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PREVALENCE OF FUNGAL DISEASES IN MEDICINAL PLANTS IN NORTHERN REGION OF BANGLADESH

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ABSTRACT

A season wise survey was conducted on the fungal diseases of some important cultivated medicinal plants in two consecutive years 2014 and 2015 in the northern region of Bangladesh. Eleven fungal diseases namely root rot (*Fusarium solani*) and leaf blight (*Alternaria alternata*) of Ashwagandha, leaf spot (*Curvularia lunata*) and collar rot (*Fusarium oxysporium*) of Alovera, powdery mildew (*Erysiphe* sp.) and root rot (*Fusarium oxysporium*) of Tulsi, collar rot (*Fusarium oxysporium*) and leaf spot (*Collettotrichum gloeosporioides*) of Kalmegh, tuberous rot (*Fusarium solani*) and stem rot (*Fusarium oxysporium*) of Satamuli, and root rot (*Fusarium solani*) of Basak were recorded. Most of the diseases were found in the rainy season's comparative to other seasons. Among all the above-mentioned diseases, the powdery mildew (*Erysiphe* sp.) of Tulsi was found mainly in winter season. With the spreading of these fungal diseases on medicinal plants could be a set back to the industry associated with the formulation of its medicinal products. Therefore, this work may encourage other researchers to study these diseases further for development of proper management.

Keywords: Medicinal plant, Survey, Fungal diseases, Causal organism, Disease incidence.

INTRODUCTION

The importance of medicinal plants is increasing day by day. In recent years, traditional medicine has made a comeback for a variety of reasons including side-effects and toxicity of modern synthetic drugs, evolution of multi-drug resistance microorganisms, and the inability of modern medicine to find effective cures for a number of diseases. More than 70% of the developing world's population now depends on traditional medicinal system, otherwise known as complementary or alternative systems of medicine (Azaizeh et al., 2010). In Bangladesh, about 500

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plant species have been identified as medicinal plant because of their therapeutic properties (Ghani, 1998). A large number of industries (400 herbal factories) have been established in this country for producing Ayurvedic, Unani and Kabiraji medicines and about six thousand metric tons of medicinal plants are required annually by the relevant industries in Bangladesh for producing traditional medicines (Sharmin, 2004). There is worth of 11 million US dollars medicinal plant market in Bangladesh (Bregum, 2004). Considering of its market potential, government and some non-government organization have taken mass program to cultivate medicinal plants in to the northern areas of Bangladesh organizing farmers of low-income group, especially the woman. Major cultivated plant species are Ashwagandha (*Withaniasomnifera* L.), Basak (*Adhatodavasica*), Tulsi (*Ocimum sanctum* L.), Kalmegh (*Andographispaniculata*), Aloevera (*Aloe indica* L.) and Satamuli (*Asparagus racemosus*). These medicinally important plants are facing serious problems of the fungal attack. It's adversely affected the medicinal plant parts and decreases the medicinal value of that part. It may be harmful to the human body while using these infected parts as a medicine (Chavan and Korekar, 2011). But in Northern area of Bangladesh the research in diseases of medicinal plants is very few or none. So, identification of the infected fungi is important. Therefore, the purpose of this study was to survey and identify fungal diseases and pathogens associated with the selected medicinal plants of the northern areas of Bangladesh.

MATERIALS AND METHODS

Survey Area

Four districts of Rajshahi and Rangpur division which are mid-western and northern region of Bangladesh were selected for the survey study. Natore, Bogra and Jaoypurhat districts of Rajshahi Division and Gaibandha district of Rangpur Division were designated for survey. A total of seven (7) Thana/ Sub-station were surveyed of four selected districts. The selected region has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, moderately warm temperatures and high humidity. Three seasons are generally recognized: a hot, humid summer from April to June; Rainy monsoon season from June to October and a cool, dry winter from October to March. In general, maximum summer temperatures range 32ºC-38ºC. April is the warmest month of the country. January is the coldest month, when the average temperature for most of the country is 10ºC. The northern part is mainly agriculture-based area, which is 23% of total area of Bangladesh and 24% of total population live here (Banglapedia, 2012). The mass population of northern Bangladesh is under poverty line, struggling hard for a better living standard. Recently, medicinal plants are commercially cultivated (Ashwaganda, Aloevera, Kalmegh, Tulsi, Basak and Satamuli) in the district of Natore, Bogra, Gaibandha, Joypurhat, Rangpur and Naogoan to fulfill the demand of Pharmaceuticals, Ayurvadic and Kabirazi uses. In order to study the disease incidence (%) of selected medicinal plant was surveyed in summer, rainy and winter season in selected region of Bangladesh during 2014-2015.

