SEEDLING DISEASES OF MANGO (*Mangifera indica*) IN DHAKA AND MANIKGONJ

A THESIS

BY

MOHAMMAD AMINUL ISLAM
REGISTRATION NO. 00879/2000-2001

MASTER OF SCIENCE (M.S.)
IN
PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
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CERTIFICATE

This is to certify that thesis entitled "**SEEDLING DISEASES OF MANGO (*Mangifera indica*) IN DHAKA DIVISION**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of *MASTER OF SCIENCE IN PLANT PATHOLOGY* embodies the result of a piece of bonafide research work carried out by Mohammad Aminul Islam, Registration No. 00879/2000-2001 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.

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

Dated:
Dhaka, Bangladesh

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Dedicated to

My Beloved Mother

&

Heavenly Father

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SEEDLING DISEASES OF MANGO (*Mangifera indica*) IN DHAKA AND MANIKGONJ

By
Mohammad Aminul Islam

ABSTRACT

Occurrence and prevalence of diseases of mango was studied in five nurseries located at Dhaka and Manikgonj during January to October, 2007. Altogether six diseases were recorded during the survey. The diseases, in order of prevalence (Incidence and Severity) were Anthracnose (51.14% and 37.39%), Alternaria leaf spot (47.14% and 32.55%), Powdery mildew (33.30% and 26.03%), Red rust (24.05% and 13.05%), Sooty mould (10.50% and 10.95%) and Bacterial leaf spot (9.75% and 10.12%). Three fungi- *Colletotrichum gloeosporioides, Alternaria alternaae* and *Oidium mangiferae and* an alga- *Cephaleuros virescencs* were identified from Anthracnose, Altermaria leaf spot and Powdery mildew *and* Red rust infected leaves respectively. However, Sooty mould and Bacterial leaf spot were recorded only on the basis of symptoms observed. The prevalence of the recorded six diseases varied to each other with respect to nursery and its location. Positive correlation was observed between prevalence of Anthracnose and Alternaria leaf spot with temperature and relative humidity. The highest prevalence of Anthracnose and Alternaria leaf spot was observed in October and lowest in January. Negative correlation was observed between prevalence of Red rust and incidence of Powdery mildew. The highest prevalence of Red rust and Powdery mildew was in the month of March, but the disease was observed in October. Report on Alternaria leaf spot first of its kind in mango seedling in the country.

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LIST OF ABBREVIATIONS

%	=	Percent
°C	=	Degree Centigrade
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
DMRT	=	Duncan's Multiple Range Test
et al.	=	And Others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
hr	=	Hour(s)
LSD	=	Least Significant Difference
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
Viz	=	For example

Chapter 1
Introduction

CHAPTER-I

INTRODUCTION

Mango (*Mangifera indica* L.) belongs to family Anacardiaceae is one of the most important popular and delicious fruits grown throughout the tropics and sub-tropics of the world. It was thought to be originated in the region of Eastern Indo-Bangladesh, Myanmar, Malaysia (Anonymous, 1989). According to Mukherjee (1958), its natural spread was limited to the Indo-Malaysian region, stretching from India to the Philippines and New Guinea in the east. Mango is being cultivated for more than 4000 years (Candole, 1984). It is considered as the class one fruit in the country. Popenoe (1964) mentioned mango as "the king of the oriental fruits". It is widely grown all over Bangladesh; while the quality mangoes solely concentrated in the north-west areas, especially greater Rajshahi, Dinajpur and Rangpur (Karim, 1985). It ranks third among the tropical fruits grown in the world with a total production of 28.85 million tons (FAO, 2002). In Bangladesh, mango ranks second fruit in terms of area cultivated and third in production. The country produced 640 thousand tons of mangos in 25.91 thousand ha of mango orchard during the period of 2005-06 (BBS, 2006). In Bangladesh, there exists a wide variability in mango due to its cross pollination and seed propagation. Altogether 55 germplasms of mango have been characterized as per IPGRI descriptor utilizing 56 characters (Anonymous, 2003).Besides, a number of unrecognized local varieties available in Bangladesh.

It is a popular fruit in the country having some special organoleptic features such as excellent flavor, pleasant aroma, attractive colour and taste. It is a rich source of

vitamins, minerals and total soluble solids (Pramanik, 1995). It is also a medium source of carbohydrate as ripe mango pulp contains 16.9% carbohydrate (Salunkhe and Desai, 1984). The minimum dietary requirement of fruit/day/head is 85g, whereas our availability is only 30-35g, which is much lower than recommended daily allowance (Siddique and Scanlan, 1995).

The demand of fruit (mango) is increasing day by day with growing population and decline in production results in scarcity every year. Disease is a major cause of lower production of mango in Bangladesh (Meah and Khan, 1987). Meah and Khan (1987) conducted a survey throughout Bangladesh and reported that mango is attacked by as many as 18 different diseases. Out of these disease anthracnose, die-back, powdery mildew, leaf spot, sooty mould and red rust are important.

Healthy and disease free seedlings are of prime need and basic raw material for establishment of orchards as well as production of mango. But seedling diseases are one of the important problems in the tropics. Although a huge number of nurseries are engaged in producing seedlings, they fail to produce high quality seedlings due to lack of knowledge about diseases. Seeds after germination are liable to attack by different soil borne and seed borne organisms. Even after emergence of the seedling, it could be attacked by different diseases which may reduce the viability of seedling or it may carry the organisms to a distant place where it is transplanted in the orchard. In severe case, diseases cause mortality of many seedlings after plantation. For these reasons, seedlings are to be reared up with proper care in order to avoid the diseases and to ensure establishment of

healthy mango orchard and eventually increasing production. Thus production of healthy seedlings ensures good plantation and save money, labour and energy of mango gardeners.

Mango seedlings suffer from various diseases in Bangladesh (Suchana, 2008), but no concrete information regarding their distribution, incidence, severity and epidemiology all over Bangladesh is available. Therefore, attempt should be put forward to study the prevalence of various diseases occurring on mango seedlings in some selected nurseries of Dhaka and Manikgonj.Considering the above facts, the present research program has been designed with the following objectives:

1. Survey on the nursery diseases of mango in selected nurseries of Dhaka and Manikgonj.
2. To identify the pathogen(s) associated with the diseases.
3. To study the epidemiology specially in relation to the effect of temperature and relative humidity on incidence and severity of nursery diseases of mango.

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Mango plants are prone to attack by many diseases at all stages of growth. The diseases of mango trees as well as fruits have been studied in Bangladesh in some details but little attention has been paid to the nursery diseases. In this Chapter, an attempt has been made to review the available literatures on symptoms of nursery diseases of mango, their causal organisms, disease status and their epidemiology.

2.1. Diseases of mango

Bitancourt and Jenkins (1943) studied symptoms of scab of mango. The disease attacked leaves twigs blossoms panicles and fruits. On these lesions were formed which varied in color and shape according to the age of the host and the country in which scab occurred. These lesion spots, on young nursery plants in Cuba, were pale to brown and covered with a delicate bull down, which represented the vegetative stage of the fungus. On older foliage, the lesions showed a larger size and wore grey in appearance, surrounded by a darker margin, and bore on their surface small dot-like structures, which were the ascomata, the perfect stage of the fungus. In Brazil, however the lesions were circular to elongated or irregular, with a grey centre and a darker periphery. These were mainly centered on the midrib or were disposed in close proximity to it. Both foregoing types of lesion had been observed in Puerto Rico, the Canal Zone, and Florida.

Suit and Du charme (1946) observed that the red rust alga attack the foliage, bark and twig of the host plant (mango, litchi etc). They also observed that in serious infection the bark become thickened and the twigs enlarged and remain stunted. Many species of *Cephaleuros* were reported to infect different host in all parts of the world.

