.00 i	0.00 k	0.00 j	0.00 g	0.00 h	0.00 g	0.00 f
	V <sub>6</sub>	1.75 c-e	1.00 f-i	1.25 g-k	2.75 c-i	1.50 d-g	0.00 h	0.00 g	0.00 f
	V <sub>7</sub>	1.50 c-e	1.50 d-i	1.50 f-k	0.75 h-j	1.25 d-g	0.00 h	0.00 g	0.00 f
	V <sub>8</sub>	1.50 c-e	1.25 e-i	1.50 f-k	0.75 h-j	0.75 fg	0.00 h	0.00 g	0.00 f
Cumilla	V <sub>1</sub>	3.00 b-d	4.00 a-c	4.75 a-e	5.00 b-d	4.50 a	4.25 a	4.00 a-d	2.50 a-c
	V <sub>2</sub>	2.50 b-e	2.25 b-i	1.75 e-k	1.25 f-j	1.50 d-g	1.25 e-h	1.25 e-g	1.25 c-f
	V <sub>3</sub>	3.25 a-d	3.75 a-d	3.50 b-j	2.75 c-i	3.25 a-e	3.25 a-c	5.50 a	1.25 c-f
	V <sub>4</sub>	5.25 ab	4.75 a	6.75 a	6.25 ab	4.00 a-c	3.25 a-c	4.00 a-d	2.25 a-d
	V <sub>5</sub>	1.75 c-e	2.50 a-h	2.75 c-k	1.75 e-j	1.75 c-g	0.75 f-h	1.25 e-g	0.75 d-f
	V <sub>6</sub>	2.75 b-e	3.25 a-f	4.00 a-h	3.75 b-f	1.75 c-g	0.75 f-h	1.25 e-g	1.00 c-f
	V <sub>7</sub>	3.75 a-c	2.75 a-h	5.50 a-c	4.25 b-e	2.50 a-f	3.00 a-d	1.25 e-g	1.75 b-e
	V <sub>8</sub>	2.75 b-e	3.00 a-g	3.25 b-j	2.50 d-j	2.50 a-f	1.25 e-h	1.50 e-g	1.00 c-f
Kishoregonj	V <sub>1</sub>	3.75 a-c	4.5 ab	5.00 a-d	4.25 b-e	3.25 a-e	3.25 a-c	5.00 ab	3.75 a
	V <sub>2</sub>	3.00 b-d	2.75 a-h	3.00 b-k	1.75 e-j	1.75 c-g	1.50 d-h	1.75 e-g	1.75 b-e
	V <sub>3</sub>	2.75 b-e	3.25 a-f	3.75 a-i	4.25 b-e	4.25 ab	2.50 b-e	4.00 a-d	2.50 a-c
	V <sub>4</sub>	6.00 a	4.75 a	6.00 ab	7.75 a	4.50 a	3.50 ab	4.50 a-c	3.00 ab
	V <sub>5</sub>	2.50 b-e	2.25 b-i	2.75 c-k	2.00 e-j	2.00 b-g	1.50 d-h	1.75 e-g	1.25 c-f
	V <sub>6</sub>	3.00 b-d	3.75 a-d	4.00 a-h	3.75 b-f	2.00 b-g	1.50 d-h	2.25 d-f	1.50 b-f
	V <sub>7</sub>	3.25 a-d	2.25 b-i	5.00 a-d	5.00 b-d	3.00 a-f	3.50 ab	1.50 e-g	1.50 b-f
	V <sub>8</sub>	2.75 b-e	3.50 a-e	3.50 b-j	3.00 c-i	2.25 a-g	1.75 c-g	2.00 d-g	1.25 c-f
SE		1.44	1.19	1.53	1.30	1.16	0.88	1.03	0.84
LSD (0.05)		2.85	2.35	3.03	2.57	2.30	1.74	2.05	1.66



Figure 1. Growth of different types of seed borne fungal pathogens (A-H) on Tossa jute seed under stereo- microscope (X 250).

