SURVEY ON NURSERY, FIELD AND POST HARVEST DISEASES OF MEDICINAL PLANTS IN DHAKA, BANGLADESH

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SURVEY ON NURSERY, FIELD AND POST HARVEST DISEASES OF MEDICINAL PLANTS IN DHAKA, BANGLADESH

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CERTIFICATE

*This is to certify that, the thesis entitled, "**SURVEY ON NURSERY, FIELD AND POST HARVEST DISEASES OF MEDICINAL PLANTS IN DHAKA, BANGLADESH**" submitted to the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN PLANT PATHOLOGY** embodies the result of a piece of bona fide research work carried out by **SK. TAYEABUR RAHMAN**, Registration No.: **09-03449** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly been acknowledged by him.

Dated: 26 May, 2016
Place: Dhaka, Bangladesh

(Abu Noman Faruq Ahmmed)
Associate Professor
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Dedicated to

My

Beloved Parents

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ABSTRACT

Three experiments were conducted for detection and identification of diseases of selected medicinal plants at nursery, field and post harvest conditions during January, 2015 to December 2015 in Dhaka, Bangladesh. Ten important medicinal plant species were considered for field survey, viz. Aloe vera (*Aloe barbadensis*), Akondo (*Calotropis gigantea*), Arshogondha (*Withania somnifera*), Bashok (*Adhatoda vasica*), Dadmordan (*Cassia alata*), Dhutra (*Datura metel*), Gulancha (*Tinospora cordifolia*), Asma lota (*Mikania scandens*), Tulshi (*Ocimum sanctum*) and Ulotkambol (*Abroma augusta*). Only one Aloe vera was considered for nursery and postharvest survey. The disease incidence and severity were recorded under natural epiphytic conditions in three major seasons of Bangladesh, viz. winter, summer and rainy season. In Aloe vera, six diseases were identified in both nursery and field conditions. These were Alternaria leaf spot caused by *Alternaria* sp., Curvularia leaf spot caused by *Curvularia* sp., basal rot caused by *Fusarium* sp., bacterial rot caused by unidentified bacterium, anthracnose caused by *Colletotrichum* sp. and tip blight caused by *Alternaria* sp. However, the first four diseases were also identified in postharvest condition. The only identified disease of Akondo and Arshogondha was leaf spot caused by *Alternaria* spp. Leaf spot disease caused by *Alternaria* spp. was also identified from Dadmordon, Dhutra, Tulshi, Asma lota and Ulotkambol. In case of Bashok and and Gulancha, two diseases viz. leaf blight caused by *Alternaria* sp. and leaf spot caused by *Alternaria* sp. and *Cercospora* sp. were identified. The incidence and severity of the identified diseases varied significantly among these seasons. The disease incidence and severity were varied 0-36.33% and 0-75%, respectively. In most cases disease incidence and severity were higher in rainy season followed by summer and winter. However, the diseases of Akondo, Arshogondha, Bashok and Dadmordon were highest in winter season. Depending on the disease incidence and severity, the major diseases of inspected medicinal plants were; leaf spot, tip blight, basal rot and bacterial leaf rot of Aloe vera; leaf spot of Arshogondha; Cercospora leaf spot of Bashok and Gulancha.

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LIST OF ABBREVIATIONS

Full word	Abbreviations
Agro-Ecological Zone	AEZ
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Coefficient of Variance	CV
Degree Celsius	°C
Etcetera	etc.
Food and Agricultural Organization	FAO
Gram	g
Kilogram	Kg
Least Significant Difference	LSD
Meter	m
Milliliter	ml
Millimeter	mm
Percentage	%
Ton per hectare	t/ha
Sher-e-Bangla Agricultural University	SAU
Videlicet (namely)	viz.
World Health Organization	WHO

CHAPTER 1
INTRODUCTION

Medicinal plants are the important natural wealth for our country as well as for the world. From the ancient time the people used as important therapeutic agents as well as important raw materials for the manufacture of traditional and modern medicines. The plants which are useful for healing several diseases are called medicinal plant. Many definitions have been proposed for medicinal plants. According to the World Health Organization (WHO), a medicinal plant is any plant which, in one or more of its organs, contains substances that can be used for therapeutic purposes, or which are precursors for chemo-pharmaceutical semi-synthesis (Shahriar *et al.*, 2014). Plants that possess therapeutic properties or exert beneficial pharmacological effects on the human body are generally designated as medicinal plants (Houghton, 1995). Medicinal plants naturally synthesized and accumulate some secondary metabolites, like alkaloids, sterols, volatile oils etc. (Rattan, 2010). Medicinal plants are regarded as the amplest bio-resource of drugs of traditional medicines, modern medicine, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for synthetic drugs (Ncube *et al*., 2008; Nirmala *et al*., 2011).

Medicinal plants have a rich history and traditional uses for health care of the local communities of this subcontinent (Caniago and Siebert, 1998). According to the WHO a total of 2,50,000 species of flowering plants are referred to as medicinal plants. Estimates for the numbers of species used medicinally include: 35,000-70,000 or 53,000 worldwide (Farnsworth and Soejarto, 1991). The World Health Organizations (WHO) enlisted 21,000 medicinal plant species in the world. It is estimated that about 25-30% of all modern medicines are directly or indirectly derived from higher plants. The global demand for herbal medicine is not only large but also growing (Srivastava, 1996). According to FAO (2007), 1,21,505 tones of medicinal plants and aromatic products extracted globally out of which 90181 tones are collected from Asia. According to WHO, at present the medicinal plants have 62 billion US dollar market value which is poised to

grow to 5 trillion US dollar by the year 2050. This figure is expanding by 15 to 20 percent annually (Subrat, 2002).

In Bangladesh, about 500 plant species have been identified as medicinal plant because of their therapeutic properties (Ghani, 2003). There are 422 traditional medicine manufacturing companies are present in Bangladesh by 2008 (Wadley, 2014) and they used 3000 metric tons herbal raw material per year (Mamun, 2014). Plants are used an excellent source of drugs and some of currently available drugs were derived from the plant sources (Patel and patel, 2013). Medicinal and aromatic plants play a significant role in the life of people and are present in innumerable forms. These plants are used as raw materials for medicines, cosmetics, perfumery, insecticides and fungicides and in the various industries. A number of medicinal plants also produce essential oils as well as being used for perfumery products. It is estimated that around 12,000 tons of dried medicinal plants are sold from the rural collection and production areas worth around 4.5 million USD to the rural economy. The wholesale value is estimated to be USD 6 million and the import of around 5,000 tons worth USD 8 million. In total the medicinal and aromatic plants sector in Bangladesh is worth USD 14 million with local supply comprising of 70% by volume and 40% by value (Shackleton *et al.*, 2011).

The Government of Bangladesh has been launched campaign to create awareness for planting of medicinal plant as a safe, side effect less, low cost and very effective sources of disease prevention and cure. Millions of village people can cultivate medicinal plants in their homestead garden which will give them benefit of chief medication as well as green plantation of agro-social forestry. The government is also selling different medicinal plants seedlings at a subsidized rate in 400 different government nurseries all over the country. There are also 450 sub-centers in each upazila under the 400 government nurseries (BPC).

Since the medicinal plants grow mostly in natural forest and fallow lands many of them have become threatened. Medicinal plants face a high risk of extinction in Asia and the Pacific. It is estimated that some 25,000 species of plants will cease to exist (UNEP,

2010). Besides, commercially cultivated medicinal plants hampered due to some pest and disease infestation. Disease is one of the major threats to expand the commercial cultivation of medicinal plant in this country. The medicinal plants are affected by fungal pathogens which degrade the quality of medicinal plant directly by disturbing the physiological and metabolic procedures of affected plant parts (Kadam *et al*., 2012). Besides many bacterial diseases, viral diseases and nematode and other microorganisms causes great damages of medicinal plants.

There are some instance of diseases those cause huse loss of the medicinal plants. For example, infection of Aloe vera by *Alternaria brassicae* not only reduces the yield and market value but it may reduce antioxidant property and other medicinal efficacy of the herb (Pritam and Kale, 2007). Leaf spot disease of *Calotropis gigantea* (Akondo) plant caused by *Alternaria alternate* occurred in India. The disease incidence was greater than 80% and shrubs suffered by extensive defoliation (Sain *et al.*, 2009). Phoma leaf spot disease of *Tinospora cordifolia* (Guloncha) reduces secondary metabolite production (Shivanna *et al.*, 2014). However, unfortunately these types of blessing plants have taken very little care that leads to extinct of the medicinal plants.

There is very little reliable information about the diseases of medicinal crops in Bangladesh. The growers suffer great loss due to various diseases every year. So, this is an important issue to detect and identify the diseases of medicinal corps in Bangladesh. It is also essential to measure the incidence and severity of diseases to find out the major diseases of those crops. Moreover, it is also necessary to make a list of diseases and pathogens for import and export of raw medicinal plant in quarantine aspect and for issuing phytosanitary certificate by the quarantine authority.

Considering the above facts and points this research work was designed to achieve the following objectives:

1. To identify the diseases of some important medicinal plants with their causal organisms; and
2. To measure the incidence and severity of major diseases of selected medicinal plants.

CHAPTER 2

REVIEW OF LITERATURE

Very few research works directly has been carried out in this area in Bangladesh. There is also a very limited significant research works on diseases of medicinal plant in the South Asia. However, some research works are found regarding diseases of few medicinal plants in the world. This chapter is to review the previous studies that are related to the present study. The review of some related studies are described below:

2.1. Diseases of Aloe vera or Ghritakumari (*Aloe barbadensis*)

Avasthi *et al*. (2015) reported occurrence of leaf spot diseases on *Aloe vera* (L.) caused by *Curvularia* species from Madhya Pradesh, India. On the basis of morphological and microscopic characteristics of the fungus, two species of *Curvularia* i.e. *Curvularia lunata* and *Curvularia ovoidea*, were found to be associated with the leaf spot diseases. Leaf spot disease caused by *C. lunata* began in the form of circular, water soaked lesions on the tip and abaxial surface of the leaves. Gradually the size of the lesion expanded and became light red in color bordered by water soaked tissues. As the disease progressed, the lesions were sunken, maroon color with an average size of 0.5-1.4 × 0.4-1.0 cm. In later stages, lesions became dry, necrotic and turned into dark maroon in color. The disease was observed during both the rainy and winter seasons. In case of *C. ovoidea symptoms* appeared as elongated, water soaked lesions, generally occurred on the spiny margins and abaxial surface of the leaves. Progressively, these lesions became sunken and light brown in color. Later, these lesions were enlarged, centre of the lesions dark brown in color with maroon red margins, and measured about 0.7-1.7 × 0.6-1.3 cm in size. In severe infection, the spiny margin of the leaves was twisted inside due to necrosis of the tissues. Interestingly, the disease was observed only in the winter season.

Ghosh and Banerjee (2014) first reported about the *Aloe vera* leaf spot disease and disease intensity in West Bengal, India. They reported the causal fungal pathogen of this disease was *Alternaria brassicae*. The symptoms appeared on the leaves in form of small

dark brown necrotic spots on both sides which gradually enlarge to cover up an area of 2-8 cm in diameter. The infected area transforms from dark brown to black. Gradually the leaf surface is covered with numerous such lesions which become rotten and dried within 4-7 days with a central cup shaped depression having a depth of 5-8 mm. These disease symptoms indicate that it is leaf spot. The disease intensity was peak from April to July (83.28-95.71%) in four places of their survey. While the minimum percentage of disease intensity was recorded in December (25.71-50%) of four study areas. This work not only globally establishes Aloe vera as a new host of *Alternaria brassicae* but also this disease of Aloe vera is first reported from the district of West Bengal.

Khadka and Rawal (2014) found the association of *Fusarium oxysporum* species with Aloe vera leaf and basal rot disease in Western Terai of Nepal.

Zhai *et al.* (2013) first reported that leaf spots in Aloe vera caused by *Nigrospora oryzae* in China.

Rajendran and Gnanavel (2011) recorded Alternaria leaf spot disease caused by *Alternaria alternata*; Cercospora leaf spot disease caused by *Cercospora* sp. and anthracnose disease caused by *Colletotrichum* sp. in Aloe vera. They also reported rust spots and basal stem rot disease.

Avasthi *et al.* (2011) observed a typical anthracnose symptom on the leaf surface of Aloe vera during the survey of various nurseries of Gwalior city, India, in August, 2010. The symptoms of anthracnose were begun with a small round to oval, water-soaked dark green area about 1-2 mm in diameter. These area increase into circular spots with tan to light brown centre bordered by water soaked tissue. As these spots expand, centre of the lesion became reddish brown to brown color. The average diameter of the spots was 3-30 mm and the size of the necrotic areas increases as spots coalesce. The acervuli on infected leaves produced black colored spore mass under high humid condition. In the advance stage of infection, spots appeared on both the surfaces of the leaves. The affected area lost the mucilaginous gel and leads the death of infected leaves. Based on

the symptoms, mycelia and conidial characters, the fungus was identified as *Colletotrichum gloeosporioides* which was further confirmed at Indian Agricultural Research Institute, New Delhi.

Chavan and Korekar (2011) reported leaf spot disease of Aloe vera caused by *Alternaria alternata, A. tenuissima, Fusarium* spp. and for root disease caused by *Aspergillus verocosa, Fusarium oxysporum.* They found leaf spot disease in winter and rainy season but not in summer season and root disease of Alovera was found in summer, winter and rainy season. Their survey was conducted in Osmanabad District, India during the years 2008 and 2009.

Bijwa *et al*. (2010) first reported the leaf spot disease of Aloe vera caused by *Alternaria alternata* in Pakistan. On the basis of morphological characteristics, the fungus was identified as *Alternaria alternata* by the Fungal Culture Bank of Pakistan (FCBP).

Kawuri *et al*. (2010) first reported the leaf rot disease of Aloe vera, since it was introduced in Bali, 2006.

Rajendran and Gnanavel (2008) reported black or sooty mold disease of *Aloe vera* (L.) They also reported bacterial leaf rot disease of Aloe vera caused by *Erwinia chrysanthemi*. Infected Aloe vera suddenly shows the symptoms of vigor loss. The symptoms started as water-soaked lesions at the base of the leaves. The rotting progressed very fast and the whole plant died within two to three days. They also reported root rot disease caused by *Fusarium* sp. This disease infects when Aloe vera plant's soil or surroundings are too moist. The leaves may yellow or seem to wilt. The stem may become dark and the leaves even fall off.

Ayodele and Ilondu (2008) reported that, fungi associated with base rot disease of Aloe vera in Niger Delta Area of Nigeria. Fungi and their percentage frequency were *Aspergillus verocosa* (28.03%), *Fusarium oxysporum* (24.24%), *Plectosphaerella cucumerina* (16.67%), *Mammeria ehinobotryoides* (15.91%) and *Torula herbarium*

*(*15.15%). None of the fungi isolated have been previously reported on *Aloe vera* in Nigeria. In pathogenecity tests, the fungi isolated produced a variety of symptoms ranging from slowly progressive to rapidly progressive lesions leading to complete disintegration of the leaf bases of Aloe vera plants ten days after inoculation.

According to Mandal and Maiti (2005), a new leaf rot disease of Aloe vera (*Aloe barbadensis*) was observed for the first time in Gujarat, India, in 2000. The disease was serious when abundant moisture was available. Symptoms started as water-soaked lesions at the leaf base. Rotting progressed very quickly and the whole plant died after 2-3 days. As rotting progressed, the leaf epidermis bulged out due to gas formation and the leaf content was converted to a slimy mass which was eventually released.

In Texas Plant Disease Handbook, there is a good description about the tip dieback on tip blight of Aloe vera plant. It is defined as a physical oedema. The initial symptom is a water-soaked appearance at the tips of leaves. The tissue remains rigid and the discoloration does not progress to the crown. Several days later, the affected portion dries and shrivels, leaving a string of firm, brown tissue, while the rest of the leaf remains green and succulent. This disorder is uncommon and occurs with certain weather patterns. It was documented early one summer when a period of overcast weather with heavy rain was followed by hot, sunny weather. Plants in water logged soil that were exposed to the sun were injured, while those that were shaded were not. There is no remedy for this injury, but leaves can still be processed if the affected portion is removed.

2.2. Diseases of Madar or Akondo (*Calotropis gigantean*)

Mukhtar *et al*. (2011) first reported the leaf spot disease of *Calotropis gigantea* caused by *Passalora calotropis* in Lahore, Pakistan.

Sain *et al.* (2009) first reported the leaf spot disease of *Calotropis gigantea* caused by *Alternaria alternata* in Rajasthan, India. Disease incidence was greater than 80% and shrubs suffered extensive defoliation. Symptoms on infected leaves were small, circular spots with large yellow to dark brown haloes on both sides of the lower and middle

leaves. The spots gradually enlarged in size and later became irregular in shape or remained circular with concentric rings or zones. During the later stage of infection, these spots coalesced to cause necrosis of the leaves causing withering, extensive drying, and ultimately death of leaves. Here Koch's Postulates were completed by spraying 75-day-old healthy madar plants with an aqueous spore suspension of 1×10^6 conidia per ml using an atomizer in the late evening. Inoculated plants were placed in an environmental chamber at 23°C with 8 h of daily light and 75% relative humidity for 48 h. Thereafter, inoculated and non inoculated plants were moved to a 25°C green house bench and watered twice per day. Leaf spots initially appeared on the upper surface of older leaves after 7 days and by 12 to 15 days, leaf spot symptoms similar to those described previously developed on every inoculated plant. No symptoms developed on plants sprayed with distilled water. *Alternaria alternata* was consistently re-isolated from the inoculated plants. This is the first record of the disease from the Sikar district of the Rajasthan state of India.

2.3. Diseases of Winter cherry or Arshawgandha (*Withania somnifera*)

Shivanna *et al.* (2014) reported that, *Withania somnifera* is a promising revitalizing medicinal herb. The plant is affected by foliar diseases in Lakkavalli forest region of Bhadra Wildlife Sanctuary. The symptomatology of foliar fungal disease incidence, severity and distribution in the study area was examined during 2006–2009. The seed borne nature and transmission of the causal pathogen and its management with seed dressing fungicides were studied. The results of the study indicated that *Alternaria alternata* caused severe leaf spot disease, while *Myrothecium roridum* and *Fusarium oxysporum* caused minor diseases. Based on the internal transcribed spacer (ITS1 and ITS2) regions of rDNA, the major pathogen was identified as *A. alternata.* The disease is homogeneously distributed in Lakkavalli forest region and high severity is recorded during November. *Alternaria alternata* and *Fusarium oxysporum* were the dominant seed borne pathogens that are transmitted to seedlings.

Saroj *et al.* (2014) reported of black leaf spot mold (*Pseudocercospora fuligena*) on *Withania somnifera* from India. During the monsoon of July 2011, black spots on the

leaves of infected plants were observed in the Arshwagandha growing Lucknow, Raibareilly, and adjoining areas of Uttar Pradesh zed by the presence of light chlorotic spots on both sides of old leaves that later turned into dark black spots resulting in early defoliation.

Chavan and Korekar (2011) reported leaf spot disease of *Withania somnifera* caused by *Fusarium solani, Alternaria alternata, Aspergillus niger* in all season and for leaf rust disease they found *Aecidium withaniae, Mucor mucedo* except summer. They also found *Rhizopus solani* in the root disease of *Withania somnifera* in rainy season. This survey was conducted in Osmanabad District, India during the years 2008 and 2009.

Pati *et al.* (2008) investigated the disease profile of *Withania somnifera* and observed that leaf spot is the most prevalent disease. Repeated isolations from infected leaf tissues and pathogenicity tests showed the association of fungal pathogen identified as *Alternaria alternata* (Fr.) Keissler.

Awasthi *et al.* (2008) stated that severe mosaic disease of Ashwagandha (*Withania somnifera*), of family Solanaceae was observed in the plants maintained for research work. The disease was characterized by stunted growth of plants, mosaic on foliage, reduced and pale colored flowers. In severe cases of infection, leaf size was reduced and downward curling of leaf lamina was observed. The disease incidence was 40-90%.

Maiti *et al.* (2007) first reported of *Alternaria dianthicola* causing leaf blight on *Withania somnifera* from India. Leaf blight disease of this plant generally occurs during the month of March in various districts of South Bengal, India. At the initial stage of infection, symptoms appear 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. A species of *Alternaria* was isolated from the lesions.

Zaim and Samad (1995) observed a witches-broom disease of *Withania somnifera* first appeared in 1988 at CIMAP experimental fields, Lucknow, India. Thereafter, it spread to the commerical fields causing severe damage to the crop during that last 5 years. Phytoplasma was associated with the disease on the basis of symptomatology, mode of transmission, electron-microscopic studies and response of tetracycline spray on the recovery from diseased symptoms. Typical symptoms of the disease consisted of little leaf, shortening of internodes, excessive branching giving witches-broom appearance and premature drying and death of infected twigs and leaves. Ultrathin sections of infected leaf tissue showed pleomorphic bodies (measuring 250–550 nm) in sieve tubes of phloem. Disease was transmitted from infected plants to healthy plants through grafting. The treatment of infected plants with tetracycline provided temporary recovery from the infection.

2.4. Diseases of Malabur nut or Bashok (*Adhatoda vasica*)

Gautam and Avasthi (2013) observed a severe leaf spot disease on *Adhatoda vasica* leaves collected from different regions of Bilaspur, Himachal Pradesh, India. *Colletotrichum gloeosporioides* was identified as the causal agent based on disease symptoms, the morphological and microscopic characteristics of the isolated fungus and pathogenicity tests. This was the first report of *C. gloeosporioides* on leaves of *A. vasica* in India.

Kadam *et al.* (2012) mentioned *Cercospora adhatodae*, *Colletotrichum capsici, Corynespora sp*. were responsible for the leaf spot of *Adhatoda vasica* on the basis of growth pattern, hyphal details and spore type.

Sutare and Kareppa (2010) studied the fungal diseases of *Adhatoda zeylanica.* He found *Alternaria alternata* in leaf spot. *Colletotricum capsici* for anthracnose disease, *Aecidium adhatodae* for leaf rust disease. *Phoma vasicae Shreemali* for leaf spot disease.

Singh and Verma (2009) studied the incidence of Alternaria blight caused by *Alternaria alternata* in *Adhatoda vasica* (*Justicia adhatoda*) plantations in Jaipur and Sikar

districts, Rjasthan, India, was studied during October 2003-04. Disease incidence was greatest (between 26.25 and 32.25%) on 19 March in Sikar and 23 March in Jaipur; the temperatures during these periods were 26.87 and 23.10 °C, and the humidity levels were 59.75 and 60.25%, respectively. The disease intensity was lowest in June at both locations, when the temperature was more than 34°C and the humidity was less than 44%. The pathogen survived longer under laboratory conditions (up to 10 months) than under natural conditions (up to 8 months).

Verma *et al.* (2006) found a leaf spot disease in *Adhatoda vasica* caused by *Rhizoctonia solani* during October-November in 2005. The disease was present on all *A. vasica* plantations located in the foothills on the outskirts of Jaipur, covering an area of 8–10 km^2. The disease was present on leaves of all ages but was more severe on older (lower) leaves. Symptoms start as minute, round, light brown spots. Within 8-10 days the spots grow and acquire a round to irregular shape. Some spots coalesce. Fully developed spots were water-soaked, dark brown to blackish, scattered all over the leaf lamina. Margins of the spots were diffuse and each spot had a light colored dot in the centre. The spots were equally visible on lower and upper leaf surfaces. Severe infection resulted in defoliation.

2.5. Diseases of Ringworm shrub or Dadmordan (*Cassia alata*)

Shamsi *et al.* (2014) observed a total of 8 species of fungi belonging to 8 genera of Deuteromycetes were associated with *Senna alata* (*Cassia alata*). The fungi *Acromoniella* sp., *Arthrinium saccharicola*, *Aspergillus niger*, *Cladosporium cladosporioides*, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Nigrospora sphaerica, Pestalotiopsis guepinii* and unidentified Hyphomycetes *C. gloeosporioides* and *P. guepinii* were found to be pathogenic to *Senna alata.*

Boyette (1988) reported *Alternaria* species are responsible for foliar and seedling blights and *Alternaria cassia* causes foliar blight of several Cassia species in India and USA. Serious seedling blight of *C. obtusifolia* and *C. occidentalis* in was noticed in the USA.

Walker (1982) reported seedling blight disease and also described the severe leaf lesions resulting in defoliation, severe stem lesions developing into cankers, stunting and plant death in Cassia plant.

2.6. Diseases of Devil's trumpet or Dhutra (*Datura metel*)

Aktaruzzaman *et al.* (2013) collected leaf spot disease samples of *Datura metel* from Gangneung, Gangwon Province, Korea. The observed symptoms were small circular to oval dark brown spots with irregular in shape or remained circular with concentric rings. Then it was cultured in PDA media. The examined the fungus morphologically and confirmed its pathogenicity according to Koch's postulates. The results of morphological examinations, pathogenicity tests, and the rDNA sequences of the internal transcribed spacer regions (ITS1 and ITS4), glycerol-3-phosphate dehydrogenase (G3PDH) and the RNA polymerase II second largest subunit (RPB2) gene sequence revealed that the causal agent was *Alternaria tenuissima*. That was the first report of leaf spot disease of *D. metel* caused by *A. tenuissima* in Korea as well as worldwide.

Kadam *et al*. (2012) reported Kala Dathura (*Datura fastluosa*) is affected by some fungal pathogens such as *Alternaria, Ascochyta, Cercospora, Colletotrichum, Phyllosticta, Pseudoercorpora* which degrade the quality of medicinal plant directly by disturbing the physiological and metabolic procedures of affected plant parts.

2.7. Disesases of Heartleaf moonseed or Gulancha (*Tinospora cordifolia*)

Achar *et al.* (2014) observed a new leaf spot disease in *T. cordifolia* caused by *Xanthomonas campestris* Bhadra in Wildlife Sanctuary, Karnataka, India. The disease affected stem, leaf lamina, and midrib and occurred, particularly, during the post-monsoon months (October-November).

Shivanna *et al.* (2014) reported the Phoma leaf spot disease of *Tinospora cordifolia* and its effect on secondary metabolite production. A three-year (August 2006-July 2009) study of the disease due to the pathogen indicated that the disease incidence (DI) ranged

from 0 to 100% (maximum in Kakanahasudi), while disease severity (DS) ranged from 1.60 to 45.00% (maximum in Madhuguni).

Braun (2013) found leaf spot disease of *Tinospora cordifolia* caused by *Pseudocercospora tinosporae.* The spots were amphigenous, sub circular to irregular, blackish brown, scattered along the veins, to 16 mm in diameter.

Mishra *et al.* (2012) isolated a total of 1,151 endophytic fungal isolates representing 29 taxa from symptom-less, surface-sterilized segments of stem, leaf, petiole, and root of *Tinospora cordifolia* which had been collected at three locations differing in air pollution in India (Ramnagar, Banaras Hindu University, Maruadih) during three seasons (summer, monsoon, winter). Endophytes were most abundant in leaf tissues (29.38% of all isolates), followed by stem (18.16%), petiole (10.11%), and root segments (6.27%). The frequency of colonization (CF) varied more strongly among tissue type and season than location. CF was maximal during monsoon followed by winter and minimal during summer. A species each of *Guignardia* and *Acremonium* could only be isolated from leaves, whereas all other species occurred in at least two tissue types. *Penicillium* spp. were dominant (12.62% of all isolates), followed by *Colletotrichum* spp. (11.8%), *Cladosporium* spp. (8.9%), *Chaetomium globosum* (8.1%), *Curvularia* spp. (7.6%), and *Alternaria alternata* (6.8%).

Gupta and Verma (1987) found leaf spot diseases on *Tinospora cordifolia* caused by *Cercospora madhauliensis*.

2.8. Disease of Mikania vine or Asma Lota (*Mikania scandens*)

Wu *et al.* (2013) reported about the diseases of three species of *Mikania, viz. M. cordifolia, M. scandens* and *M. micranta.* They reported *Alternaria, Fusarium* and *Colletotrichum* pathogens which caused foliar diseases in Mikania species.

Sapkota (2007) reported that Mikaniaplants infected by the rust fungi *Puccinia spegazzinii* grew more slowly than uninfected Control plants.

Evans and Ellison (2005) collected three microcyclic rust species were during surveys of the perennial asteraceous vine *Mikania micrantha (Eupatorieae*: *Asteraceae)* through out its native range. The commonest species, *Puccinia spegazzinii* with brown telioid telia, occurred wherever *M. micrantha* was found in South and Central America including the Caribbean island of Trinidad. *Dietelia portoricensis,* with occasional vestigial spermogonia and grayish white to pale yellow columnar aecioid telia, was collected only in Costa Rica; while *D. mesoamericana*, apparently restricted to Mesoamerica, can be distinguished by its abundant, yellowish-orange, fertile spermogonia, yellow to pale brown telial columns, larger teliospores, and 4-spored rather than 2- spored metabasidia. The fact was that all three species were fundamentally similar.

2.9. Diseases of Basil or Tulshi (*Ocimum basilicum*)

Banerjee and Ghosh (2015) reported fungal disease of some important medicinal plants in West Bengal. They observed leaf blight of *Ocimum sanctum* caused by *Alternaria* sp.in January- December, 2013 and 2014.

Garibaldi *et al*. (2011) first reported the leaf spot disease of sweet basil (*Ocimum basilicum*) caused by *Alternaria alternata* in Italy.

Tran (2011) observed that, Fusarium wilt (caused by *Fusarium oxysporum*) was one of the most common basil diseases. Besides, bacterial leaf spot (*Pseudomonas cichorii*), gray mold (*Botrytis cinerea*) and damping off or root rot (*Rhizoctonia solani*; *Pythium* sp.) were also responsible for disease development. Moreover, downy mildew (*Peronospora belbahrii*) was very destructive, and widespread occurrence can happen if it is uncontrolled.

Taba *et al*. (2009) reported about the Alternaria leaf spot of basil caused by *Alternaria alternata* in Japan.

Alam and Janardhanan (1994) ware first reported the leaf spot disease of basil from Kerala caused by C*olletotrichum gloeosporioides*. The leaf blight of *Ocimum basilicum*

by *Colletotrichum capsici* was also reported from India. *C. gloeosporioides* is a common organism causing leaf spot disease (anthracnose) in a wide array of fruit trees, spices and medicinal plants in Kerala. This has to be taken note of in the context of cultivating basil in farming systems with susceptible crops.

Alam *et al.* (1980) noticed basil suffers from several plant pathogens that can ruin the crop and reduce yield. Fusarium wilt was a soil-borne fungal disease that quickly killed younger basil plants. Seedlings may also be killed by *Pythium* damping off. A common foliar disease of basil was gray mold caused by *Botrytis cinerea*; it can also cause post-harvest infections and is capable of killing the entire plant. Black spot can also be seen on basil foliage and is caused by the *Colletotrichum*. Leaf blight of Basil, caused by *C. capsici* has been causing considerable damage to the commercial field of basil during August-September, when it appears in severe form.

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site

Field, nursery and post harvest diseases of medicinal plants were evaluated in this study. The survey was conducted at Sher-e-Bangla Agricultural University (SAU) campus for field diseases, nurseries situated at Sher-e-Bangla Nagar for investigating the diseases of medicinal plants in nursery and Kawranbazar, Gulisthan, Jatrabari market were selected for survey of post harvest diseases. The experimental field was located at 90°22′E longitudes and 23°41′N latitude at an altitude of 8.6 meters above the sea level and under the agro-ecological region of "Madhupur Tract" (AEZ NO. 28). For better understanding, the experimental site is shown in the map of AEZ of Bangladesh in Appendix I.

3.2. Experimental period

The experiment was carried out during the period from January, 2015 to December 2015. Data was collected in three times for each season in 2015 during this survey. For winter season, data were collected in January, February and December month, in 2015, for summer season, April to June in 2015 and for rainy season July to September in 2015.

3.3. Characteristics of soil

The farm belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. Organic matter and fertility status were moderate.