Singh (1968) described the symptoms of anthracnose, powdery mildew, red rust, sooty mould, malformation, scab, malformation, bacterial leaf spot and gumosis.

According to Singh (1968) the thallus of red rust alga of mango was a pseudoparenchymatous tissue one to several cells in thickness, in which the cells were radially arranged. A discord mass, which grows just beneath the circular layer of epidermal cells, often has regular branches on its underside. It grows down between the cells of the epidermis and the deeper-lying tissues. The under surface of the algal mass bears numerous unbranched filaments, which project through the cuticle. Some of these erect filaments were sterile hairs, others bear a cluster of sporangia or gamentangia at their apex. Cells of both sterile and fertile hairs were usually reddish-brown.

Singh (1968) further stated that reproduction of red rust algae in mango was by means of zoospores which were formed in sporangia produced at the extremities of fertile hairs. The sporangia were borne in clusters and each lies at the end of short stalk-cell. When mature, the sporangia break away and dispersed by the wind. They produce biflagellate zoospores as soon as they were moistened. If the sporangium is one that has fallen on a leaf or twig of a suitable host, the zoospore

may germinate to form a new thallus. There were also formation biflagellate gametes within the gagametingum resulting from enlargement of certain cells in the pseudo parenchymatous portion of the thallus.

Singh (1978) described the symptoms of bacterial leaf spot of mango. In the initial stages, tiny water soaked dark brown spots appeared on leaves. Later on the spots gradually increased in area and become slightly raised. If at this juncture rain occurred, the bacterial infection increased enormously taking on an epidemic form. The affected tissue exhibited deep longitudinal cracks, exuding gum. In 1978 Singh also slated that anthracnose mostly affected the tender parts of the tree such as the young shoots, leaves, panicles, flowers and fruits. The symptoms varied according to the plant part infected. Dark brown necrotic areas were appeared on the leaves, elongated black necrotic patches on the twigs.

Pathak (1980) stated powdery mildew of mango appeared in the form of whitish or grayish powdery areas on tender foliage and inflorescence. The powdery mass consisted mainly of fungal spores. Normally infection spread from tip of inflorescence and covered the floral axis, young leaves and stem, Moreover, he described the symptoms of sooty mould of mango. The mould grew on the honey-dew secreted by hoppers, scales and coccids on leaves and twigs, and produced masses of black spores which sticks to the leaf surface. He also described the symptoms of bacterial leaf spot of mango, the small water soaked lesions appeared in groups towards the tip of the leaf blade. He also mentioned that red rust of mango could easily be recognized by the rusty-red spots mainly on leaves and

sometimes on petioles young twigs. The spots were at first greenish-grey in colour and velvety in texture. Later they turned reddish-brown

Fitzell and Peak (1984) stated that the conidia of *Colletorichum gloesporiodes* were produced in lesions on leaves, defoliated branch terminals, mummified infloresence and flower bracts over a wide range of environmental conditions(10-30^0 C, >95% relative humidity)

Mango malformation caused by *Fusarium moniliforme* was first reported from Florida in 1972. Mango malformation was not an important problem in Florida but the incidence of infection seemed to be increasing slowly. Symptoms were observed in several orchards in Dad and Palm Beach counties. Infections were most severe under usually wet conditions. A good general program of diseased and pest control kept mango malformation under control, if it was combined with prompt removal of diseased tissues from the trees (Campbell and Marlatt, 1986).

Peterson (1986) reported that anthracnose (*Colletorichum gloesporiodes*, *Glomerella cingulata*),stem end rot (*Botryodiplodia theobromae, Dothiorella dominicana and Phomopsis mangiferae*),soft brown rot (*Hendersonia creberrima*), mango malformation(*Fusarium subglutinans)*,bacterial black rot (*Xanthomonas campestris* pv. *mangiferaeindicae*) and powdery mildew (*Oidium mangiferae*) were the major diseases aspects of etiology and epidemiology.

The occurrence and severity of various disease of mango throughout the year in the porchards of Chapai Nawabganj and Rajshahi were recorded (Anonymous,

1990). It was observed that anthracnose, sooty mould and powdery mildew were predominant diseases in the orchard of the surveyed area, the highest incidence of anthracnose was observed in the variety Aswina (37.16%) and Gootee (37.8%) in Chapai Nawabganj district and the lowest in the variety Kuapahari in the same district.

Mortuza (1990) recorded the occurrences and severity of various diseases of mango from January 1990 to June 1990 in different orchards of Chapai Nawabganj and Rajshahi districts. Different diseases and their severity were recorded, infected leaves and panicles were measured at every two months. Red rust, a new disease (*Cephaleuros virescens*) was recorded. Other recorded diseases were anthracnose (*Colletotrichum gloeosporioides*), sooty mould (*Capnodium ramosum*), powdery mildew(*Oidium mangiferae*), Die-back (*Diplodia natalenis*) and malformation (unknown). The highest incidence of anthracnose was observed in Gooti and Aswina varieties by 28.95% and 28.32%, respectively in the Chapai Nawabganj district.

Ploetz *et al.*, (1994) described the symptoms of Alternaria leaf spot, Anthracnose, Gray leaf spot, Malformation, Powdery mildew, Pink disease, Red rust, Bacterial leaf spot and Scab.

Reza and Kader (1996a) conducted an experiment to evaluate 27 germplasms against the major disease of mango at Mango Research Station. Chapai Nawabganj Bangladesh. They observed the incidence of anthracnose was maximum in Rad (4.20%) and minimum in Misridagi (0.02%). Red rust was highest in Ruby and the

lowest in Baromashi (0.62%). Sooty mould was the highest in Lata Bombai, Keitt. Golapkhas, Baromashi and was free from Sooty mould. Floral malformation was the highest in Lata Bombai(60.05%), Agmamshu, Zill and Ruby were affected by vegetative malformation. Zill was susceptible to scab disease. Lata Bombai, Agmamshu, Totapuri, Gohapkhash and Misridagi were tolerant to scab disease.

Reza and Kader (1996b) conducted a survey program to record the prevalence of different diseases of mango in Chapai Nawabganj district, Bangladesh during June 1996. They found that Khir Mohanada and Kalia were free from anthracnose on leaves and shoots. Sooty mould disease was found minimum in all varieties. Lata Bombai was susceptible to red rust.At Horticulture base of Kallyanpur, Chapai Nawabganj, the variety Gopalbhog was severely infected by anthracnose and Fazli was susceptible to red rust. Infections of sooty mould were the highest in Langra.
Conde *et al.* (1997) identified *Elsinoe mangiferae*, the cause of mango scab for the first time in Australia as a result of intense investigation into Severe scarring and distortion of mangoes in the Darwin rural area of the Northern Territory. Spotting and scarring of mango fruit had been observed in the Northern Territory since about 1990 and was believed by growers to be due to a form of anthracnose caused by *Colletotrichum gloeosporioides*.

Hussein (1997) studied leaf spot of mango in El-Minia Governorate, Egypt. He isolated and identified *Alternaria altenata* ,*Cladosporium sphaerospermum* and *Epicoccum nigrum* as the causal agents of the disease. Leaf spot severity increased with increasing period after artificial inoculation of these pathogens.

Jeger *et al.* (1988) reported that anthracnose caused by *Colletotricchum gloeosporioides* (*Glomerella cingulata)* was a major constraint on the expansion of export trade in fruits such as mango

Singh (1998) described the symptoms of bacterial leaf spot of mango. Minute water-soaked lesions appeared in groups towards the tip of the leaf blade. They increased in size to about 1-4mm, brown to black in colour and surrounded by chlorotic haloes. They were surrounded by the veins. Large necrotic patches might be formed by coalescing of several lesions. The patches sometimes dried up. These patches were often rough and raised due to heavy bacterial exudate. When a greater portion of the lamina surface had been affected, the leaf fall occurred. Petioles and tender stems were also infected.

