

Examining and assessing the prevalence of field diseases affecting tuberose (*Polianthes tuberosa* L.) cultivation: A study conducted in the Jashore District of Bangladesh

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Research Article

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Abstract

A research investigation was conducted in the Jashore district of Bangladesh to examine diseases affecting tuberose plants. The laboratory analysis was performed at the plant disease study facility at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The study encompassed eighteen villages across four unions within the Jhikargacha upazila of the Jashore district. The primary objective was to document the occurrence and severity of diseases in tuberose fields under natural conditions. Seven fungal diseases were detected in the natural field setting and were subjected to further scrutiny in the research facility. The pathogens responsible for these diseases were isolated and identified, revealing botrytis blight (*Botrytis cinerea*), blossom blight (*Fusarium equiseti*), alternaria leaf spot (*Alternaria polyanthi*), leaf tip blight (*Phoma* sp.), peduncle blight (*Lasidiplodia theobromae*), stem rot (*Sclerotium rolfsii*), and tuber rot (*Fusarium oxysporum*). Disease incidence ranged from 0% to 64.33%, and severity ranged from 0% to 24.00%. Stem rot, botrytis blight, alternaria leaf spot, and leaf tip blight were identified as significant challenges in tuberose cultivation in the Jashore district. This study represents the first documentation of tuberose pathogen prevalence in Bangladesh, providing valuable insights for disease management strategies and contributing to the improvement of tuberose cultivation practices in the region.

1. Introduction

Flowers, symbols of elegance and cultural importance, play a vital global role, used not only for decoration during festivities but also as essential ingredients in various products like perfumes and cosmetics [1]. In Bangladesh, floriculture surged in the late seventies, led by tuberose growers. Sher Ali pioneered commercial flower farming in Jashore's Godkhali area in 1983, marking a significant industry milestone, followed by extensive production in Jhikargacha upazila [2]. Flowers hold immense importance in Bangladesh, offering substantial returns and engaging thousands of farmers, particularly in Jashore district, spanning 9,000 hectares [3,4]. Domestic flower marketing is valued at Tk. 300 crore, while international sales reach Tk. 16,000 crore [5]. Despite challenges like insect pest infestation, flower cultivation remains profitable, with tuberose flower agribusiness boasting an impressive average annual profit margin of 257% over a six-month harvest cycle [6,7].

Cut flowers, including tuberose (*Polianthes tuberosa* L.), are cultivated for various purposes such as container displays and individual arrangements. Tuberose is a significant commercial cut flower from tropical and subtropical regions known locally as Rajanigandha in Bangladesh and India [8]. Tuberose, originating from Mexico in the 16th century, is highly valued for its long-lasting spikes and delightful fragrance. It's a key commodity in the floral trade, prized for its essential oil and resilience during transportation [9]. Tuberose flowers are valued for their calming aroma and are in high demand for perfume and oil production [10].

In Bangladesh, disease is a major obstacle in tuberose farming, with fungi accounting for over 80% of plant ailments [11]. Farmers and experts in Bangladesh have identified a total of sixteen diseases affecting tuberose blooms and leaves. Among these, ten are fungal diseases, three are bacterial, one is caused by a nematode, and two affect both flowers and foliage due to viral infections [12].

This study aims to assess tuberose plant diseases in Bangladesh's Jashore district, employing various identification methods at the Plant Pathology Laboratory of Sher-e-Bangla Agricultural University. Using cultural, morphological, and microscopic the study targets causal organisms for seven diseases: botrytis blight, blossom blight, alternaria leaf spot, leaf tip blight, peduncle blight, stem rot, and, tuber rot. Additionally, it quantifies disease occurrence and intensity in natural field conditions, emphasizing disease prevalence variability. This study represents the first comprehensive investigation into tuberose pathogen prevalence and in Bangladesh.