3.4. Weather conditions

The experiment was carried out during the period from January, 2015 to December 2015. So the average temperature, precipitation and relative humidity of those months are given below:

Table 1. Average weather conditions in Dhaka, Bangladesh in 2015

Season and year	Average Temperature (°C)	Average Precipitation (mm)	Average Humidity (%)
Winter, 2015 (January+February +December)	20.5	16.67	72
Summer, 2015 (April+May+June)	30	233.33	74.67
Rainy, 2015 (July+August+September)	28	310	81.33

Source: Metrological Department of Bangladesh

3.5. Experiments

Three experiments were conducted under this research works. These were-

1. Survey on field diseases of medicinal plant at Sher-e-Bangla Agricultural University, Dhaka.
2. Survey on nursery diseases at nurseries of Sher-e-Bangla Nagar, Dhaka
3. Survey on post harvest diseases at Kawranbazar, Gulisthan and Jatrabari Dhaka.

3.6. Test materials

In this study, ten medicinal plants species were selected field survey, while only Aloe vera was selected for survey in nursery and postharvest diseases. The details of the experimental plants are given below:

Table 2. Details of the experimental medicinal plants

Sl No:	Common Name	English Name	Scientific Name	Family
1	Ghritakumari	Aloe vera	*Aloe barbadensis*	Xanthorrhoeaceae
2	Akondo	Madar	*Calotropis gigantea*	Apocynaceae
3	Arshogondha	Winter cherry	*Withania somnifera*	Solanaceae
4	Bashok	Malabur nut	*Adhatoda vasica*	Acanthaceae
5	Dadmordan	Ringworm shrub	*Cassia alata*	Fabaceae
6	Dhutra	Devil's trumpet	*Datura metel*	Solanaceae
7	Gulancha	Moon creeper	*Tinospora cordifolia*	Menispermaceae
8	Asma lota	Mikania vine	*Mikania scandens*	Asteraceae
9	Tulshi	Basil	*Ocimum sanctum*	Lamiaceae
10	Ulotkambol	Devil's cotton	*Abroma augusta*	Malvaceae

Source: Islam *et al.* (2014); Mamun (2014)

3.7. Sampling

The data were collected in winter, summer and rainy season by using the following sampling:

Table 3. Number of samples for data collection for a season

Plants species	Experiments		
	Field	Nursery	Post harvest
Ghritakumari	50 plants	100 plants	100 leaves/stall
Akondo	5 plants	---	---
Arshogondha	5 plants	---	---
Bashok	5 plants	---	---
Dadmordan	3 plants	---	---
Dhutra	5 plants	---	---
Guloncha	10 plants	---	---
Asma lota	10 plants	---	---
Tulshi	3 plants	---	---
Ulotkambol	3 plants	---	---

3.8. Data collection

The surveys were conducted under natural epiphytic condition. Data was collected in each season with three replications on the following parameters:

I. disease incidence (% Plant leaf infection)
II. disease severity (% Leaf area infection)

3.9. Sample collection

Diseased leaves exhibited different types of typical symptoms were collected from different medicinal plants at Sher-e-Bangla Agricultural University (SAU) campus for field diseases. For investigation of the nursery diseases, different nurseries situated at Sher-e-Bangla Nagar were observed and for post harvest diseases Kaowranbazar, Gulisthan, Jatrabari market areas were observed. Then the samples were carried to the Plant Pathology Laboratory of SAU in individual snap locked plastic bags. The collected samples were preserved in refrigerator at 4°C before investigation. In the laboratory they were examined for visible symptoms as well as for microscopic examination and isolation of causal organism(s).

3.10. Isolation of causal organism(s) by tissue planting method

Plant parts showing the typical disease symptoms were cut into small pieces aseptically, washed thoroughly in running tap water, then surface sterilized with 1% Mercuric Chloride ($HgCl_2$) for 30 seconds to1 minute and washed three times in sterile distilled water. The surface sterilized leaf pieces were then aseptically plated on Blotter paper and Potato Dextrose Agar (PDA) medium and incubated at 25±2 ºC for 6-7 days under 12 hours light and dark conditions. Hyphal tips from the margin of each developing colony were subcultured on PDA to get pure culture. Microscopic examinations were carried out to study morphological charecteristics. The pathogen was identified from all infected samples (Agrios, 1997).

3.11. Identification of causal organism(s)

Identification of causal organisms was done by the following methods:

3.11.1. Identification by direct observation

The samples were taken to the laboratory. Then temporary slides were prepared from the diseased samples, observed under compound microscope and identified the organism(s) according to CMI description (Firoj, 2015).

3.11.2. Identification by growing on blotter paper

The diseased leaves, stems, roots were cut into pieces (5 mm diameter) and surface sterilized with $HgCl_2$ (1: 1000) for 30 seconds. Then the cut pieces were placed in sterile blotting paper. The plates containing leaf pieces were incubated at room temperature for seven days. When the fungus grew well and sporulated it was observed under stereo microscope, to observe the growth characteristics. The slides were prepared from the pathogenic structures and observed in compound microscope and identified with the help of relevant literature (CMI description).

3.11.3. Identification by growing on culture medium

The diseased leaves, stems, roots were cut into pieces (5 mm diameter) and surface sterilized with $HgCl_2$ (1: 1000) for 30 seconds. Then the cut pieces were washed in sterile water thrice and placed on to acidified PDA medium in petridish. (Mehrota and Aggarwal, 2003). The plates containing leaf pieces were incubated at room temperature for seven days. When the fungus grew well and sporulated, the organism was re-cultured by single spore or tip culture method to obtain pure culture. Then slides were prepared from pathogenic structures and observed under microscope and identified with the help of relevant literature (CMI description).

3.11.4. Identification by symptomological study

Symptomological study was done for all diseases. Bacterial diseases were identified according to their symptoms. The development of symptoms was closely observed to confirm the disease.

3.12. Measurement of plant diseases

Measurement of plant disease was calculated by measuring disease incidence and disease severity.

3.12.1. Disease incidence

The plants under investigation were keenly observed to watch the typical symptoms of the disease concerned. The plants showing typical symptoms by the pathogenic infection were considered as diseased plant. Disease incidence was calculated by the number of proportion of the plant units diseased in relation to the total number of units examined. Plant units mean the leaves, stems, fruits, tubers, rhizomes, bulb etc. that show any symptoms. The disease incidence was calculated using the following formula (Islam *et al.*, 2001).

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

3.12.2. Disease severity

Disease severity was calculated in the proportion of amount of plant tissues infected in relation to the total amount of tissue examined. Disease severity data were collected on the following parameters (Agrios, 2005).

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

3.13. Analysis of data

The recorded data were analyzed using MSTAT-C computer package program following the statistical procedures of Gomez and Gomez (1983). For field and nursery the experiment was designed in RCBD single factor and for post harvest condition RCBD double factor. The mean differences were judged by Least Significant Difference (LSD) at the 5% level of significance.

(A) Ghritakumari plant (*Aloe barbadensis*)

(B) Akondo plant(*Calotropis gigantea*)

(C) Arshogondha plant (*Withania somnifera*)

(D) Basak (*Adhatoda vasica*)

(E) Dadmordan (*Cassia alata*)

Plate 1. Selected medicinal plants (A-E)

(F) Dhutra plant (*Datura metel*)

(G) Guloncha plant (*Tinospora cordifolia*)

(H) Asma lota plant (*Mikania scandens*)

(I) Tulshi plant (*Ocimum sanctum*)

(J) Ulot kombal (*Abroma augusta*)

Plate 2. Selected medicinal plants (F-J)

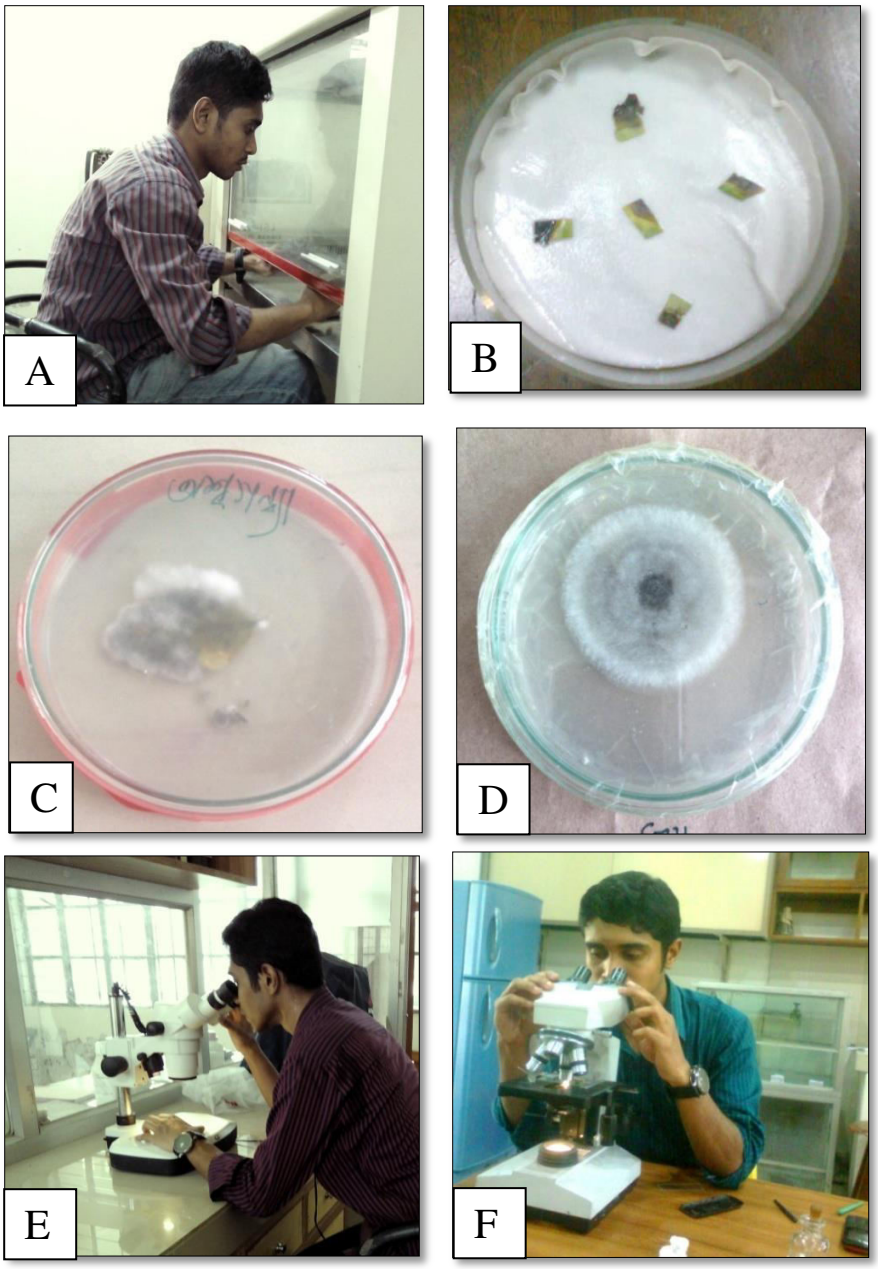

Plate 3. Isolation of causal organism from infected plant tissue; (A) Isolation of causal organisms in laminar airflow cabinet; (B) Incubation of diseased sample in moist blotter paper; (C) Incubation of diseased sample on PDA medium; (D) Pure culture of causal organism; (E) Sterio microscopic observation of causal organism and (F) Compound microscopic observation of causal organism

CHAPTER 4

RESULTS

4.1 Experiment 1: Survey on field diseases of medicinal plants at Sher-e-Bangla Agricultural University, Dhaka

4.1.1 Diseases of Aloe vera

4.1.1.1 Alternaria leaf spot disease of Aloe vera

A. Symptomological study

Circular to oval from dark brown to black color small spots were observed on leaves surface. Gradually the leaf surface is covered with numerous such lesions, which become rotten and dried within few days with a central cup shaped water soaked depression having a depth of 5-8 mm. After progression of this disease the spot spread over the leaf and the succulent part become thin (Plate 4.A).

B. Identification of causal organism

The identified causal organism of leaf spot disease of Aloe vera was *Alternaria* sp. The mycelium was septated, branched, hyaline in tender age. The conidiophore was simple, short, septated, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 5-8 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Plate 4.B-C). The pure culture of *Alternaria* sp. was prepared (Plate 4.D). In the culture the colonies of *Alternaria* are moderately fast growing and produce dark brown to blackish culture on PDA medium within 7 days.

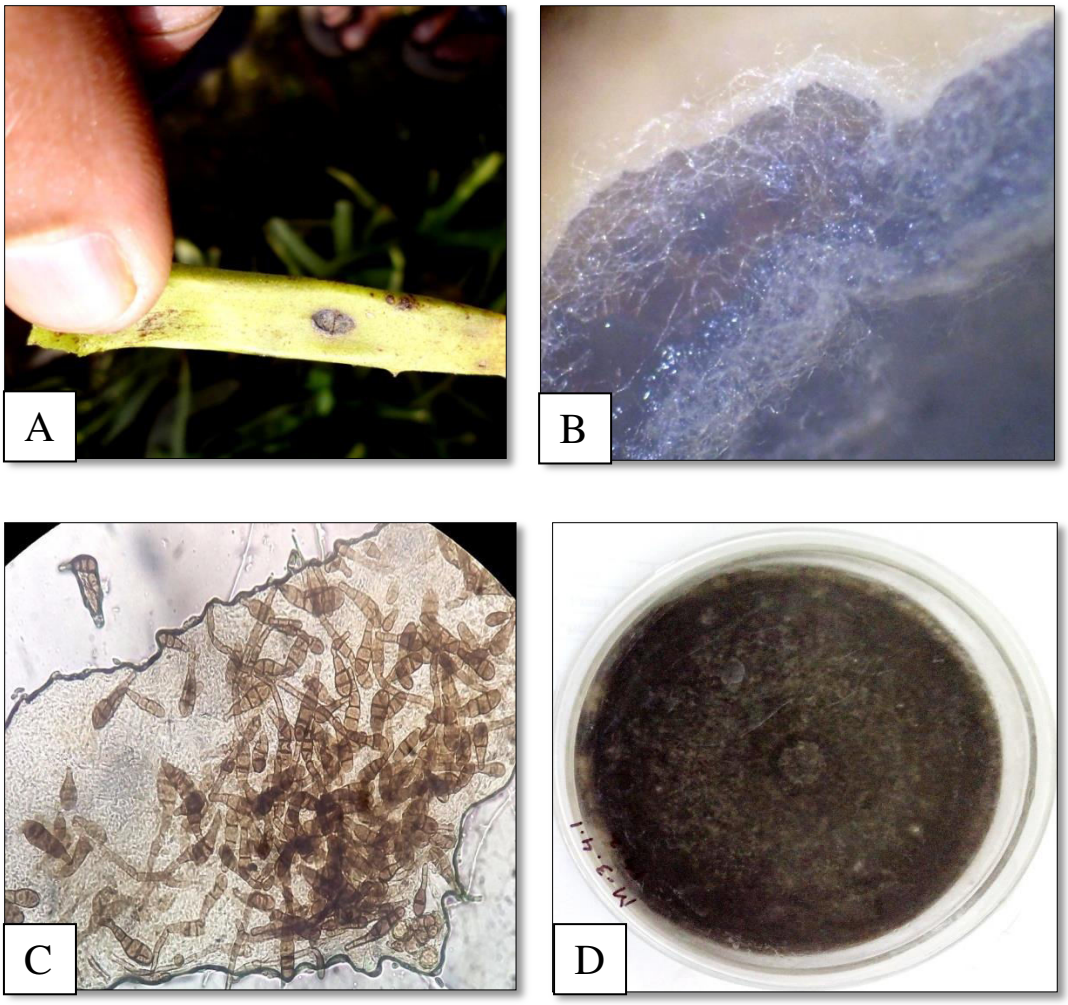

Plate 4. Symptoms and causal organism of Alternaria leaf spot disease of Aloe vera; (A) Alternaria leaf spot in Alo vera plant; (B) Sterio microscopic view (40×); (C) Compound microscopic view of *Alternaria* sp. (10×40) and (D) Pure culture of *Alternaria* sp.

C. Incidence and severity of the disease

Incidence of Alternaria leaf spot varied significantly among the seasons from January 2015 to December, 2015 and that ranged from 5 to 17.67 % (Table 4). The highest disease incidence was recorded in rainy season (17.67%) and the lowest disease incidence was 5% in winter season. In summer the disease incidence was 12.33%.

In case of disease severity, similar results were observed. Severity of Alternaria leaf spot also varied significantly from January, 2015 to December, 2015 (Table 4). The highest disease severity was observed in rainy season followed by summer and winter. In rainy season disease severity was 18% whereas the disease severity in summer was 13%. Moreover, in winter the lowest disease severity was observed 3.33%.

D. Relationship of disease incidence and severity with weather parameters indifferent seasons

The disease incidence and severity of Alternaria leaf spot of Aloe vera progressed from winter season to rainy season (Figure 1). The highest disease incidence and severity of Alternaria leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. Whereas, the lowest disease incidence and severity of Alternaria leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the Alternaria leaf spot disease of Aloe vera.

Table 4. Incidence and severity of Alternaria leaf spot of Aloe vera from January to December, 2015 in field condition

Season of data collection	Alternaria leaf Spot	
	% Disease incidence	% Disease severity
Winter	5.00 c	3.33 c
Summer	12.33 b	13.00 b
Rainy season	17.67 a	18.00 a
CV %	17.50	9.21
LSD	4.69	2.39
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

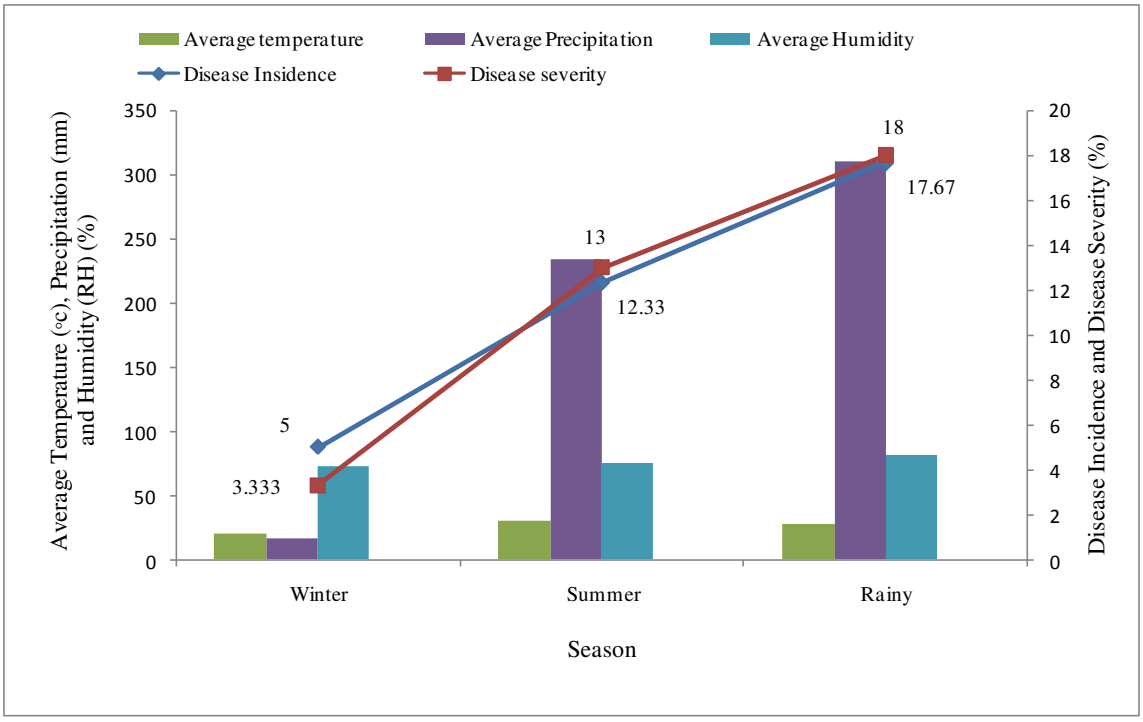

Figure 1. Relationship of disease incidence and severity of Alternaria leaf spot with the weather parameters in different seasons

4.1.1.2 Curvularia leaf spot of Alo vera

A. Symptomological study

Characteristics leaf spot began in the form of circular, water soaked lesions on the tip and abaxial surface of the leaves or margin. Gradually the size of the lesion expanded and produced gray to black irregular spots surrounded by bright margin. In later stage, lesion became dry, necrotic and turned into grayish in color. The disease may also appeared as elongated, water soaked lession, occurred on the spiny margins and abaxial surface of the leaves. Progressively, these lesions became sunken and light brown in color. Later, these lesions were enlarged, centre of the lesions dark brown in color with dark black margins, and measured about 0.5-1.5× 1-2 cm in size. In severe infection, the spiny margin of the leaves was twisted inside due to necrosis of the tissues (Plate.A).

B. Causal organism

The pathogen was identified as *Curvularia* sp. based on morphological and cultural characteristics of the pathogen (Plate 5.B-D). The growth of fungal colony on PDA was initially light grey and circular, becoming velvety, pale brown to dark brown to black in color (Plate 5.D). The reverse side of the PDA turned into black color. Conidiophores were pale brown, straight, cylindrical and multi septate. Conidia were ovoid, straight or curved brown with paler end cells. Most of them were three septate. The central cell was typically darker and larger as compared to the end cells.

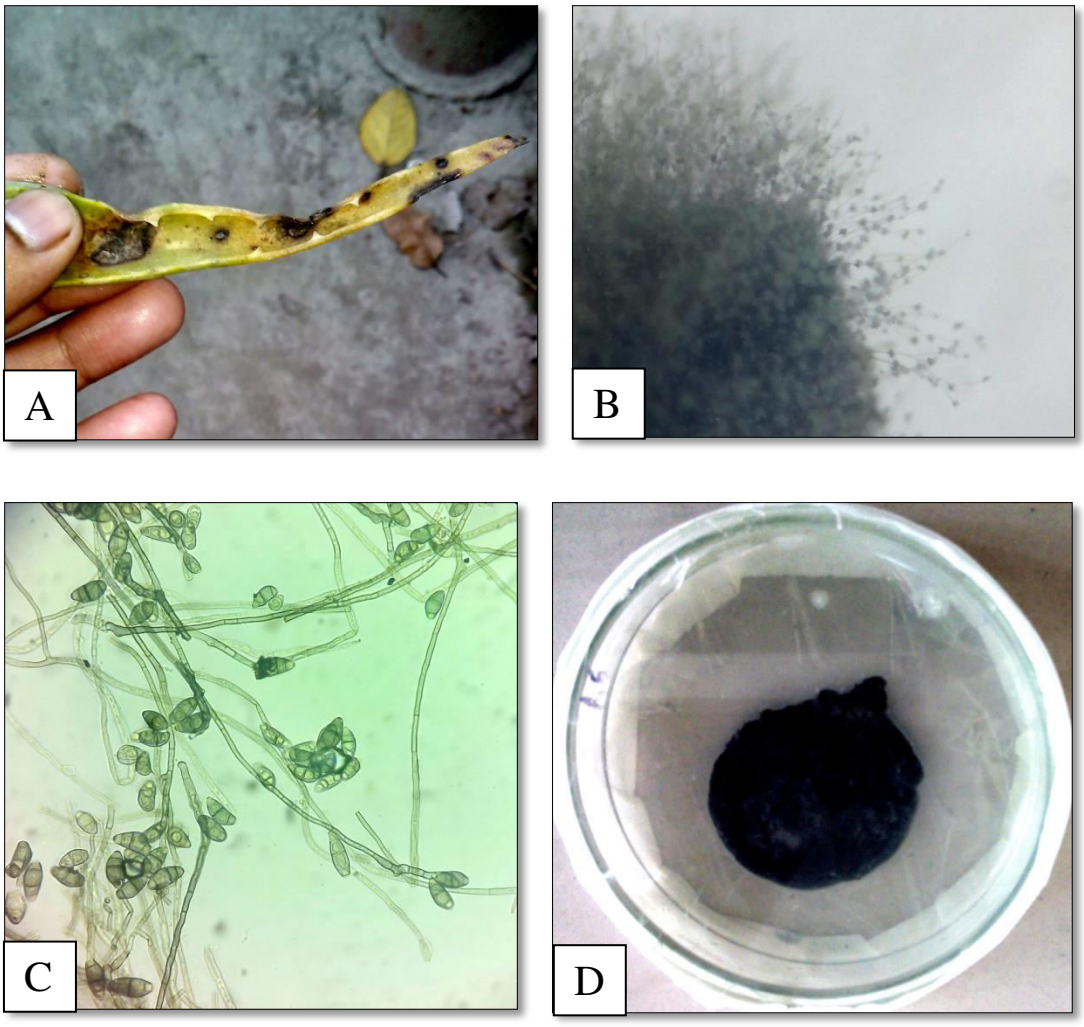

Plate 5. Symptoms and causal organism of Curvularia leaf spot disease of Aloe vera; (A) Symptomsof Curvularia leaf spot in Alo vera plant; (B) Stereo microscopic view of *Curvularia* sp. (40×); (C) Compound microscopic view of *Curvularia* sp. (10×40) and (D) Pure culture of *Curvularia* sp.

C. Incidence and severity of the Curvularia leaf spot disease

Incidence of Curvularia leaf spot varied significantly from January, 2015 to December, 2015 and that ranged from 6.33 to 16 % (Table 5). The highest disease incidence was 16% recorded in rainy season followed by summer (10.67%) and the disease was recorded lowest (6.33%) in winter season.

In case of disease severity, similar results were observed. Severity of Curvularia leaf spot also varied significantly from January, 2015 to December, 2015 (Table 5). The highest severity was 12.33% found in rainy season which is significantly varied from the disease severity of summer (6.67 %) and the winter (5%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Curvularia leaf spot of Aloe vera progressed from winter season to rainy season (Figure 2). The highest disease incidence and severity of Curvularia leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of Curvularia leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the Curvularia leaf spot disease of Aloe vera.

Table 5. Incidence and severity of Cuarvularia leaf spot of Aloe vera from January to December, 2015 in field condition

Season of data collection	Curvularia leaf spot	
	% Disease incidence	% Disease severity
Winter	6.33 c	5.00 b
Summer	10.67 b	6.67 b
Rainy season	16.00 a	12.33 a
CV %	11.74	20.35
LSD	2.92	2.92
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

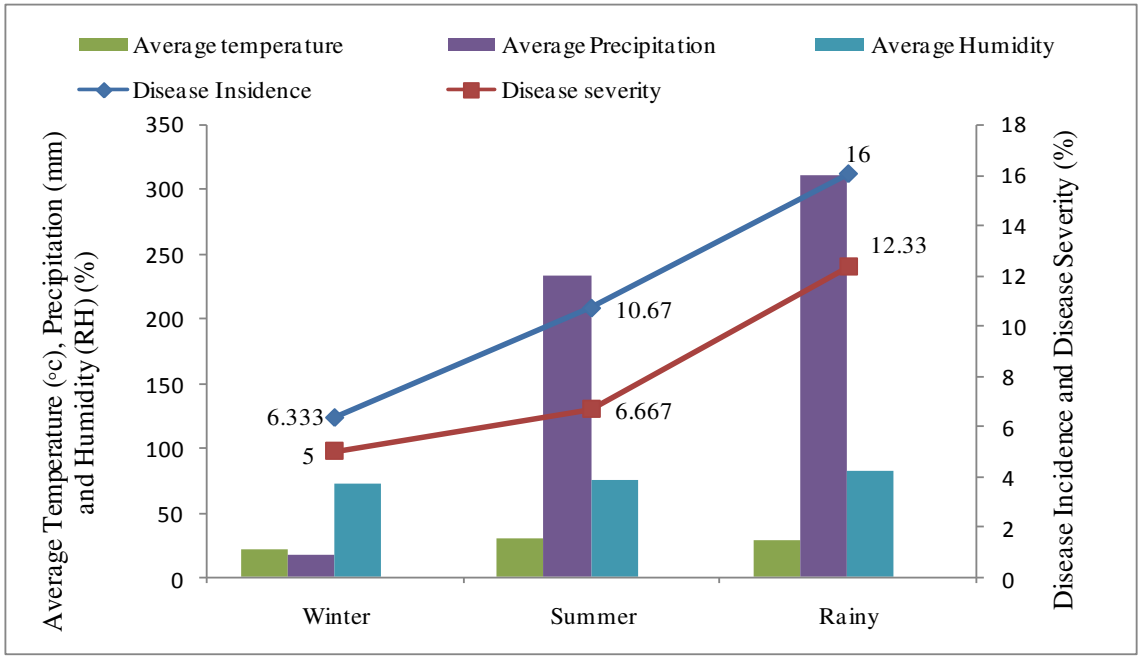

Figure 2. Relationship of disease incidence and severity of Curvularia leaf spot with the weather parameters in different seasons

4.1.1.3 Basal rot of Aloe vera

A. Symptomological study

Basal stem rot of Alo vera was a fatal soil borne disease that was favored by cool and damp conditions of soil. The base of the Aloe vera plants were affected in basal portion which were turned dark brown to black and then quickly begun to rot. Basal stem rot was a fungal disease that leaded to rot the stem near the soil level. This was often caused by prolonged exposure of the stems near the soil to excessively wet soil. As the tissue rots, it changes reddish brown to black in color (Plate 6.A). Sometimes whitish fungal growth appeared on the basal portion of the plant leaf (Plate 6.B).

B. Identification of causal organism

The identified causal organism was *Fusarium* sp. for the basal rot of Alo vera. Mycelium of *Fusarium* sp. was hyaline, septate branched and aggregated. Conidiophores were simple or branched. The macroconidia were nearly straight, slender, thin-walled, several celled, slightly curved or bent at the pointed ends or sickle shaped (Plate 6.D). Microconidia were usually one celled, oval or oblong or reniform or elliptical in shape. This fungus produced asexual fruiting body called sporodochium by aggregation of short and branched conodiophore. The fungus produced cottony, fluffy and whitish colony on PDA medium (Plate 6.C and E).