Xie and Xie (1999) observed that anthracnose disease (*Glomerella cingulata*) usually affected the leaves, flowers, fruit and new shoots of mango trees. When young leaves were attacked, many small brown round spots with faint yellow margins appeared and the badly infected leaves then curled. Infected shoots withered and dried and infected flower clusters turned black and rotted. Infected fruits were abnormal in shape, becoming black then dropping. Spraying with chlorothalonil, carbendazim, or Topsin-M (thiophanate-methyl) during the flowering and fruit growing period controlled the disease

Rivas and Edwin (2001) reported that diverse fungal parasites damaged leaves, flowers and fruits of mango (*Mangifera indica*) which may affect production. In this work, a new disease that causes defoliation in young leaves was observed.

Symptomatology was described and pathogenicity was proved by Koch's postulates. The incubation period was determined (16 h) and its colony was characterized. The aetiological agent identified was the fungus *Cylindrocladium scoparium* [*Calonectria kyotensis*]. In the pathological spectrum of mango in Cuba, similar symptoms did not occur.

Kuo (2001) reported that in order to monitor the sensitivity of the mango anthracnose fungus, *Colletotrichum gloeosporioides [Glomerella cingulata]*, to the eradicative imidazole fungicide prochloraz, a total of 43 mango orchards were surveyed throughout the Tainan area in Taiwan, covering a 4000 ha region of mango plantations.

Misra (2001) observed that powdery mildew caused by *Oidium mangiferae*, was the most important disease of mango. It was reported from 35 countries in the world and reported to cause up to 90% loss in India. Besides inflorescence infection, it caused different types of symptoms on leaves and fruits. Based on epidemiological studied and control measures conducted for the last 15 years at CISH, Lucknow (Uttar Pradesh, India), a disease cycle and an integrated disease management practice was proposed. Disease can easily be controlled by adopting suitable cultural practices and timely application of spray schedule. As the disease was weather-sensitive, need-based control measures were suggested based on the prevailing environmental conditions

Colon *et al.* (2002) reported *Colletotrichum gloeosporioides* (*Giomerella cingulata*) as cause of anthracnose in various tropical crops, including mango (*Mangifera indica*). In Puerto Rico, estimated losses in mango fruits were as high

as 75%. Intensive chemical applications used to control this disease resulted in fungicide resistance and potential environmental pollution. An alternative control could be including resistance in mango with hypovirulent (HV) isolates of *C. gloeospo*roies. Hypovirulent mutants were obtained by conidial mutagenesis using ultraviolet light. Mycelial plugs (4 mm) of HV mutants were used to inoculate the surface of detached mango fruits, either 24 or 120 h previous to the virulent isolate inoculation. Fruits were kept in humid chamber (i.e. 100% relative humidity). Lesion size was measured 8 and 14 days after inoculation with the HV mutants 120h prior to the virulent isolate inoculation and kept under shade-house virulent isolate. Lesion size was measured 4 and 10 days after inoculation with the virulent isolate. Fourteen days after inoculations, 3 HV mutants reduced lesion size in detached fruits by 50%. Locally induced resistance (in situ) was observed in middle leaves of mango seedlings. All 3 HV mutants tested reduced lesion development in middle leaves of mango seedling 10 days after inoculation. Hypovirulent isolates HV-49 and HV-165 induced systemic resistance to the upper leaves of the plant. The HV mutants appeared to inhibit pathogen development by activating defense mechanisms in mango fruits and seedlings.

Jianguo *et al.* (2002) found that antagonistic microorganisms significantly reduced in incidence of leaf anthracnose disease caused by (*Colletotrichum gloeosporioides)* on mango, and markedly increased the activites polyphenol oxidase (eatechol oxidase), phenylalanine ammonia-lyase and peroxidase in host leaves. The result indicated that the pathogen suppressive substances produced by the antagonistic microorganisms and the increase in enzyme activity in host leaves

reduced disease severity.

Awasthi *et al.* (2005) surveyed different orchards, nurseries and market in new alluvial plains of West Bengal, India to observe the prevalence of different diseases of some major fruit crops. On mango, four diseases, naimly anthracnose (*Colletotrichum gloeosporiodes*), Powdery mildew (*Oidium mangiferae*). Leaf blight (*Macrophoma mangiferae*), phoma blight (*Phoma glomerata*) and red rust (*Cephaleuros* sp.) were found to occur in the orchard and two diseases, namely vegetative malformation (*Fosarium moniliforme* var. *subglutinans*) and wilt (*Fusarium* sp.) in the nursery, while two diseases, namely anthracnose (*Colletotrichum gloeosporiodes*) and diplodia stem end rot (*Diiplodia natalensis*) were the major problem causing post harvest fruit rot.

Hamid and Jalaluddin (2006) studied and identified the association of 18 fungi including species of *Aspegillus, Alternaria, Botryodiplodia, Capnodia, Colletotrichum, Curvularia, Fusarium* and *Helminthosporium* in sooty mass on the upper leaves of mango from Karachi in Pakistan.

Tiwari *et al.* (2006) studied the resistance of 44 mango cultivates to powdery mildew caused by *Oidium mangiferae* in Madhya Pradesh, India. They found that powdery mildew incidence ranged for 0 to 75%. Cultivers Baigan Phalli, Barbalia, Dabari, Dilpasand, Khirama, Nagarideeh, Oloor and Totapari were highly resistant recording 0% incidence of powdery mildew, whereas cv. Aamrpali was the most susceptible, recording 75% incidence of the disease.

According to Dey *et al.* (2007) anthracnose, stem end rot, powdery mildew, sooty mould, malformation and fruit rot complex were very common and destructive diseases in Bangladesh.

Suchana (2008) surveyed nursery diseases of mango in Rajshahi, Chapai Nawabganj and Mymensingh. She recorded Anthracnose, Powdery mildew, Red rust, Scab, Bacterial leaf spot, Sooty mould, Malformation and Die-back.

2.2. Isolation and identification of the pathogen

Ploetz *et al.,* (1994) isolated and identified the causal organism of Alternaria leaf spot (*Alternaria alternate*), Anthracnose (*Colletotrichum gloeosporioides*), Powdery mildew (*Oidium mangiferae*), Red rust (*Cephaleurous virescencs*), Bacterial leaf spot (*Xanthomonas campestris*), Pink disease (*Erythricium salmonicolor*), Gray leaf spot (*Pestalotiopsis mangiferae*), Malformation (*Fusarium mangiferae*) and Scab (*Elsinoe mangiferae*).

Akhtar *et al.* (1999) studied that healthy and malformed samples of both floral and vegetative tissues were collected from different varieties of mango grown in several locations to verify the association of *F. moniliforme* [*Gibberella fujikuroi*] with mango malformation disease in Pakistan. The fungus was isolated and cultured. Frequency of fungal association with the disease ranged between 90-94%. However, seedling germplasm and land races showing resistance to mango malformation were identified. The in vitro growth characters of the fungus were determined on different culture media, at varying temperatures, light and pH

conditions. Mycelial growth on potato dextrose agar was better than on 9 other media tested. At pH 7, the ideal temperature for growth was between 25-30 degrees C. Normally, the malformation is not controlled by fungicide application. The in vitro sensitivity of fungus to six fungicides at three concentrations was determined to seek potential means of chemical control.