2. Materials And Methods

2.1. Study site

An investigation into tuberose diseases was conducted in the fields of eighteen villages in the Jhikargacha upazila of Jashore district, Bangladesh. Research activities within the laboratory were undertaken at the Plant Disease Study of Sher-e-Bangla Agricultural University in Dhaka, Bangladesh, spanning between February and May 2019. The field survey encompassed eighteen villages spread across four unions of Jhikorgacha Upazila in the Jashore district. From the Godkhali union, it includes Patuapara, Godkhali, Sadirali, Dhalipara, and Belemath. From the Panisara union, it comprises Syedpara, Panisara, Nilkonthonogor, Krishnachandrapur, and Kuliya. From the Navaron union, it consists of Nimtola, Hariya, Baisha, Chadpur, Mathuapara, and Sharifpur. Lastly, from the Nirbashkhola union, it involves Shiorda and Nirbashkhola. During this period, a total of fifty-four fields, with three fields per village across the eighteen villages, were thoroughly investigated.

2.2 Data collection

The field research took place in the natural environment on the surface of plants. A survey sheet for plant diseases was employed to collect data, encompassing information on symptoms, affected plant materials, disease distribution, disease status, percentage of disease occurrence, and percentage of the disease intensity. Thirty plants were selected from five locations within each field to collect data on occurrence and intensity of the disease. Disease occurrence and intensity was calculated employing the subsequent formula [13]:

$$\text{Disease incidence (\%)} = \frac{\text{Plant units diseased}}{\text{Plant units examined}} \times 100$$

$$\text{Disease severity (\%)} = \frac{\text{Area of tissues infected}}{\text{Area of tissues inspected}} \times 100$$

2.3. Separation and identification of causal organisms

Diseased plant parts displaying distinct symptoms were collected from various affected tuberose plants in the fields. These specimens were temporarily stored in sealed zip-lock poly bags, labeled, and transported to the Plant Disease Study laboratory. Stored at 4°C, they were examined for symptoms, subjected to analysis, and isolated to identify the causative microorganisms. The tissue planting method was employed, involving careful slicing of plant sections into small fragments, followed by rinsing and surface sterilization with 1% Mercuric Chloride (HgCl₂). The sterilized fragments were then placed on Potato Dextrose Agar (PDA) medium and incubated for 6-7 days at 25±2 °C. Hyphae tips from growing colonies were transferred to new PDA media to establish pure cultures, with morphological features observed under a microscope.

Identifying disease-causing organisms began with a visual assessment of symptoms during field surveys, followed by careful inspections to observe symptom development, pathogen signs, and environmental conditions, adhering to established procedures [14,15]. In the second step, diseased tissue samples underwent direct microscopic examination using stereoscopic and compound microscopes. Fungal structures were scrutinized for identification. The third phase involved cultivating fungi on infected plant tissues using the moist incubation technique. Diseased specimens were sterilized and incubated on sterile blotting paper for seven days. After fungal growth and spore production, stereo-microscopic examination was conducted to assess growth structures. Pathogenic structures were prepared on slides for scrutiny under a compound microscope. Identification was facilitated by consulting relevant literature. The final phase involved cultivating causal organisms on PDA medium in petri dishes after sterilizing the samples [16]. The leaf dishes sat at room temperature for three days, allowing fungal growth and sporulation. Pure cultures were then obtained through reculturing, using single spore or tip culture methods. Slides prepared from disease-causing structures were examined under a microscope for identification, referencing literature and the CMI Description, as cited [17-21].

2.4. Statistical analysis

The acquired data underwent analysis through the application of descriptive statistics. The assessment of statistics utilized the STATISTIX-10 computer software package, utilizing a one-way analysis of variance (ANOVA). In this study, individual villages were treated as distinct treatments. Within each village, three fields were considered as replications in this analysis. With significance set at $P \leq 0.05$, mean comparisons were executed utilizing the Least Significant Difference (LSD) test. Data pertaining to incidence and severity of the disease underwent square root transformation. The data from the survey underwent analysis using an average mean test.

3. Results

Symptoms analysis study

During the field investigation, ten diseases of the tuberose plant were observed visually and confirmed by the symptomological study. Fungi were linked to seven diseases, bacteria to one, nematodes to one, and viruses to one among the identified diseases. Table 1 provides a description of the symptoms associated with the identified diseases, while Fig 1 visually represents them.

Identifying the causative agents

In the laboratory, different isolated diseased plant parts were studied and seven pathogens were identified through the observation of the pure cultures, and microscopic characteristics of the causal organisms are shown in Fig 2.