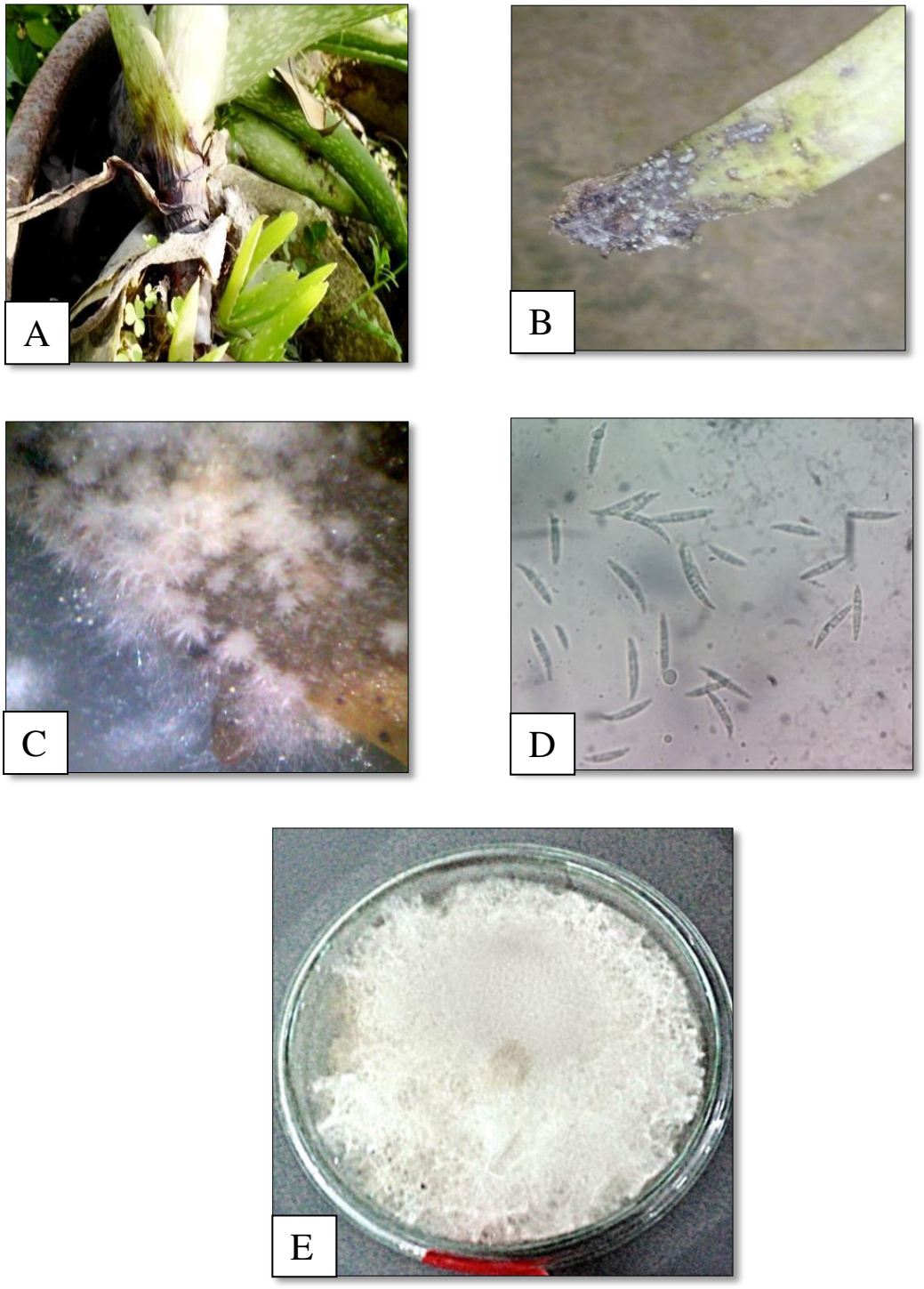

Plate 6. Symptoms and causal organism of basal rot disease of Aloe vera; (A) Infected plant due to basal rot; (B) Infected leaf; (C) Colony of *Fusarium* over leaf tissue (D) Macroconidia of *Fusarium* sp. (10×40) and (E) Pure culture of *Fusarium* sp. on PDA medium

C. Incidence and severity of Basal rot of Aloe vera.

Incidence of Basal rot of Aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 6.33% to12% (Table 6). The highest incidence (12%) was recorded in rainy season followed by summer (8%) and the lowest (6.33%) was recorded in winter in 2015.

In case of disease severity, approximately similar results were observed. Severity of basal rot of Aloe vera also varied significantly from January, 2015 to December, 2015 (Table 6). The highest (21.67%) severity was found in rainy season which was not statistically varied from the disease severity of summer (17.67%) and significantly varied with the winter (14%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of basal rot of Aloe vera progressed from winter season to rainy season (Figure 3). The highest disease incidence (12%) and severity (21.67%) of basal rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. Whereas, the lowest disease incidence and severity of basal rot disease of Aloe vera was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the basal rot disease of Aloe vera.

Table 6. Incidence and severity of basal rot of Aloe vera from January to December, 2015 in field condition

Season of data collection	Basal rot	
	% Disease incidence	% Disease severity
Winter	6.33 b	14.00 b
Summer	8.00 b	17.67 ab
Rainy season	12.00 a	21.67 a
CV %	8.91	9.65
LSD	1.77	7.04
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

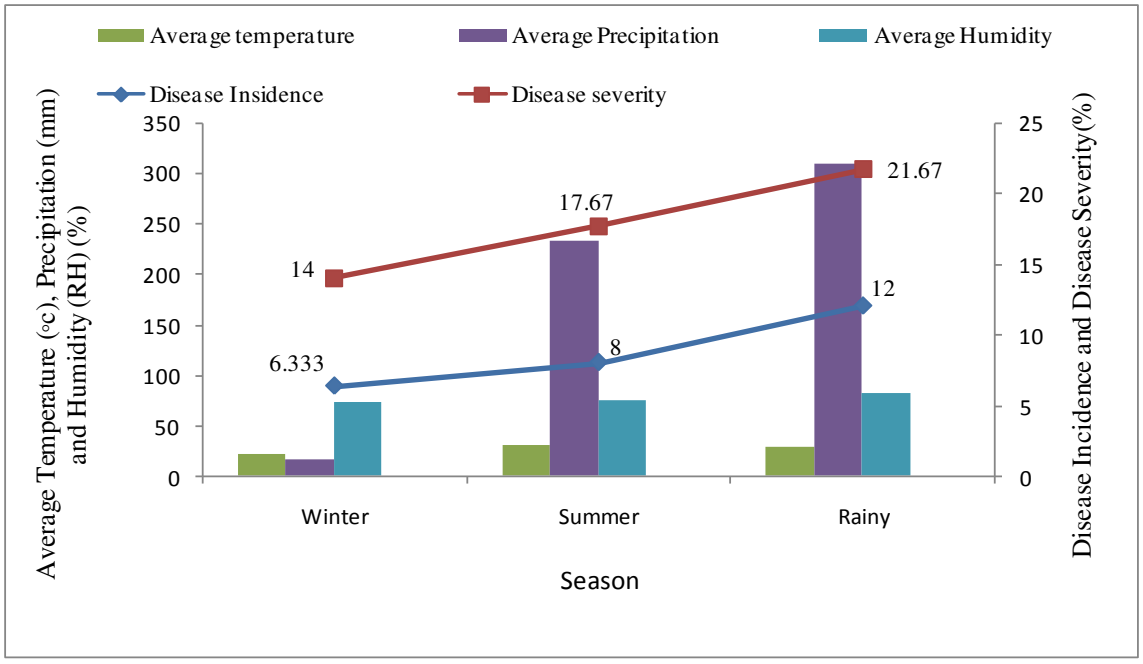

Figure 3. Relationship of disease incidence and severity of basal rot of Aloe vera with the weather parameters in different seasons

4.1.1.4 Anthracnose in Alo vera

A. Symptomological study

Small round to oval, water-soaked dark green area of about 1-2 mm in diameter were found on leaves. The area increased into circular spots with tan to light brown centre bordered by water soaked tissue. As these spots expand, centre of the lesion became reddish brown to brown color (Plate 7.A). The average diameter of the spots was 3-30 mm and the size of the necrotic areas increased by coalescing several spots (Plate 7.B). The acervuli on infected leaves may produce orange-pink to brownish spore masses on older lesions under high humid condition (Plate 7.C). In the advance stage of infection, spots appeared on both the surfaces of leaf and affected area lost the mucilaginous gel and leads the death of infected leaves.

B. Causal organism

The identified causal organism was *Colletotrichum* sp. The fungus produces spores within an acervulus (fungal fruiting structure). The disk or cushion shaped acervuli break through the surface of host tissue. Short, simple, colorless conidiophores produce abundant conidia. Long, black setae may or may not be produced among conidiophores (Plate 7.D). Conidia are colorless when viewed alone, but it may appear pink or salmon colored en mass. Spores are short, ovoid to cylindrical, and single celled (Plate 7.E).

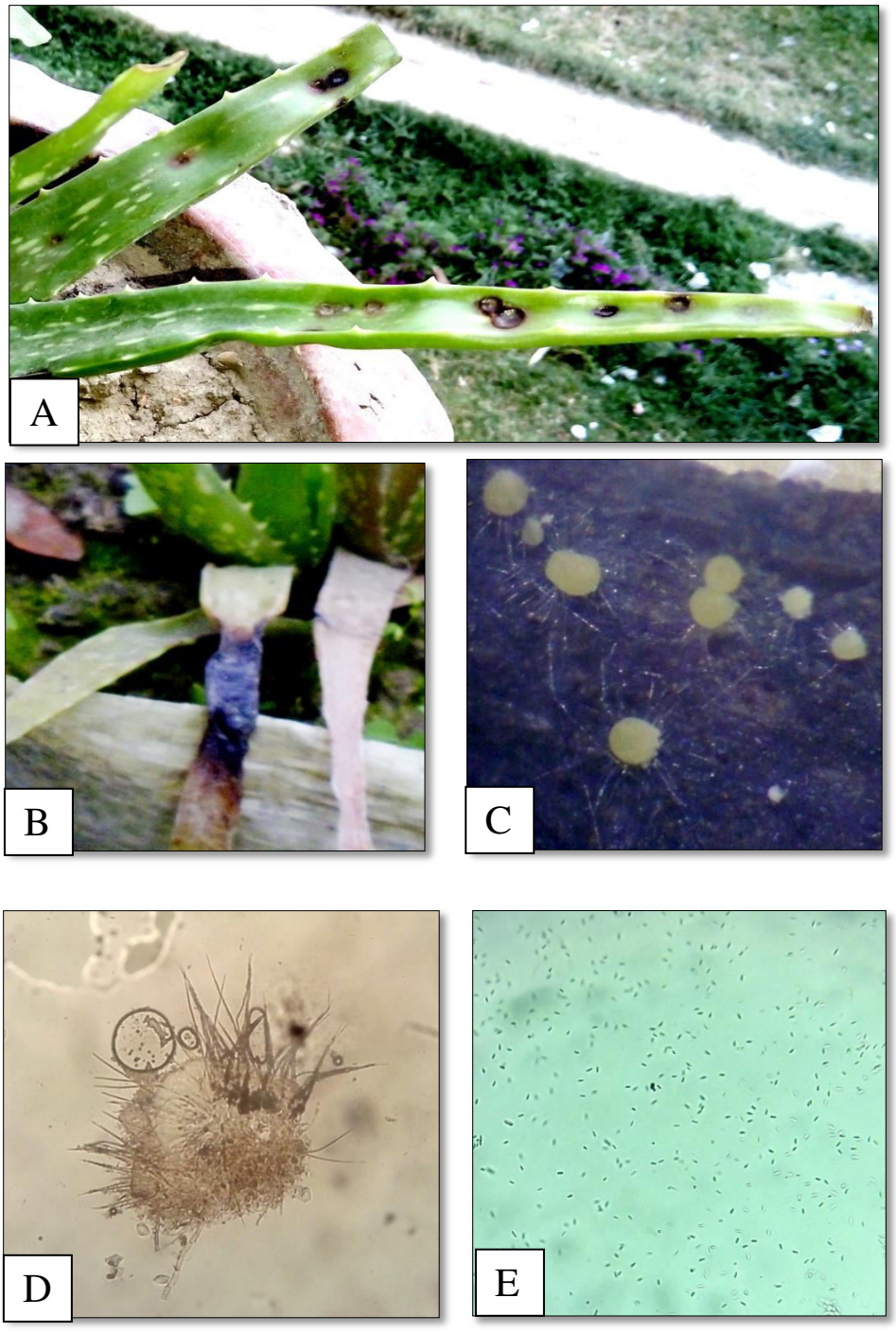

Plate 7. Symptoms and causal organism of anthracnose disease of Aloe vera; (A) Anthracnose leaf spot on Aloe vera leaf, (B) Leaf rot due to Anthracnose, (C) Stereo microscopic view and (D) Acervulus of *Colletotrichum* sp. (10×40) (E) Conidia of *Colletotrichum* sp. (10×40)

C. Incidence and severity of the disease

Incidence of Anthracnose disease in Aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 4.67% to12.33% (Table 7). The highest incidence (12.33%) was recorded in rainy season which is significantly varied from summer (5.67%) and the winter season (4.67%) in 2015.

In case of disease severity Anthracnose of Aloe vera also varied significantly from January, 2015 to December, 2015 (Table 7). The highest (14.67%) disease severity was found in rainy season which is not significantly varied from the disease severity of summer (12.33%) but significantly varied the winter (6%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of anthracnose of Aloe vera progressed from winter season to rainy season (Figure 4). The highest disease incidence and severity of basal rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. The lowest disease incidence and severity of anthracnose in Aloe vera plant was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the anthracnose disease of Aloe vera.

Table 7. Incidence and severity of anthracnose of Aloe vera from January to December, 2015 in field condition

Season of data collection	Anthracnose	
	% Disease incidence	% Disease severity
Winter	4.67 b	6.00 b
Summer	5.67 b	12.33 a
Rainy season	12.33 a	14.67 a
CV %	27.37	9.82
LSD	4.69	2.45
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

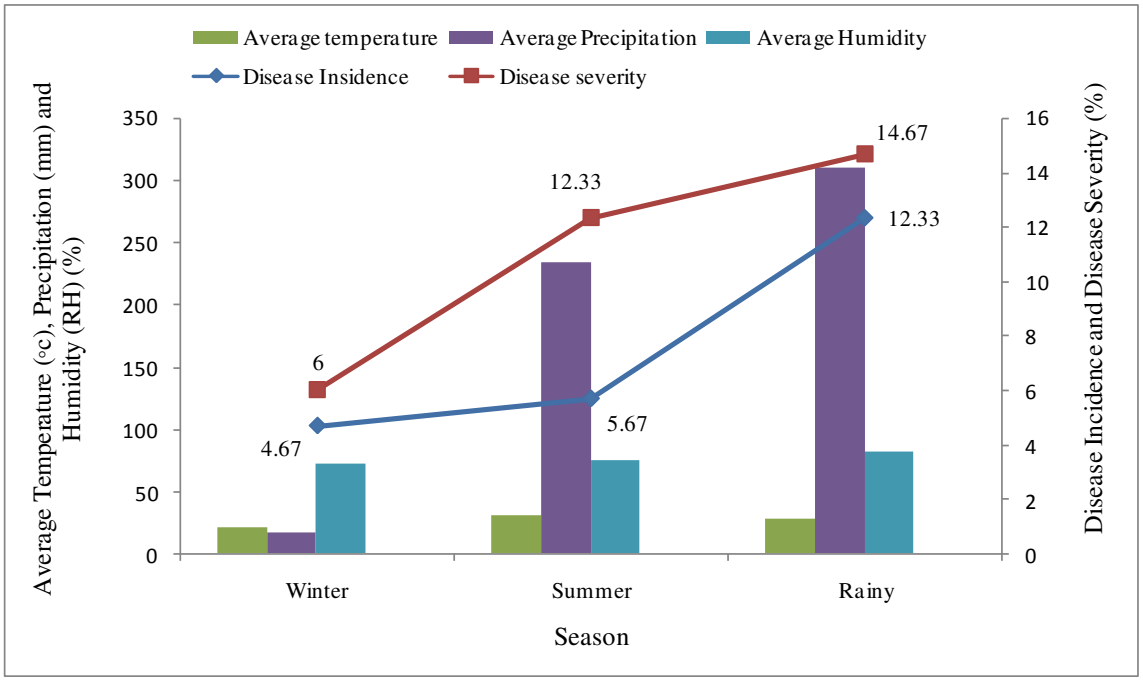

Figure 4. Relationship of disease incidence and severity of anthracnose of Aloe vera with the weather parameters in different seasons

4.1.1.5 Tip blight in Aloe vera

A. Symptomological study

The initial symptom was water-soaked appearance at the tips of leaves. Tissue became necrotic that leads to tip blight which is like the die back symptom. Prominently 3 to 5 cm leaf portion of the leaf become dry but rest portion of the leaf remained rigid and the discoloration does not progress to the crown. After few days, the affected portion was dried and shriveled. By leaving a string of firm, brown tissue, while the rest of the leaf remains green and succulent (Plate 8.A-B).

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. Mycelium was septate, branched, pale color. Conidiophores simple, short, septate. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present) (Plate 8.C-D).

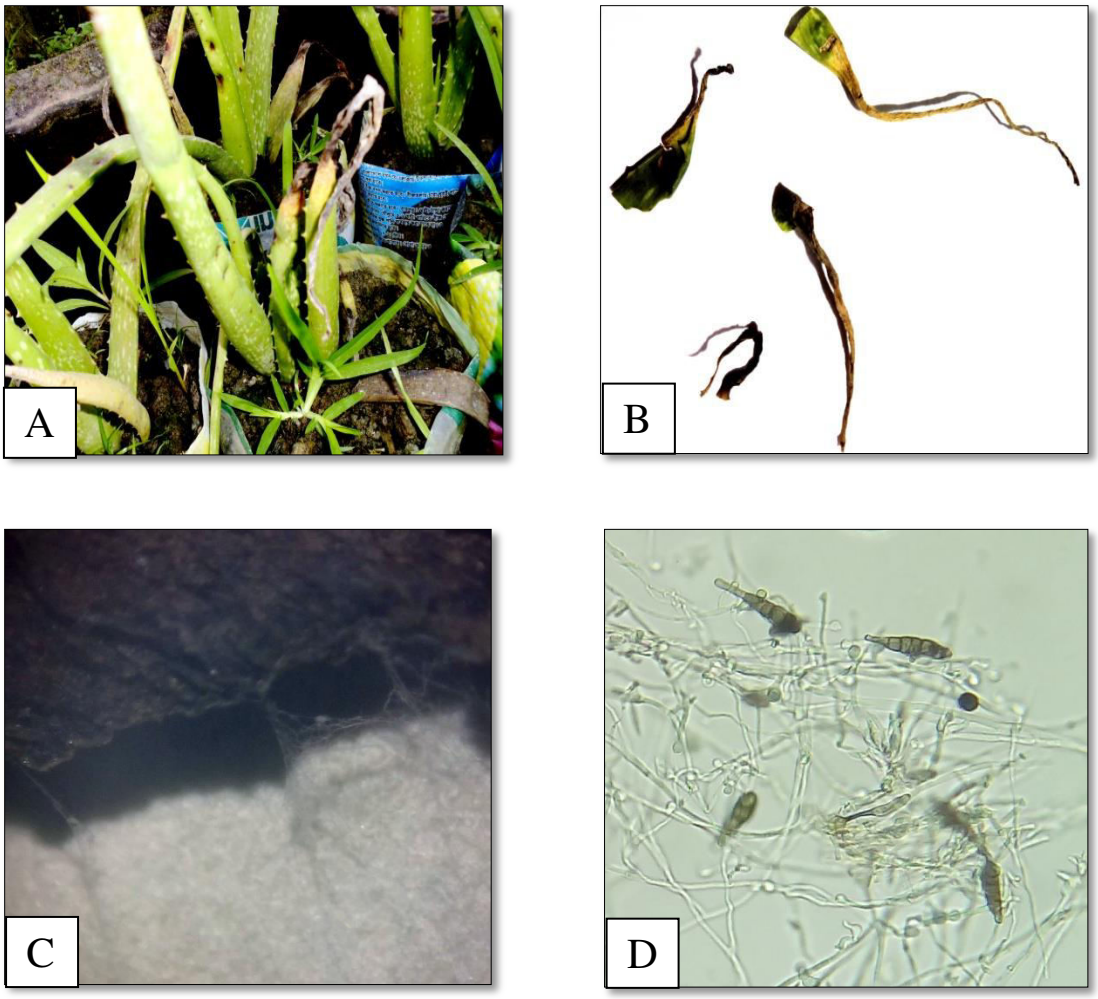

Plate 8. Symptoms and causal organism of tip blight disease of Aloe vera; (A) Aloe vera plant infected by tip blight; (B) Collection of infected portion; (C) Sterio microscopic view of *Alternaria* sp. mycellium and (D) Compound microscopic view of *Alternaria* sp. (10×40)

C. Incidence and severity of Tip blight disease in Aloe vera plant

Incidence of tip blight disease in Aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 9.67 to 21.67% (Table 8). The highest incidence (21.67%) was recorded in rainy season which is significantly varied from summer (14.33%) and winter season (9.67%) in 2015.

In case of disease severity tip blight of Aloe vera did not significantly varied from January, 2015 to December, 2015 (Table 8). The highest (17.33%) severity was found in rainy season which is not significantly varied from the disease severity of summer (16.33%) and winter (12%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of tip blight of Aloe vera progressed from winter season to rainy season (Figure 5). The highest disease incidence and severity of tip blight was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. Whereas, the lowest disease incidence and severity of tip blight of Aloe vera was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. However, though the incidence was significantly varied with rainy season and winter season but there were no statistically dissimilarities among those seasons. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the tip blight disease of Aloe vera.

Table 8. Incidence and severity of Tip blight of Aloe vera from January to December, 2015 in field condition

Season of data collection	Tip blight	
	% Disease incidence	% Disease severity
Winter	9.67 b	12.00
Summer	14.33 b	16.33
Rainy season	21.67 a	17.33
LSD	14.85	17.10
CV %	5.13	----
Significant level	**	NS

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability, NS denotes Not significant

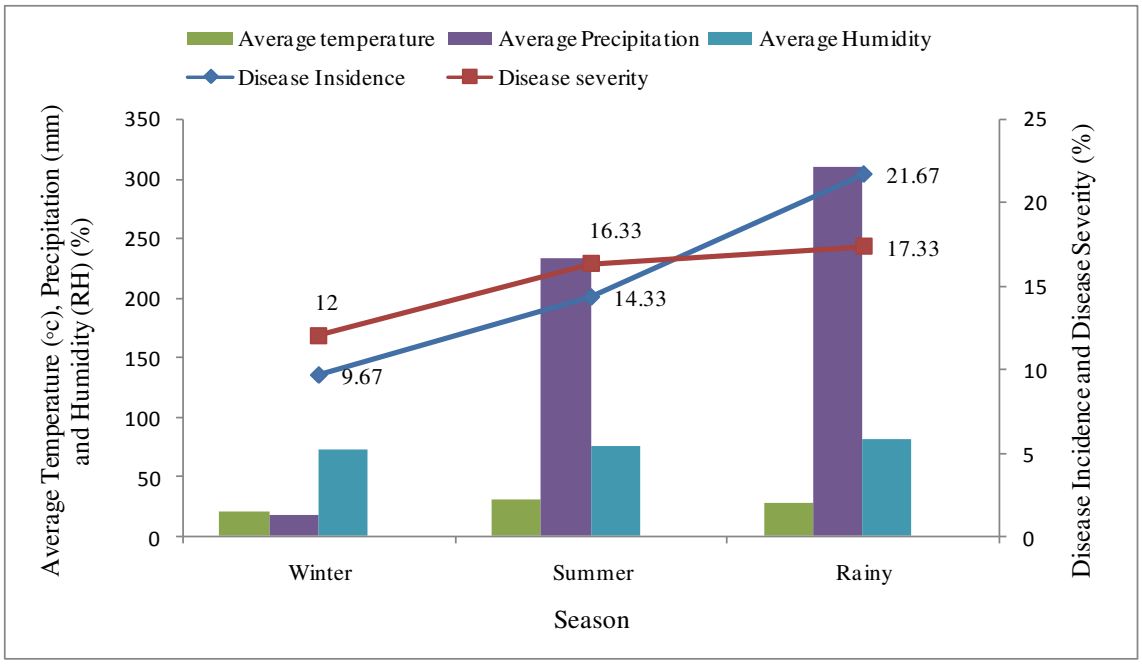

Figure 5. Relationship of disease incidence and severity of tip blight of Aloe vera with the weather parameters in different seasons

4.1.1.6 Bacterial leaf rot of Aloe vera

A. Symptomological study

The disease started from the lowest leaves. The symptoms started as water soaked lesions at the base of the leaves, where leaves are jointed to the stem. Rotting progressed very quickly and the whole plant died after 2-3 days. As rotting progressed, the leaf epidermis bulged out due to gas formation and the leaf content was converted to a slimy mass which was eventually released. Odd odor is produced from the diseased part (Plate 9. A-B).

B. Identification of causal organism

The pathogen was a bacterium which formed whitish colony on nutrient agar medium (Plate 9. D). Genus was not identified.

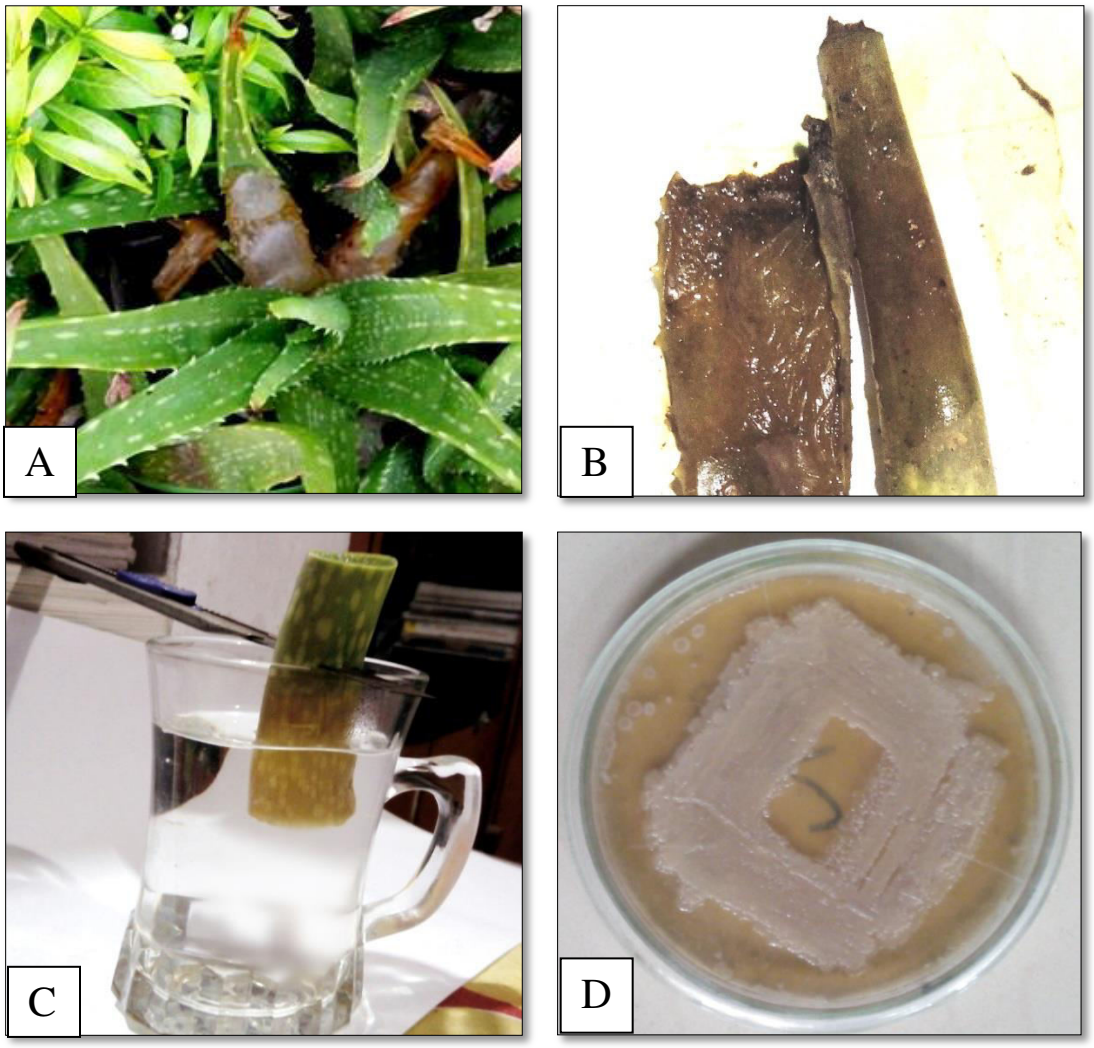

Plate 9. Symptoms and causal organism of bacterial leaf rot disease of Aloe vera; (A) Alo vera leaf epidermis bulged out due to gas formation; (B) Rotten leaf caused by *Bacteria;* (C) Bacterial ooze come out from the diseased sample and (D) *Bacteria* grows on NA media

C. Incidence and severity of bacterial rot in Aloe vera plant

Incidence of bacterial leaf rot of Aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 2.67 to12.67% (Table 9). The highest incidence (12.67%) was recorded in rainy season which is significantly varied from summer (4%) and the winter season (2.67%) in 2015.

In case of disease severity, approximately similar results were observed. Severity of bacterial rot of Aloe vera also varied significantly from January, 2015 to December, 2015 (Table 9). The highest (25.67%) severity was found in rainy season which is statistically varied from the disease severity of summer (13.67%) and the winter (13.33%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of bacterial rot of Aloe vera progressed from winter season to rainy season (Figure 6). The highest disease incidence and severity of bacterial rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. Whereas, the lowest disease incidence and severity of bacterial rot disease of Aloe vera were recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the bacterial rot disease of Aloe vera.

Table 9. Incidence and severity of bacterial leaf rot of Aloe vera from January to December, 2015 in field condition

Season of data collection	Bacterial rot	
	% Disease incidence	% Disease severity
Winter	2.67 b	13.33 b
Summe	4.00 b	13.67 b
Rainy season	12.67 a	25.67 a
CV %	24.26	16.22
LSD	3.54	6.46
Significant level	**	**

Each data represents the mean value of three replications. Values with by the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

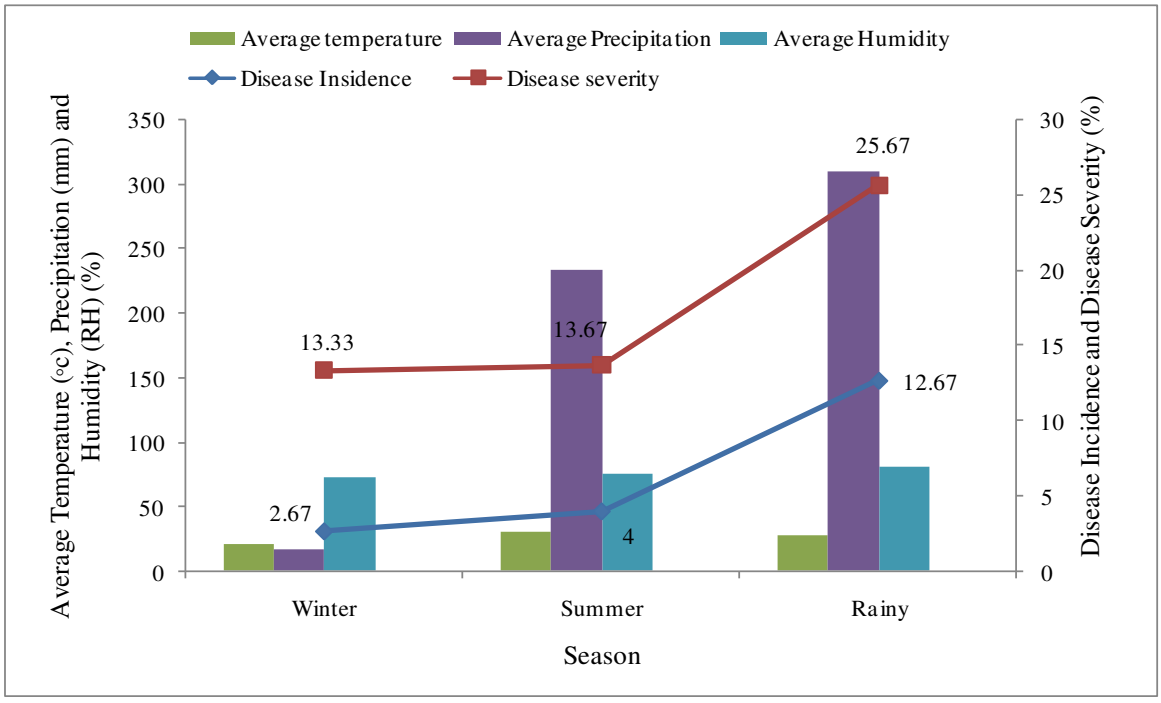

Figure 6. Relationship of disease incidence and severity of bacterial leaf rot of Aloe vera with the weather parameters in different seasons

4.1.2 Disease of Akondo

4.1.2.1 Leaf spot of Akondo

A. Symptomological study

The symptoms on infected leaves were small, circular spots with large yellow to dark brown haloes on both sides of the lower and middle leaves. The spots gradually enlarged in size and later became irregular in shape or remained circular with concentric rings or zones. At later stage of infection, these spots coalesced together to cause necrosis of the leaves causing withering, extensive drying and ultimately death of leaves (Plate 10 .A).

B. Identification of causal organism

The pathogen was identified as *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyaline in tender age. The conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 5-8 transverse septa and few longitudinal septa. Their shapes were obclavate to elliptical or ovoid which were pointed at distal end (Plate 10.B-C).