Lahav *et al.* (2001) said that the presence of *Fusarium subglutinans* [*Gibberella fujikuroi* var. *subglutinans*] causing mango malformation in several orchards in Israel was determined by PCR analysis using samples from infected portions of the main branches of mango trees. In a related experiment to determine the direction of the growth of the fungal mycelium, saplings grafted with infected scion material were tested using PCR.

Okigbo and Osuinde (2003) found that the incidence of fungal leaf spot diseases on mango (*Mangifera indica*) in Southeastern Nigeria during 1999-2001. The survey proved that the incidence of leaf spot diseases was greatest in Umuahia (72%) followed by Okigwe and Ojoto, with a peak at the beginning of the rainy season (February-March). Three pathogenic fungi, *Pestalotiopsis mangiferae, Botryodiplodia theobromae* [*Lasiodiplodia theobromae*], *Alternaria alternata* and *Macrophoma mangiferae*, were isolated from leaf spots. Pathogenicity tests showed that *P. mangiferae, B. theobromae* and *M. mangiferae* were the causal agents of the fungal leaf spot diseases. Symptoms developed 5 weeks after inoculation of healthy leaves. *Bacillus subtilis*, isolated from soil under a mango tree, inhibited *P. mangiferae, B. theobromae* and *M. mangiferae* by 57, 61 and 58%, respectively, on agar plates.

Freeman *et al.* (2004) cultured ten *Fusarium mangiferae* isolates were on potato dextrose agar containing chloramphenicol. Conidia were mixed with soil and incubated at 25^{0}C. Conidial presence and survival in flowers, fruitlets and mature fruits were assessed. Decline in survival rate was very rapid for all 10 *F. mangiferae* isolates including the NitM mutant isolate. Within 102 days, under controlled conditions, survival declined to zero compared to the control, while less than 40% population survival was recorded after 28 days. The fungi were detected in stem sections, 15 months after inoculation. All flowers and fruitlets from diseased panicles were 100% infected, whether surface disinfected or not. *F. mangiferae* was not detected in comparable flowers and fruitlets from healthy trees. The pathogen was not detected within the seed or on seed coats, or in the flesh of any diseased fruit.

2.3. Epidemiology of disease incidence and severity

Occurrence and severity of various diseases of mango throughout the year in the orchards of Nawabganj and Rajshahi (Kajla) were recorded (Annonymous, 1990). Anthracnose, sooty mold and powdery mildew diseases was observed in the orchards of the surveyed area. The highest incidence of anthracnose was observed in the variety Aswina (37.16%) and Gootee (37.8%) in Nawabganj district and the lowest in the variety Kuapahari in the same district.

Ploetz *et al.*, (1994) described the epidemiology of Alternaria leaf spot, Anthracnose, Powdery mildew, Red rust and Bacterial leaf spot. A minimum of 350 hr of relative humidity over 80% was needed for Alternaria leaf spot disease

development. The conidia of *Colletotrichum gloeosporioides* spread by rain, 70-90% relative humidity and 22-28°C temperature helps to develop the mango Anthracnose disease. Conidia germination of Powdery mildew taken 5-6 hr at 23°C temperature and 20% relative humidity, but optional disease development occured in the diurnal range of 10-30°C and 50-80% relative humidity. A wet and humid environment within the tree canopy was conducive to spread and establishment of alga.

Akhtar *et al.* (1999) studied powdery mildew disease of mango and found *Oidium mangiferae* was associated with the disease. They found that there was a positive trend between rising temperature, lowering relative humidity and number of spores in the air after a low temperature, high humidity and cloudy spell of weather. The maximum spore occurrence was noted around 25^0 C and relative humidity of 4O-6O%. It took 5-8 days for the emergence of disease symptoms after the first detection of air borne conidia.

Yamashita (2000) reported that mango production in Japan was restricted to the southernmost district of the country. Cv. Irwin grafted on Formosa seedling was grown in plastic houses to be free from winter injury and anthracnose disease. Flower bud differentiation proceeds in autumn in response to cool weather on the terminal buds of the new shoots flushed after summer pruning. House heating started in January with a night temperature regime over 23 degrees C. Flowers open in February and fruits were harvested in June. This was the standard type of production. Another 2 methods were developing to expand the harvesting period to

May and August. Flowering control was imperative to both systems. In all systems, fully red-coloured mature fruits with a Brix value of >15 degrees were harvested. They were very expensive, but they satisfy urban consumers in place of the low quality imported mangoes (10 000 t/year).

Ekbote, Padaganur and Anahosur (2001) conducted a survey during November 1993, and April and August 1994 in Dharwad, Karnataka, India to determine the prevalance of anthracnose in mangoes caused by *Colletotrichum gloeosporioides [Glomerella cingulata]*. The highest incidence of the disease was recorded during August 1994, which was characterized by high relative humidity (78-98%) and temperature (22-28^{0}C)

Akem (2006) studied the occurrence and importance, symptoms, and epidemiology of mango anthracnose caused by *Colletotrichum gloeosporioides* (*Glomerella cingulata*) and *C. acutatum* (*G. acutata*). Different strategies for field (including resistant cultivars, cultural control, chemical control and forecasting systems) and postharvest control (including hot water treatment, fungicide application, cold or modified atmosphere storage, and biological control) were discussed.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

Three experiments were carried out throughout the study period in order to study the seedling diseases of mango.

3.1. Experiment I. Survey on the diseases of mango in some selected nurseries of Dhaka and Manikgonj districts

3.1.1. Survey on the nursery diseases of Mango

Prevalence of diseases occurring on mango seedlings raised in the selected nurseries was surveyed.

3.1.2. Location of survey area

The survey was done out in five nurseries of Dhaka and Savar Upazila of Dhaka District and one nursery in Manikgonj Upazila of Manikgonj District. The nurseries were located in AEZ 12 and AEZ 28.

3.1.3. Selection of Nursery

The five nurseries surveyed in the two selected districts are:

Dhaka district	Manikgonj district
Borishal Nursery, Savar Bazar, Dhaka ArichaRoad, Savar Dhaka	BRAC Nursery, Baniajuri Manikgonj
Liza Nursery, Gulshan -1, Dhaka	
BRAC Nursery, Gulshan-1 Dhaka	
Bonayon Nursery, Asulia Bazar Road, Ashulia Bazar, Dhaka	

3.1.4. Age (Year) and number of seedlings:

The age (year) and number (population) of the seedlings included for the survey are presented in Table 1.

Table 1. Age of the mango seedlings and total number of seedlings in selected five nurseries from January, 2007 to October, 2007

Nursearies	Age of the seedlings (Years)	Total number of seedlings (January)	Total number of seedlings (March)	Total number of seedlings (July)	Total number of seedlings (October)
Borishal Nursery, Savar Bazar, Dhaka Aricha Road, Savar Dhaka	1.2	120	100	200	140
Liza Nursery, Gulshan -1, Dhaka	1.2	110	120	170	90
BRAC Nursery, Gulshan-1 Dhaka	1	170	190	210	190
Bonayon Nursery, Asulia Bazar Road, Ashulia Bazar, Dhaka	1	130	110	180	150
BRAC Nursery, Baniajuri Manikgong	1	340	310	600	400

3.1.5. Observation of the symptoms

In the five selected nursery more or less similar kinds of diseases were observed. Symptoms of the diseases were studied by visual observation. Sometimes hand lens was used for critical observation of the disease and sometimes a disease was identified based on matching the observed symptoms in the infected plants with the symptoms published in Amer rog (Mean and Khan, 1987). Besides, the symptoms of the diseases were recorded following the descriptions of Singh (1968), Singh (1978), Pathak (1980), Peterson (1986), Singh (1996), Singh (1998) and Ploetz *et al.* (1998).