Organisms identified as the causative agents for stem rot disease in tuberose were *Sclerotium rolfsii* and *Fusarium oxysporum*. *S. rolfsii* exhibited white-cottony mycelium on PDA medium within 7 days, with compact, mustard seed-like sclerotia turning from whitish to brown or black as they matured. *F. oxysporum* displayed white cottony mycelial growth turning pinkish upon maturity in a 7-day PDA culture. Under a compound microscope, small oval-shaped microconidia, occurring singly or in pairs, and hyaline macroconidia with multiple cells and three septations were observed. The macroconidia displayed a sickle-shaped form, characterized by a notched base at one end.

Botrytis cinerea was confirmed as the causative organism for botrytis blight disease in tuberose. A pure culture of *Botrytis cinerea* was cultivated, revealing its moderately fast growth. Within 8 days on PDA culture media, a whitish cottony colony emerged. A vague and grizzle cluster of reproductive cells was noticed. Filamentous, branching hyphal formations were identified, featuring long and smooth brown, tree-like conidiophores. Numerous hyaline and non-septate globose conidia were also observed in abundance.

Leaf tip blight disease in tuberose was attributed to *Phoma* sp. A pure culture, exhibiting a grayish top and a black underside, was grown on PDA medium. Black and depressed pycnidia were noted in the host tissues, accompanied by the absence of conidiophores. The conidia displayed a unicellular structure, were hyaline, and had elongated shapes with rounded tips.

Alternaria polyanthi was recognized as the causative agent responsible for tuberose alternaria leaf spot disease. On PDA medium, the pure culture exhibited a cottony growth with a color ranging from grayish to blackish, displaying a moderate to slow growth rate. In its early stages, the mycelium was characterized by being septate, branched, and hyaline. The conidiophore, resembling of a beard, exhibited simplicity, septation, shortness, and coloration. It bore conidia at its apex. At the apex of conidiophores, the conidia were characterized by their dark color, short beaks, multicellular structure, and muriform, displaying both longitudinal and transverse septa. They were observed either individually or in brief chains. The conidia were

marked by 4-8 transverse septa and a limited number of longitudinal septa. Varied shapes, including elliptical, obclavate, or ovoid, were observed in the conidia, all featuring a pointed distal end.

The identified causal organism from blossom blight disease of tuberose was *Fusarium equiseti*. Within 7 days on PDA medium, a pure culture exhibited the emergence of a white, cottony mycelial growth. Upon microscopic examination using a compound microscope, small oval-shaped microconidia, occurring either as single cells or in pairs, were identified. Additionally, hyaline multicelled macroconidia with three septations were also observed. The macroconidia displayed a sickle shape with a notched base at one end.

Fusarium oxysporum was responsible for inducing tuber rot disease in tuberose. In a pure culture, a white, cottony mycelial growth became noticeable on PDA medium within a span of 7 days. Then culture shifted to a deep pinkish color over time. Microscopic examination unveiled microconidia that were small and oval-shaped occurring individually or in pairs. Furthermore, hyaline macroconidia with multiple cells and three septations were also present. The macroconidia featured a sickle shape, characterized by a notched base at one end.

The isolation of *Lasiodiplodia theobromae* was carried out from the tuberose, specifically from the peduncle blight disease. In the initial stages, a whitish mycelial growth was evident on the culture medium, progressing to a later stage characterized by a shift to a black to grey color, accompanied by the development of black pycnidia. Tiny, slightly raised spots with a dark brown color represented the manifestation of pycnidial primordia. Subsequently, flask-shaped pycnidia with dark brown color and ostioles became evident. Positioned at the apex of an elongated neck, the ostiole, circular in shape, served as the exit point for the extrusion of conidia. The conidia initially exhibited a round to oblong shape, were transparent, and consisted of a single cell. Over time, they underwent a change, adopting a brown coloration and developing septa, indicating a transition in their characteristics.