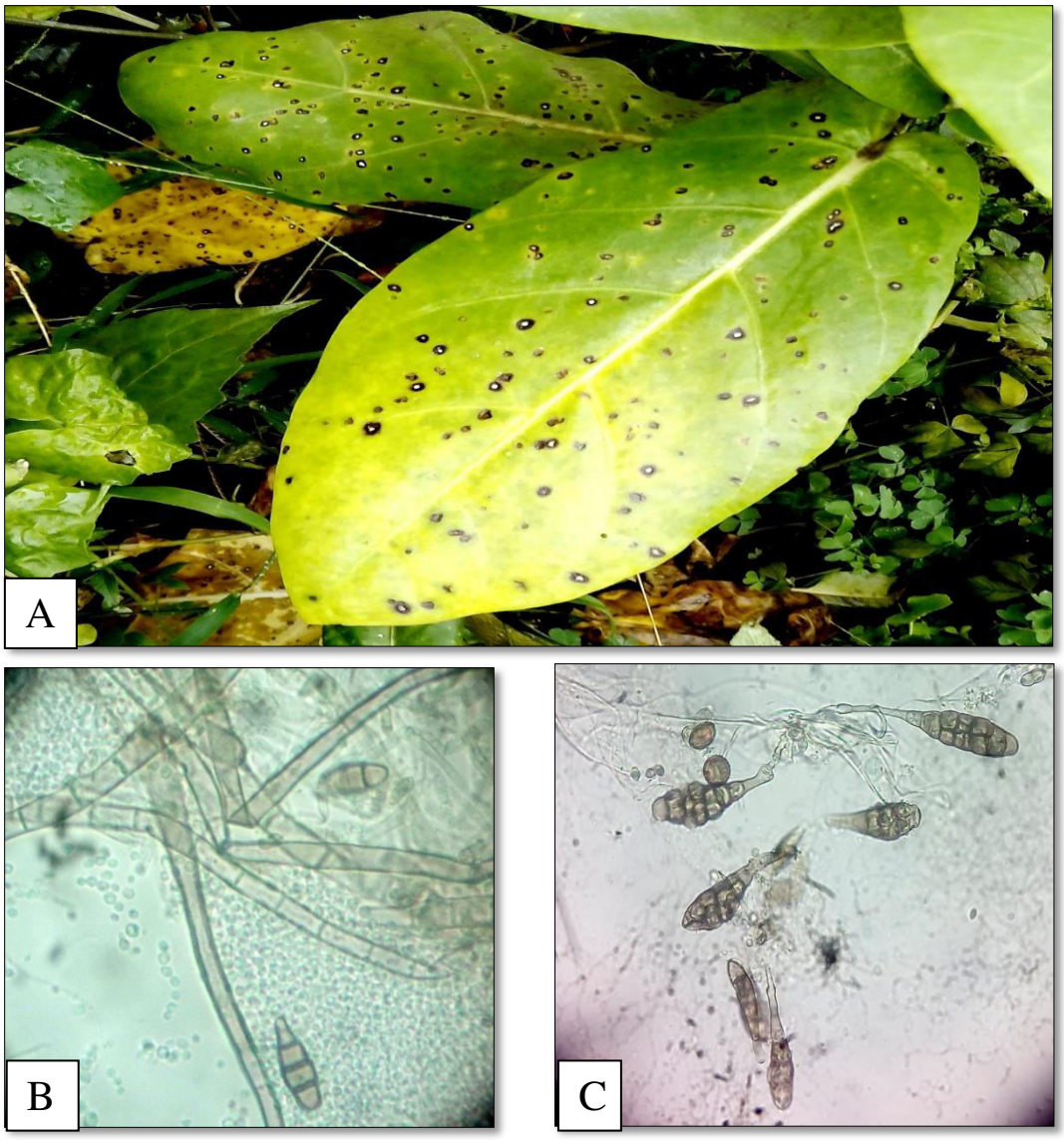

Plate 10. Symptoms and causal organism of leaf spot disease of Akondo; (A) Akondo leaf spot in older leaf; (B) *Alternaria* sp. with mycelium (10×40) and (C) *Alternaria* sp. (muriform condia) (10×40)

C. Incidence and severity of leaf spot disease in Akondo plant

Incidence of leaf spot disease in Akondo varied significantly from January, 2015 to December, 2015 and that ranged from 1.33% to12% (Table 10). The highest incidence (12%) was recorded in winter season which is significantly varied from summer (4.33%) and rainy season (1.33%) in 2015.

In case of disease severity leaf spot disease in Akondo also significantly varied from January, 2015 to December, 2015 (Table 10). The highest (30%) severity was found in winter season which is significantly varied from the disease severity of summer (4%) and rainy (2.33%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf spot of Akondo progressed from rainy season to winter season (Figure 7). The highest disease incidence and severity of leaf spot was observed in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. Whereas, the lowest disease incidence and severity of leaf spot disease of Akondo were recorded in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, low temperature, low humidity and precipitation favors the leaf spot of Akondo plant.

Table 10. Incidence and severity of Akondo leaf spot from January to December, 2015 in field

Seasons	Leaf spot	
	% Disease incidence	% Disease severity
Winter	12.00 a	30.00 a
Summer	4.33 b	4.00 b
Rainy season	1.33 b	2.33 b
CV %	34.43	15.69
LSD	4.6	4.39
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

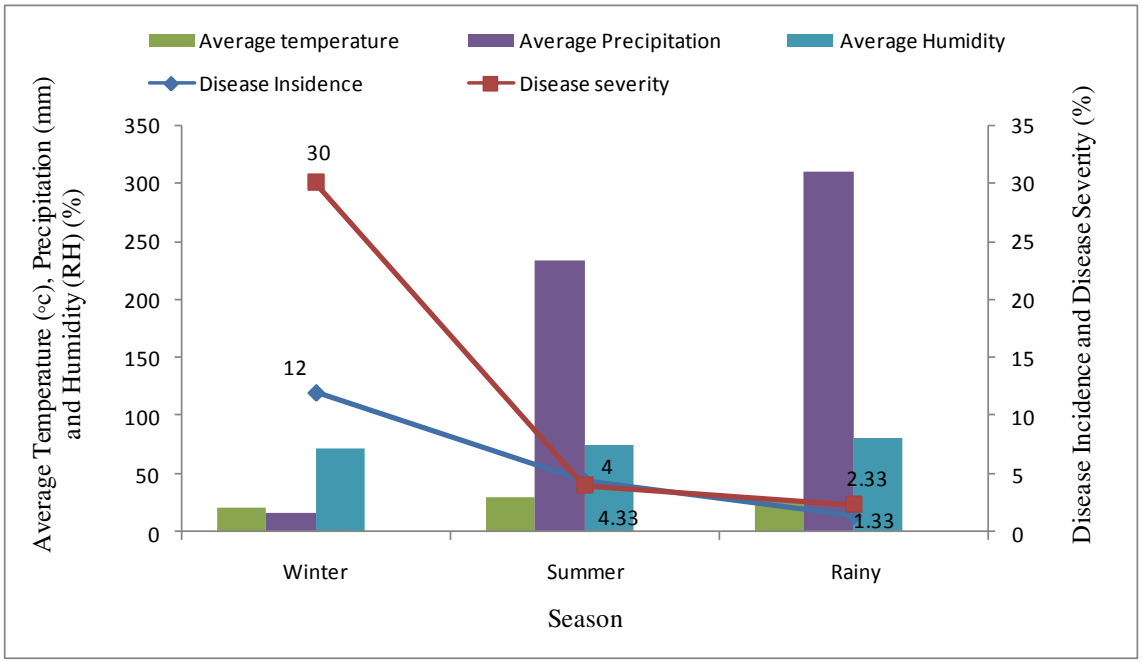

Figure 7. Relationship of disease incidence and severity of leaf spot of Akondo with the weather parameters in different seasons

4.1.3 Disease of Arshowgondha

4.1.3.1 Leaf spot disease of Arshowgondha

A. Symptomological study

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 were observed in the advance stage of infection (Plate 11.A-B).

B. Identification of causal organism

Alternaria sp. was isolated from this diseased sample. In stereo microscopic view long chain of conidia was found (Plate 11.C). Conidiophores arose singly or in groups, straight or flexous, cylindrical, septate, pale to olivaceous brown. The conidia produced on conidiophores acropetally. The conidia were straight, obclavate, pale olivaceous brown, smooth, with up to 15 transverse and rarely 1 or 2 longitudinal or oblique septa (Plate 11.D).

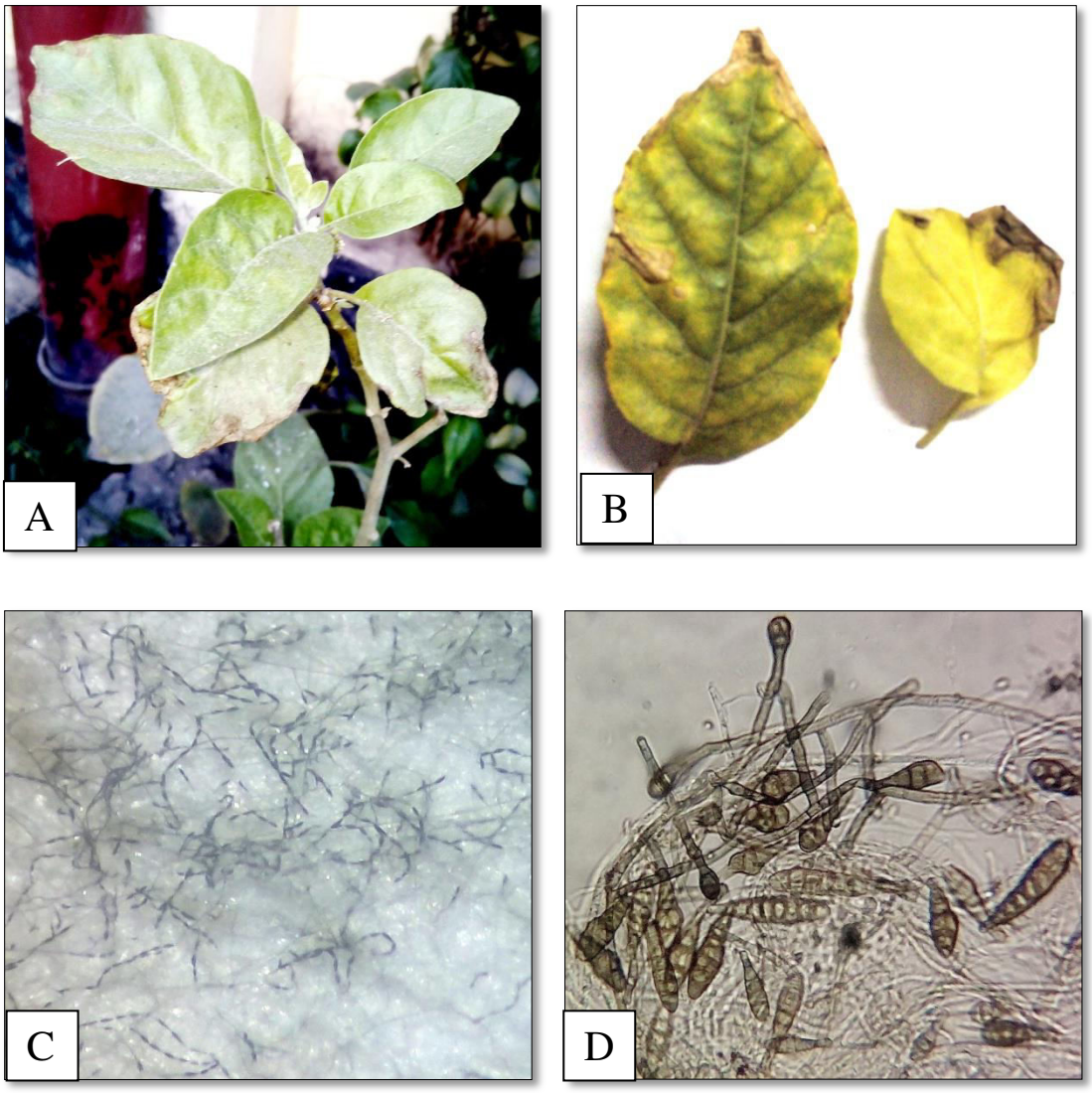

Plate 11. Symptoms and causal organism of leaf spot disease of Arshowgondha; (A) Arshowgondha plant is infected by leaf blight; (B) Leaf blight in Arshowgondha leaf; (C) Chain of conidia of *Alternaria* sp. (stereo view) and (D) *Alternaria* sp. (conidia with mycelium) (10×40)

C. Incidence and severity of leaf spot disease in Arshowgondha plant

Incidence of leaf spot disease in Arshowgondha varied significantly from January, 2015 to December, 2015 and that ranged from 2.33% to 21.67% (Table 11). The highest incidence (21.67%) was recorded in winter season which is significantly varied from summer (4.67%) and rainy season (2.33%) in 2015. The incidence of the disease did not vary significantly in summer and rainy season.

In case of disease severity leaf spot disease in Arshowgondha also significantly varied from January, 2015 to December, 2015 (Table 11). The highest (13.33%) severity was found in summer season which is not significantly varied from the disease severity of winter (12.33%) but significantly varied with the rainy (3.33%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf blight of Arshowgondha progressed from rainy season to winter season (Figure 8). The highest disease incidence and severity of leaf blight was observed in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. Whereas, the lowest disease incidence and severity of leaf blight disease of Arshowgondha were recorded in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, moderate humidity and precipitation favors the leaf blight of Arshowgondha plant.

Table 11. Incidence and severity of Arshowgondha leaf spot from January to December, 2015 in field condition in field condition

Seasons	Leaf spot	
	% Disease incidence	% Disease severity
Winter	21.67 a	12.33 a
Summer	4.67 b	13.33 a
Rainy season	2.33 b	3.33 b
CV %	48.08	21.53
LSD	10.42	4.719
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

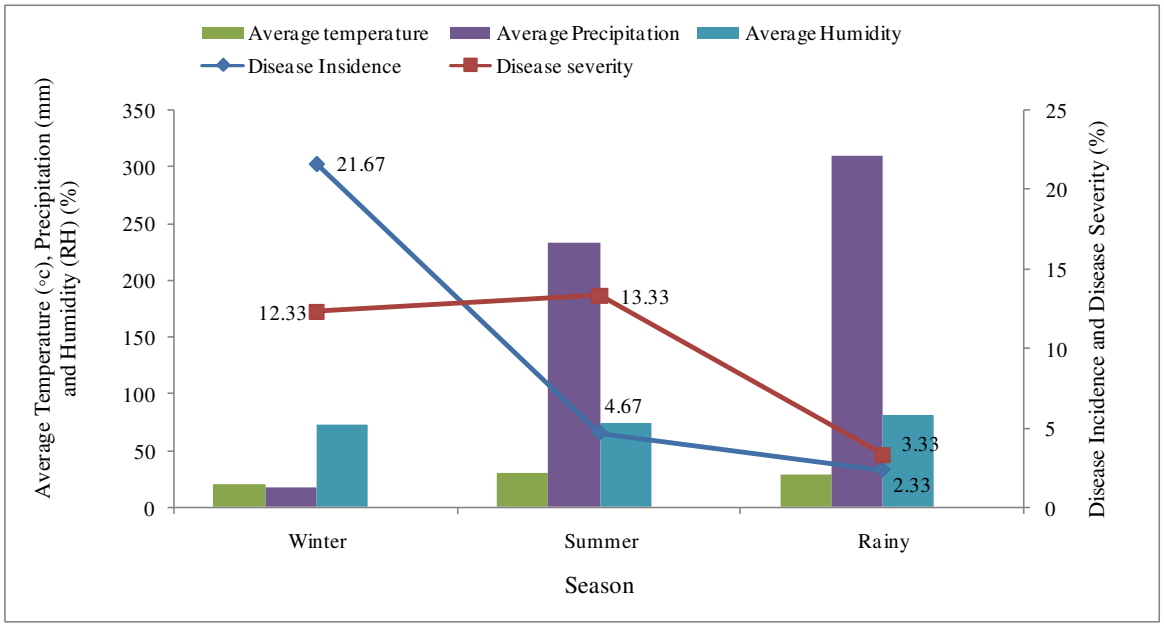

Figure 8. Relationship of disease incidence and severity of leaf spot of Arshowgondha with the weather parameters in different seasons

4.1.4 Disease of Bashok

4.1.4.1 Alternaria leaf blight of Bashok

A. Symptomological study

Brown necrotic lesions were found on leaves, with typical bull's eye appearance of concentric rings and well defined margins. Several lesions fused and in advance stage of the diseases, several spots coalesced together and turned into blight which covered a great area of the leaf followed by leaf drop. Usually spots were surrounded by a chlorotic halo. Damage caused is mostly present in older leaves (Plate 12.A).

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyalinin tender age. The Conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 5-8 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Plate12.B). Pure culture was done. In the culture the colonies of *Alternaria* sp. are moderately fast growing and produce dark brown to blackish culture on PDA medium within two weeks.

Plate 12. Symptoms and causal organism of Alternaria leaf blight disease of Bashok; (A) Alternaria leaf blight in Bashok leaf and (B) *Alternaria* sp. (conidia with mycelium) (10×40)

C. Incidence and severity of Alternaria leaf blight disease in Bashok plant.

Incidence of Alternaria leaf blight disease in Bashok varied significantly from January, 2015 to December, 2015 and that ranged from 1.67% to12% (Table 12). The highest incidence (12%) was recorded in winter season which is significantly varied from summer (5.67%) and rainy season (1.67%) in 2015.

In case of disease severity leaf spot disease of Bashok also significantly varied from January, 2015 to December, 2015 (Table 12). The highest (17.67%) severity was found in winter season which is significantly same to the disease severity of summer (11%) and but varied with rainy (6%) season in 2015. Again summer and winter also the same significant level for this disease severity.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Alternaria leaf blight of Bashok progressed from rainy season to winter season (Figure 9). The highest disease incidence and severity of leaf blight was observed in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. Whereas, the lowest disease incidence and severity of leaf blight disease of Bashok were recorded in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, low humidity and precipitation favors the leaf blight of Bashok plant.

Table 12. Incidence and severity of Alternaria leaf blight disease in Bashok plant from January to December, 2015 in field condition

Seasons	Alternaria Leaf Blight	
	% Disease incidence	% Disease severity
Winter	12.00 a	17.67 a
Summer	5.66 b	11.00 ab
Rainy season	1.66 b	6.00 b
CV %	30.16	32.32
LSD $_{(P\leq 0.05)}$	4.40	8.46
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

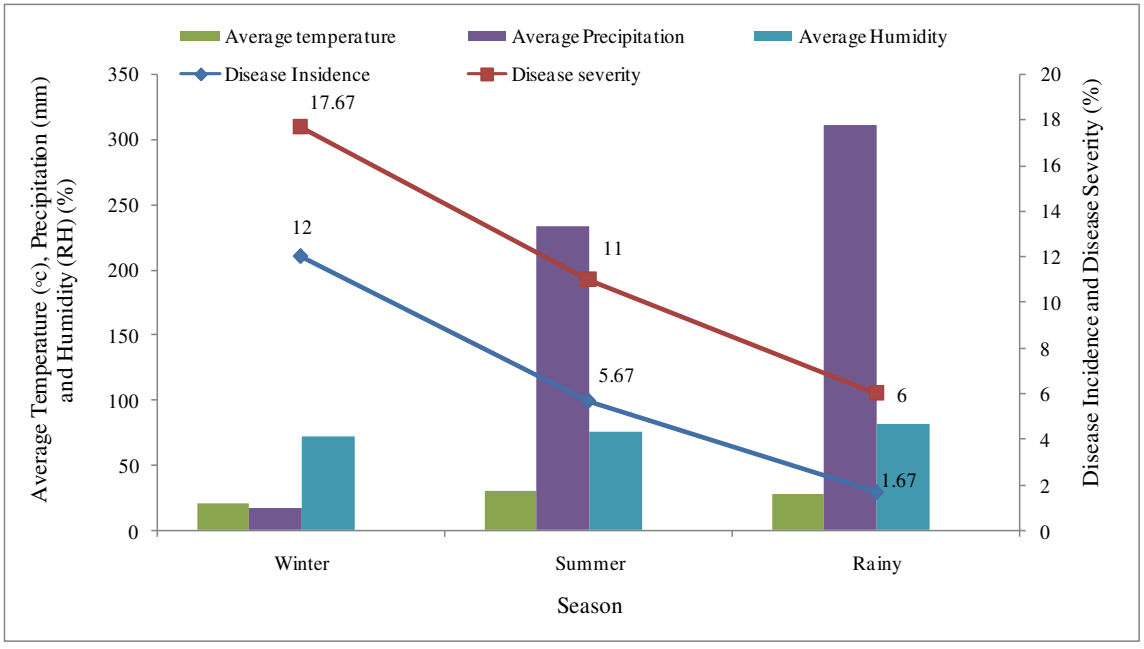

Figure 9. Relationship of disease incidence and severity of Alternaria leaf blight of Bashok with the weather parameters in different seasons

4.1.4.2 Cercospora leaf spot of Bashok

A. Symptomological study

Leaf spots were amphigenous (growing on both sides of leaves), circular, subcircular to slightly angular-irregular shaped was with narrow shaped up to 1 cm diameter. The spots were at first showed brown, but soon turned grey-white to white, margin narrow (Plate 13.A).

B. Identification of causal organism

The identified causal organism was *Cercospora* sp. Conidiophores was small, moderately large and densely fascicles, arising from substomatal or intraepidermal hyphae or stromata, emerging through stomata or erumpent, erect, straight to curved, subcylindrical or somewhat attenuated towards the tip to moderately geniculate-sinuous, unbranched, 0–3-septate, pale olivaceous to olivaceous-brown, paler towards the tip, thin-walled and smooth. Conidia solitary and catenate, simple, narrowly cylindrical-fusiform, short obclavate, septate, hyaline (Plate 13.B).

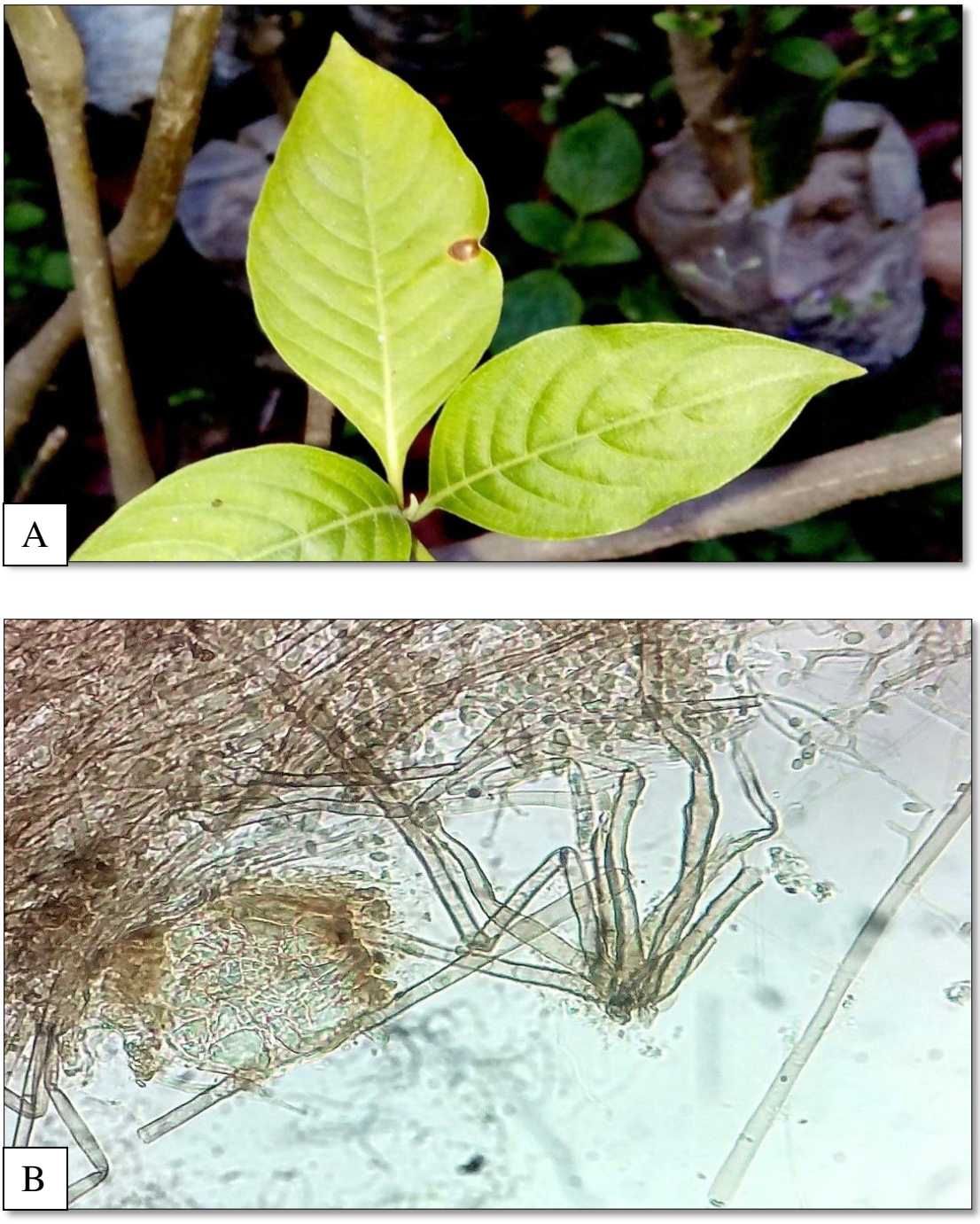

Plate 13. Symptoms and causal organism of Cercospora leaf spot disease of Bashok (A) Cercospora leaf spot in Bashok leaf (B) *Cercospora* sp. with conidiophores and conidia (10×40)

C. Incidence and severity of Cercospora leaf spot disease in Bashok leaf

Incidence of leaf spot disease in Bashok varied significantly from January, 2015 to December, 2015 and that ranged from 0% to 26.33% (Table 13). The highest incidence (26.33%) was recorded in winter season which is significantly varied from summer (1.67%) and rainy season (0%) in 2015. Though the incidence of the disease is absent in rainy season but incidence significance was similar in summer and winter.

In case of disease severity leaf spot disease in Bashok also significantly varied from January, 2015 to December, 2015 (Table 13). The highest (16.33%) severity was found in winter season which is significantly varied from the disease severity of summer (7.33%) and rainy (0%) season and disease severity of summer season was significantly varied in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Cercospora leaf blight of Bashok progressed from rainy season to winter season (Figure 10). The highest disease incidence and severity of Cercospora leaf spot was observed in winter season when the average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. Whereas, the lowest (Almost zero) disease incidence and severity of Cercospora leaf spot disease of Bashok were recorded in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, low temperature, low humidity and precipitation favors the Cercospora leaf spot of Bashok plant.

Table 13. Incidence and severity of Cercospora leaf spot disease in Bashok plant from January to December, 2015 in field condition

Season of data collection	Cercospora leaf spot	
	% Disease incidence	% Disease severity
Winter	26.33 a	16.33 a
Summer	1.67 b	7.33 b
Rainy season	0.00 b	0.00 c
LSD	23.56	25.70
CV %	4.98	4.6
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

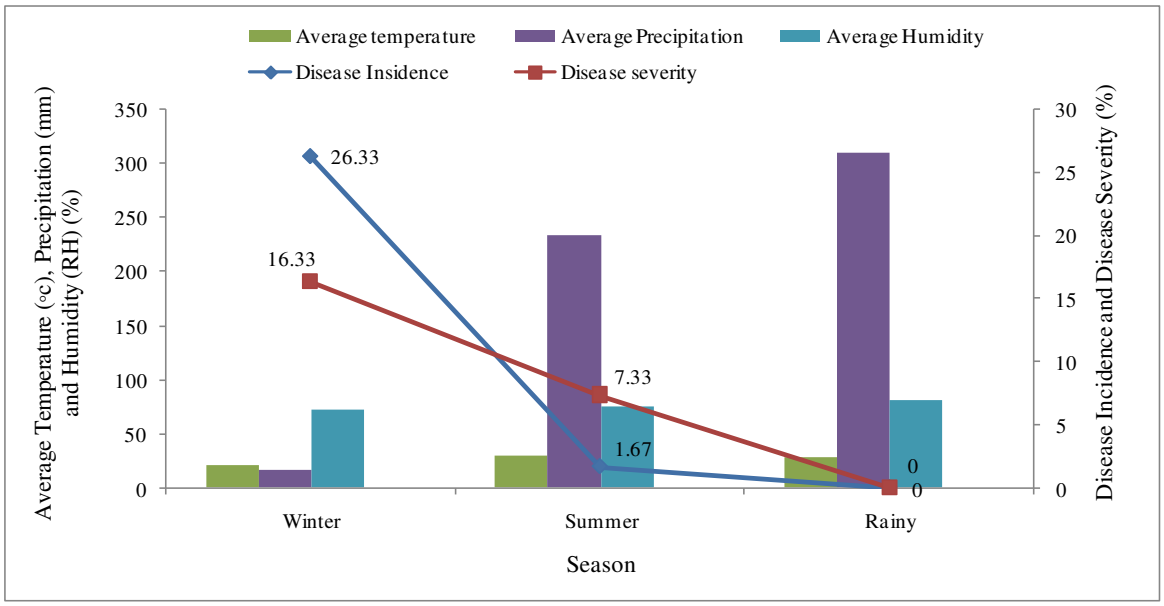

Figure 10. Relationship of disease incidence and severity of Cercospora leaf spot of Bashok with the weather parameters in different seasons

4.1.5 Disease of Dadmordon

4.1.5.1 Leaf blight of Dadmordon

A. Symptomological study

The symptoms appeared as irregular brown spots, often beginning for the leaf margins. Lesions initially had an irregular yellow halo and appeared water soaked. Spots coalescd together and caused leaf blight symptoms. Dark and dark brown streaks develop on leaf petioles. The blighted area of leaves became dark black colored (Plate 15.A).

B. Identification of causal organism

The pathogen was identified as *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyalin in tender age. The conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present), borne at the tip of conidiophores singly or in short chains. The conidia contained 5-8 transverse septa and few longitudinal septa (Plate 15.B). Their shape ware obclavate to elliptical or ovoid which were pointed at distal end. The pure culture was done. In the culture the colonies of *Alternaria* sp. are moderately fast growing and produce dark brown to blackish culture on PDA medium within 10-15 days.