3.2. Experiment II: Identification of causal organisms

3.2.1. Collection of diseased specimen

Diseased leaves were collected from the infected plants representing the different areas of survey. The specimens were preserved in the laboratory following standard procedure of preservation of disease specimens until isolation was made.

3.2.2. Isolation of causal organisms was made by two methods as follows:

3.2.2.1. Moist blotter method

The pathogen associated with the disease plant parts (Leaves) were cut into several pieces by scissors and placed on the moist filter paper (Whatman no.1). Three pieces of filter paper were moistened by dipping in sterile water. The petridishes with the diseased specimens were incubated at 22±2°C under 12/12 alternating cycles of NUV and darkness in the incubation room of the Seed Pathology Lab (SPL) for three to five days. After incubation the plates were examined under stereomicroscope for primary identification of the organisms (fungi). The fungi

were transferred to PDA plates for proper sporulation and purification.

3.2.2.2. Agar plate method

The diseased plant parts (leves) were surface sterilized by dipping them in 0.001% $HgCl_2$ solution for 1.5 minutes and washed three times with sterile water and there after placed on PDA (Potato = 200g, Dextrose = 17g, Agar = 17 - 20g, Water = 1000ml) plates aseptically. The plates were incubated at 28°±1°C for several days and examined daily for any fungal growth.

3.2.3. Purification

The fungi which grew out on medium were transferred to PDA plates following isolation of single hyphal tip technique Riker and Riker (1921). On PDA media *Oidium mangiferae* and *Cephaleuros virescens* did not sporulate and for that matter it was not sub-cultured.

3.2.4. Identification of the pathogen

Slides were prepared directly from diseased specimens and observed under compound microscope for identification of the associated organisms specially for *Oidium mangiferae* and *Cephaleuros virescens* Attempts were also made to identify the fungal organisms grown out of the inocula incubated in sterile wet filter paper by observing their growth characteristics under stereo-microscope (Mathur and Kongsdal, 2003). The fungal organisms, cultured on PDA media, were also identified under compound microscope following the keys of Govindu and Thirumalachar (1954), Barnett and Barry (1972) and Mathur and Kongsdal (2003).

3.3. Experiment III: Epidemiology of disease incidence and severity

3.3.1. Survey period

Altogether four surveys were made during the period from January to October 2007, where First, second, third and fourth surveys were made in January, March, July and October respectively.

3.3.2. Data collection during survey

During the survey in the nurseries, total mango seedlings found in the nurseries were recorded. Total number as well as number of diseased seedlings were recorded. Then 30 seedlings were randomly selected for counting diseased leaves and disease free leaves. Moreover, five leaves per plant were randomly selected to determine the disease severity.

3.3.3. Determination of disease incidence and disease severity

For calculation of incidence of disease every seedling was counted in the nursery, and also counted the infected seedlings and then expressed in percentage. The disease incidence of mango seedling was determined by the following formula (Islam, 2005):

$$\text{Disease Incidence of mango seedling} = \frac{\text{No. of infected seedlings}}{\text{No. of total seedlings}} \times 100$$

The disease incidence of foliar diseases was determined by the following formula (Islam, 2005):

$$\text{Disease Incidence (Leaves)} = \frac{\text{No. of diseased leaves}}{\text{No. of total leaves}} \times 100$$

Disease severity was determined by the following formula (Islam, 2005):

$$\text{Disease Severity (Leaves)} = \frac{\text{Leaf area diseased}}{\text{Total Leaf area}} \times 100$$

The following rating scales were used for the foliar diseases, Alternaria leaf spot, Anthracnose, Powdery mildew and Red rust.

Criteria	Ratings
No visible symptoms	0
1-5% leaf area diseased	1
5.1-12% leaf area diseased	2
12.1-25% leaf area diseased	3
25.1-50% leaf area diseased	4
>50% leaf area diseased	5

Leaf area diseased was measured by eye estimation following disease rating scales and then summations of each leaf area diseased in each seedling were made. Total area of a leaf was considered as 100%

$$\text{Disease Severity} = \frac{\text{Sum of total rating} \times 100}{\text{No. of total observation} \times \text{highest grade of the scale}}$$

Where as, Sum of total rating = No. of observation × Grade

3.4. Meteorological data collection

Meteorological data were collected from regional meteorological station.

3.5. Statistical analysis

The collected data on different parameters were analyzed statistically by using MSTAT-C package program. The means for all the treatments were compared by DMRT (Duncan Multiple Range Test). The significance of the difference among the means was calculated by LSD test (Least Significance Difference).

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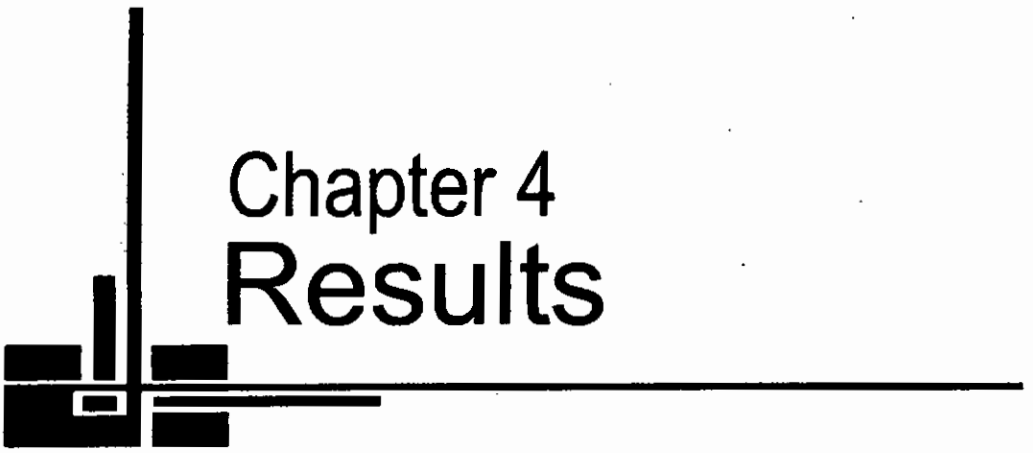


Chapter 4
Results

CHAPTER 4

RESULTS

4.1. Nursery diseases of mango

Six different diseases viz. Anthracnose, Alternaria leaf spot, Powdery mildew, Red rust, Bacterial leaf spot and Sooty mould were recorded in the survey conducted in five nurseries of Dhaka and Manikgonj district (Plate 1-6). The symptoms of different diseases as observed in the nurseries were as follows:

Anthracnose

Numerous oval, irregular brown spots of different sizes were found on the leaves. These spots were present at the tip or any other portion of the margin or centre of the leaves. The spots elongated to necrotic areas resulting leaf perforated or tattered appearances. Young leaves were most susceptible and the petioles turned gray to black, the leaves drooped down or became dry. Black and necrotic areas were formed on the affected twigs, which dry out from the tip downwards. At this stage the leaves on the twig shed, living it bare; the twig subsequently showed blackening, and finally dried up (Plate 1).

Powdery mildew

Whitish or grayish powdery areas on tender foliage, scattered patches of superficial and whitish powdery bloom covered the leaves (Plate-2). Infected young leaves and twigs exhibited distorted growth. Young leaves affected by Powdery mildew appeared bluish mauve to brown, particularly where the mycelia collapsed or was rubbed away.

Alternaria Leaf spot

The spots were deep brown to black due to *Alternaria* (Plate 3). The spots were irregular in shape and surrounded by the veins and make concentric ring. The spots were found mainly on the tip of the leaf.