Disease incidence and severity

Disease frequency and intensity varied significantly across different locations, as shown in Table 2. Stem rot peaked at 64.33% in Kulia but was milder at 16.33% in Dhalipara. Severity ranged from 2.83% to 20.33%, with Chandpur experiencing the highest severity. Botrytis blight reached 60% incidence in Dhalipara and 22.33% in Chandpur, with severity ranging from 8.50% to 24%. Alternaria leaf spot had the highest incidence in Mothbari (25%) and the lowest in Chandpur and Mathuapara (2.33%). Blossom blight peaked at 26.67% in Kanarali and Gaburapur but dropped to 6.67% in the latter. Leaf tip blight had the highest incidence in Patuapara (40.33%) and the lowest in Kuliya (5.67%), with severity ranging from 2% to 17%. Peduncle blight incidence ranged from 10.33% to 30.67%, with Mothbari, Kuliya, and Gaburapur recording the highest incidences. Disease severity varied from 1.33% to 4.33%, with Mothbari and Gaburapur exhibiting the highest severity and Hariya the lowest. Tuber rot disease was notably absent in several sites, including Godkhali, Patuapara, Mothbari, Hariya, Baisa, Dhalipara, Mathuapara, Chandpur, and Sharifpur. Its occurrence ranged from 0% to 15%, with the highest prevalence in Shiorda. Disease intensity varied from 0% to 2.67%, with the highest intensity in Krishnachandrapur.

4. Discussion

A research was undertaken to investigate tuberose diseases in the Jashore district of Bangladesh, where information was gathered in natural environmental settings and later processed using the STATISTIX-10 computer software. In tuberose fields across Bangladesh, a comprehensive survey revealed the presence of seven diseases. Of these, four ailments were widespread across most locations, while the remaining three were observed in only a few specific locations. Seven fungi - *Botrytis cinerea*, *Alternaria polyanthi*, *Sclerotium rolfsii*, *Phoma* sp., *Fusarium equiseti*, *Lasiodiplodia theobromae* and *Fusarium oxysporum* were isolated from seven distinct tuberose diseases. Previous literature suggests the involvement of several pathogens in these diseases. The incidence and severity of tuberose diseases exhibited significant variation, ranging from 0% to 64.33% and 0% to 24.00%, respectively, across different locations in Bangladesh.

A previous report indicated that the tuberose crop is afflicted by numerous fungal diseases, with stem rot being particularly destructive. This disease is attributed to *Sclerotium rolfsii*. This fungus is characterized as polyphagous and widespread, exhibiting an extensive host range [22]. Another narration observed that the occurrence of stem rot, attributed to *Sclerotium rolfsii* Sacc., can pose a significant threat to tuberose cultivation, especially in warm and humid conditions. This recently identified ailment is distinguished through the abrupt drooping of the upper leaves at ground height, accompanied by degeneration of the floral stem [23].

As per a preceding report, the occurrence of botrytis blight, a newly recognized disease affecting tuberose crops and induced by *Botrytis cinerea*, has been identified in Tamil Nadu, India. This pathogen has been associated with significant reductions in tuberose yield. The elevated occurrence of the disease in the winter season is linked to the optimal conditions for pathogen growth, characterized by high relative humidity at 95% and a lower temperature of 20°C [24]. Acreo et al. [25] isolated *Botrytis cinerea* from tuberose and noticed that the hyphal mass exhibited alternating branches. Conidia at the tip were clustered, presenting a resemblance to a bunch of grapes. Featuring transparency, the single conidia had an ovoid, elliptical shape with a hilum positioned at the apex.

A prior report documented *Phoma* sp. as the causative organism of leaf tip blight in tuberose [26]. Adhikary [27] recorded field observations of tuberose diseases as well as performed tests to assess pathogenicity for verifying the causative agents the noticed ailments. *Xanthomonas campestris* was identified as the primary cause, with bacterial leaf blight being the most prevalent within diseases, leading to a 100% infection rate in plants. Blossom blight, attributed to *Fusarium equiseti*, was the subsequent prevalent disease, affecting 44% of plants, followed by alternaria leaf spot at 36%, with root-knot and stem rot each contributing to 5% of the infections.

According to a report, a prevalent and impactful disease in tuberose significantly reduces yield. This fungal infection leads to leaf spots and is attributed to *Alternaria* sp. [28]. Tuberose, grown in tropical and subtropical regions, suffers from leaf spot disease caused by *Alternaria polianthi*. High temperature and humidity exacerbate this problem, leading to growth reduction and yield loss. A survey conducted in Melachinnampatti village, Alanganallur block, Madurai district, recorded a maximum disease incidence of 50.34%. In vitro tests evaluated bio-control agents (*Trichoderma asperellum* and *Bacillus subtilis*), along with various plant extracts and oils. Among the tested extracts at a 10% concentration, Ginger extract exhibited the highest inhibition (66.34%) against the pathogen [29]. Another separate study indicates that tuberose cultivation typically flourishes with limited protective measures. However, shifts in climatic conditions have led to the rise of leaf blight disease, primarily attributed to *Alternaria polyanthi*. This disease presents a significant challenge to tuberose cultivation in Maharashtra, resulting in notable losses of approximately 15-20% in both crop yield and overall quality [30]. Other report stated that tuberose crop has experienced the impact of several fungal and viral diseases, leading to hindered growth and reduced flower yield. Notably, leaf spot, initiated by *Alternaria polianthi*, stands out as a significant fungal disease in tuberose [31].