Sample collection, isolation of fungi and estimation of disease incidence

Leaf blight, leaf spot, root rot, stem rot, powdery mildew, tuberous rot and collar rot samples were collected during field survey. All the samples with the symptoms of disease were collected in separate plastic bags. The name of plant, places and time of samplings were recorded. Samples were taken into the laboratory (Lab.) and the fungi were isolated by using standard moist blotter method (SBM) and Agar plate methods (APM). The survey was conducted on the basis of random sampling method. The disease incidence (%) was calculated by following formula.

$$\text{Disease incidence (\%)} = \frac{\text{Number of plants affected}}{\text{Total number of plants observed}} \times 100$$

Identification of fungi

Fungi were identified on the basis of morphological and microscopic characteristics. Pure cultures of these fungi were prepared and maintained on potato dextrose agar (PDA) slants. Plant pathogenic agents of powdery mildews could not grow on most commonly used nutrient media in lab conditions. So, this fungus was identified as such, according to microscopic structures and classified on several related keys and references (Barnett and Hunter, 1999). Pathogenicity tests were carried out in field conditions and the fungi were re-isolated from these plants and identified. The causal organism, morphological and microscopic characteristics of the pathogen and symptoms of the diseases were examined and recorded during experimentation.

Statistical analysis

All data were analyzed by Duncan's Multiple Range Test (DMRT) using the computer based program SPSS (SPSS Inc., Chicago, IL, USA).

Results and Discussion

Several fungal diseases were found from the infected medicinal plants in survey areas. The causal organism, morphological and microscopic characteristics of the pathogen and symptoms of the diseases are summarized in Table 1 and 2. After identification of the pathogens the result indicated that the medicinal plant *Withania somnifera* was attacked by the leaf blight and root rot disease caused by *Alternaria alternata* and *Fusarium solani*, respectively. These diseases were found in summer, winter and rainy season. It was observed that the rainy season is more favorable for both diseases. In rainy season, the highest disease incidence (%) of root rot and leaf blight was recorded 96.74 and 92.16% at Laxmipur village, Natore sadar thana, Natore district and Mohadipur village, Polashbari thana, Gaibandha district, respectively. The lowest disease incidence (%) of root rot and leaf blight were recorded 43.87 and 55.64 % at Tilakpur village, Akkelpurthana, Joypurhat district, and Kagoil village, Gabtoli thana, Bogra district, respectively (Table 3). *Alternaria* leaf spot of Ashwagandha (*W. somnifera*), caused by *A. alternata* and root rot wilt

caused by *Fusarium solani* is one of the serious diseases of Ashwagandha in the nursery as well as in the commercial fields at Lucknow and its adjoining areas in North India. These diseases may cause the adverse effect on medicinal value of the Withania plant (Gupta et al., 2004). Root rot disease of *W. somnifera* plant caused by *Fusarium solani* was also recorded by Rahman et al. (2014) and reported that this fungus can adversely affected at nursery level. Gupta et al. (2004) reported that root rot disease of Ashwagandha caused by *Fusarium soalani* is one of the destructive diseases and this fungus can affect the nursery plant. The affected plants in the nurseries showed symptoms of yellowing, dropping and decay at seedling stage leading to 30-50% mortality.

Table 1. Diseases, causal organism and disease symptoms of the some commercially cultivated medicinal plant in northern region of Bangladesh

Medicinal plant	Local name	Diseases	Causal Organism	Symptoms
Withenia somnifera L.	Ashwagandha	Root rot	*Fusarium solani*	The root of infected plant showed pulpiness with brownish color. Diseased areas of the plant enlarged with age and turn brown. Longitudinal cracks were developed in older lesion and cortical tissues were discolored and decayed (Fig. 1a).
		Leaf blight	*Alternaria alternata*	At the initial stage of infection, symptoms appeared as small, light brown spots, gradually becoming irregular, dark brown, concentrically zonate with a diffuse margin, frequently surrounded by light yellow haloes, conspicuous brownish concentric rings in the advance stage of infection (Fig. 1b).
Aloe indica L.	Aloevera	Leaf spot	*Curvularia lunatus*	Small, circular to oval dark brown necrotic sunken spots appeared on the leaves. As these spots expanded, centre of the lesion became reddish brown to brown color. In the advance stage of infection, spots appeared on both the surfaces of leaf; affected area lost the mucilaginous gel and leads the death of infected leaves (Fig. 1c).
		Collar rot	*Fusarium oxysporium*	Small brown spot appeared near collar region and spread to leaf. As the disease progressed, growth was stunted and the affected plants died (Fig. 1d).

Medicinal plant	Local name	Diseases	Causal Organism	Symptoms
Ocimum sanctum L.	Tulsi	Powdery mildew	*Erysiphe* sp.	The disease first appeared on young leaves as slightly raised blister like areas that soon became covered with greyish, white and powdery growth of the pathogen on mature leaves (Fig. 1e).
		Root rot	*Fusarium oxysporium*	The lower taproot and lateral roots of infected plants was appeared brown to black in color and showed cortical decay or vascular discoloration. Lateral roots also died and decomposed and secondary roots were developed above them on the upper taproot (Fig. 1k).
Andrographis paniculata	Kalmegh	Collar rot	*Fusarium oxysporium*	The affected plants showed typical rotting symptoms at the collar region on which numerous yellowish brown colored (Fig. 1h).
		Leaf spot	*Collettotrichum gloeosporioides*	Infected plants were brown or black water-soaked spots on the foliage, sometimes with a yellow halo, usually uniform in size (Fig. 1g).
Asparagus racemosus	Satamuli	Tuberous rot	*Fusarium solani*	Rotten roots were soft and give out offensive odour particularly in infections involving pathogen. Stems became weak at the base and lodge. (Fig. 1e).
		Stem rot	*Fusarium oxysporium*	Initial symptoms showed as pale yellow lesions at the stem base. These lesions were expanded and spread to cause a root and stem rot. Plants were eventually turned brown and die (Fig. 1f).
Adhatoda vasica	Basak	Root rot	*Fusarium oxysporium*	Symptoms were generally included dark brown to black, discolored, decaying or completely rotted roots (Fig. 1i).