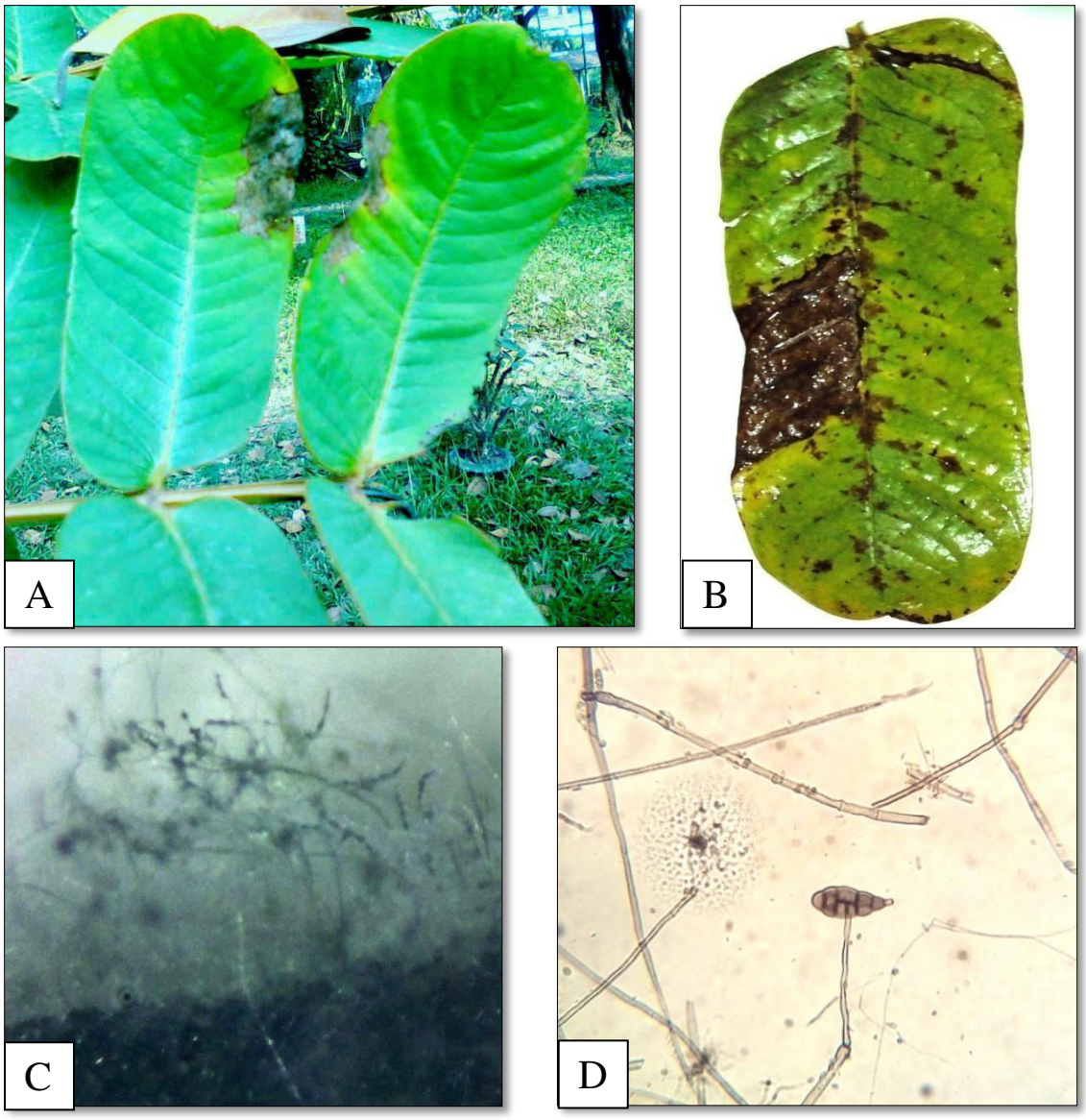

Plate 15. Symptoms and causal organism of leaf blight disease of Dadmordon; (A) Blighted symptom in Dadmordon leaf; (B) Leaf necrosis due to severe infection; (C) Chain of *Alternaria* sp. in sterio view and (D) *Alternaria* sp.- conidia with mycelium (10×40)

C. Incidence and severity of leaf blight disease in Dadmordon

Incidence of leaf blight disease in Dadmordon varied significantly from January, 2015 to December, 2015 and that ranged from 3.67% to17.67% (Table 14). The highest incidence (17.67%) was recorded in winter season which is significantly varied from summer (3.67%) and rainy season (3.67%) and the incidence of this disease in summer season was similar to the rainy season in 2015.

In case of disease severity leaf blight disease in Dadmordon also significantly varied from January, 2015 to December, 2015 (Table 14). The highest (12.67%) severity was found in winter season which is significantly varied from the disease severity of summer (4.33%) and rainy (1.33%) season and severity was statistically same at summer and rainy season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf blight of Dadmordon progressed from rainy season to winter season (Figure 11). The highest disease incidence and severity of leaf blight was observed in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. Whereas, the lowest disease incidence and severity of leaf blight disease of Dadmordon were recorded in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, low temperature, low humidity and precipitation favors the leaf blight of Dadmordon plant.

Table 14. Incidence and severity of leaf blight disease in Dadmordon plant from January to December, 2015 in field

Seasons	Leaf Spot of Dadmordon	
	% Disease incidence	% Disease severity
Winter	17.67 a	12.67 a
Summer	3.67 b	4.33 b
Rainy season	3.67 b	1.33 b
CV %	16.25	25.58
LSD	3.07	3.54
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

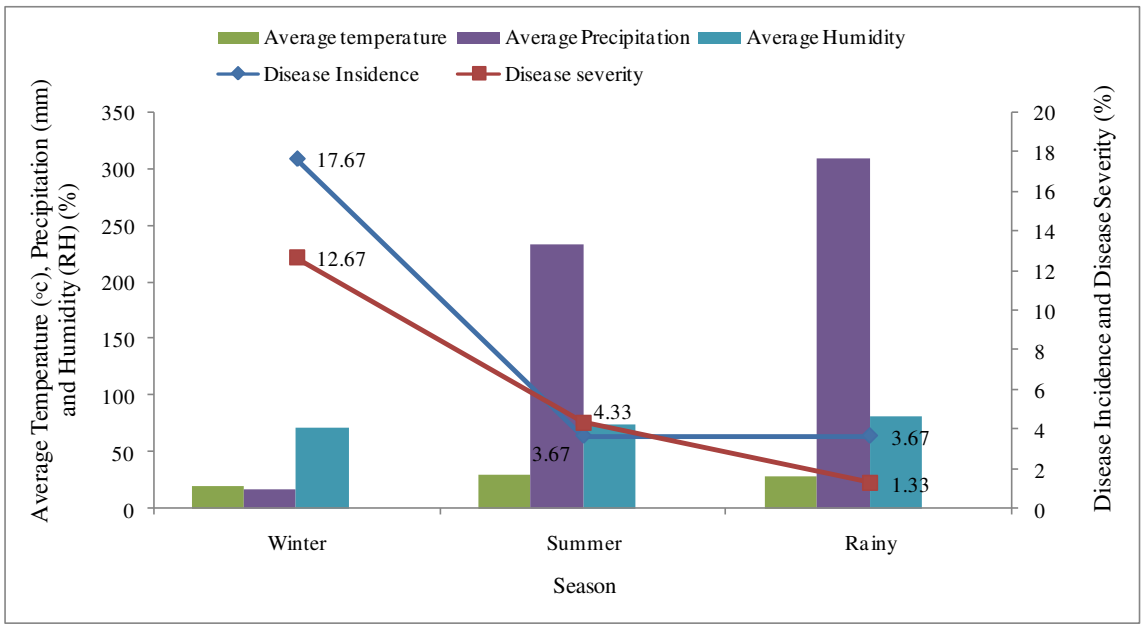

Figure 11. Relationship of disease incidence and severity of leaf blight of Dadmordon with weather parameters in different seasons

4.1.6 Disease of Datura

4.1.6.1 Dhutra leaf spot

A. Symptomological study

The symptoms were small circular to oval dark brown spots with concentric rings. The spots were irregular in shape or remained circular. In most case, the spots were started from the margin of the leaves and gradually progressed towards the inside of the leaf. Gradually the infected area was increased and the leaf turned into blight (Plate 15.A).

B. Identification of causal organism

The causal organism was identified *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was saptate, branched, hyaline in tender age. The conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (Plate 15.B-C).

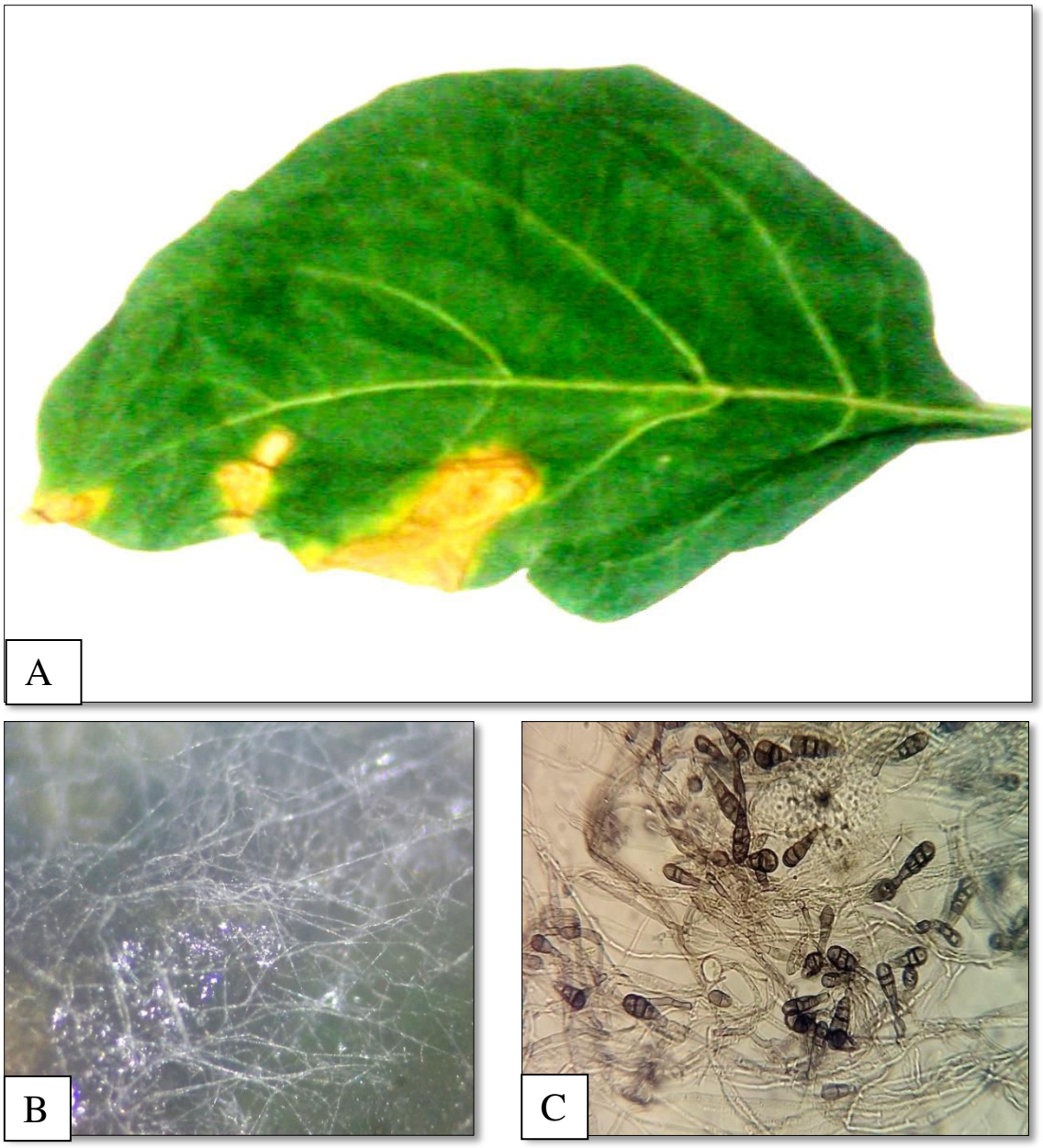

Plate 15. Symptoms and causal organism of leaf spot disease of Dhutra; (A) Brown spot on Dhutra leaf with concentric ring; (B) Mycelium of *Alternaria* sp. in sterio view and (C) *Alternaria* sp. (10×20)

C. Incidence and severity of leaf spot disease in Dhutra

Incidence of leaf spot disease in Dhutra did not vary significantly from January, 2015 to December, 2015 and that ranged from 2.33% to 4.33% (Table 15). The highest incidence (4.33%) was recorded in summer season which is not significantly varied from winter (2.33%) and rainy season (3.67%) in 2015.

In case of disease severity leaf spot disease in Dhutra is significantly varied from January, 2015 to December, 2015 (Table 15). The highest (17.33%) severity was found in summer season which is significantly varied from the disease severity of winter (7.67%) and rainy (10%) season in 2015.the severity did not vary statistically in winter and rainy season.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf spot of Dhutra progressed from rainy season to winter season (Figure 12). The highest disease incidence and severity of leaf spot was observed in summer season. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. Whereas, the lowest disease incidence and severity of leaf spot disease of Dhutra were recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. From the above findings, it is indicated that, high temperature, high humidity and precipitation favors the leaf spot of Dhutra plant.

Table 15. Incidence and severity of leaf spot disease in Dhutra leaf spot from January to December, 2015 in field

Seasons	Leaf Spot of Datura	
	% Disease incidence	% Disease severity
Winter	2.33	7.67 b
Summer	4.33	17.33 a
Rainy season	3.67	10.00 b
CV %	51.21	17.50
LSD	-	4.63
Level of Significance	NS	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability, NS denotes Not significant

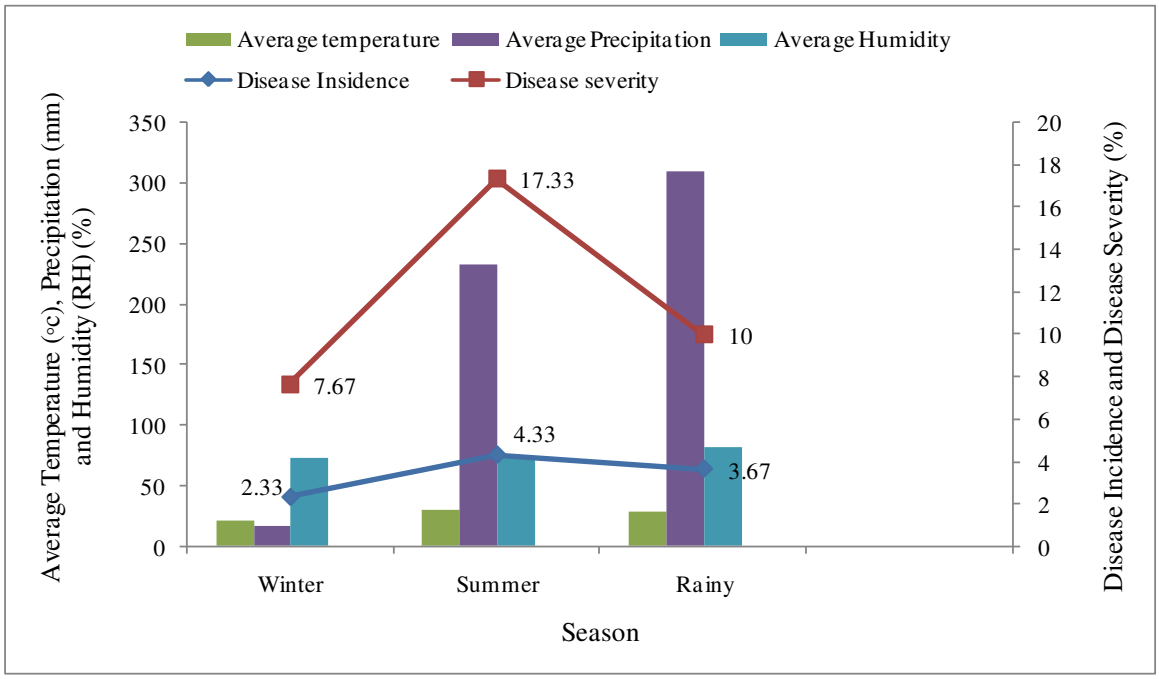

Figure 12. Relationship of disease incidence and severity of leaf spot of Dhutra with weather parameters in different seasons

4.1.7 Disease of Gulancha

4.1.7.1 Alternaria leaf spot of Gulancha

A. Symptomological study

Leaf spots start as small brown spots, often with a yellow halo, and progressed to irregular brown spots up to 3 or 4 cm in diameter. The presence of brown necrotic lesions on older leaves, with a typical bull's eye appearance of concentric rings that was 1 to 5 mm wide with well defined margins that was the most evident symptom of this disease. As the disease develops, light brown lesions are formed with concentric rings. Several lesions can fuse and cover a large area of the leaf. When this occurred, the leaf became dropped out. Usually spots are surrounded by a chlorotic halo (Plate 16.A).

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyalin in tender age. The conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present). Beak was long. The conidia contained up to 5-7 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Figure 16.B).

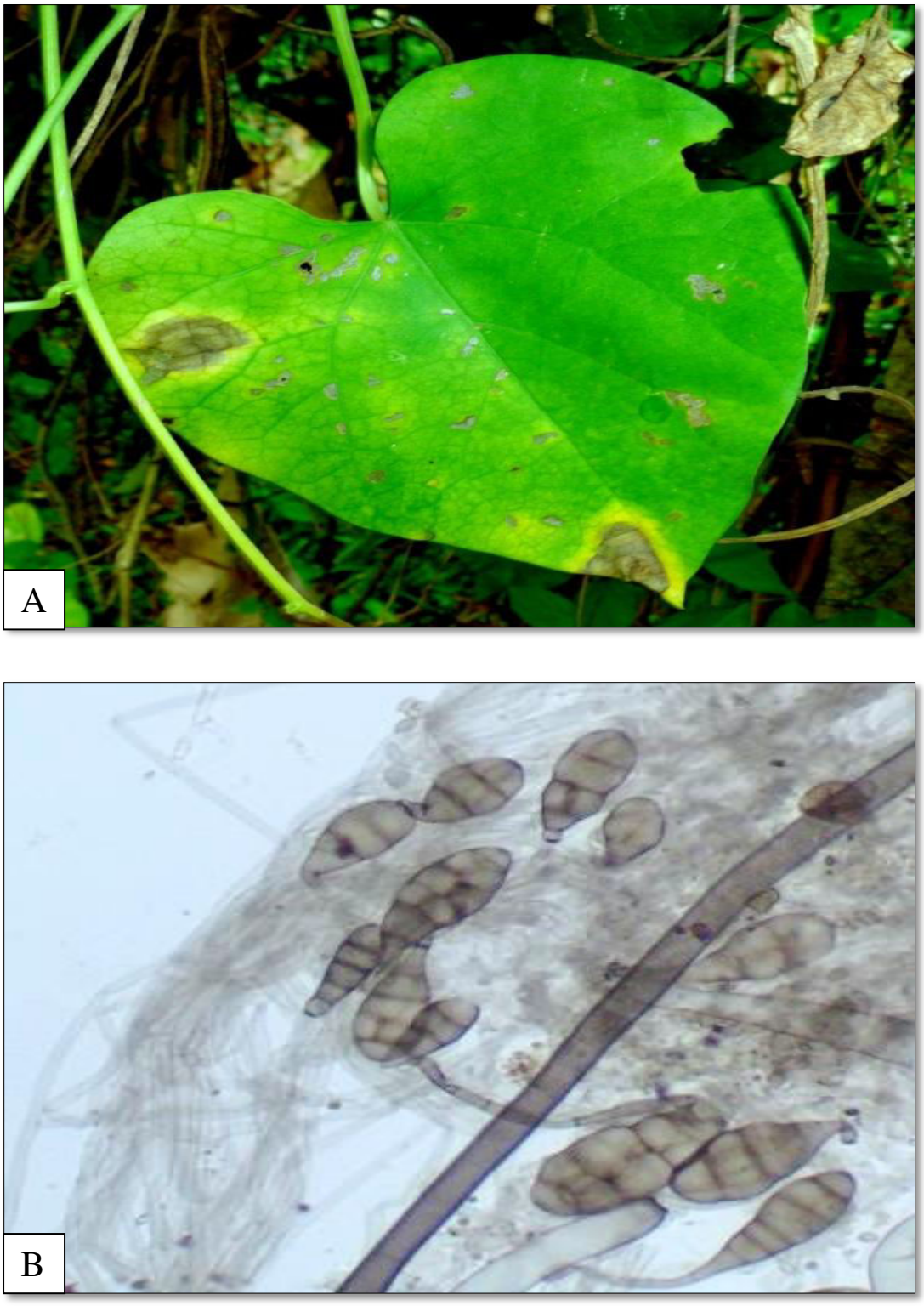

Plate 16. Symptoms and causal organism of Alternaria leaf spot disease of Gulancha; (A) Alternaria leaf spot on Gulancha leaf and (B) *Alternaria* sp. (10×40)

C. Incidence and severity of the disease

Incidence of Alternaria leaf spot disease in Gulancha varied significantly from January, 2015 to December, 2015 and that ranged from 4.33% to12.33% (Table 16). The highest incidence (12.33%) was recorded in rainy season which is significantly varied from summer (4.33%) and winter season (7.33%) in 2015.

In case of disease severity leaf spot disease in Gulancha also significantly varied from January, 2015 to December, 2015 (Table 16). The highest (14%) severity was found in rainy season which is not significantly varied from the disease severity of winter (12.33%) but varied with summer (6.67%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Alternaria leaf spot of Gulancha progressed from winter season to rainy season (Figure 13). The highest disease incidence and severity of Alternaria leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of Alternaria leaf spot was recorded in summer season. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. In winter the average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the Alternaria leaf spot disease of Gulancha.

Table 16. Incidence and severity of Alternaria leaf spot disease of Gulancha plant from January to December, 2015 in field condition

Seasons	Alternaria Leaf Spot	
	% Disease incidence	% Disease severity
Winter	7.33 b	12.33 a
Summer	4.33 b	6.67 b
Rainy season	12.33 a	14.00 a
CV %	26.02	21.64
LSD	4.72	5.4
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

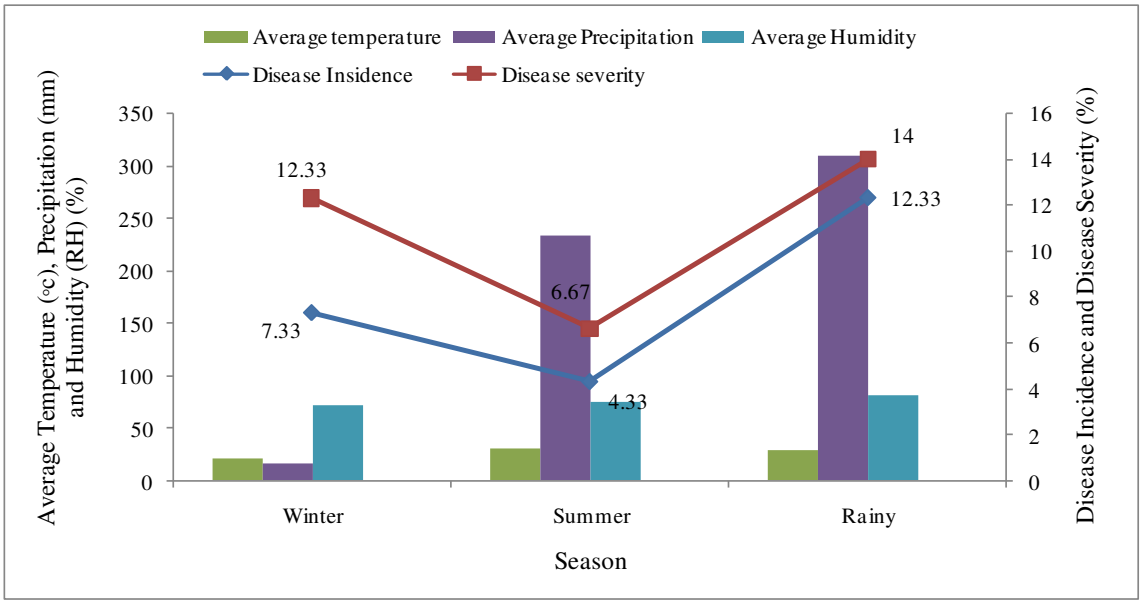

Figure 13. Relationship of disease incidence and severity of Alternaria leaf spot of Gulancha with weather parameters in different seasons

4.1.7.2 Cercospora leaf spot of Gulancha

A. Symptomological study

Leaf spotswere circular, subcircular to slightly angular-irregular, up to 1 cm diameter, at first brown, but soon turning greyish white to white, margin narrow, somewhat raised, dark, brown, dark violet to almost blackish (Plate 17.A).

B. Identification of causal organism

The identified causal organism was *Cercospora* sp. Conidiophores in small, loose to moderately large and dense fascicles, arising from substomatal or intraepidermal hyphae or stromata, emerging through stomata or erumpent, erect, straight to curved, subcylindrical or somewhat attenuated towards the tip to moderately geniculate-sinuous, unbranched, 0-3-septate, pale olivaceous to olivaceous-brown, paler towards the tip, thin-walled, smooth; conidiogenous cells integrated, terminal or conidiophores reduced to conidiogenous cells (Plate 17.B). Conidia solitary and catenate, in simple or occasionally branched chains, narrowly cylindrical-fusiform, short obclavate, septate, hyaline (Plate 17.C).

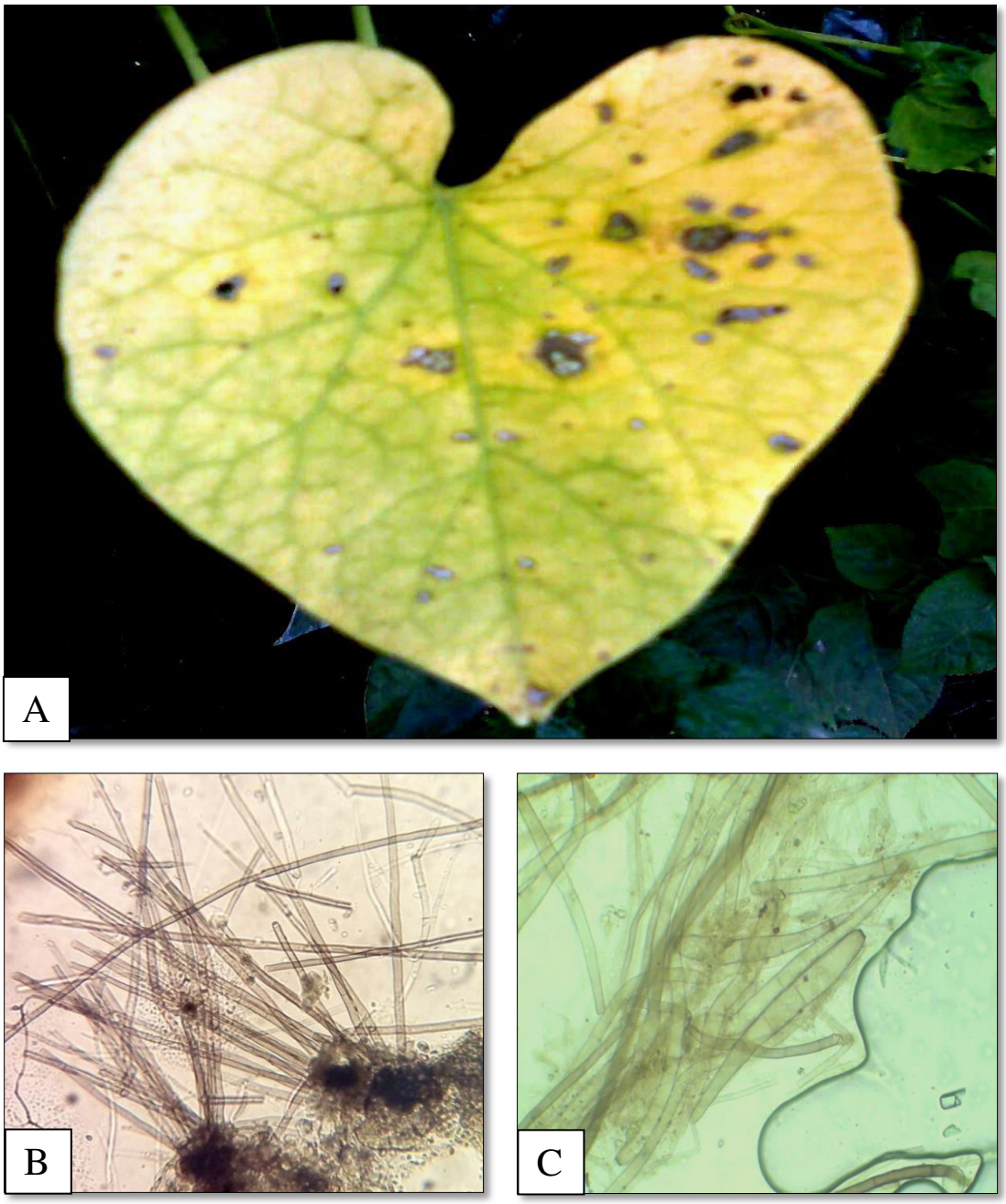

Plate 17. Symptoms and causal organism of Cerrcospora leaf spot disease of Gulancha; (A) Cercospora leaf spot on Gulancha leaf and (B) Conidiophore of *Cercospora* sp. and (C) Conidia of *Cercospora* sp. (10×40)

C. Incidence and severity of Cercospora leaf spot disease in Gulancha

Incidence of Cercospora leaf spot disease in Gulancha varied significantly from January, 2015 to December, 2015 and that ranged from 3% to17.67% (Table 17). The highest incidence (17.67%) was recorded in rainy season which is significantly varied from summer (3.33%) and winter season (3%) in 2015.

In case of disease severity leaf spot disease in Gulancha also significantly varied from January, 2015 to December, 2015 (Table 17). The highest (32.67%) severity was found in rainy season which is significantly varied from the disease severity of summer (7.67%) and winter (6%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Cercospora leaf spot of Gulancha progressed from winter season to rainy season (Figure 14). The highest disease incidence and severity of Cercospora leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33 %. Whereas, the lowest disease incidence and severity of Cercospora leaf spot was recorded in winter season. In winter the average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the disease incidence and severity were similar at winter. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. However, the disease was same in winter and summer season which was progressed gradually but drastically became high in rainy season. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the Cercospora leaf spot disease of Gulancha.

Table 17. Incidence and severity of Cercospora leaf spot disease in Gulancha plant from January to December, 2015 in field condition

Season of data collection	Cercospora Leaf Spot	
	% Disease incidence	% Disease severity
Winter	3.00 b	6.00 b
Summer	3.33 b	7.67 b
Rainy season	17.67 a	32.67 a
CV %	20.41	10.46
LSD	3.702	3.698
Significant level	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

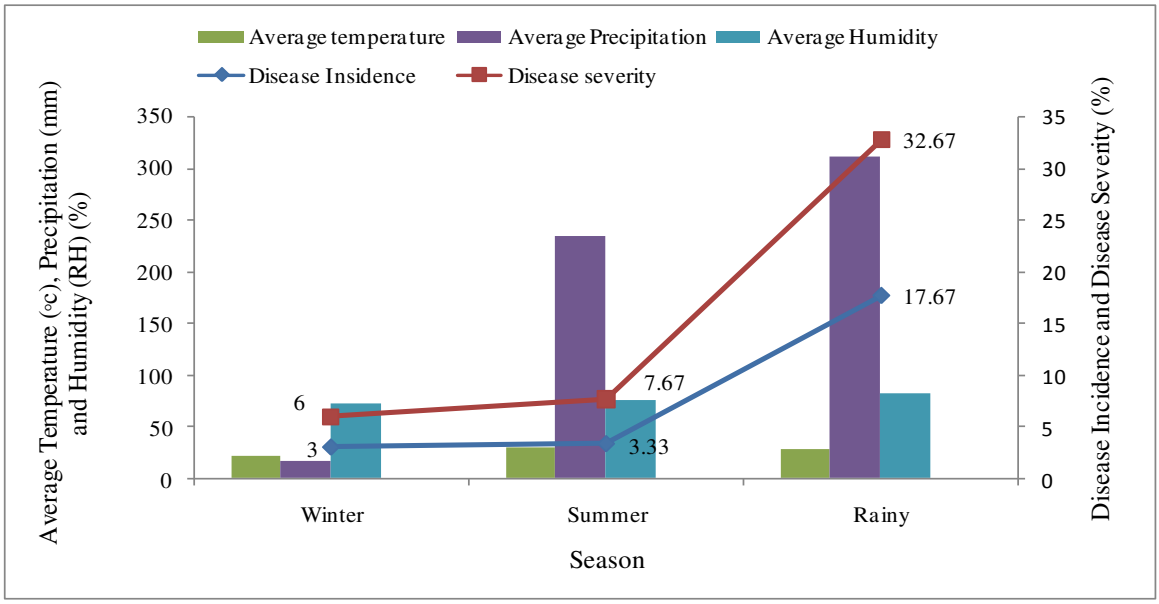

Figure 14. Relationship of disease incidence and severity of Cercospora leaf spot of Gulancha with weather parameters in different seasons

4.8 Disease of Makania lota (Asma lota)

4.8.1 Leaf Spot of Makania lota

A. Symptomological study

At first brown minute to large necrotic lesions were found on leaves, with typical concentric rings and well defined margins. Several lesions were fuse together and cover a large area of the leaf followed by leaf drop. Usually spots are surrounded by a chlorotic halo. Infection was mostly present in the older leaves. In advanced stage, fungal infection progress to the younger leaf (Plate 18.A).