Efforts were undertaken to manage *Fusarium equiseti* the predominant pathogen causing blossom blight in tuberose. Different techniques were utilized in laboratory conditions, encompassing the use of fungicidal substances, organic modifications, and the implementation of *Trichoderma harzianum*. Cupravit, aimcozim, newban and dithane M-45; these four fungicides were chosen for assessment during the laboratory trials. For evaluating their capacity to impede the lateral expansion of *F. equiseti*. A complete inhibition of lateral expansion was observed with Aimcozim, displaying considerably superior results compared to the other fungicides [32].

Top of Form

During a 2010 survey in the Tamil Nadu State of India, tuberose plants were identified to be affected by peduncle blight, which was traced back to the presence of *Lasidiplodia theobromae*. The incidence of peduncle blight in the area was noted to be as high as 43%. When the infection affected blossoms, it resulted in a total absence of flower bloom. Many pycnidia were noticed on the affected flower bloom [33].

A previous report highlighted the susceptibility of tuberose to various fungal and viral diseases. Notably, tuber rot induced by *Fusarium oxysporum* stands out as a significant and serious disease in tuberose. This disease leads to significant reductions in yield. For the first time, *Fusarium oxysporum* has been isolated from tuberose tubers exhibiting infection, playing a crucial role in the development of tuber rot in the [34]. After that another work was conducted on the tuber rot disease affecting tuberose. This disease is resulting from vascular wilt pathogen *Fusarium oxysporum* and poses a notable obstacle to cultivation in areas specifically designated for tuberose production [35].

This study delves into the prevalence and impact of tuberose diseases in Bangladesh's Jashore district. Employing a comprehensive approach, it identifies eight diseases, mostly fungal, affecting tuberose plants, with occurrences ranging from 0% to 64.33%. Stem rot, botrytis blight, alternaria leaf spot, and blossom blight are prominent challenges. Understanding specific pathogens aids in selecting suitable control measures. Spatial variation highlights the need for tailored management strategies based on local conditions. Integrated pest management approaches are essential for sustainable disease control.

In summary, the findings of this study contribute to our understanding of the prevalence and impact of field diseases on tuberose cultivation in the Jashore district, Bangladesh. By identifying key disease challenges and causal organisms, the research provides valuable insights for developing effective disease management strategies to support the sustainable production of tuberose flowers in the region.

5. Conclusions

Employing a comprehensive approach integrating cultural and morphological seven distinct diseases were identified illuminating their distribution and severity across different locations. This study highlights the variability in disease occurrence and intensity, with stem rot, botrytis blight, alternaria leaf spot, and leaf tip blight emerging as significant threats to tuberose cultivation in the Jashore district, Bangladesh. Effective disease management strategies are crucial in addressing these challenges. The insights gained here can inform the development of targeted interventions to mitigate the impact of these diseases and enhance tuberose production in the region, thereby contributing to the sustainability and resilience of tuberose cultivation in Bangladesh, to the benefit of farmers and stakeholders in the floral industry.

Declarations

Compliance with ethical standards

Conflict of interest

The authors declare that there are no conflicts of interest.

Ethical approval

This study does not include human or animal subjects.

Data Availability Statement

All relevant data are available in the study.

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Author contribution statement

RZ = Conceptualization, Investigation, Writing - original draft, Data curation, Software, Methodology, Funding Acquisition, Project Administration, Formal analysis, Writing - review & editing, Visualization, Resources, Validation. ANFA = Supervision, Conceptualization, Methodology, Writing – Original Draft, Data curation, Validation; RF = Methodology, Resources, Visualization, Writing - review & editing, Formal analysis, Validation. All authors have reviewed the manuscript and provided their feedback.