Table 2. Morphological and cultural characteristics of the pathogen

Medicinal plant	Local name	Disease	Causal organism	Morphological and cultural characteristics
Withenia somnifera L.	Ashwagandha	Root rot	*Fusarium solani*	Colony grown on PDA became whitish to brown. Macroconidia were hyaline, two-to several-celled, fusiform-to sickle-shaped. Microconidia were 1-to 2-celled, hyaline, pyriform, fusiform to ovoid, straight or curved (Fig 2 a & b).
		Leaf blight	*Alternaria alternata*	Mycelium was hyaline that turned to grey-brownish. The conidiophores measured 42.26 µm (27.30-112 µm) in length and 4.29 µm (3.12-8.43 µm) in width (Fig. 2 c & d).
Aloe indica L.	Aloevera	Leaf spot	*Curvularialunata*	The colony was dark olive-gray in color and on the reverse side was greyish black. Conidiophores were erect, long and unbranched. Conidia were four transverse septa and 18-29 × 10^{-8} µm in size (Fig 2 g & h).
		Collar rot	*Fusarium oxysporium*	The colonies were white with numerous microconidia in false heads on short phialides Microconidia were hyaline, generally single-celled, oval or cylindrical to slightly curved, and 5.5 to 17.2 × 2.6 to 5.5 µm. Macroconidia were hyaline, fusiform, slightly to moderately curved or cylindrical (2 j & k).
Ocimum sanctum L.	Tulsi	Root rot	*Fusarium oxysporium*	The colony formed with white aerial mycelia. Microconidia produced on microconidiophores had elliptical shape and no septate. Macroconidia were straight to slightly curve in shape with 3 septa.
		Powdery mildew	*Erysiphe* sp.	Conidia were hyaline, ellipsoid to cylindrical, measuring 28.1 to 35.7 × 12.9 to 14.4 µm (average 32.8 × 13.4 µm). The conidiophore foot cell was cylindrical and the appressorium lobed (Fig. 2 i).
Angraphis peniculata	Kalmegh	Collar rot	*Fusarium oxysporium*	The mycelium was white usually becoming purple. Microconidia abundant and characteristic (bean shape). Macroconidia fusiform, slightly curved.
		Leaf spot	*Collettotrichum gloeosporioides*	Mycellium formed velvety, gray colonies with slightly wavy margin. The conidiogenous cells were hyaline, cylindrical, or tapered and measured up to 20 by 3 to 4 µm (2 e & f).
Asparagus	Satamuli	Tuberous	*Fusarium*	The fungus formed white colony with dense aerial mycelium. Microconidia measuring 3-16 × 3-5

Medicinal plant	Local name	Disease	Causal organism	Morphological and cultural characteristics
racemosus		rot	*solani*	µm. Macroconidia were fusoid with a well-marked foot cell, and 5 to 7 septate measuring 14-46 × 3-5 µm. Chlamydospores were globose to oval, 6-9×7-10 µm, and terminal or intercalary.
		Stem rot	*Fusarium oxysporium*	Of-white floccose (cottony) mycelia observed that becoming tinged in purple. Microconidia (5 - 12 X 2.3 – 3.5 µm) were usually non-septate, ellipsoidal and were straight. Macroconidia (23-54 X 3.0 – 4.5 µm) were fusiform in shape.
Adhatoda vasica	Basak	Root rot	*Fusarium oxysporium*	The mycelia were white to pink and often with purple tinge. Microconidia were oval-ellipsoid, straight to curved, 5-12 x 2.2-3.5 µm, and nonseptate. Macroconidia were three- to five-septate, fusoid-subulate and pointed at both ends. Chlamydospores, both smooth and rough walled.

Aloevera (Aloe indica) plant was affected by the leaf spot disease caused by the Carvularia lunatain in winter, summer and in rainy season. In winter season, the highest disease incidence of leaf spot was recorded 96.75% at Kantalbaria village, Natore sadar thana, Natore district and the lowest disease incidence was 59.92% recorded at Harinathpur village, Polashbari thana, Gaibandha district (Table 4). The collar rot disease of Aloevera plant caused by Fusarium oxysporium was also found in all three seasons and the rainy reason is favorable for this disease. In rainy season, the highest disease incidence of collar rot was 89.56% at Kantalbaria village, Natore sadar thana, Natore district and the lowest disease incidence was recorded 53.28% at Harinathpur village, Polashbari thana, Gaibandha district (Table 4). The leaf spot disease on Aloe plant first came into limelight as purple spot disease on Aloe arboescens Mill. caused by Fusarium phyllophilum (Kinshi et al., 1999) and later Haematonectria haematococca (anamorph: Fusarium sp.) causing ring spot disease on Aloe barbadensis (Hirooka et al., 2007). Zhai et al. (2013) was first reported of leaf spots in Aloevera caused by Nigrospor aoryzae in China.