## 4. Discussion

Total yield (Fibre & stick) loss due to diseases is about 8 - 20% depending on the disease severity which caused by mainly fungal pathogens [23]. In this present investigation, the availability of seed borne fungi in different Tossa jute varieties collected from different districts of Bangladesh was studied. Eight seed borne fungi were detected and identified on the seeds of Tossa jute samples. Least amount of pathogens was observed in seeds collected from Rangpur District almost at each variety. This may be caused for low humidity. Maximum amount of pathogens was observed in seeds collected from Kishoregonj District almost at each variety. The climate of Bangladesh is very suitable for the growth of fungi [24]. High humidity and rainfall during flowering stage which is convenient for the seed borne fungal infection in jute [25]. Seed borne mycoflora is one of the key factors for lessening yield of jute crop. So, the prevention of seed borne mycoflora gets extensive importance. Results of this study revealed that the Tossa jute seeds produced in experimental plot or by farmers are very recurrently infected by seed borne fungi. *Macrophomina phaseolina* and *Botryodiplodia theobromae* are transmitted from seed to plant to seed [26]. The pathogens identified and detected in the present study were *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Fusarium spp.*, *Alternaria spp.*, *Aspergillus spp.*, *Penicillium spp.*, *Chaetomium spp.*, *Curvularia spp.* Seed of all Tossa jute varieties is free from *Colletotrichum corchori* due to species immunity. In case of the countries outside Bangladesh, a large number of scientists reported that *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Alternaria tenuis*, *Colletotrichum corchori*, *Fusarium spp.*, *Curvularia lunata*, *Cephalosporium spp.*, are very much associated with jute seed. [27-30]. In Bangladesh perspective, previously, many personnel investigated the fungal flora coupled with the jute seeds and reported that the seed/soil borne fungi are *Botryodiplodia theobromae*, *Macrophomina phaseolina*, *Chaetomium*, *Curvularia lunata*, *Fusarium spp.*, *Colletotrichum corchori*, *Ascochyta corchoricola*, *Corynespora cassiicola*, *Cercospora corchori*, *Sclerotium rolfsii*, *Phomopsis spp.*, and *Rhizoctonia solani*, which were found to be associated with the jute seeds [31, 32]. The main predominant detected fungi were *Macrophomina phaseolina*, *Botryodiplodia theobromae*, *Fusarium spp.* in Tossa jute seed [33]. In the jute seed samples used in this study, *Trichothecium spp.*, *Phomopsis spp.*, *Cephalosporium spp.*, *Ascochyta corchoricola*, *Rhizoctonia* and *Periconia spp.* were not found to be associated. The incidence of seed borne infection is responsible for lower germination [34]. There may be some reasons behind such a difference between the prior and the present results. These are - Varietal resistance, procedural differences in sample collection, Environmental prevention to grow those fungi, or the way/practices/process of seed production that prevents the growing/multiplication of fungi. Meanwhile, the availability of fungi affects the germination

of jute seeds [35-38]. Availability of pathogens e.g. fungi on seed might be depending on seed processing, seed crop management and storage condition after harvest. Root rot and stem rot of jute caused by *Macrophomina phaseolina* are major diseases of Tossa jute (*C. olitorius*) [39]. The pathogenic potentiality of *Fusarium spp.* on jute seeds may cause seedling blight and germination failure/seed rot/wilt to the crop [40]. *Aspergillus spp.* were quite frequently detected and identified in germinated/rotted seeds in wet blotter paper. Same result was found by [41]. More intensive study about the role of two storage fungi *Fusarium* and *Aspergillus* on is required. They might affect the seed health of jute at storage [42]. The prevalence of *Penicillium spp.*, *Alternaria spp.*, *Chaetomium spp.*, *Curvularia spp.* was lower in comparison to *Macrophomina phaseolina*, *Botryodiplodia theobromae* or *Fusarium spp.* in this present study. This might be due to *Penicillium*, *Alternaria*, *Chaetomium*, and *Curvularia* free seeds used by the farmers, fewer inoculum potential and lessening infection of the jute. *Penicillium chrysogenum* and *P. notatum*, and *Aspergillus fumigatus* were found to be fungal species causing blighted seedling of *Corchorus olitorius* (Tossa jute) [43]. From the above study it was absolutely proved that the availability and invasion of fungi on jute seed is very common. In such a situation, proper attention should be applied on the health status of Tossa jute seed before sowing. Seed treatment by natural ingredients or chemicals before sowing might be an easy & appropriate way to eliminate or reduce the seed borne pathogens from the skin of Tossa jute seed. Lab study is not enough in this case. To find out the amount of damage in crop by each of these fungi individually, further research on field trial of this seeds may be required.

## 5. Conclusions

The jute variety namely BJRI Tossa pat 5 (O-795) was observed with the lowest fungal incidence e.g. 1.19 MP, 1.31 BT, 1.56 Asp, 1.06 Fus, 1.25 Pen, 0.69 Cur, 0.94 Alt and 0.50 Cha were found per 25 seeds. And the jute variety namely BJRI Tossa pat 4 (O-72) was observed with the maximum fungal incidence e.g. 4.56 MP, 4.38 BT, 5.63 Asp, 5.69 Fus, 3.19 Pen were found per 25 seeds. Fungi incidence is shown utmost in seeds collected from Kishoregonj district and minimal from Rangpur district. BJRI Tossa pat 5 (O-795) seeds collected from Rangpur district was found fungi/pathogen free.

## Abbreviation

TLS=Truthfully labelled seeds  
 BJRI=Bangladesh jute Research Institute  
 MP=*Macrophomina phaseolina*  
 BT=*Botryodiplodia theobromae*  
 Asp=*Aspergillus spp.*  
 Fus=*Fusarium spp.*  
 Pen=*Penicillium spp.*

Cur=*Curvularia spp.*

Alt=*Alternaria spp.*

Cha=*Chaetomium spp.*

LSD=Least Significant Differences

SE=Standard error

## Authors' Contributions

Fakhar Uddin Talukder conducted the experiment, collected data and prepared the manuscript. Md. Sohanur Rahman and Md. Mia Mukul helped in conducting the experiment and data analysis. Saleh Md. Ashraf Haque supervised the experiment.

## Conflict of Interests

The authors declare that they have no competing interests.

## Acknowledgments

Authors are highly grateful of Plant Pathology Laboratory - BJRI, Dhaka for providing technical support.

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