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Tables

Table 1. Tuberose diseases with symptoms observed under field conditions in the Jhikargacha Upazila of the Jashore district, Bangladesh

Sl.	Name of disease	Observable symptom	Disease type
1.	Stem rot	Initially, fields showed sudden wilt and collapse of crown leaves, accompanied by flower stalk rot. Prominent cottony mycelial growth and sclerotia were evident on infected leaves or near the soil level. Light-colored spots due to rotting extended across the entire leaf, leading to detachment.	Fungal
2.	Botrytis blight	Characteristic symptoms include withering and tannish-brown color in infected inflorescence petals, extending to leaves and stalks. Botrytis mycelium can persist, causing matted petals and flower collapse. Dark brown spots appear, leading to the drying up of the entire inflorescence.	Fungal
3.	Alternaria leaf spot	The disease is characterized by brown spots with faint concentric rings on the midrib and occasionally on the leaf margin. Infected peduncles may exhibit circular to oval spots, measuring 10-30 mm in length and 4-5 mm in diameter. Top of Form	Fungal
4.	Blossom blight	Initially, water-soaked spots appear on the petals, which later darken and result in petal drying. This leads to flower drop-off from the plant. Infection is also observed on the flower stalk, causing its collapse. In humid conditions, flower tips turn brown, developing a brown spore mass.	Fungal
5.	Leaf tip blight	Brown lesions initially appear on both leaf margins, merging into a water-soaked patch that progresses downward. The leaf tip dries up basipetally, changing to straw color. Black dot-like erumpent pycnidia form sub-epidermally on the dead tissues. Top of Form	Fungal
6.	Tuber rot	It is a severe field and storage ailment, manifests as brownish to black dry rot on bulbs. Oval sunken brown spots appear initially, progressing to tan, brown, or blackish lesions. Foliage turns yellow, then brown. Infected roots shrink and gradually die, leading to the demise of the entire plant.	Fungal
7.	Peduncle blight	Initially, tuberoses infection occurs on blossoms, causing spots on infected flowers and spreading to surrounding buds. This leads to a complete loss of all buds. Top of Form	Fungal

Table 2. Frequency and intensity of various tuberose diseases in the Jhikargacha Upazila of the Jashore district, Bangladesh