Table 3. Disease incidence (%) in Ashwagandha at survey areas

Location			Disease incidence (%)					
			Seasons					
District	Thana	Village	Summer		Winter		Rainy	
			RRA	LBA	RRA	LBA	RRA	LBA
Gaibandha	Sadullapur	Banagram	90.12 b	75.62 b	57.12 a	58.16 a	96.26 ab	88.13 b
		Dhaperhat	85.76 d	69.95 def	53.23 c	54.43 b	88.54 d	73.65 ef
		Idilpur	78.97 f	73.54 c	46.86 f	43.86 d	87.42 d	78.75 c
	Polashbari	Kamarpara	88.39 c	60.18 h	54.76 bc	41.76 e	94.53 bc	64.75 kl
		Manoharpur	68.87 jk	57.86 i	55.98 ab	40.32 e	73.42 ij	63.53 l
		Harinathpur	75.86 g	54.75 j	54.98 b	38.43 g	79.66 fg	68.86 ij
		Mohadipur	88.28 c	89.26 a	46.46 f	47.24 c	94.63 bc	92.16 a
Natore	Natore sadar	Kholabaria	70.29 ij	68.16 f	35.38 j	36.28 h	78.71 g	71.28 gh
		Barabaria	69.54 ijk	74.21 bc	32.93 k	38.12 g	76.93 h	76.12 d
		Kantalbaria	78.19 f	70.12 de	40.78 h	30.13 kl	82.93 e	72.13 fg
		Toltoliapara	71.18 hi	68.54 def	38.23 i	33.24 i	80.83 f	70.42 ghi
Bogra	Bogra sadar	Laxmipur	92.63 a	70.38 d	50.94 d	37.91 gh	96.74 a	73.92 e
		Rajapur	81.18 e	68.21 f	42.82 g	31.18 j	84.12 e	71.16 gh
		Shabgram	75.87 g	54.64 j	48.97 e	43.86 d	74.65 i	65.64 k
	Gabtoli	Baliadighi	68.13 k	69.54 def	33.75 k	34.18 i	72.23 j	70.63 ghi
		Kagoil	72.32 h	43.75 l	38.87 i	39.32 fg	74.65 i	55.64 o
Joypurhat	Panchbibi	Balighata	69.22 jk	65.63 g	37.98 i	25.14 m	70.21 k	69.18 ij
		Mohammadpur	65.54 l	59.98 h	43.54 g	32.53 ij	76.86 h	64.97 kl
		Kusumba	43.75 n	54.87 j	32.65 k	39.42 fg	54.43 m	61.16 m
		Dharangi	53.42 m	64.65 g	38.87 i	55.39 b	58.96 l	68.12 j
	Akkelpur	Gopinathpur	36.85 p	45.76 l	25.65 m	32.75 ij	46.75 n	57.86 n
		Roykali	42.89 n	49.86 k	29.87 l	40.31 ef	53.36 m	69.53 hij
		Tilakpur	39.97 o	53.32 j	17.53 n	28.53 l	43.87 o	57.64 n

RRA=Root rot of Ashwagandha, LBA=Leaf Blight of Ashwagandha,

In a column same latters are not significantly different by DMRT at 5% lavel.