Red rust

Red rust was recognized by the presence of rusty-red spots mainly on leaves and sometimes on petioles and young twigs (Plate 4). The spots were greenish-gray in colour and velvety in texture; spot turned reddish-brown and bear hair like structures which gave the characteristic red-rust appearances. These spots often merged and formed large irregular patches. Long after the spores were shredded, the algal matrix remained attached to the leaf surface, leaving a creamy white mark at the original rust spot. Rusty spots also occurred on twigs and branches causing the bark to crack.

Bacterial leaf spots or blight

Minute water socked spots appeared in groups at the tip of the leaf blade that turned brown to black in colour and surrounded by cholrotic halos (Plate 5). They were also surrounded by veins and hence angular in shape. Large necrotic patches were formed by coalescing of several lesions. The patches sometimes dried up, often rough and rose due to heavy bacterial exudates. Petioles and tender stems were also infected and longitudinal cracks developed on the petioles.

Sooty mould

The disease was recognized in the nursery by the presence of a black velvety covering on the leaf surface of seedlings (Plate 6). The entire leaf surface was covered by black mould in patches on the leaf the mould formed a thin membranous covering over the affected parts. The covering can be rubbed off easily from the leaf surface.

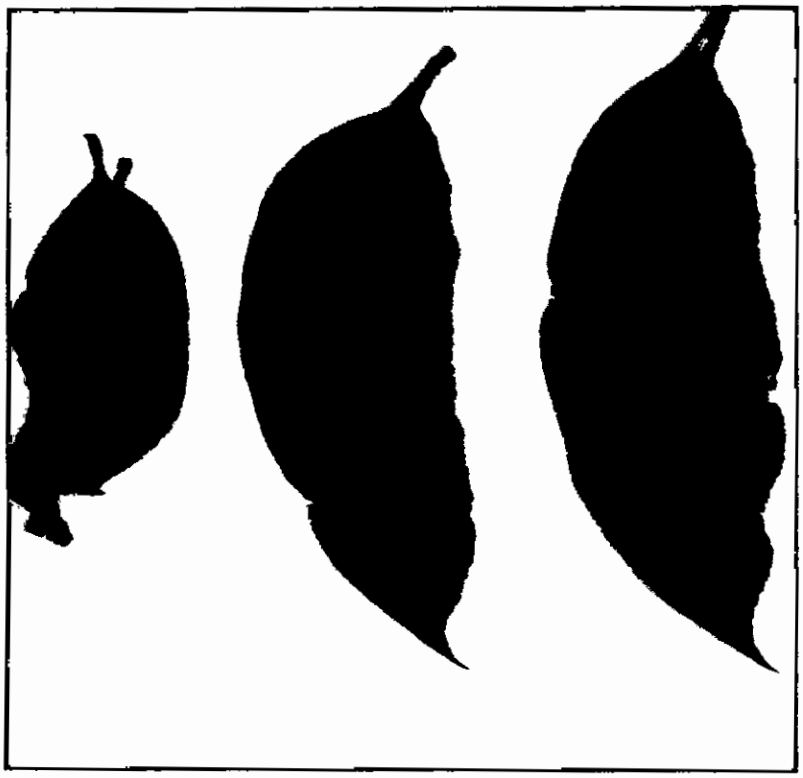


Plate 1. Symptom of Anthracnose of mango

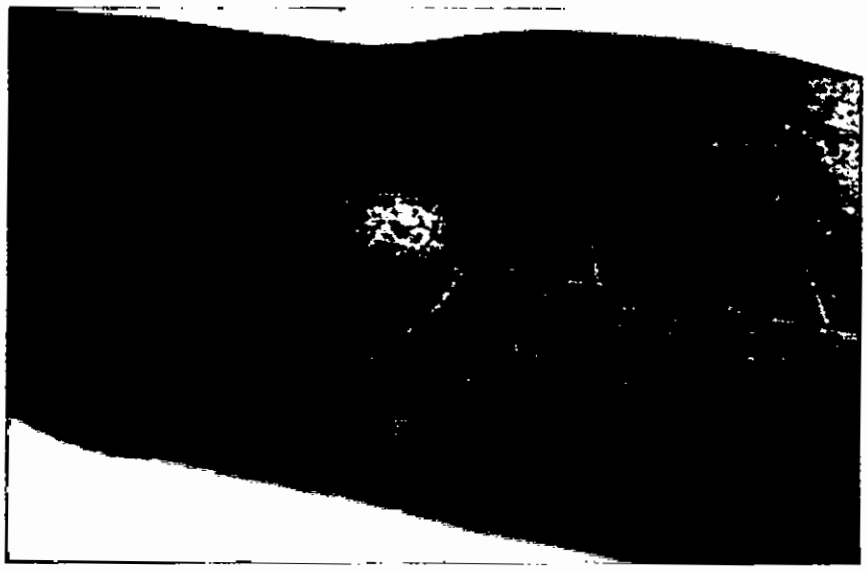


Plate 2. Symptom of Powdery mildew of mango

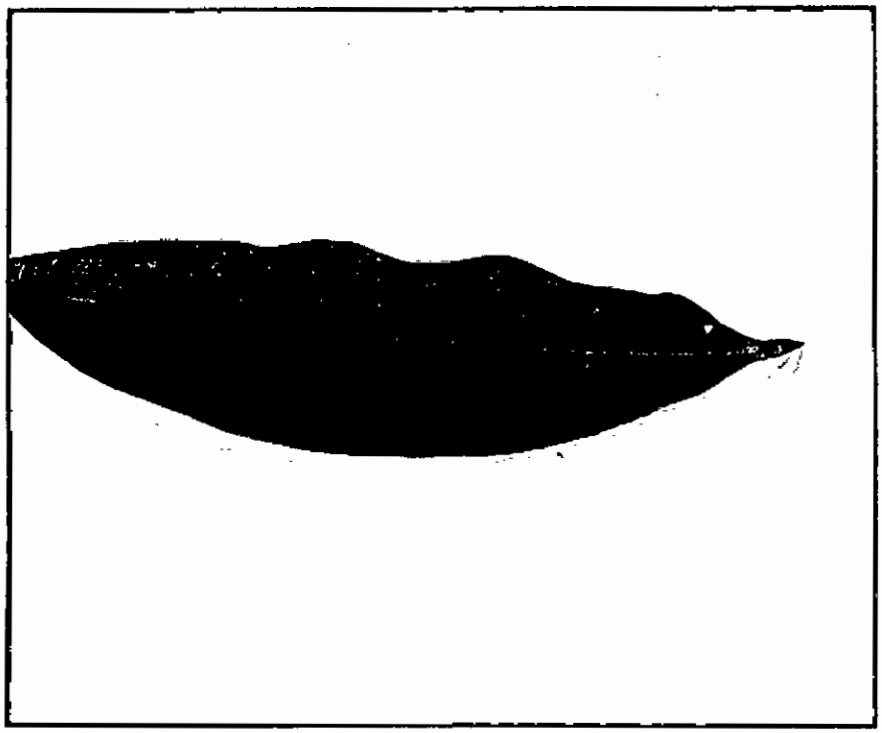


Plate 3. Symptom of Alternaria leaf spot of mango

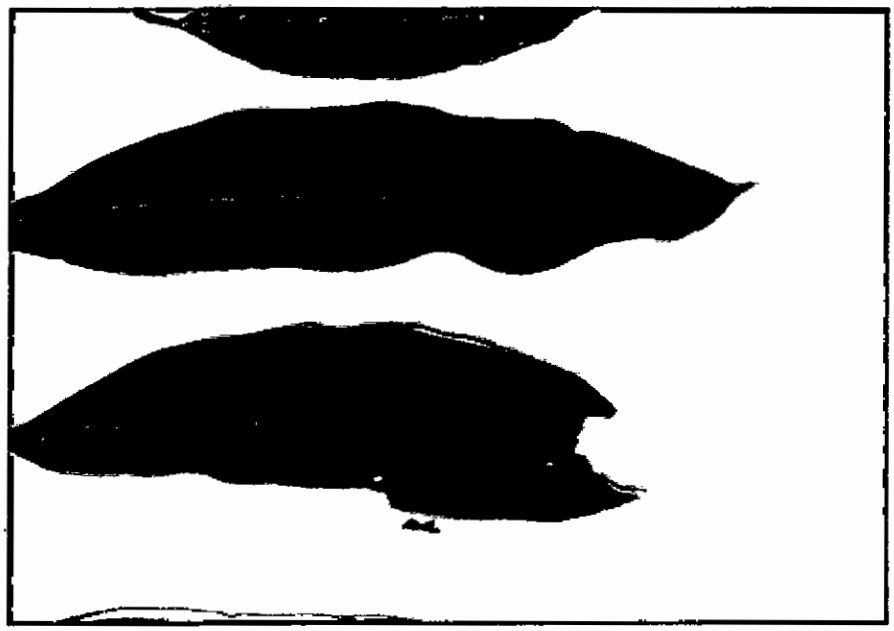


Plate 4. Symptom of Red rust of mango

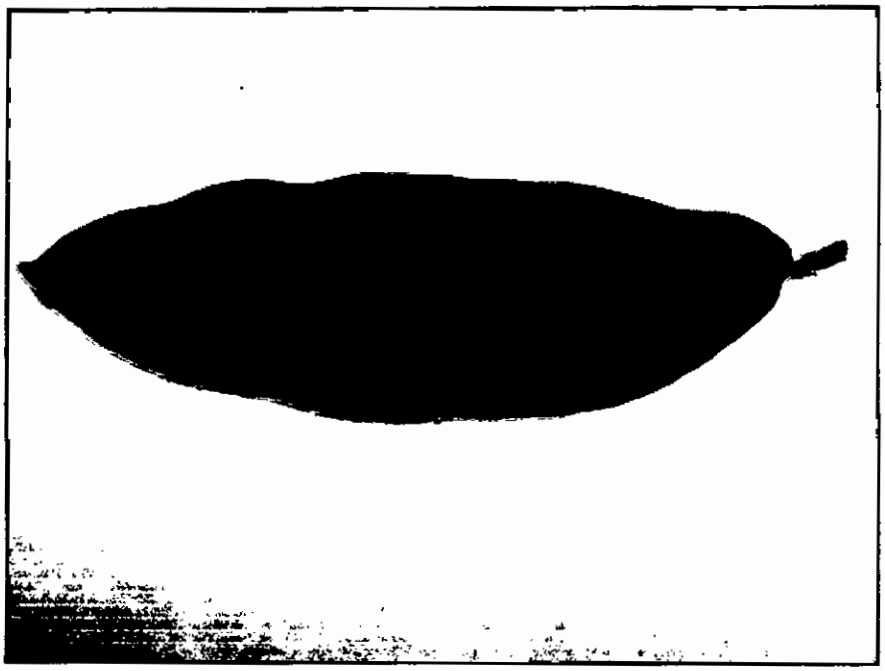


Plate 5. Symptom of bacterial leaf spot/blight of mango

Plate 6. Symptom of sooty mould of mango

4.2. Pathogen Identified