Location (Villages)	Stem rot		Botrytis blight		Alternaria leaf spot		Blossom blight		Leaf tip blight		Peduncle blight		Tuber rot	
	DI(%)	DS(%)	DI(%)	DS(%)	DI(%)	DS(%)	DI(%)	DS(%)	DI(%)	DS(%)	DI(%)	DS(%)	DI(%)	DS(%)
Godkhali	41.33 a-c	10.67 ab	34.33 ab	12.67 a	24.00 ab	4.33 ab	25.33 a	4.03 a	10.00 b	4.33 b	14.00 a	2.67 a	0.00 (0.50) e	0.00 (0.50) g
Patuapara	49.33 a-c	13.00 ab	38.67 ab	10.00 a	13.00 cd	2.00 b-e	7.00 a	1.00 a	40.33 a	17.00 a	19.00 a	3.67 a	0.00 (0.50) e	0.00 (0.50) g
Sadirali	35.67 a-c	8.67 ab	53.00 ab	17.00 a	11.33 c-e	2.00 b-e	20.33 a	2.33 a	17.33 b	8.67 ab	14.00 a	3.00 a	0.00 (0.50) e	0.00 (0.50) g
Belemath	27.67 a-c	4.67 b	39.00 ab	10.33 a	25.00 a	4.67 a	20.33 a	2.70 a	11.00 b	2.67 b	30.67 a	4.33 a	0.00 (0.50) e	0.00 (0.50) g
Dhalipara	16.33 c	2.83 b	60.00 a	24.00 a	16.00 a-c	3.33 a-c	19.00 a	3.00 a	8.33 b	3.00 b	22.00 a	2.83 a	0.00 (0.50) e	0.00 (0.50) g
Panisara	40.67 a-c	11.67 ab	42.67 ab	16.00 a	10.67 c-e	2.00 b-e	10.00 a	2.00 a	25.00 ab	10.33 ab	24.00 a	3.00 a	6.67 (2.54) bc	1.33 (1.14) c-e
Syedpara	48.00 a-c	11.67 ab	44.67 ab	18.67 a	10.00 c-e	2.00 b-e	14.33 a	2.33 a	15.00 b	4.67 b	18.33 a	3.33 a	8.00 (2.83) a-c	1.67 (1.28) cd
Nilkonthonogor	29.33 a-c	5.00 b	34.67 ab	12.00 a	14.33 bc	3.00 a-d	17.00 a	3.00 a	10.00 b	4.33 b	10.33 a	1.67 a	15.00 (2.70) a-c	3.00 (1.73) a
Kuliya	64.33 a	16.00 ab	40.67 ab	14.00 a	14.67 bc	3.00 a-d	18.67 a	2.67 a	5.67 b	2.00 b	30.67 a	4.00 a	3.00 (1.08) de	0.67 (0.83) f
Krishnachandrapur	33.33 a-c	10.50 ab	24.67 ab	8.50 a	8.33 c-e	2.67 a-e	6.67 a	1.33 a	22.67 ab	8.33 ab	30.67 a	4.33 a	6.67 (1.73) cd	1.49 (0.97) ef
Hariya	23.33 bc	7.67 ab	49.33 ab	14.00 a	6.00 c-e	1.33 c-e	8.33 a	2.00 a	20.00 ab	7.33 b	13.33 a	1.33 a	0.00 (0.50) e	0.00 (0.50) g
Nimtola	33.00 a-c	11.67 ab	51.67 ab	16.67 a	7.33 c-e	1.00 c-e	21.67 a	3.67 a	18.67 ab	6.00 b	19.67 a	3.00 a	0.00 (0.50) e	0.00 (0.50) g
Baisha	38.00 a-c	11.83 ab	39.33 ab	15.67 a	7.67 c-e	1.33 c-e	18.00 a	2.00 a	17.00 b	6.33 b	13.33 a	2.67 a	0.00 (0.50) e	0.00 (0.50) g
Sharifpur	60.00 ab	20.33 a	22.33 b	10.67 a	2.33 e	2.00 b-e	15.67 a	1.67 a	25.00 ab	8.33 ab	11.67 a	3.83 a	0.00 (0.50) e	0.00 (0.50) g
Chadpur	61.00 ab	17.33 ab	29.00 ab	12.00 a	2.33 c-e	0.33 e	17.33 a	1.83 a	25.33 ab	7.00 b	22.67 a	3.67 a	0.00 (0.50) e	0.00 (0.50) g
Mathuapara	35.00 a-c	7.67 ab	34.67 ab	14.67 a	8.33 c-e	1.33 c-e	20.33 a	4.00 a	23.33 ab	9.00 ab	22.33 a	4.00 a	11.33 (3.20) ab	2.00 (1.38) bc
Nirbashkhola	32.67 a-c	9.33 ab	29.00 ab	9.67 a	3.67 de	0.67 de	23.33 a	4.00 a	22.33 ab	9.67 ab	18.33 a	2.83 a	14.67 (3.77) a	2.67 (1.63) ab
Shiorda	45.33 a-c	11.00 ab	33.00 ab	14.33 a	6.33 c-e	1.00 c-e	26.67 a	4.33 a	13.00 b	5.33 b	13.00 a	2.67 a	5.00 (2.20) bc	1.00 (1.00) d-f
LSD 0.05	39.75	14.72	35.38	17.84	10.24	2.37	22.09	3.53	21.82	9.25	22.11	3.50	1.11	0.30
CV (%)	60.00	83.38	54.78	77.14	55.34	67.79	77.33	79.99	71.73	80.67	68.93	66.83	48.21	21.78

*DI- Disease incidence, DS- Disease severity, Means followed by the same letters in a column do not differ at 5% level of significance by LSD