Table 4. Disease incidence (%) in Aloevera and Basak at survey areas

Location			Disease incidence (%)								
			Seasons								
District	Thana	Village	Summer			Winter			Rainy		
			LSA	CRA	RRB	LSA	CRA	RRB	LSA	CRA	RRB
Gaibandha	Sadullapur	Banagram	72.53 g	75.45 cd	78.13 d	69.76 d	65.52 b	50.13 h	85.92 f	84.75 d	83.72 fg
		Dhaperhat	65.48 i	70.21 f	81.18 c	61.64 f	60.18 c	49.28 hi	81.16 g	75.96 f	89.19 de
		Idilpur	61.93 j	58.18 j	79.32 d	59.84 g	47.81 g	59.41 c	78.81 h	71.64 g	85.42 f
	Polashbari	Kamarpara	58.73 k	65.72 g	76.18 e	54.73 i	55.19 d	56.73 d	76.84 i	79.73 e	83.25 g
		Manoharpur	45.13 o	49.13 m	72.57 g	42.97 m	38.92 k	51.93 g	60.73 l	59.43 j	78.42 ij
		Harinathpur	44.88 o	46.62 n	68.53 hi	41.24 no	36.14 l	49.18 hi	59.92 l	53.28 k	81.21 h
		Mohadipur	78.71 e	55.18 k	66.93 i	70.84 cd	44.92 h	40.32 k	90.47 d	62.53 i	76.49 k
Natore	Natore sadar	Kholabaria	86.73 c	81.53 a	89.54 a	79.17 b	40.89 j	38.27 l	93.86 c	84.65 d	96.15 b
		Barabaria	89.54 b	76.74 c	79.53 e	82.64 a	50.12 f	35.48 m	94.75 bc	87.32 bc	98.64 a
		Kantalbaria	90.53 b	74.49 d	81.63 c	79.95 b	49.93 f	30.75 o	96.75 a	89.56 a	89.53 d
		Toltoliapara	93.53 a	79.73 b	69.63 h	83.73 a	59.96 c	25.75 p	95.96 ab	88.43 ab	91.53 c
Bogra	Bogra sadar	Laxmipur	85.42 c	72.18 e	72.73 g	82.75 a	61.32 c	53.64 efg	90.74 d	74.54 f	85.38 f
		Rajapur	52.48 m	51.93 l	69.95 h	45.64 l	45.96 h	32.64 n	74.97 j	64.19 h	76.42 k
		Shabgram	48.93 n	52.17 l	78.95 d	41.98 mn	40.75 j	54.75 ea	69.86 k	59.53 j	85.53 f
	Gabtoli	Baliadighi	45.68 o	60.68 i	84.63 b	39.85 o	48.86 fg	72.86 a	85.64 f	78.73 e	89.53 d
		Kagoil	49.65 n	74.64 d	74.75 ef	35.97 p	71.74 a	67.76 b	88.75 e	86.37 cd	94.64 b
		Balighata	54.76 l	73.85 d	62.53 j	47.85 k	65.53 b	53.86 ef	73.96 j	79.64 e	78.36 ij
Joypurhat	Panchbibi	Mohammadpur	49.68 n	65.85 g	58.83 k	39.74 o	48.75 fg	49.75 h	68.86 k	72.16 g	69.53 l
		Kusumba	75.89 f	63.98 h	62.37 j	71.95 c	53.21 e	52.76 fg	78.95 h	87.96 abc	85.39 f
		Dharangi	82.95 d	61.14 i	59.65 k	65.85 e	49.75 f	46.86 j	88.43 e	75.64 f	76.75 jk
	Akkelpur	Gopinathpur	58.86 k	52.97 l	69.86 h	51.64 j	39.63 jk	57.12 d	69.84 k	64.63 h	87.65 e
		Roykali	65.74 i	48.63 m	75.53 ef	59.96 g	35.85 l	53.86 ef	74.85 j	59.32 j	89.74 d
		Tilakpur	69.74 h	49.73 m	73.95 fg	56.52 h	42.63 i	47.65 ij	85.42 f	64.89 h	79.96 hi

LS=Leaf Spot of Aloevera, CRA= Collar Rot of Aloevera, RRB=Root rot of Basak.

In a column same latters are not significantly different by DMRT at 5% lavel.

Powdery mildew of Tulsi (*Ocimum sanctum*) caused by the fungus *Erysiphe* sp. was found only in winter season. The highest disease incidence was recorded 99.16% at Mohadipur village, Polashbari thana, Gaibandha district and the lowest disease incidence was recorded 53.53% at Kusumba village, Panchbibi thana, Jaypurhat district (Table 5). The powdery mildew fungi is a significant diseases on a range of crops, and different species of fungi are involved depending on the plant affected (Jahn et al., 2002, Lebeda et al., 2008 and Kristkova et al., 2009). They are important plant pathogens, which are obligate parasitic on the surface of leaves, stems, fruits,

and flowers of a wide range of angiosperms (Takamatsu et al., 2008). On vegetable crops, powdery mildew usually appears first as yellow spots on the upper leaf surface of older leaves; these spots develop the characteristic powdery growth and symptoms speared to the undersides of leaves and stems (Flint, 1998). Root rot of Tulsi caused by the fungus *Fusarium oxysporium* was found in summer, winter and in rainy season. The rainy season is more favorable for the disease. In rainy season, the highest disease incidence was recorded 79.96% at Kamarpara village, Sadullapur thana, Gaibandha district. The lowest disease incidence was recorded 55.75% at Dharangi village, Panchbibi thana, Joypurhat district (Table 5). *Fusarium*a is a soil inhabiting pathogen, attacks a large number of host plants including oilseeds, pulses, vegetables and ornamentals (Mani and Sethi, 1968, Bazalar and Delgadi, 1981, Kumar et al., 1983, Kore and Mane, 1992). *Fusarium* has been contributing significantly for low yield in plant which causes wilting of leaves, tips, loss of turgidity followed by yellowing and drooping of leaves and underground stem become dry, brown and peeling of epidermis. Roots become soft, watery and browning of vascular bundle (Gangopadhyay, 1984).

Collar rot of Kalmegh (*Andrographis paniculata*) caused by the fungus *Fusarium oxysporium* was found in summer, winter and in rainy season. The rainy season is more favorable for this disease. In rainy season, the highest and lowest disease incidence was recorded 64.32 and 34.28% at Tilakpur villagae, Akkelpurthana, Joypurhat district and Kantalbaria village, Natore sadar thana, Natore district, respectively (Table 5). Leaf spot of Kalmegh caused by the fungus *Colletotrichum gloeosporioides* was also found in summer, winter and in rainy season. The rainy season is more favorable for this disease. In rainy season, the highest disease incidence was recorded 65.84% at Manoharpur village, Polashbari thana, Gaibandha district and the lowest disease incidence 39.37% was recorded at Roykali, village, Akkelpurthana, Joypurhat district (Table 5).