Colletotrichum gleosporoides

The pathogen isolated from the Anthracnose symptom was identified as *Colletotrichum gloesporiodes* author(s) (Plate-7) by observing the following charachteristics:

Acervulus: Irrigular in shape and approximately 500 μm in diameter.

Conidiophore: Hyaline to finally brown.

Conidia: Hyaline, unicellular and either cylindrical with obtuse ends or ellipsoidal with a rounded apex and a narrow, truncate base.

Setae: One to four septate, brown, slightly swollen at the bases and tapered at the apex.

Oidium mangiferae

The pathogen isolated from the diseased symptom was identified as *Oidium mangiferae* (Plate 8) by observing the conidiophore and conidial characteristics: Conidiophore: Brunched or sometimes unbrunched, nodose with terminal and intercalary conidiogenous, mid to dark brown.

Conidia: Conidia aseptate, hyaline and elliptical to barrel shaped. Conidia are usually produced singly.

Alternaria alternata

The pathogen isolated from the diseased symptom was identified as *Alternaria alternata* (Plate 9) by observing conidial characteristics:

Conidiophore: Singly or in small group, simple or brunched, straight or flexuous. Sometimes geniculate , pale to golden brown.

Conidia: Formed in long often brunched obclavate, ovoid or ellipsoidal, often with a short conical or cylindrical beak, sometimes up to or not more than 1/3 the length of the conidium. Pale to golden brown, smooth with up to eight transverse or or usually several longitudinal or oblique septa.

Cephaleuros virescens

The pathogen isolated from the diseased symptom was identified as *Cephaleuros virescens* (Plate 10). By observing conidiophore and conidial chracteristics.

Thallus: Thallus made up of a subcuticular expanseof cells from which erect, bristlelike branches arise. The apical part of some cells swell to form enlarged support cells that produce several stalked.

Sporangia: Terminal or ovoid sporangia that were 30X40 µm.