Figures

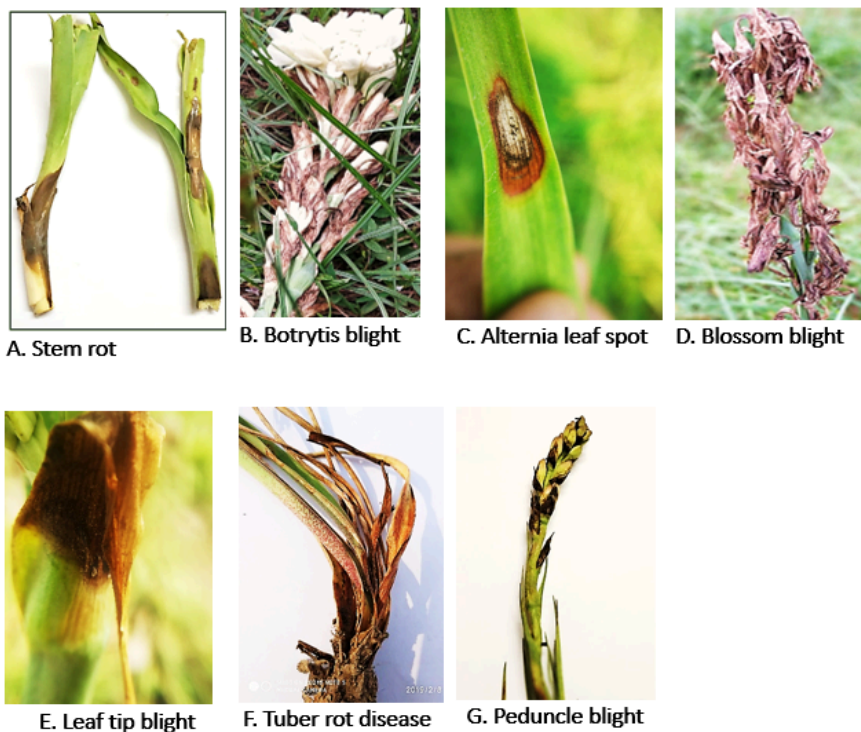


Figure 1

Symptoms observed in the field for different tuberose diseases **A.** Stem rot, **B.** Botrytis blight, **C.** Alternaria leaf spot, **D.** Blossom blight, **E.** Leaf tip blight, **F.** Tuber rot disease, **G.** Peduncle blight

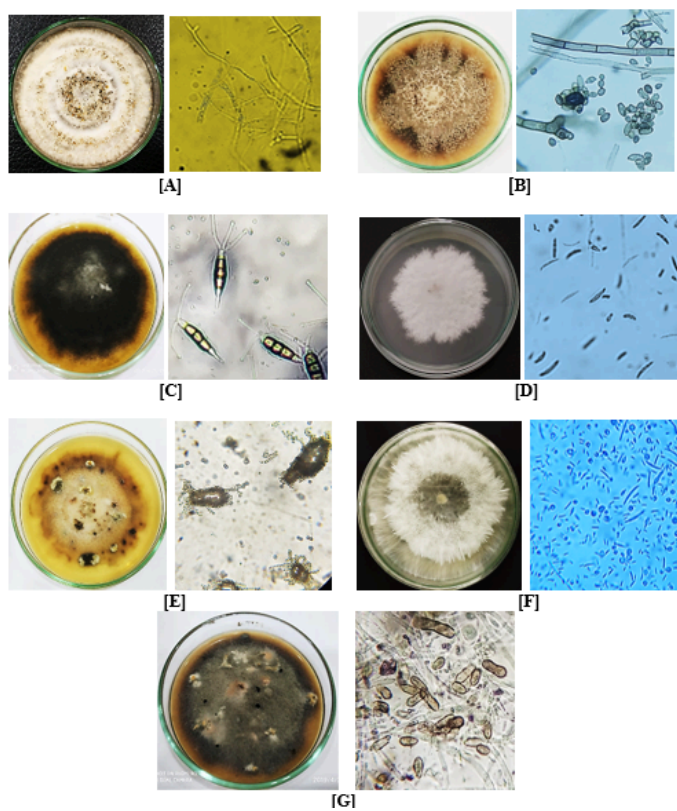


Figure 2

Pure Culture (left) and compound microscopic view 10X (right) of the isolated pathogens. **A.** *Sclerotium rolfii* isolated from stem rot disease of tuberose, **B.** *Botrytis cinerea* isolated from botrytis blight disease of tuberose, **C.** *Alternaria polyanthi* isolated from alternaria leaf spot disease of tuberose,

D. *Fusarium equiseti* isolated from blossom blight disease of tuberose, **E.** *Phoma* sp. isolated from leaf tip blight disease of tuberose, **F.** *Fusarium oxysporum* isolated from tuber rot disease of tuberose, **G.** *Lasidiplodia theobromae* isolated from peduncle blight disease of tuberose