B. Identification of causal organism

The pathogen was identified as *Alternaria* spp. on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. Two types of Alternaria were isolated from the diseased plant parts. The mycelium was septate, branched, hyaline in tender age. The conidiophore was simple, short, septated, colored and beard conidia at the top. Conidia were pale brown to brown, beaked, multicelled and muriform (both longitudinal and transverse septum was present). Beak is long. The conidia contained 5-10 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Plate 18.B- C).

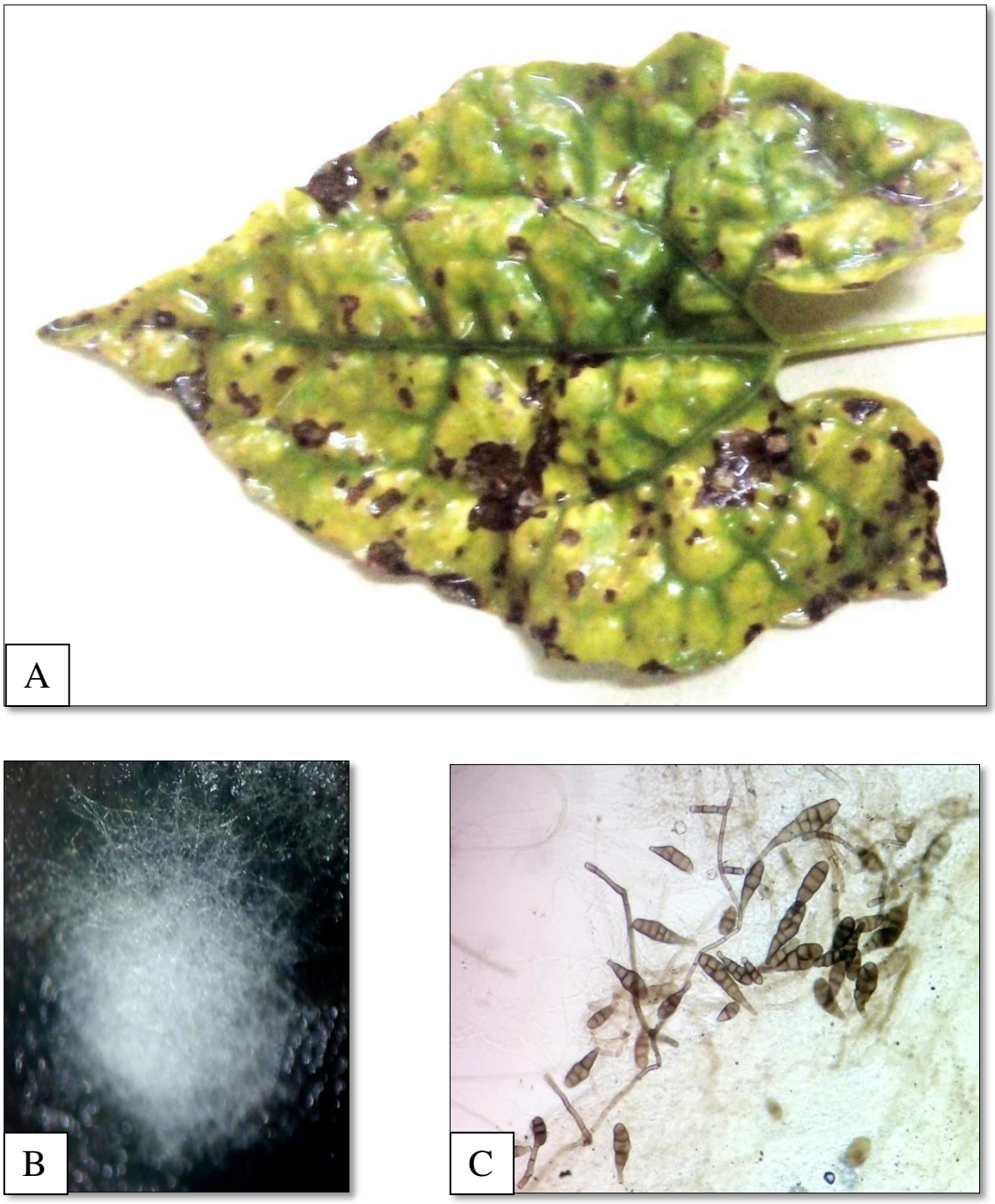

Plate 18. Symptoms and causal organism of leaf spot disease of Makania lota; (A) Black spot with hallow is present on Makania lota leaf; (B) Stereo view of mycelium of *Alternaria* sp. (40×) and (C) Microscopic view of *Alternaria* sp. (10×40)

C. Incidence of leaf spot disease in Makania Lota in Januery to December, 2015

Incidence of leaf spot disease in Machania lota varied significantly from January, 2015 to December, 2015 and that ranged from 4% to17.33% (Table 18). The highest incidence (17.33%) was recorded in rainy season which is significantly varied from summer (9.67%) and winter season (4%) in 2015.

In case of disease severity leaf spot disease in Makania lota also significantly varied from January, 2015 to December, 2015 (Table 18). The highest (23.33%) severity was found in rainy season which is significantly varied from the disease severity of summer (8.67%) and winter (8.33%) season in 2015 but the severity was same in summer and winter season.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf spot of Makania lota progressed from winter season to rainy season (Figure 15). The highest disease incidence and severity of leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. The lowest disease incidence and severity of leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the leaf spot disease of Makania lota.

Table 18. Incidence and severity of leaf spot disease in Machania lota plant from January to December, 2015 in field condition

Seasons	Leaf Spot	
	% Disease incidence	% Disease severity
Winter	4.00 c	8.33 b
Summer	9.67 b	8.67 b
Rainy season	17.33 a	23.33 a
CV %	13.10	12.02
LSD $_{(P\leq 0.05)}$	3.069	3.66
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

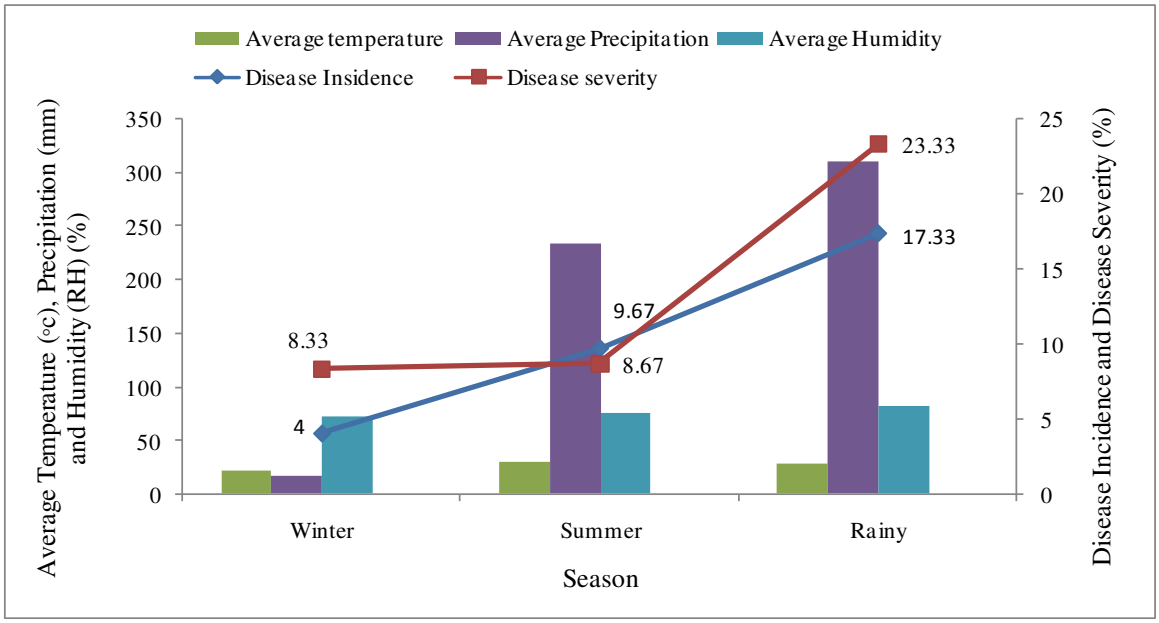

Figure 15. Relationship of disease incidence and severity of leaf spot of Makania lota with weather parameters in different seasons

4.9 Disease of Tulshi

4.1.9.1 Tulshi leaf spot

A. Symptomological study

Brown minute to large spots were found on leaves, with typical concentric rings and well defined margins. Several lesions can fuse and cover a great area that tends to blight of the leaf followed by leaf drop. Usually spots are surrounded by a chlorotic halo. Damage caused mostly in older leaves (Plate 19.A- B).

B. Identification of causal organism

The pathogen was identified as *Alternaria* sp.on the basis of morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyalin in tender age. The conidiophore was simple, short, saptate, colored and beard conidia at the top. Conidia were dark, beaked, multicelled and muriform (both longitudinal and transverse septum was present). Beak is long. The conidia contained 5-8 transverse septa and few longitudinal septa. Their shape was obclavate to elliptical or ovoid which were pointed at distal end (Plate 19.C- D).

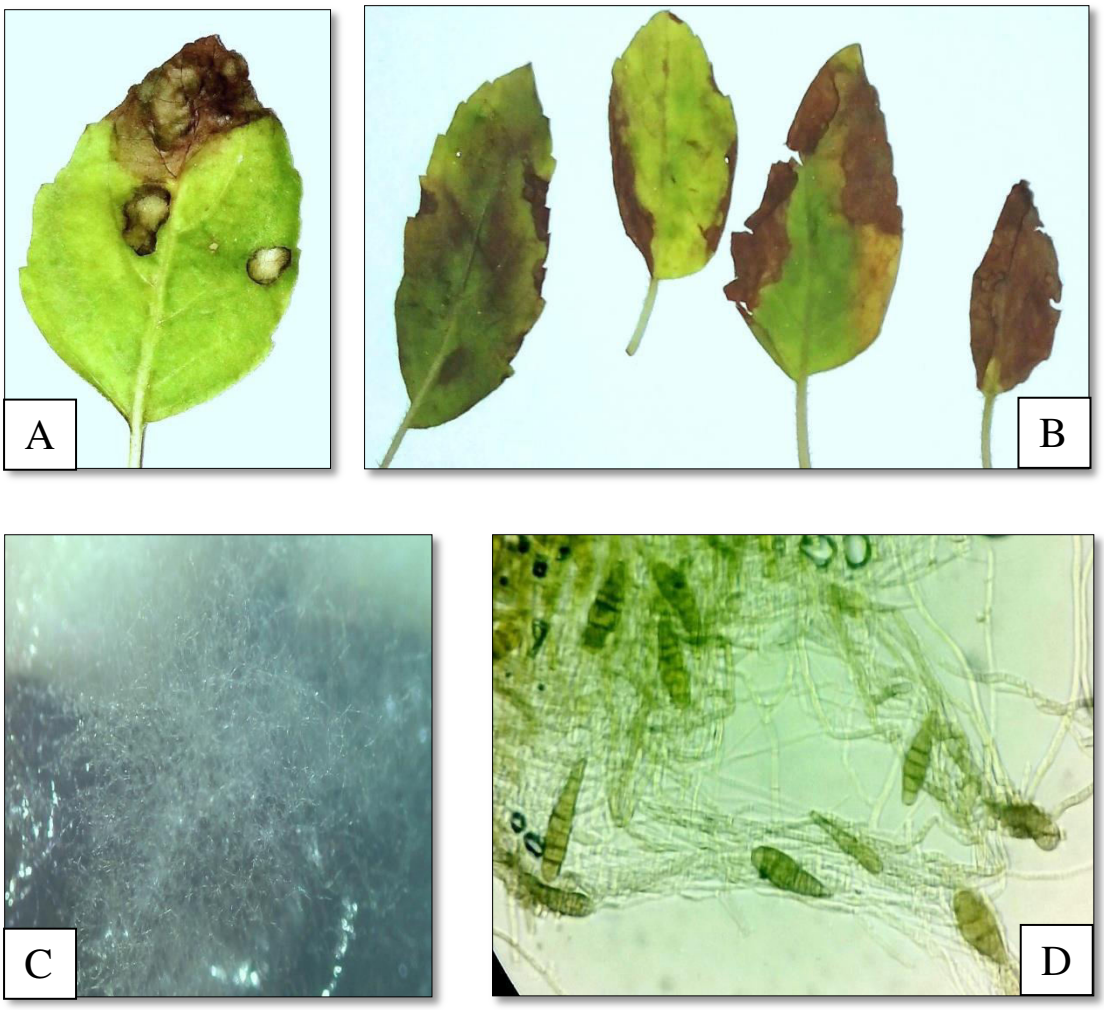

Plate 19. Symptoms and causal organism of leaf spot disease of Tulshi; (A) Leaf spot on Tulshi leaf; (B) Leaf blight disease of Tulshi leaf ; (C) Conidialchain and mycelium of *Alternaria* sp. (stereo view) and (D) *Alternaria* sp. with mycelium (10×40)

C. Incidence and severity of the disease

Incidence of leaf spot disease in Tulshi varied significantly from January, 2015 to December, 2015 and that ranged from 5% to14% (Table 19). The highest incidence (14%) was recorded in rainy season which is not significantly varied from summer (12.33%) and significantly varied from winter (5%) in 2015.

In case of disease severity leaf spot disease in Tulshi also significantly varied from January, 2015 to December, 2015 (Table 19). The highest (17.67%) severity was found in rainy season which is significantly varied from the disease severity of summer (12.33%) and winter (3.33%) season in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of leaf spot of Tulshi progressed from winter season to rainy season (Figure 16). The highest disease incidence and severity of leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. The lowest disease incidence and severity of leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the leaf spot disease of Tulshi plant.

Table 19. Incidence and severity of leaf spot disease in Tulshi from January to December, 2015 in field condition

Seasons	Leaf Spot	
	% Disease incidence	% Disease severity
Winter	5.00 b	3.33 c
Summer	12.33 a	12.33 b
Rainy season	14.00 a	17.67 a
CV %	19.80	20.35
LSD	4.07	5.13
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

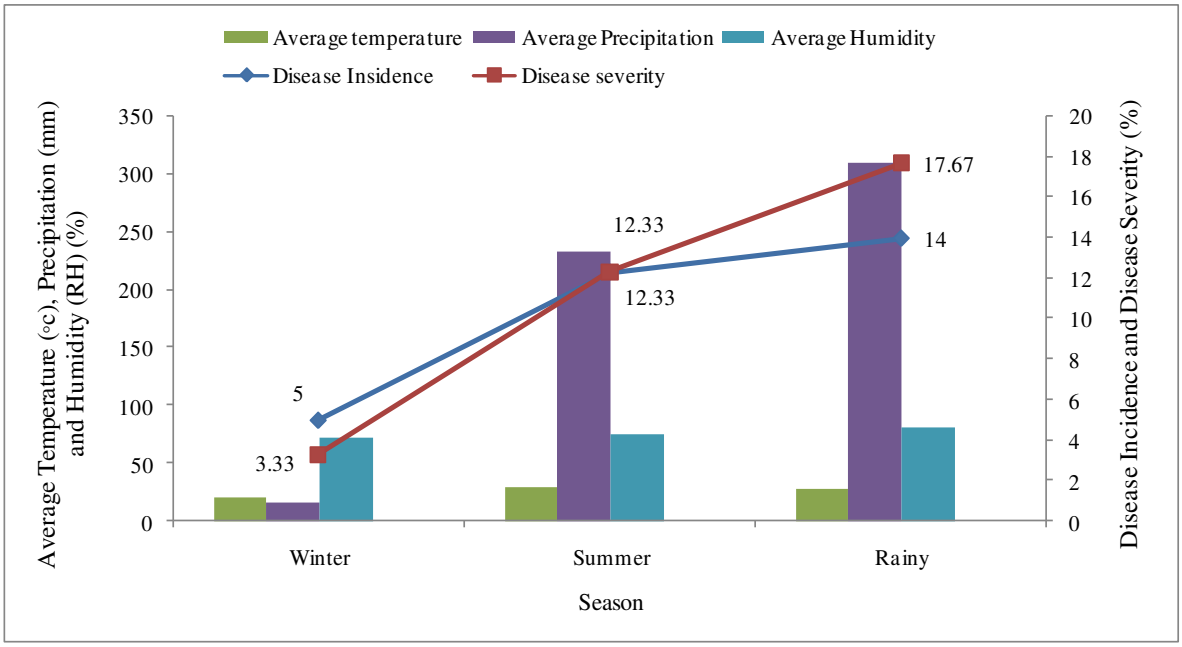

Figure 16. Relationship of disease incidence and severity of leaf spot of Tulshi with weather parameters in different seasons

4.1.10 Disease of Ulotkambol

4.1.10.1 Leaf spot of Ulotkambol

A. Symptomological study

Leaf spots were started as small brown spots, often with a yellow halo, and grow into irregular brown spots. The spots were 1 to 5 mm diameter with well defined margins. As the disease developed, the leaves turn to blighted symptom (Plate 20.B -C).

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. on the basis of its morphological and cultural characteristics of conidia, conidiophores and mycelium. The mycelium was septate, branched, hyaline in tender age. The conidiophore was simple, short, septate, colored and beard conidia at the top (Figure 20.D). Conidia were pale brown to brown, beaked, multicelled and muriform (both longitudinal and transverse septum was present). The conidia contained 5-8 transverse septa and few longitudinal septa. Their shape ware obclavate to elliptical or ovoid which were pointed at distal end (Figure 20.E).

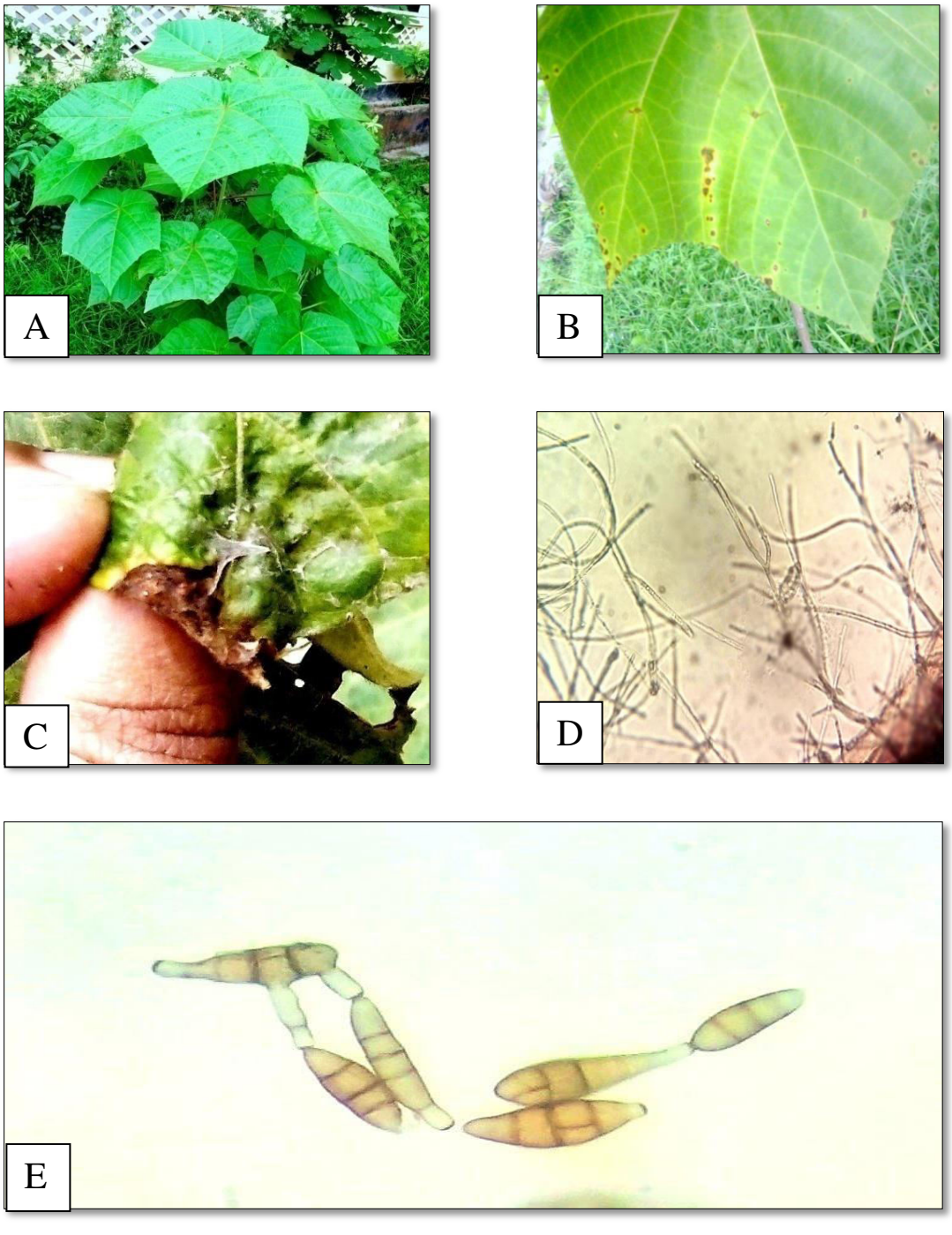

Plate 20. Symptoms and causal organism of leaf spot disease of Ulotkambol; (A) Healthy plant of Ulotkambol; (B) Black spot with yellow hallow in Ulotkambol leaf; (C) Mycelium grown on Ulotkambol leaf; (D) Mycelium of *Alternaria* sp. (10×10) and (E) Compound microscopic view of *Alternaria* sp. (10×40)

C. Incidence and severity of leaf spot of ulotkambol caused by *Alternaria* sp.

Incidence of leaf spot disease in Ulotkambol did not vary significantly from January, 2015 to December, 2015 and that ranged from 1.67% to 4% (Table 20). The highest incidence (4%) was recorded in summer season which is not significantly varied with winter (3.33%) and rainy season (1.67%) in 2015.

But in case of disease severity leaf spot disease in Ulotkambol significantly varied from January, 2015 to December, 2015 (Table 20). The highest (26.67%) severity was found in summer season which was significantly varied from the disease severity of winter (15.33%) and rainy (7.33%) season, here winter and rainy season also significantly varied.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The incidence of the disease did not varied in season to season but the disease severity was varied significantly in season to season. The highest (26.67%) severity was found in summer season which was significantly varied from the disease severity of winter (15.33%) and rainy (7.33%) season, here winter and rainy season also significantly varied. In the year of 2015 the average temperature in winter was 20.5° C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer season the average temperature was 30° C, average precipitation was 233.33 mm and average relative humidity was 74.67% while the average temperature in rainy season was 28° C, average precipitation was 310 mm and average relative humidity was 81.33% (Figure 17). From the above findings, it is indicated that, high temperature, high humidity and precipitation favors the leaf spot disease of Ulotkambol.

Table 20. Incidence and severity of Ulotkambol leaf spot in January to December, 2015 in field condition

Seasons	Leaf Spot	
	% Disease incidence	% Disease severity
Winter	3.33	15.33 b
Summer	4.00	26.67 a
Rainy season	1.67	7.33 c
CV %	43.03	4.05
LSD	----	1.51
Level of Significance	NS	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability, NS denotes Not significant

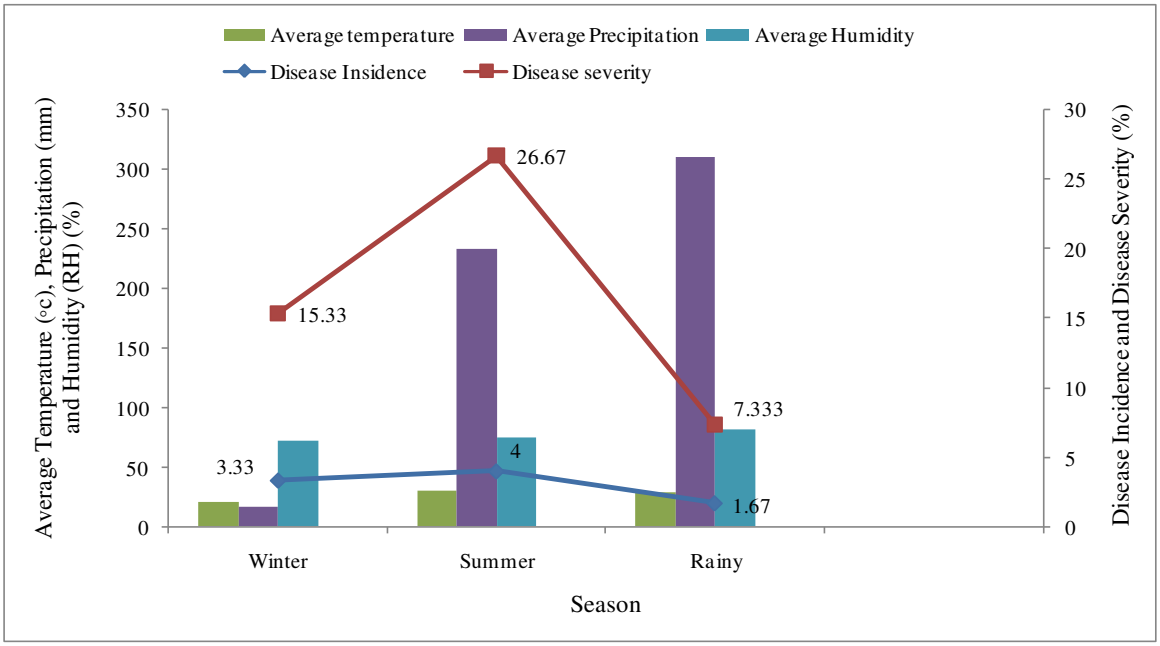

Figure 17. Relationship of disease incidence and severity of leaf spot of Ulotkombol with weather parameters in different seasons

4.2 Experiment 2. Survey on nursery diseases of medicinal plants at Sher-e-Bangla Nagar, Dhaka

Plate 21. Aloe vera plant in nursery

4.2.1 Diseases of Aloe vera in nursery

4.2.1.1 Alternaria leaf spot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of Alternaria leaf spot disease observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

C. Incidence and severity of Alternaria leaf spot of Aloe vera

In nursery incidence of Alternaria leaf spot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 12.33% to 36.33% (Table 21). The highest incidence (36.33%) was recorded in rainy season which is significantly varied with summer (21%) and the winter (12.33%) in 2015.

In case of disease severity, similar results were observed. Severity of Alternaria leaf spot also varied significantly from January, 2015 to December, 2015 (Table 21). The highest (14.33%) severity was found in rainy season which is not significantly varied from the disease severity of summer (12.67%) but varied with the winter season (4.67%) in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Alternaria leaf spot of Aloe vera progressed from winter season to rainy season (Figure 18). The highest disease incidence and severity of Alternaria leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of Alternaria leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the

average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the Alternaria leaf spot disease of Aloe vera.

Table 21. Incidence and severity of Alternaria leaf spot of Aloe vera in nursery

Seasons	Alternaria Leaf Spot	
	% Disease incidence	% Disease severity
Winter	12.33 c	4.67 b
Summer	21.00 b	12.67 a
Rainy season	36.33 a	14.33 a
CV %	14.57	23.42
LSD	7.67	5.60
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

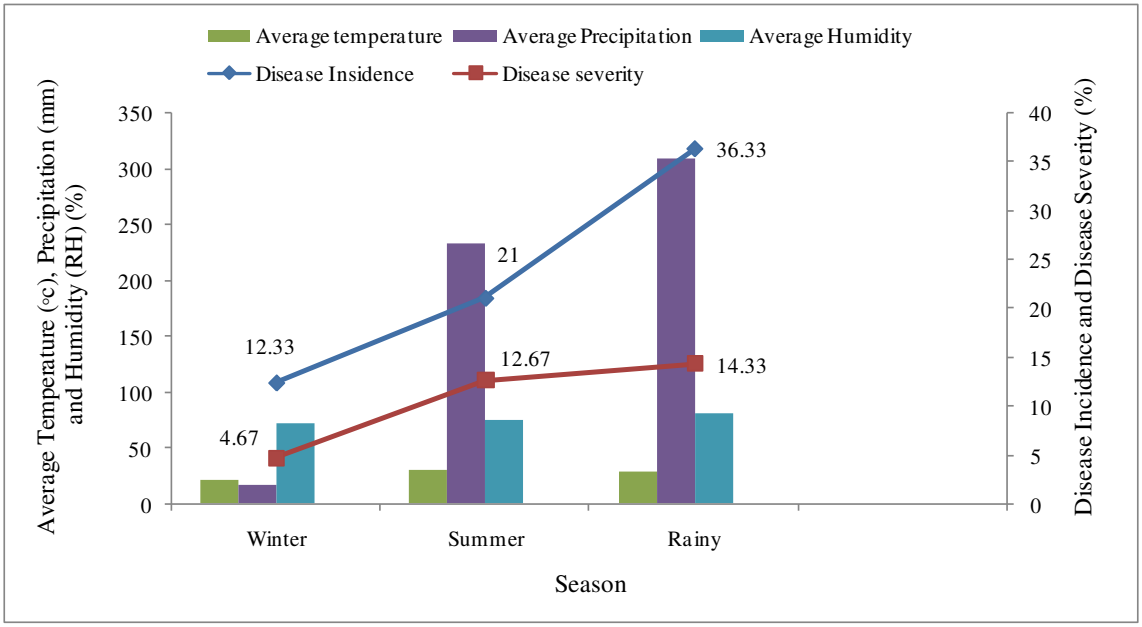

Figure 18. Relationship of disease incidence and severity of Alternaria leaf spot of Aloe vera with weather parameters in different seasons

4.2.1.2 Curvularia Leaf Spot

A. Symptomological study

The symptom was similar as the symptom of Curvularia leaf spot disease observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Curvularia* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

C. Incidence and severity of Curvularia leaf spot of Aloe vera in nursery

In nursery incidence of Curvularia leaf spot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 7.67% to 15.67% (Table 22). The highest incidence (15.67%) was recorded in rainy season which is significantly varied with summer (11%) and the winter (7.67%) in 2015.

In case of disease severity, similar results were observed. Severity of Curvularia leaf spot also varied significantly from January, 2015 to December, 2015 (Table 22). The highest (12.67%) severity was found in rainy season followed by summer (8.33%) and winter season (6.67%) in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of Curvularia leaf spot of Aloe vera progressed from winter season to rainy season (Figure 19). The highest disease incidence and severity of Curvularia leaf spot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of Curvularia leaf spot was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From the above findings, it is indicated that, moderate

temperature, high humidity and precipitation favors the Curvularia leaf spot disease of Aloe vera.