Table 5. Disease incidence (%) in Tulsi and Kalmegh at survey area

Location			Disease incidence (%)											
			Seasons											
			Summer				Winter				Rainy			
District	Thana	Village	PMT	RRT	CRK	LSK	PMT	RRT	CRK	LSK	PMT	RRT	CRK	LSK
Gaibandha	Sadullapur	Banagram	-	56.87 de	51.74 b	35.74 i	99.64 a	48.16 b	10.13 k	25.75 h	-	67.32 ef	60.28 bc	55.86 d
		Dhaperhat	-	58.14 d	50.61 bc	32.85 j	95.14 b	42.76 c	12.29 i	22.53 i	-	69.95 d	51.43 ef	46.73 h
		Idilpur	-	51.65 hi	42.21 fg	30.76 k	89.28 c	39.62 d	16.72 e	25.21 h	-	62.21 h	58.48 c	48.75 g
	Polashbari	Kamarpara	-	68.95 ab	41.82 g	45.85 e	80.98 f	58.64 a	19.36 d	28.54 g	-	79.96 a	52.54 de	54.85 de
		Manoharpur	-	49.53 jk	46.84 e	44.63 ef	86.29 d	44.32 c	14.73 fg	23.53 i	-	59.85 i	48.68 gh	65.84 a
		Harinathpur	-	53.78 g	43.72 f	42.86 f	82.91 e	38.43 de	11.92 ij	32.85 e	-	64.63 g	48.94 gh	52.85 f
		Mohadipur	-	48.69 k	41.13 gh	40.63 g	99.16 a	43.74 c	17.82 de	26.95 gh	-	59.95 i	47.74 h	42.17 i
		Kholabaria	-	53.32 gh	42.64 fg	56.96 a	78.26 g	48.18 b	10.12 k	32.64 e	-	55.61 jk	44.98 i	64.74 ab
Naore	Natore sadar	Barabaria	-	63.67 c	30.58 k	55.84 a	69.18 i	24.31 k	16.26 ef	43.85 a	-	74.43 c	38.16 j	59.95 c
		Kantalbaria	-	55.85 ef	32.12 jk	48.95 d	63.12 l	36.19 f	10.58 jk	35.85 d	-	68.95 de	34.28 k	53.21 ef

Location			Disease incidence (%)											
			Seasons											
			Summer				Winter				Rainy			
District	Thana	Village	PMT	RRT	CRK	LSK	PMT	RRT	CRK	LSK	PMT	RRT	CRK	LSK
Bogra	Bogra sadar	Toltoliapara	-	69.64 a	34.99 i	53.85 b	66.51 j	58.53 a	16.23 ef	40.73 b	-	73.21 c	36.76 j	59.95 c
		Laxmipur	-	67.53 b	20.28 l	51.32 c	60.23 m	49.79 b	13.42 ghi	43.74 a	-	77.91 b	49.84 fg	54.73 de
		Rajapur	-	57.24 de	30.98 jk	38.85 h	79.18 g	42.86 c	14.33 gh	32.85 e	-	65.84 fg	50.78 f	48.53 i
		Shabgram	-	53.78 g	41.37 gh	49.75 cd	75.34 h	38.75 d	13.21 ghi	38.87 c		62.28 h	48.69 gh	53.63 ef
	Gabtoli	Baliadighi	-	51.19 ij	40.88 gh	53.64 b	65.54 jk	39.18 d	26.64 b	34.25 de	-	67.95 e	53.32 d	59.53 c
		Kagoil	-	50.38 ijk	34.74 i	55.86 a	75.88 h	33.85 g	27.84 b	30.86 f	-	59.32 i	63.42 a	64.84 ab
		Balighata	-	49.48 jk	32.63 j	43.86 f	59.53 n	31.64 h	19.53 d	34.87 d	-	56.49 jk	59.53 c	53.32 ef
Joypurhat	Panchbibi	Mohammadpur	-	55.85 ef	39.75 h	49.64 cd	64.43 kl	27.85 j	12.63 hi	40.64 b	-	64.34 g	63.76 a	54.94 de
		Kusumba	-	53.21 gh	48.98 cd	55.63 a	53.53 n	43.32 c	19.53 d	38.85 c	-	68.58 de	59.53 c	63.49 b
		Dharangi	-	49.87 ijk	52.52 a	48.75 d	65.95 jk	32.21 gh	23.75 c	34.43 de	-	55.75 jk	61.42 b	52.85 f
		Gopinathpur	-	57.94 d	42.31 fg	44.64 ef	60.32 m	29.63 i	29.95 a	39.86 bc	-	64.26 g	60.32 bc	49.29 g
	Akkelpur	Roykali	-	54.36 fg	48.75 d	32.86 j	78.95 g	36.85 ef	31.32 a	26.43 h	-	59.55 i	59.64 bc	39.37 j
		Tilakpur	-	51.28 ij	53.32 a	39.86 gh	84.83 d	26.53 j	16.31 ef	30.42 f	-	57.42 j	64.32 a	43.53 i

PMT=Powdery mildew of Tulsi, RRT=Root rot of Tulsi, CRK= Collar Rot of Kalmegh, LSK= Leaf spot of Kalmegh..