Table 22. Incidence and severity of Curvularia leaf spot of Aloe vera in nursery

Seasons	Curvularia Leaf Spot	
	% Disease incidence	% Disease severity
Winter	7.67 b	6.67 b
Summer	11.00 b	8.33 ab
Rainy season	15.67 a	12.67 a
CV %	14.12	22.86
LSD	3.66	4.77
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

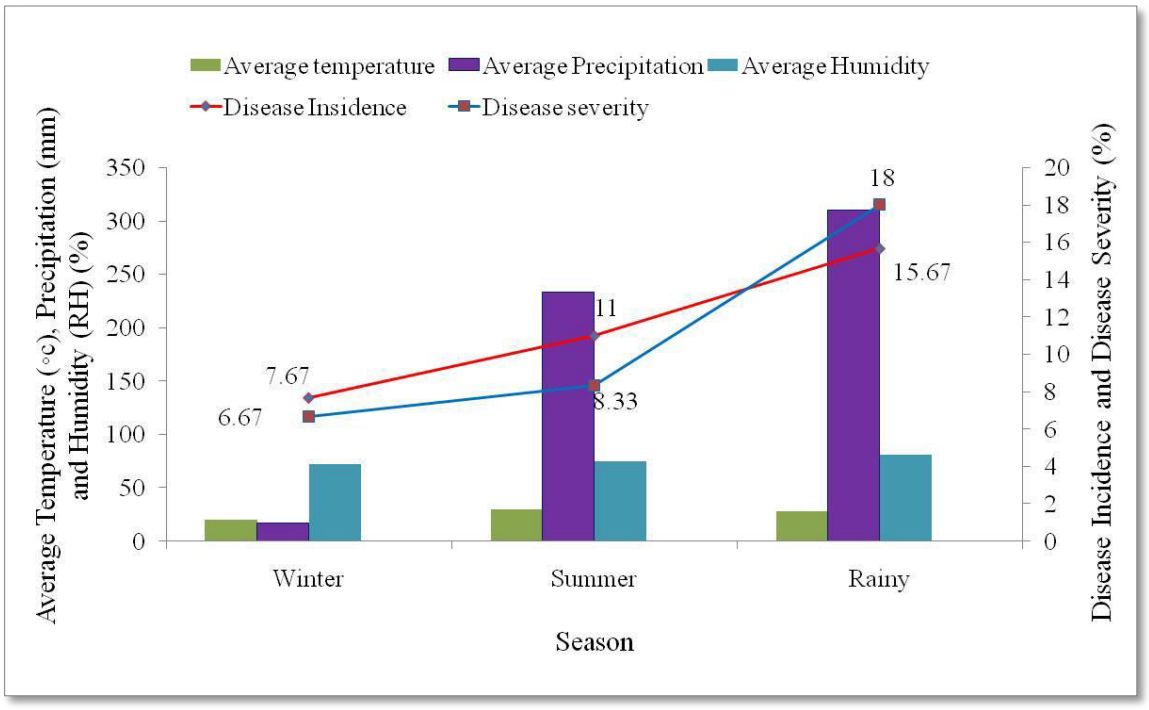

Figure 19. Relationship of disease incidence and severity of Curvularia leaf spot of Aloe vera with weather parameters in different seasons

4.2.1.3 Basal Rot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of basal rot of Aloe vera disease observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Fusarium* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

D. Incidence and severity of Basal rot of aloe vera:

In nursery incidence of basal rot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 4.67% to 12.33% (Table 23). The highest incidence (12.33%) was recorded in rainy season which is significantly varied with summer (6.67%) and the winter (4.67%) in 2015.

In case of disease severity, similar results were observed. Severity of basal rotalso varied significantly from January, 2015 to December, 2015 (Table 23). The highest (16%) severity was found in rainy season which is significantly varied from the disease severity of summer (9.67%) and winter season (8.33%) in 2015. But disease severity in summer and winter was statistically similar in the year of 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of basal rot of Aloe vera progressed from winter season to rainy season (Figure 20). The highest disease incidence and severity of basal rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of basal rot disease of Aloe vera was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%.

From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the basal rot disease of Aloe vera.

Table 23. Incidence and severity of Basal rot of Aloe vera in nursery

Seasons	Basal rot	
	% Disease incidence	% Disease severity
Winter	4.67 b	8.33 b
Summer	6.67 b	9.67 b
Rainy season	12.33 a	16.00 a
CV %	25.70	19.40
LSD	4.6	4.98
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

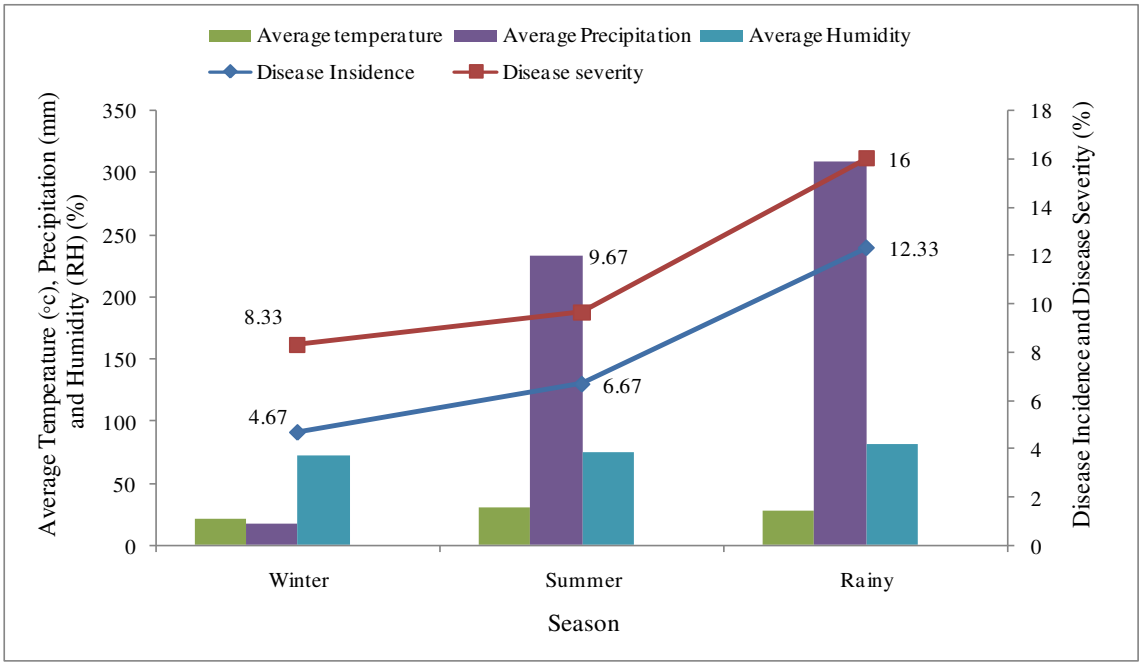

Figure 20. Relationship of disease incidence and severity of basal rot with the seasons and weather conditions

4.2.1.4 Anthracnose of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of anthracnose of Aloe vera disease observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Colletotrichum* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

C. Incidence and severity of Anthracnose of Aloe vera

In nursery incidence of anthracnose of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 4.33% to 12.33% (Table 24). The highest incidence (12.33%) was recorded in rainy season which is not significantly varied with summer (9.33%) but varied with winter (4.33%) in 2015.

In case of disease severity, similar results were observed. Severity of anthracnose also varied significantly from January, 2015 to December, 2015 (Table 24). The highest (17.33%) severity was found in rainy season which is significantly similar with the disease severity of summer (12.33%) but varied with winter season (6.67%) in 2015. Again the severity of summer was statistically similar with rainy season.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of anthracnose of Aloe vera progressed from winter season to rainy season (Figure 21). The highest disease incidence and severity of basal rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. The lowest disease incidence and severity of anthracnose in Aloe vera plant was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. From

the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the anthracnose disease of Aloe vera.

Table 24. Incidence and severity of anthracnose of Aloe vera in nursery

Seasons	Anthracnose of Aloe vera	
	% Disease incidence	% Disease severity
Winter	4.33 b	6.67 b
Summer	9.33 a	12.33 ab
Rainy season	12.33 a	17.33 a
CV %	16.32	24.46
LSD	3.21	6.72
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

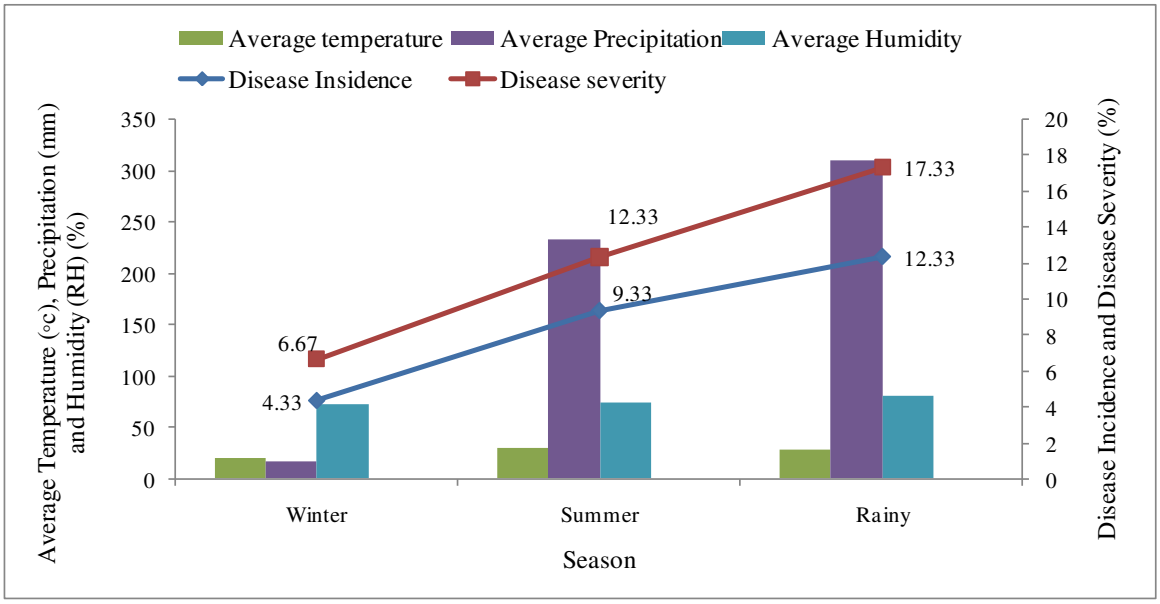

Figure 21. Relationship of disease incidence and severity of anthracnose of Aloe vera with the seasons and weather condition

4.2.1.5 Tip blight of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of tip blight disease of Aloe vera observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

C. Incidence and severity of tip blight of Aloe vera

In nursery incidence of tip blight of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 6.67% to 27.67% (Table 25). The highest incidence (27.67%) was recorded in rainy season which was significantly varied with summer (12%) and the winter (6.67%) in 2015.

But in case of disease severity, no significantly variance was observed in 2015. The highest (14%) severity was found in rainy season which is not significantly varied from the disease severity of summer (10.67%) and winter season (9.67%) in 2015 (Table 25).

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of tip blight of Aloe vera progressed from winter season to rainy season (Figure 22). The highest disease incidence and severity of tip blight was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of tip blight of Aloe vera was recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative humidity was 74.67%. However, though the incidence was significantly varied with rainy season and winter season but there were no statistically dissimilarities among those seasons. From the above findings, it

is indicated that, moderate temperature, high humidity and precipitation favors the tip blight disease of Aloe vera.

Table 25. Incidence and severity of Tip blight of Aloe vera in nursery

Seasons	Tip blight of Aloe vera	
	% Disease incidence	% Disease severity
Winter	6.67 c	9.67
Summer	12.00 b	10.67
Rainy season	27.67 a	14.00
CV %	11.11	15.41
LSD	3.89	----
Level of Significance	**	NS

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability, NS denotes Not significant

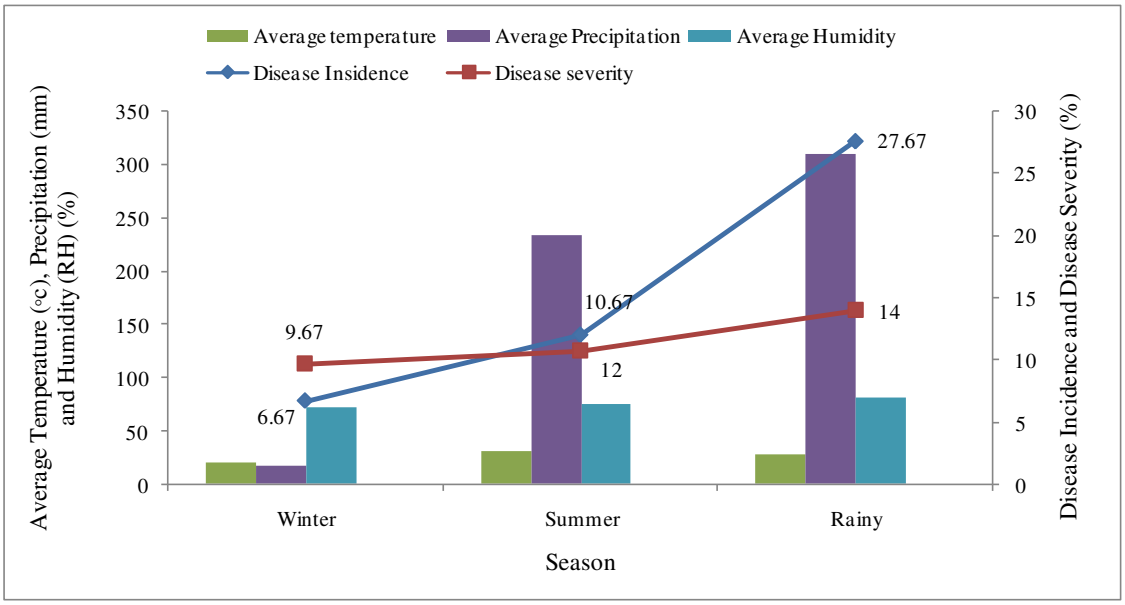

Figure 22. Relationship of disease incidence and severity of Tip blight of Aloe vera with the seasons and weather condition

4.2.1.6 Bacterial leaf rot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of bacterial rot disease of Aloe vera observed in the field as described before.

B. Identification of causal organism

The causal organism was identified as *Bacteria* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field condition.

C. Incidence and severity of bacterial rot of aloe vera

In nursery incidence of bacterial rot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 2.67% to 10% (Table 26). The highest incidence (10%) was recorded in rainy season which is significantly varied with summer (4%) and the winter (2.67%) in 2015.

In case of disease severity, similar results were observed. Severity of bacterial rotalso varied significantly from January, 2015 to December, 2015 (Table 26). The highest (75%) severity was found in rainy season which is significantly varied from the disease severity of summer (22.67%) and winter season (12.33%) in 2015.

D. Relationship of disease incidence and severity with weather parameters in different seasons

The disease incidence and severity of bacterial rot of Aloe vera progressed from winter season to rainy season (Figure 23). The highest disease incidence and severity of bacterial rot was observed in rainy season. In rainy season the average temperature was 28 °C, average precipitation was 310 mm and average relative humidity was 81.33%. Whereas, the lowest disease incidence and severity of bacterial rot disease of Aloe vera were recorded in winter season. The average temperature was 20.5 °C, average precipitation was 16.67 mm and average relative humidity was 72%. In summer, the average temperature was 30 °C, average precipitation was 233.33 mm and average relative

humidity was 74.67%. From the above findings, it is indicated that, moderate temperature, high humidity and precipitation favors the bacterial rot disease of Aloe vera.

Table 26. Incidence and severity of bacterial rot of Aloe vera in nursery

Seasons	Bacterial rotof Aloe vera	
	% Disease incidence	% Disease severity
Winter	2.67 b	12.33 c
Summer	4.00 b	22.67 b
Rainy season	10.00 a	75.00 a
CV %	29.09	7.30
LSD	3.66	6.07
Level of Significance	**	**

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
** denotes significant at 0.01 level of probability

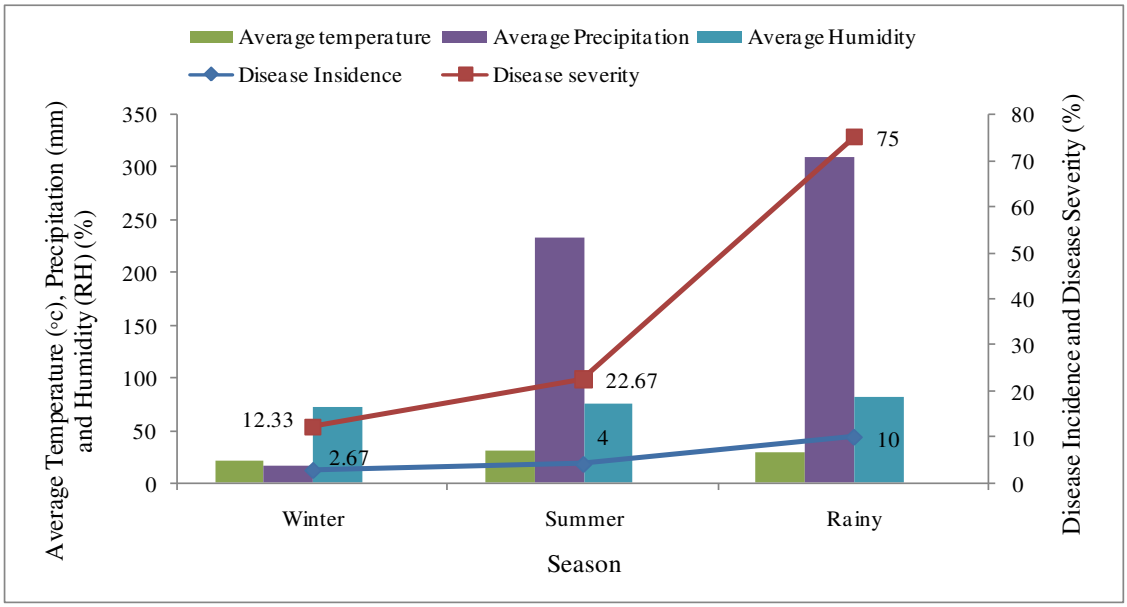

Figure 23. Relationship of disease incidence and severity of bacterial rot with the seasons and weather conditions

4.3 Experiment 3. Survey on post harvest diseases of medicinal plants at Kawranbazar, Gulisthan and Jatrabari market in Dhaka

Disease in Postharvest condition

Three important whole sale market of Dhaka city were surveyed to find out the diseases of medicinal plants in post harvest condition. Only aloe vera leaves are found in raw condition which is used as a medicinal product. During the research time (January 2015 to December 2015) six diseases were identified in both nursery and field condition. However, only four diseases of aloe vera were recorded in post harvest condition.

Plate 22. Aloe vera leaf in post harvest condition

4.3.1 Post harvest diseases of Aloe vera

4.3.1. 1 Alternaria leaf spot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of Alternaria leaf spot disease observed in the field andnurseryas described before.

B. Identification of causal organism

The causal organism was identified as *Alternaria* sp. This causal organism was same as the causal organism that was identified in the infected plant from the nursery and field condition.

C. Incidence and severity of Alternaria leaf spot of Aloe vera

In post harvest condition the incidence of leaf spot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 6.44% to 20.67%. The highest incidence (20.67%) was recorded in rainy season which is significantly varied with summer (11%) and winter (6.44%) season in 2015. The disease severity of Alternaria leaf spot also varied significantly from January, 2015 to December, 2015. The highest (12.44%) severity was found in rainy season which is significantly varied from the disease severity of summer (6.11%) and winter season (6.33%) in 2015 (Table 27).

In case of market, disease incidence and severity also varied significantly from January 2015 to December 2015. The incidence was highest at Gulisthan market (14.89%), second highest at Kawranbazar market (12.89%) and lowest in Jatrabari market (10.33%) and they are significantly varied with each other. The severity was highest at Gulisthan market (10.11%), which is significantly varied with Jatrabari market (6.78%) and Kawranbazar market (8%). There are no statistically dissimilarities between Jatrabari market and Kawranbazar market for disease severity of Aloe vera leaf spot disease (Table 27).

In case of combination factor leaf spot disease was significantly varied in January to December 2015. The highest incidence was observed in rainy season at Gulisthan market (23.33%), followed by Kawranbazar market (21.67%) and Jatrabari market (17%). In case of summer Gulisthan market (13.33%), Kawranbazar market (11%) and Jatrabari market (8.67%). On the other hand, in winter season Gulisthan market (8%), Kawranbazar market (6%) and the lowest at Jatrabari market (5.33%). The severity was also significantly varied in January to December 2015. The highest disease severity was observed in rainy season at Gulisthan market (14.33%), followed by Kawranbazar market (12.67%) and Jatrabari market (10.33%). In summer season the highest disease severity was in Gulisthan market (8.33%) followed by Jatrabari market (5.66%) and Kawranbazar market (4.33%). In winter season, disease severity was lowest in Jatrabari market (4.33%) where as Kawranbazar showed (7.00%) and Gulisthan market (7.66%) (Table 27).

Table 27. Incidence and severity of Alternaria leaf spot of aloe vera in post harvest condition

Seasons and market		Disease Incidence	Disease Severity
Seasons	Winter	6.44 c	6.33 b
	Summer	11.00 b	6.11 b
	Rainy season	20.67 a	12.44 a
LSD (0.05)		1.77	1.80
Level of Significance		**	**
Markets	Kawranbazar	12.89 b	8.00 b
	Gulistan	14.89 a	10.11 a
	Jatrabari	10.33 c	6.77 b
LSD (0.05)		1.77	1.80
Level of Significance		**	**
Combination	WK	6.00 fg	7.00 de
	WG	8.00 ef	7.66 de
	WJ	5.33 g	4.33 f
	SK	11.00 cd	4.33 f
	SG	13.33 c	8.33 cd
	SJ	8.66 de	5.66 ef
	RK	21.67 a	12.67 ab
	RG	23.33 a	14.33 a
	RJ	17.00 b	10.33 bc
LSD (0.05)		2.54	2.59
Level of Significance		*	*
CV%		14.00	21.71

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
* denotes significant at 0.05 level of probability, ** denotes significant at 0.01 level of probability, NS denotes Not significant
WK- Winter-Kawranbazar, WG-Winter-Gulisthan, WJ-Winter-Jatrabari
SK-Summer-Kawranbazar, SG-Summer-Gulisthan, SJ-Summer-Jatrabari
RK-Rainy season-KAwranbazar, RG-Rainy season-Gulisthan, RJ-Rainy season-Jatrabari

4.3.1.2 Curvularia Leaf Spot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of Curvularia leaf spot disease observed in the field and nursery as described before.

B. Identification of causal organism

The causal organism was identified as Curvularia sp. This causal organism was same as the causal organism that was identified in the infected plant from the nursery and field condition.

C. Incidence and severity of Curvularia leaf spot of Aloe vera

In post harvest condition the incidence of Curvularia leaf spot of Aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 3.78% to 12.11%. The highest incidence (12.11%) was recorded in rainy season which is significantly varied with summer (3.78%) and winter (6.78%) season in 2015. The disease severity of Curvularia leaf spot also varied significantly from January, 2015 to December, 2015 (Table 26). The highest (11.67%) severity was found in rainy season which is significantly varied from the disease severity of summer (5.44%) and winter season (6.22%) in 2015 (Table 28).

In case of market disease incidence and severity also varied significantly from January 2015 to December 2015. The incidence was highest at Gulisthan market (9%), which is significantly varied with Kawranbazar market (7.33%) and the lowest in Jatrabari market (6.33%). The severity was highest at Gulisthan market (9.78%), which is significantly varied with Jatrabari market (6%) and Kawranbazar market (7.56%). There were no statistically dissimilarities between Jatrabari market and Kawranbazar market for disease severity of Curvularia leaf spot disease of Aloe vera (Table 28).

In case of combination factor leaf spot disease was significantly varied in January to December 2015. The highest incidence was observed in rainy season at Gulisthan market (14.33%), then Kawranbazar market (11.33%) in rainy season, then Jatrabari market in

rainy season (10.67%), then Gulisthan market in winter season (8%), then Kawranbazar market in winter season (7%) , then Jatrabari market in winter season (5.33%), then Gulisthan market in summer season (4.67%), then Kawranbazar market in summer season (3.67%) and the lowest at Jatrabari market in summer season (3%). The severity was also significantly varied in January to December 2015. The highest severity was observed in rainy season at Gulisthan market (14.33%), then Kawranbazar market in rainy season (11.67%), then Jatrabarimarket in rainy season (9%), then Gulisthan market in winter season (8%), then Gulisthan market in summer season (7%), then Kawranbazar market in winter season (5.67%), then Kawranbazar market in summer season (5.33%) then Jatrabari market in winter season (5%) and the lowest was observed at Jatrabari market in summer season (4%) (Table 28).

Table 28. Incidence and severity of Curvularia leaf spot of Aloe vera in post harvest condition

Seasons and market		Disease Incidence	Disease Severity
Seasons	Winter	6.78 b	6.22 b
	Summer	3.78 c	5.44 b
	Rainy season	12.11 a	11.67 a
LSD (0.05)		1.20	1.69
Level of Significance		**	**
Markets	Kawranbazar	7.33 b	7.55 b
	Gulistan	9.00 a	9.77 a
	Jatrabari	6.33 b	6.00 b
LSD (0.05)		1.20	1.69
Level of Significance		**	**
Combination	WK	7.00 cd	5.67
	WG	8.00 c	8.00
	WJ	5.33 e	5.00
	SK	3.67 ef	5.33
	SG	4.67 ef	7.00
	SJ	3.00 f	4.00
	RK	11.33 b	11.67
	RG	14.33 a	14.33
	RJ	10.67 b	9.00
LSD (0.05)		2.08	----
Level of Significance		*	NS
CV%		15.91	21.75

Each data represents the mean value of three replications. Values followed by the same letter within a column are not significantly different according to least significant difference.

* denotes significant at 0.05 level of probability, ** denotes significant at 0.01 level of probability, NS denotes Not significant

WK- Winter-Kawranbazar, WG-Winter-Gulisthan, WJ-Winter-Jatrabari

SK-Summer-Kawranbazar, SG-Summer-Gulisthan, SJ-Summer-Jatrabari

RK-Rainy season-KAwranbazar, RG-Rainy season-Gulisthan, RJ-Rainy season-Jatrabari

4.3.1.3 Basal rot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of basal rot of aloe vera disease observed in the field and nursery as described before.

B. Identification of causal organism

The causal organism was identified as *Fusarium* sp. This causal organism was same as the causal organism that was identified in the infected plant from the nursery and field condition.

C. Incidence and severity of Basal rot of aloe vera:

In post harvest condition the incidence of basal rot of Alo vera varied significantly from January, 2015 to December, 2015 and that ranged from 5.11% to 13.78%. The highest incidence (13.78 %) was recorded in rainy season which is significantly varied with summer (5.11%) and winter (8.22%) season in 2015. The disease severity of basal rot also varied significantly from January, 2015 to December, 2015. The highest (22.11%) severity was found in rainy season which is significantly varied from the disease severity of summer (7.11%) and winter season (6.67%) in 2015 (Table 29).

In case of market disease incidence and severity also varied significantly from January 2015 to December 2015. The incidence was highest at Gulisthan market (11.22 %) which is significantly varied with Kawranbazar market (8.67%) and lowest in Jatrabari market (7.22%). The severity was highest at Gulisthan market (15.33%), which is significantly varied with Jatrabarimarket (9.56%) and Kawranbazar market (11%). There are no statistically dissimilarities between Jatrabari market and Kawranbazar market for disease severity of Aloe vera basal rot disease (Table 29).

In case of combination factor basal rot disease was significantly varied in January to December 2015. The highest incidence was observed in rainy season at Gulisthan market (16%), then Kawranbazar market (14.67%) in rainy season, then Jatrabari market in rainy season (10.67%), then Gulisthan market in winter season (10%), Gulisthan market in

summer (7.67%), then Jatrabari and kawranbazar market in winter (7.33%), then Kawranbazar in summer season (4%) and the lowest in summer season at Jatrabari market (3.67%). The severity was also significantly varied in January to December 2015. The highest severity was observed in rainy season at Gulisthan market (27.33%), then Kawranbazar market in rainy season (22.33%), then Jatrabari market in rainy season (16.67%), then Gulisthan market in summer season (9.67%), then Gulisthan market in winter season (9%), then Jatrabari market in summer season (6.67%), then Kawranbazar market in winter season (5.67%), then Jatrabari market in winter season (5.33%) and the lowest was observed at Kawranbazar market in summer season (5%) (Table 29).

Table 29. Incidence and severity of basal rot of Aloe vera in post harvest condition

Seasons and market		Disease Incidence	Disease Severity
Seasons	Winter	8.22 b	6.67 b
	Summer	5.11 c	7.11 b
	Rainy season	13.78 a	22.11 a
LSD (0.05)		1.65	1.77
Level of Significance		**	**
Markets	Kawranbazar	8.67 b	11.00 b
	Gulistan	11.22 a	15.33 a
	Jatrabari	7.22 b	9.56 b
LSD (0.05)		1.65	1.77
Level of Significance		**	**
Combination	WK	7.33 c	5.67 e
	WG	10.00 bc	9.00 d
	WJ	7.33 c	5.33 e
	SK	4.00 d	5.00 e
	SG	7.67 c	9.67 d
	SJ	3.67 d	6.67 de
	RK	14.67 a	22.33 b
	RG	16.00 a	27.33 a
	RJ	10.67 b	16.67 c
LSD (0.05)		2.86	3.07
Level of Significance		*	**
CV%		18.29	14.83

Each data represents the mean value of three replications. Values with the same letter within a column are not significantly different according to least significant difference.
* denotes significant at 0.05 level of probability, ** denotes significant at 0.01 level of probability, NS denotes Not significant
WK- Winter-Kawranbazar, WG-Winter-Gulisthan, WJ-Winter-Jatrabari
SK-Summer-Kawranbazar, SG-Summer-Gulisthan, SJ-Summer-Jatrabari
RK-Rainy season-KAwranbazar, RG-Rainy season-Gulisthan, RJ-Rainy season-Jatrabari

4.3.1.4 Bacterial leaf rot of Aloe vera

A. Symptomological study

The symptom was similar as the symptom of bacterial rot disease of Aloe vera observed in the field and nursery as described before.

B. Identification of causal organism

The causal organism was identified as *Bacteria* sp. This causal organism was same as the causal organism that was identified in the infected plant from the field and nursery condition.

C. Incidence and severity of Bacterial rot of aloe vera

In post harvest condition the incidence of bacterial rot of aloe vera varied significantly from January, 2015 to December, 2015 and that ranged from 4.33% to 13.78%. The highest incidence (13.78 %) was recorded in rainy season which is significantly varied with summer (5.33%) and winter (4.33%) season in 2015. The disease severity of bacterial rot also varied significantly from January, 2015 to December, 2015. The highest (30.78%) severity was found in rainy season which is significantly varied from the disease severity of summer (13.89%) and winter season (14.56%) in 2015 (Table 30).

In case of market disease incidence and severity also varied significantly from January 2015 to December 2015. The incidence was highest at Gulisthan market (9.78%) which is significantly varied with Kawranbazar market (6.89%) and lowest in Jatrabari market (6.78%). The disease severity was highest at Gulisthan market (23.89%), which is significantly varied with Jatrabari market (15.89%) and Kawranbazar market (19.44%). In case of disease severity all are statistically significant to each other (Table 30).

In case of combination factor bacterial rot disease was significantly varied in January to December 2015. The highest disease incidence was observed in rainy season at Gulisthan market (16.67%) followed by Kawranbazar market (13.67%) and Jatrabari market (11%). In summer the highest disease incidence was Gulisthan market (6.33%) followed by Jatrabari market (5.33%) and Kawranbazar market (4.33%). In winter season the disease

incidence was lowest in Kawranbazar market (2.67%) where as Jatrabari market showed (4%) and Gulisthan market (6.33%). The severity was also significantly varied in January to December 2015. The highest severity was observed in rainy season at Gulisthan market (37.67%) followed by Kawranbazar market (31.67%) and Jatrabari market (23%). In summer season the highest disease severity was Gulisthan market (16.33%) followed by Kawranbazar market (13%) and Jatrabari market (12.33%). In winter season the disease severity was lowest in Jatrabari market (12.33%) where as in Kawranbazar market (13.67%) and Gulisthan market in summer season (16.33%) (Table 30).

Table 30. Incidence and severity of Bacterial rot of Aloe vera in post harvest condition

Seasons and market		Disease Incidence	Disease Severity
Seasons	Winter	4.33 b	14.56 b
	Summer	5.33 b	13.89 b
	Rainy season	13.78 a	30.78 a
LSD (0.05)		1.11	2.19
Level of Significance		**	**
Markets	Kawranbazar	6.89 b	19.44 b
	Gulistan	9.78 a	23.89 a
	Jatrabari	6.78 b	15.89 c
LSD (0.05)		1.11	2.19
Level of Significance		**	**
Combination	WK	2.67 f	13.67 ef
	WG	6.33 d	17.67 d
	WJ	4.00 ef	12.33 f
	SK	4.33 ef	13.00 ef
	SG	6.33 d	16.33 de
	SJ	5.33 de	12.33 f
	RK	13.67 b	31.67 b
	RG	16.67 a	37.67 a
	RJ	11.00 c	23.00 c
LSD (0.05)		1.93	3.79
Level of Significance		**	**
CV%		14.28	11.12

Each data represents the mean value of three replications. Values followed by the same letter within a column are not significantly different according to least significant difference.

** denotes significant at 0.01 level of probability, NS denotes Non significant

WK- Winter-Kawranbazar, WG-Winter-Gulisthan, WJ-Winter-Jatrabari

SK-Summer-Kawranbazar, SG-Summer-Gulisthan, SJ-Summer-Jatrabari

RK-Rainy season-KAwranbazar, RG-Rainy season-Gulisthan, RJ-Rainy season-Jatrabari

CHAPTER 5

DISCUSSION

Medicinal plants are grown in natural condition in Sher-e-Bangla Agricultural University, Dhaka. Islam *et al*. (2014) described about 25 families and 29 species of medicinal plants at Sher-e-Bangla Agricultural University which was surveyed during August 2011 to October 2012. Moreover, there are two medicinal plants germplasm area in this university. There are around twenty nurseries in Sher-e-Bangla Nagar where medicinal plants are sold commercially. The largest whole sale market in Dhaka city Kawranbazar, Gulisthan, Jatrabari were alsosurveyed for taking data on post harvest diseases. During this survey ten medicinal plants viz., Ghritakumari, Akondo, Arshogondha, Basak, Dadmordan, Dhutra, Guloncha, Asma lota, Tulshi, Ulot kombal were observed in field condition and only Aloe vera plants were surveyed in nursery and post harvest condition because of their availability.

Aloe vera is the most familiar and highly usable medicinal plants in Bangladesh. During this survey six diseases were found in aloe vera in nursery and field condition. The diseases were Alternaria leaf spot caused by *Alternaria* sp., Curvularia leaf spot caused by *Curvularia* sp., basal rot caused by *Fusarium* sp., anthracnose caused by *Colletotrichum sp.*, tip blight disease caused by *Alternaria* sp. and bacterial leaf rot (soft rot) caused by a bacterium. In post harvest condition only four diseases ware observed. They were Alternaria leaf spot, Curvularia leaf spot, basal rot and bacterial rot.

The most common disease of aloe vera plant was leaf spot. This leaf spot was caused by three pathogens. They were *Alternaria* sp. *Curvularia* sp. *and Colletotrichum* sp.

In field condition, in case of Alternaria leaf spot, the highest disease incidence and severity were 17.67% and 18% in rainy season, respectively. However, the lowest incidence and severity were 5% and 3.33% in winter season, respectively. In nursery the

highest disease incidence and severity were 36.33% and 14.33% in rainy season, respectively. However, the lowest incidence and severity were 12.33% and 4.67% in winter season, respectively. In post harvest condition the highest disease incidence and severity were 20.67% and 12.44% in rainy season, respectively. However, the lowest incidence and severity were 6.44% and 6.33% in winter season respectively. In case of market factor, the highest disease incidence (14.89%) and severity (10.11%) was observed in Gulisthan market and the lowest disease incidence (10.33%) and severity (6.78%) was observed in Jatrabari market. In combination factor, the highest disease incidence (23.33%) and severity (14.33%) was observed at Gulisthan market in rainy season and the lowest disease incidence (5.33%) and severity (4.33%) was observed at Jatrabari market in winter season.These reports were similar to the report of Ghosh and Banerjee (2014). They found the *Alternaria brassicae was the* causal fungal pathogen for leaf spot. The disease intensity was peak from April to July (83.28%-95.71%). The minimum percentage of disease intensity was recorded in December (25.71%-50%) of four study areas.Similarly a survey conducted on fungal diseases of medicinal plants in Osmanabad district of Maharashtra during 2011, scientists observed leaf spot disease of *Aloe vera*. They reported three pathogens were associated with the disease namely *Alternaria alternata*, *Alternaria tenuissima and Fusarium* sp. The disease was found during rainy season and winter but absent in summer (Chavan and Korekar, 2011). From other states of Southern India the disease with same type of symptoms was reported by other workers. Leaf spot disease was found (caused by *Alternaria alternata*) in *Aloe barbadensis* in India (Kamalakannan *et al*., 2008). *Alternaria* sp. pathogen is mostly active in wet seasons and in areas with relatively high rainfall (Humpherson*et al*., 1989). Infection of Aloe vera by *Alternaria brassicae* not only reduces the crop loss and market value but it may reduce antioxidant property and other medicinal efficacy of the herb (Pritam and Kale, 2007).

The Curvularia leaf spot was also an important disease of Aloe vera. In field condition, in case of Curvularia leaf spot, the highest disease incidence and severity were 16% and 12.33% in rainy season respectively. However, the lowest incidence and severity were 6.33% and 5% in winter season respectively. In nursery the highest disease incidence and

severity were 15.67% and 12.67% in rainy season respectively. However, the lowest incidence and severity were 7.67% and 6.67% in winter season respectively. In post harvest condition, the highest disease incidence and severity were 12.11% and 11.67% in rainy season, respectively. However, the lowest incidence and severity were 3.78% and 5.44% in winter season, respectively. In case of market factor, the highest disease incidence (9%) and severity (9.78%) was observed in Gulisthan market and the lowest disease incidence (6.33%) and severity (6%) was observed in Jatrabari market. In combination factor, the highest disease incidence (14.33%) and severity (14.33%) was observed at Gulisthan market in rainy season and the lowest disease incidence (3%) and severity (4%) was observed at Jatrabari market in summer season. Avasthi *et al.* (2015) also found leaf spot of Aloe vera caused by *Curvularia* sp. which was happened during winter and rainy season. Their experiment was conducted in 2013- 2014.But during this research work in 2015 Curvularia leaf spots were found in all season in Dhaka, Bangladesh. They ware increasing with the increase of moisture and temperature. *Curvularia* is a filamentous fungus reported to cause various diseases on different plant hosts. Leaf spot disease caused by *C. lunata* and *C. ovoidea* affects the quality and quantity of aloe veraleaf gel (Avasthi*et al.*, 2015). Jat *et al.* (2013) also reported severe form of leaf spot disease on aloe veracaused by *C. lunata.*Although, *Carvulria* sp. has already been reported from Indian province, there are no reports available for Bangladesh. To the best of author knowledge, this is the first report of leaf spot disease on Aloe vera caused by *Curvularis* sp. from Bangladesh.

Another disease of Aloe vera was anthracnose. During this survey in nursery and field condition anthracnose disease was observed more in rainy season and less in winter. Moreover, in postharvest condition the disease incidence was absent. In rainy season the disease incidence and severity were 12.33% and 14.67%, respectively. However, disease incidence and severity were 4.67% and 6%, respectively in winter season. In nursery, disease incidence and severity were 12.33% and 24.46%, respectively while in winter season disease incidence and severity were 4.33% and 6.67%, respectively. Avasthi *et al.* (2011) reported that during the survey of various nurseries of Gwalior city, India, a typical anthracnose symptom on the leaf surface of *Aloe vera* was observed in the month

of August, 2010. Some instances of anthracnose disease of *Aloe vera* caused by *Colletotrichum* sp. was also reported from Lucknow (Alam *et al*., 2007). Although the anthracnose disease of Aloe vera was reported in the other countries but there were no reportsavailable for Bangladesh. To the best of author's knowledge, this is the first report of anthracnose disease on Aloe vera in Dhaka, Bangladesh.

The basal rot is also a common disease of Aloe vera plant. During this survey in field condition the highest disease incidence and severity in the field were 12% and 21.67 % in rainy season. However, the lowest disease incidence and severity were 6.33% and 14% in winter season. In nursery, the highest disease incidence and severity were 12.33% and 16% in rainy season. However, the lowest disease incidence and severity were 4.67% and 8.33% in winter season. In post harvest condition, the highest disease incidence and severity were 13.78% and 22.11% in rainy season, respectively. However, the lowest disease incidence was 5.11% in summer but the lowest disease severity was 6.67% in winter season. In case of market factor, the highest disease incidence (11.22%) and severity (15.33%) was observed in Gulisthan market and the lowest disease incidence (7.22%) and severity (9.56%) was observed in Jatrabari market. In combination factor, the highest disease incidence (16%) and severity (27.33%) was observed at Gulisthan market in rainy season and the lowest disease incidence (3.67%) was at Jatrabari in summer season and severity (5%) was observed at Kawranbazar market in summer season. Ayodele and Ilondu (2008) reported that, fungi associated with base rot disease of Aloe vera in Niger Delta area of Nigeria. The percentage frequency of the fungi *Fusarium oxysporum* was 24.24%. Rajendran and Gnanavel (2008) reported the root rot disease caused by *Fusarium* sp. Besides, Fusarium rot disease of Aloe verawas reported from Bali (Kuwari *et al.*, 2012). Khadka and Rawal (2014) reported the association of *Fusarium oxysporum* species with Aloe vera leaf and basal rot disease in Western Terai of Nepal. The highest incidence of leaf rot disease was observed in Bankatii village with disease incidence by 50%, while the lowest one was observed in Manakamana with disease incidence by 21%.

Tip blight disease was a common incidence in Aloe vera plants. During the survey tip blight was happened throughout the year. The disease incidence and severity were highest in rainy season and lowest was in winter season. The disease incidence and severity in rainy season were 21.67% and 17.33%, respectively, while in winter season disease incidence and severity were 9.67% and 12% respectively. During survey the rainy season was abundant moisture and the temperature was high so the incidence was also high. Although the severity was statistically same in all season of the year 2015. The causal organism was found *Alternaria sp.* and to the best of author knowledge, this is the first report of tip blight of Aloe vera plant from Bangladesh.

The another important disease of Aloe vera plant is bacterial leaf rot which incidence and severity was highest in rainy season and the lowest was in winter season. During this survey, in field condition, the disease incidence in rainy season was 12.67% and disease severity was 25.67%. Moreover, in winter season disease incidence and severity were 4% and 13.33%, respectively. In nursery, the highest disease incidence and severity were 10% and 75% in rainy season. However, the lowest disease incidence and severity were 2.67% and 13.33% in winter season. In post harvest condition, the highest disease incidence and severity were 13.78% and 30.78% in rainy season, respectively. However, the lowest disease incidence was 4.33% in winter but the lowest disease severity was 13.89% in summer season. In case of market factor, the highest disease incidence (9.78%) and severity (23.89%) was observed in Gulisthan market and the lowest disease incidence (6.78%) and severity (15.89%) was observed in Jatrabari market. In combination factor, the highest disease incidence (16.67%) and severity (37.67%) was observed at Gulisthan market in rainy season and the lowest disease incidence (2.67%) was at Kawranbazar in winter season and severity (12.33%) was observed at Jatrabari market in winter summer season. Bacterial leaf rot disease was first reported from the Caribbean island of Aruba (de Laat*et al.*, 1994). Rajendran and Gnanavel (2008) reported black or sooty mold disease of *Aloe vera* L. They also reported bacterial leaf rot disease of aloe vera caused by *Erwinia chrysanthemi.* According to Mandal and Maiti (2005) a new leaf rot disease of Aloe vera (*Aloe barbadensis*) was observed for the first time in Gujarat, India, in 2000. The disease was serious when abundant moisture was available.

The Akono leaf spot disease was observed during the time of winter season. The highest disease incidence and severity were 12% and 30%, respectively. On the other hand this disease incidence and severity were less (4.33% and 4%, respectively) in summer and during rainy season it was very less (1.33% and 2.33%, respectively). The *Alternaria* sp. was the causal organism which caused severe leaf spot followed by leaf blight and huge defoliation. Sain *et al*. (2009) first reported the leaf spot disease of *Calotropis gigantea* caused by *Alternaria alternata* in Rajasthan, India. In January and February 2005, they observed a leaf spot epidemic growing on wasteland sites near the Sikar district of Rajasthan, India. Disease incidence was greater than 80% and shrubs suffered extensive defoliation. This report is quite similar with this research while the incidence was also occurred in winter season (December to February, 2015). Repeated isolation was done and every time *Alternaria* sp. was identified as the causal organism of Akondo leaf spot disease. To the best of author knowledge, it is the first report from Bangladesh.

The leaf spot is the common disease of Arshawgondha. The incidence and severity was high in winter season most possibly from the late winter to early summer (February-March) in Bangladesh. The incidence and severity were 21.67% and 12.33%, respectively. On the other hand, the incidence and severity were lowest in winter season and it was 2.33% and 3.33%, respectively. Being an annual plant during this time the plant became mature and the lifecycle was nearly complete. The pathogens infection on leaf was significantly found in winter season, less in summer season and very less in rainy season. Maiti *et al*. (2007) first reported of *Alternaria dianthicola* causing leaf blight on *Withania somnifera* from India. Leaf blight disease of this plant generally occurs during the month of March in various districts of South Bengal, India. Repeated isolation and pure culture was carried out and the causal organism was found *Alternaria* sp. in Arshawgondha leaf spot which was turned into leaf blight in severe stage. To the best of author knowledge, it was the first report of Arshawgondha leaf spot disease from Bangladesh.

In Bashok plant two diseases were observed. They were Alternaria leaf blight and Cercospora leaf spot. The incidence was high in winter season, exactly in late winter

season. The highest disease incidence and severity ware 12% and 17.67%, respectively. Singh and Verma (2009) studied the incidence of Alternaria blight caused by *Alternaria alternate* in *Adhatoda vasica* (*Justicia adhatoda*) plantations in Jaipur and Sikar districts, Rjasthan, India. They studied during October 2003-04. Disease incidence was greatest (between 26.25 and 32.25%) on 19 March in Sikar and 23 March in Jaipur; the temperatures during these periods were 26.87 and 23.10°C, and the humidity levels were 59.75 and 60.25%, respectively. They observed the disease intensity was lowest in June at both locations, when the temperature was more than 34°C and the humidity was less than 44%. However, during this experiment time in 2015 the average temperature in winter was 20.5° C, average precipitation was 16.67 mm and average relative humidity was 72%. Most possibly this environment accelerated this disease development. The disease happened less in summer (disease incidence and severity were 5.66% and 11%, respectively) and very less in rainy season (disease incidence and severity were 1.66% and 6%, respectively). This time heavy rainfall and high temperature were present. The foliage became more vigorous and proliferation of new leaves was occurred. So the disease incidence and severity of Alternaria leaf blight were less at that time. However, repeated isolation and pure culture was done and *Alternaria* sp.was found as a causal organism for leaf blight of Bashok plant. To the best of author knowledge, it is the first report of leaf blight of Bashok plant from Bangladesh.

The Cercospora leaf spot of *Adhatoda vasica* was also observed much in winter season. Excessive incidence and severity caused defoliation of the plats. The highest disease incidence and severity were observed in winter (26.33% and 16.33%, respectively). During summer it occurred very less (disease incidence and severity were 1.67% and 7.33%, respectively) while in rainy season no incidence was observed. Kadam *et al.* (2012) identified on the basis of growth pattern, hyphal details and spore type. They mentioned *Cercospora adhatodae* is responsible for the leaf spot of *Adhatoda vasica.*

The leaf blight of Dadmordon (*Cassia alata*) plant was observed in early winter to winter season. During this time the leaves become old and susceptible to the blight diseases. In winter season, the incidence and severity of the disease were 17.67% and 12.67%,

respectively. In summer and rainy season disease incidence and severity were significantly less than winter season and there was no variance of disease intensity in summer and rainy season. Shamsi *et al*. (2014) observed a total of 8 species of fungi belonging to 8 genera of Deuteromycetes in Dhaka, Bangladesh which were associated with *Senna alata* (*Cassia alata*). The fungi were *Acromoniella* sp., *Arthrinium saccharicola, Aspergillus niger*, *Cladosporium cladosporioides, Colletotrichum gloeosporioides*, *Curvularia lunata*, *Nigrospora sphaerica, Pestalotiopsis guepinii* and unidentified Hyphomycetes, *C. gloeosporioides* and *P.guepinii* but they did not mention the *Alternaria*sp.however,in this experiment repeated isolation and pure culture were done and every time the *Alternaria* sp. was isolated from the diseased part. To the best of author knowledge, it is the first of report from Bangladesh that leaf blight of *Cassia alata* was caused by *Alternaria* sp.

The leaf spot of Dhutra (*Datura metel*) was caused by *Alternaria* sp. This symptom was found rarely in this surveyed time. The disease incidence was heighest in summer season (4.33%) and the lowest was in winter season (2.33%), which was not significantly varied but the disease severity was varied in summer to winter. the severity was heighest in summer (17.67%) and lowest in winter (7.67%). The severity was not significantly varied in rainy season (10%) with winter season. Aktaruzzaman *et al*. (2013) collected leaf spot disease samples of *Datura metel* from Gangneung, Gangwon Province, Korea. They observed serious leaf spot disease in the month of March, 2013. During this survey the leaf spot of *Datura metel* was observed in summer season that was happenedin April to June 2015. However, repeated isolation and pure culture was done. *Alternaria* sp. was identified as a causal organism for the leaf spot followed by leaf blight of Dhutra (*Datura metel*) plant. To the best of author knowledge, it was the first report of leaf spot of *Datura metel* from Bangladesh.

In Gulancha (*Tinospora cordifolia*) plant two diseases ware observed. They were Alternaria leaf spot and Cercospora leaf spot. The Alternaria leaf spot was observed highly in the rainy season. The disease incidence and severity were 12.33% and 14% respectively. The disease occurred lowest in summer season. The incidence and severity

were 4.33% and 6.67%, respectively. The incidence (7.33%) of this disease was occurred in winter which is statistically varied with rainy season but similar with summer season. The disease severity in winter season (12.33%) was statistically similar with rainy (14%) season. Shivanna *et al*. (2014) reported the Phoma leaf spot disease of *Tinospora cordifolia* and its effect on secondary metabolite production. A three-year (August 2006–July 2009) study of the disease due to the pathogen indicated that the disease incidence (DI) ranged from 0 to 100% (maximum in Kakanahasudi), while disease severity (DS) ranged from 1.60 to 45% (maximum in Madhuguni). The environmental parameters like rainfall and relative humidity (RH) correlated significantly with DI and DS, while temperature correlated negatively. The regression analysis indicated that DI and DS were affected due to increase in RH and decrease in temperature and rainfall. Mishra *et al.* (2012) in India reported the frequency of colonization (CF) varied more strongly among tissue type and season than location. CF was maximal during monsoon followed by winter and minimal during summer. In this experiment the *Alternaria alternata* caused 6.8% disease. These findings are similar to the author's findings. The author found it as the first of report from Bangladesh.

Another disease of Gulancha is Cercospora leaf spot. The disease incidence (17.67%) and severity (32.67%) was highest in rainy season which is significantly varied with winter and summer season. The incidence and severity was same in winter and summer season. The incidence was 3%, 3.33% and the severity was 6% and 7.67%, respectively. The disease was observed in other countries. Gupta and Verma (1987) reported leaf spot diseases on *Tinospora cordifolia* caused by *Cercospora madhauliensis,* Braun (2013). *Tinospora cordifolia* leaf spot is amphigenous, sub circular to irregular, blackish brown, scattered along the veins, about 16 mm in diameter caused by *Pseudocercospora tinosporae.* It is the first report of *Tinospora cordifolia* leaf spot from Bangladesh.

The leaf spot of Mikania lota was caused by *Alternaria* sp. The incidence (17.33%) and severity (23.33%) was height in rainy season which was significantly varied with summer and winter season. Their incidence of summer (9.67%) and winter (4%) were significantly varied and severity of summer (8.67%) and winter (8.33%) were not varied.

Wu and *et al.* (2013) reported three species of *Makania.* They are *M. cordifolia*, *M. scandens* and *M. micranta.* They mentioned some pathogens name which causes the foliar diseases of *Makania* species such as *Alternaria*, *Fusarium*, *Colletotrichum* etc. However, to the best of author knowledge, it was the first of report from Bangladesh.

Tulshi is a common medicinal plant in this sub continent. Leaf spot and leaf blight are the common diseases of this plant. During thissurvey in 2015 leaf spot disease was found which was turned into blight symptom. The causal organism was identified as *Alternaria* sp. The incidence was highest in rainy season, the disease incidence and severity was 14% and 17.67%, respectively. While the incidence in summer was 12.33% which was similar to rainy season and in winter season, disease incidence was 5% which was significantly varied with rainy season. The severity of the disease was significantly varied with each other. The disease severity in summer and winter season was 12.33% and 3.33%, respectively. Banerjee and Ghosh (2015) reported fungal disease of some important medicinal plants in West Bengal. They observed leaf blight of *Ocimum sanctum* caused by *Alternaria* sp. in January-December, 2013 and 14. Their study indicated that maximum disease intensity range (44.61%-76.66%) was between the months of July to September in all four studied areas. It was probably due to high temperature and moisture (26-38 °C and humidity 85-100%) as per record obtained from Alipore Metereological Data Station (West Bengal). Moreover minimum percentage of disease intensity (12.30-37.50%) was recorded during December-January in all four studied areas. During this time temperature and moisture are low (10- 26 °C and humidity 65-84%) and not so favorable to the fungal pathogen. Leaf blight disease of *Ocimum basilicum* was first reported from Japan (Taba *et al.*, 2009). In Italy the same disease was reported by Gariboldi *et al.*, in 2011. This blight disease caused by *Alternaria* sp. is first reported in Bangladesh.

The Ulotkambol is another important medicinal plant. However leaf spot was found in the leaf and the pathogen was identified as *Alternaria* sp. the incidence of this disease was very little and did not significantly varied with season but severity was varied significantly. The severity was highest in summer season 26.67%, second highest in

winter season 15.33% and the lowest was 7.33% in winter season. Leaf spot caused by *Alternaria* sp. is first reported in Bangladesh.

Depending on the disease incidence and severity, the major diseases of infected medicinal plants are; leaf spot, tip blight, basal rot, bacterial leaf rot of Aloe vera; leaf spot of Arshogondha; Cercospora leaf spot of Bashok and Guloncha.

CHAPTER 6

SUMMARY AND CONCLUSION

Three experiments were conducted in field, nursery and post harvest condition of medicinal plants in Dhaka, Bangladesh during January 2015 to December 2015. Very few research works were done on the disease of medicinal plants in Bangladesh. The main objectives of these experiments were to identify the diseases of medicinal plantswith causal organisms and to measure the disease incidence and severity. In field condition, ten important medicinal plants viz. *Aloe barbadensis, Calotropis gigantean, Withania somnifera, Adhatoda vasica, Cassia alata, Datura metal, Tinospora cordifolia, Mikania scandens, Ocimum sanctum, Abroma augusta*ware included. In nursery and postharvest condition only *Aloe barbadensis* was considered for disease survey. The disease incidence and severity were measured in three major seasons (winter, summer and rainy season) considering the weather conditions.

Then the samples were incubated in moist blotter paper and nutritive media following tissue planting method to isolate the causal organisms. The pathogens were observed in stereo and compound microscope and transferred into pure culture. The diseases were identified based on the symptomological and causal organisms. The causal organisms of the disease were detected and identified as CMI (Commonwealth Mycological Institute) description and other related articles. However, repeated isolation and observation was carried out to confirm the pathogen but Kotch's postulates were not done because of limitation of time and materials. The data of disease incidence and severity was analyzed by using MSTAT-C and the mean difference was judged by Least Significant Difference (LSD).

During this survey, six diseases of *Aloe barbadensis* (Ghritokumari) were found and they were Alternaria leaf spot, Curvularia leaf spot, basal rot, bacterial rot, anthracnose and tip blight. Their causal organisms were identified *Alternaria* sp., *Carvularia* sp., *Fusarium* sp., *Bacteria* sp., *Colletotrichum* sp. and *Alternaria* sp., respectively. In *Calotropis gigantean* (Akondo) plant for leaf spot disease *Alternaria* sp., in *Withania somnifera*

(Arshogondha) plant forleaf spot *Alternaria* sp., in *Adhatoda vasica* (Bashok)plant leaf blightand leaf spot caused by *Alternaria* sp.and *Cercospora* sp, in *Cassia alata* (Dadmordon) plantfor leaf blight *Alternaria* sp. in *Datura metal* (Dhutra) plant for leaf spot *Alternaria* sp., in *Tinospora cordifolia* (Guloncha) for leaf spot *Alternaria* sp.and *Cercospora* sp., in *Mikania scandens* (Asma lota) plant for leaf spot *Alternaria* sp.in *Ocimum sanctum* (Tulshi) plant for leaf spot and blight *Alternaria* sp. and in *Abroma augusta* (Ulotkombol) plant *Alternaria* sp. was identified.

Analyzed report showed that most of the cases disease incidence and severity were varied significantly in season to season. Some plant diseases were occurred highly in rainy season, some diseases were occurred more in winter and some were in summer season. The *Aloe barbadensis, Tinospora cordifolia, Mikania scandens* and *Ocimum sanctum* plants disease were occurred highly in rainy season. *Calotropis gigantean, Withania somnifera, Adhatoda vasica* and *Cassia alata* plants diseases were occurred highly in winter season while *Abroma augusta* and *Datura metal* plants diseases was observed more in summer season though last two plants diseases were not statistically dissimilar with other season but it gives us an information about the disease condition of those medicinal plants. This variation may be occurred due susceptibility of the host, seasonal factors, over wintering and over summering, presence of secondary host, life cycle of both host and pathogen, proximity and availability of the host and pathogen etc.

However, further research should be carried out to accelerate this type of outstanding research. It is necessary to check the findings of this investigation in different places of our country as well as in Dhaka. Here the causal organism only identified up to genus but it is not sufficient, mare morphological and cultural study is not enough to identify a pathogen accurately. So pathogenicity test, like Kotch's postulates and molecular level examination should be conducted to identify the pathogen species. Moreover, it may be a great source of employment and a good product for exportation. Pest risk analysis also essential to make a quarantine certificate. Research should be going on to develop the management practices of medicinal plants. Proper management and cultural practices may increase the production rate and help to reduce the threat of extinct.

All drugs are obtained from plants and animals. So that medicinal plants are the blessing for the mankind. Every creature of the world is directly or indirectly depends on medicinal plants. It is not only used for its medicinal value but also used as an aesthetic and toiletries purpose.

This research is a primary research about medicinal plants. As a fundamental research it will be a fruitful work, when medicinal plants will cultivate like a cash crop and/or main crop. Then these types of findings may pave the way of higher research. Who knows, that in future this research may be considered as the pioneer of medicinal plants disease investigation and management?

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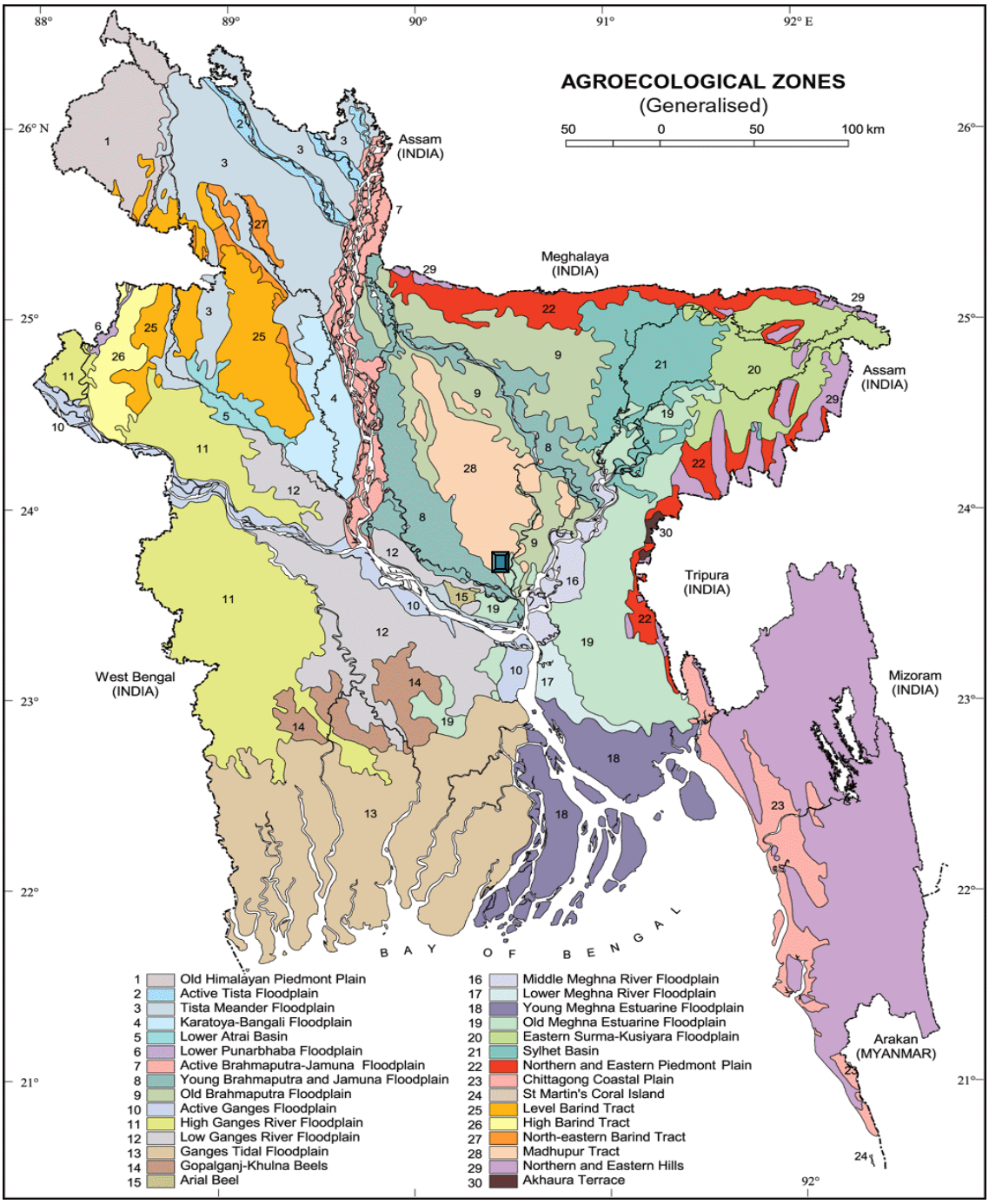
APPENDICES

Appendix I. Map showing the experimental site under the study

The experimental site under study



Appendix I I. List of medicinal plants, usable parts and their uses

Sl no	Bengali name	Scientific name	Usable parts	Uses
1	Ghritakumari	*Aloe indica*	Extract of leaf	Headache, sexual disease, metabolic problem. Fever.
2	Akondo	*Calotropis gigantea*	Root, leaf. Bark flower extract of leaf.	Ulcer, Tooth pain chronic dysentery, cold, Asthma,
3	Arshogondha	*Withania somnifera*	Leaf, root,	Headache, sexual disease, energatic
4	Basak	*Adhatoda vasica*	Leaf, root of plant	Cough,asthma, tuberculosis,cold, blood refine.
5	Dadmordan	*Cassia alata*	Leaf	Skin disease, poisonous.
6	Dhutra	*Datura metel*	Root, Leaf, Seed.	Pain killer worn killer, poisonous
7	Guloncha	*Tinospora cordifolia*	Leaf	Diabetics, skin diseases, antimicrobial
8	Asma lota	*Mikania scandens*	Leaf	Bleeding control, Dysentery, Daud etc.
9	Tulshi	*Ocimum sanctum*	Leaf	Antiviral, cough
10	Ulot kombal	*Abroma augusta*	Root, Bark and Leaf.	Vaginal pain sexual disease.

Source: '*Veshoj Udvider Chash'* by Kbd. Nurul Huda Al Mamun

Appendix III. Composition of PDA media

Material	**Volume**
Distilled water	1000 ml
Potato	200 g
Dextrose	20 g
Agar	20g

Appendix IV. Composition of NA media

Material	**Volume**
Peptone	5 g
Beef extract	3 g
Sodium chloride	8 g
Agar	15 g
Distilled water	1000 ml