In a column same latters are not significantly different by DMRT at 5% lavel.

Tuberous rot is a serious disease of Satamuli (*Asparagus racemosus*). *Fusarium solani* causes tuberous rot which were found in summer, winter and in rainy season and the highest disease incidence was recorded in rainy season. In rainy season, the highest disease incidence was recorded 91.24% at Kantalbaria village, Natore sadar thana, Natore district (Table 6). The lowest disease incidence was recorded 47.74% at Kusumba village, Panchbibi thana, Joypurhat district (Table 6). Stem rot of Satamuli caused by *Fusarium oxysporium* was also found in summer, winter and in rainy season and the highest disease incidence was recorded in rainy season. In rainy season, the highest disease incidence was 99.18% at Barabaria village, Natore sadar thana, Natore district and the lowest disease incidence was recorded 54.95% at Kusumba village, Panchbibi thana, Joypurhat district (Table 6).

Table 6. Disease incidence (%) of Satamuli at survey areas

Location			Disease incidence (%)					
			Seasons					
			Summer		Winter		Rainy	
District	Thana	Village	TRS	SRS	TRS	SRS	TRS	SRS
Gaibandha	Sadullapur	Banagram	76.26 c	39.54 jk	51.26 c	29.48 j	88.51 b	70.16 j
		Dhaperhat	67.18 f	36.24 l	31.28k l	26.58 k	76.21 e	68.45 j
		Idilpur	71.34 d	31.43 m	49.34 de	38.49 ef	80.16 d	62.51 l
		Kamarpara	69.22 e	28.18 n	38.42 i	36.73 g	78.93 d	66.18 k
	Polashbari	Manoharpur	62.38 h	24.91 o	47.83 e	34.94 h	72.16 g	90.42 c

Location			Disease incidence (%)					
			Seasons					
District	Thana	Village	Summer		Winter		Rainy	
			TRS	SRS	TRS	SRS	TRS	SRS
Natore	Natore sadar	Harinathpur	56.18 j	26.64 n	40.73 h	31.43 i	69.28h i	88.73 d
		Mohadipur	58.22 i	45.92 h	45.48 f	24.49 l	65.48 j	78.89 g
		Kholabaria	59.19 i	40.74 j	42.93 g	21.78 m	67.87 i	72.48 i
		Barabaria	82.81 a	61.48 a	43.24 g	50.81 a	89.59 b	99.18 a
		Kantalbaria	79.38 b	59.71 b	55.22 ab	49.32 ab	91.24 a	96.24 b
		Toltoliapara	79.63 c	51.13 de	56.38 b	47.18 c	85.16 c	94.74 b
Bogra	Bogra sadar	Laxmipur	76.58 c	49.52 ef	53.81 b	41.29 d	88.16 b	91.12 c
		Rajapur	65.43 g	53.64 c	43.32 g	37.45 fg	72.65 g	85.43 e
		Shabgram	46.87 m	49.86 e	39.43 hi	39.53 e	74.53 f	81.16 f
	Gabtoli	Baliadighi	54.13 k	46.32 gh	32.17 k	32.79 i	69.75 h	75.42 h
		Kagoil	59.42 i	47.86 fg	42.87 g	28.38 j	64.43 jk	73.85 hi
Joypurhat	Panchbibi	Balighata	47.18 lm	52.21 cd	29.75 l	47.94 bc	59.85 l	64.63 k
		Mohammadpur	65.32 g	58.96 b	34.64 j	38.64 ef	69.74 hi	69.27 j
		Kusumba	38.96 n	43.86 i	42.75 g	32.75 i	47.74 m	54.95 m
		Dharangi	48.64 l	49.43 ef	40.86 h	28.69 j	58.75 l	64.84 k
	Akkelpur	Gopinathpur	59.86 i	38.53 k	53.75 b	17.53 n	63.63 k	75.42 h
		Roykali	65.38 g	35.12 l	55.14 ab	22.31 m	69.53 hi	79.64 fg
		Tilakpur	69.53 e	23.41 o	49.75 cd	12.76 o	73.64 fg	86.53 e

TRS= tuberous rot of Satamuli, SRS= stem rot of Satamuli
In a column same latters are not significantly different by DMRT at 5% lavel.

Root rot of Basak (*Adhatoda vasica*) caused by *Fusarium oxysporium* were found in summer, winter and rainy season. In rainy season the highest disease incidence 98.64(%) was recorded at Barabaria village, Natore sadar thana, Natore district and the lowest disease incidence 69.53 (%) was recorded at Mohammadpur village, Panchbibi thana, Joypurhat district (Table 4).

From the above mentioned results, it was observed that most of the diseases were found in rainy season while in summer season less diseases occurred, it may happen because of favorable temperature and humid conditions. These affected plant parts may be less effective for the medicinal use and economic value. The result is also agreement with on previous study that conducted by Joshi and Kareppa (2010) they studied on disease severity of *Chlorophytum borivillianum*. They noticed that there is variation in Disease Severity Index (DSI) with respect to season and also mentioned that in rainy season disease severity index was more as compare to other seasons. Shivanna and Mallikarjunasamy (2009) also investigated that the fungal diseases and their effect on phytochemical constituents of medicinally important *Terminalia* sp. They observed high disease incidence in rainy season next to winter.

CONCLUSION

In this study, eleven fungal diseases of six commercially cultivated medicinal plants were recorded in and around different places of Northern region of Bangladesh. The diseases were found more in rainy season while in summer season fewer diseases occurred. The spreading of these fungal diseases on medicinal plants may causes a setback to the industry associated with the formulation of its medicinal products. So, this work may encourage other researcher to study these diseases further and their proper management. It is necessary to maintain the medicinal plants in gardens or nurseries by using bio-pesticides which can make the medicinal plants free from infectious fungal diseases.

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Figure 1: Disease symptoms of six commercially cultivated medicinal plant in northern region of Bangladesh. a & b: root rot and leaf blight of Ashwagandha; c & d: leaf spot and collar rot of Aloevera; e & f: tuberous rot and stem rot of Satamuli; g & h: leaf spot and collar rot of Kalmegh; i: root rot of Basak; j & k: Powdery mildew and root rot of Tulsi.

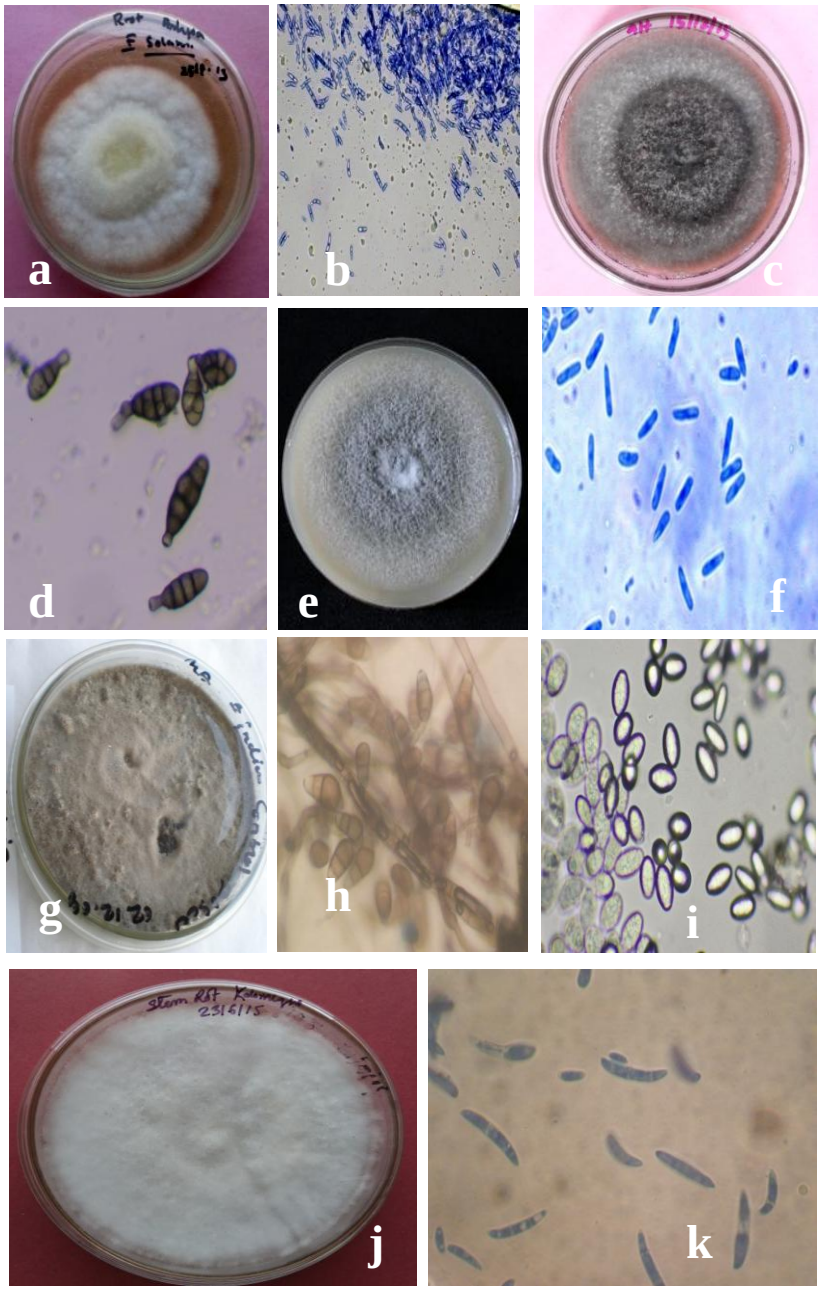

Figure 2: Colony and Conidia of identified fungus. a & b: *F. solani*; c & d: *Alternaria alternata*; e & f: *Collettotrichum gloeosporioides*; g & h: *Curvular ialunata*; i : Conidia of *Erysiphe* sp.; j & k: *Fusarium oxysporium.*