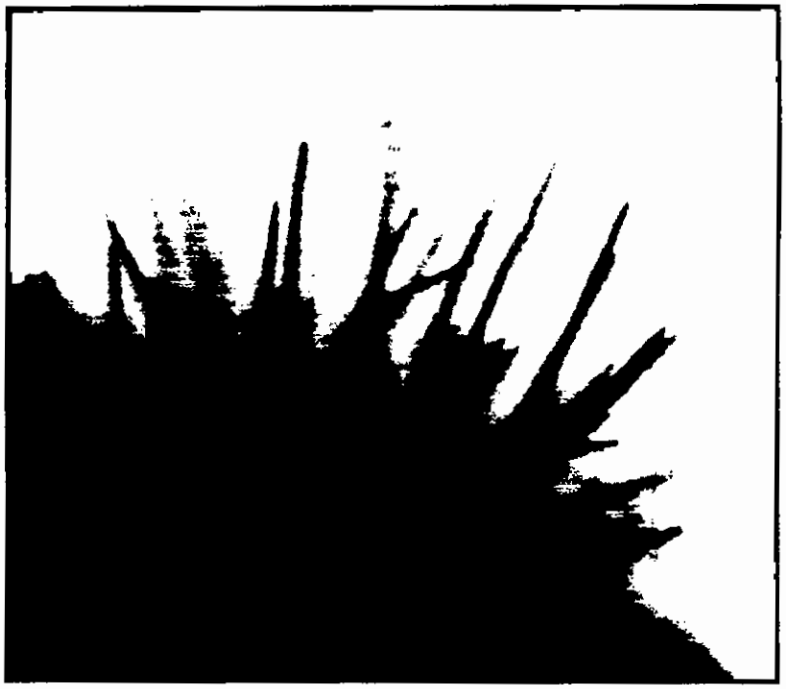


Plate 7. Conidiophores and setae of *Colletotrichum gloesporiodes*

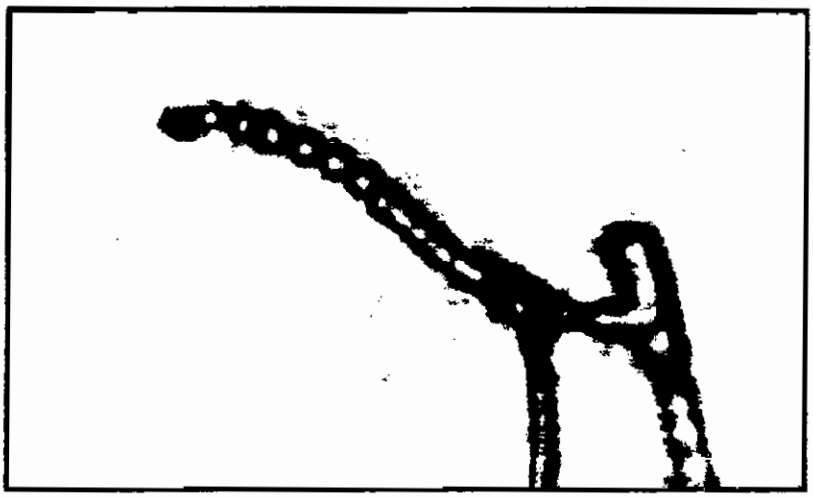


Plate 8. Conidiophore with conidia of *Oidium mangiferae*

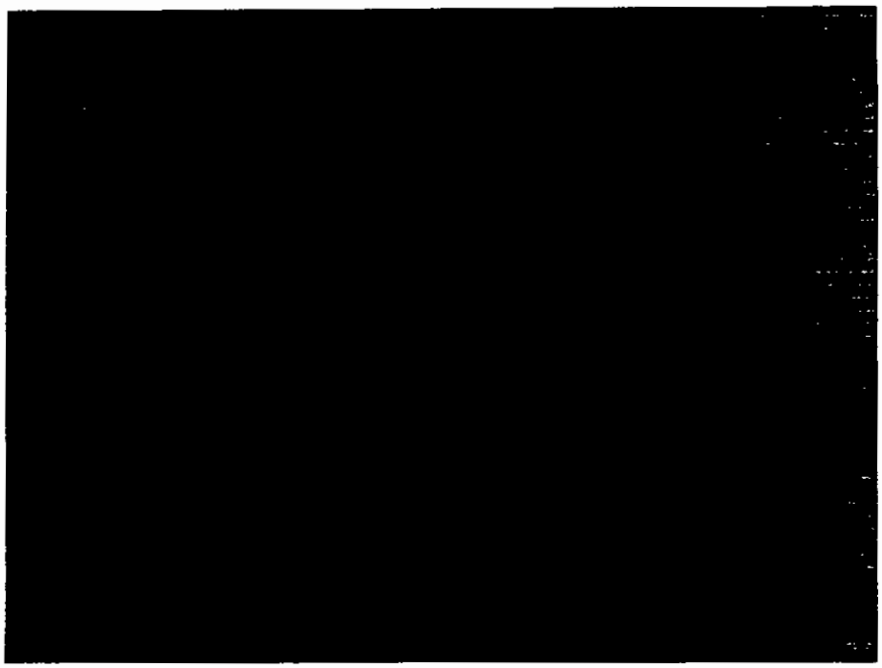


Plate 9. Conidia of *Alternaria alternata*

Plate 10. Sporangia of *Cephaleuros virescens*

4.3. Epidemiology of disease incidence and severity

4.3.1. Incidence and severity of Anthracnose of mango

In the month of January, 2007 the incidence of Anthracnose of mango varied significantly from 32.76-50.23% with respect to nurseries surveyed. The highest incidence (50.23%) was recorded at Barishal nursery, Savar followed by BRAC nursery, Manikgonj (47.04%) while the lowest incidence (32.76%) was observed in Banayan Nursery, Ashulia (Table 2). The severity of Anthracnose of mango also varied significantly from 24.42-31.52% with respect to nurseries. The highest severity (31.52%) was recorded at BRAC Nursery, Manikgonj followed by Liza Nursery Gulshan (30.62%). The lowest severity (24.42%) was observed in Banayan Nursery, Ashulia (Table 2).

In the month of March, 2007 the incidence of Anthracnose of mango varied significantly from 28.51-50.00% with respect to nurseries surveyed. The highest incidence (50.00%) was recorded at Liza Nursery Gulshan, Dhaka followed by Borishal Nursery, Savar (49.92%). The lowest incidence (31.38%) was observed in BRAC Nursery, Dhaka (Table 2). The severity of Anthracnose of mango also varied significantly from 18.65-40.41% with respect to nurseries. The highest severity (40.41%) was recorded at Liza Nursery Gulshan, Dhaka followed by Borishal Nursery, Savar (36.63%). The lowest severity (18.65%) was observed in Banayan Nursery, Ashulia (Table 2).

Table 2. Incidence and severity of Anthracnose of mango in five different surveyed nurseries of Dhaka and Manikgonj from January to October, 2007

Name of the Nursery	January		March		July		October	
	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)
Bonayon Nursery Ashulia	32.76c	24.42b	38.21b	18.65e	42.96c	33.28d	58.13d	44.88c
Borishal Nursery Savar	50.23a	28.84a	49.92a	36.63b	56.54ab	37.89c	69.19b	49.69bc
Liza Nursery Gulshan Dhaka	42.86ab	30.62a	50.00a	40.41a	56.17ab	40.83b	64.43c	57.93ab
BRAC Nursery Dhaka	36.63bc	28.53a	31.38c	25.58d	52.33b	38.69bc	70.49b	53.59a-c
BRAC Nursery Manikgong	47.04a	31.52a	40.51b	33.90c	58.05a	45.75a	75.01a	60.20a
CV%	11.49	5.82	4.23	3.30	5.03	2.56	2.34	8.80
LSD	9.069	3.153	5.037	1.927	4.594	2.756	4.328	8.827
Level of Significance	0.05	0.05	0.01	0.01	0.05	0.01	0.05	0.05

Means followed by same letter significantly different at 1% or 5% level of significance.

In the month of July, 2007 the incidence of Anthracnose of mango varied significantly from 42.96-58.05% with respect to nurseries surveyed. The highest incidence (58.05%) was recorded at BRAC Nursery, Manikgong followed by Borishal Nursery Savar (56.54%) while the lowest incidence (42.96%) was observed in Banayan Nursery, Ashulia (Table 2). The severity of Anthracnose of mango also varied significantly from 33.28-45.75% with respect to nurseries. The highest severity (45.75%) was recorded at BRAC Nursery, Manikgonj followed by Liza Nursery Gulshan (40.83%). The lowest severity (33.28%) was observed in Banayan Nursery, Ashulia (Table 2).

In the month of October, 2007 the incidence of Anthracnose of mango varied significantly from 58.13-75.01% with respect to nurseries surveyed. The highest incidence (75.01%) was recorded at BRAC nursery, Manikgonj followed by Barishal nursery, Savar (69.19%). The lowest incidence (58.13%) was observed in Banayan Nursery, Ashulia (Table 2). The severity of Anthracnose of mango also varied significantly from 44.88-60.20% with respect to nurseries. The highest severity (60.20%) was recorded at BRAC Nursery, Manikgonj followed by Liza Nursery Gulshan (57.93%). The lowest severity (44.88%) was observed in Banayan Nursery, Ashulia (Table 2).

4.3.1.1. Effect of temperature and relative humidity on the incidence and severity of Anthracnose of mango

The incidence of Anthracnose of mango was influenced by temperature and relative humidity. The incidence of Anthracnose of mango in the month of January was 41.49% when the temperature and relative humidity were 18.45°C and 68%, respectively. The incidence of Anthracnose of mango in the month of March was 39.25% when the temperature and relative humidity were 25.50°C and 54%, respectively. In the month of July the incidence of Anthracnose of mango was 50.51% when the temperature and relative humidity were 28.50°C and 84%, respectively and in the month of October the incidence of Anthracnose of mango was 66.57%, when the temperature and relative humidity were 27.60°C and 78%, respectively (Figure 1).

The severity of Anthracnose of mango was influenced by average temperature and average relative humidity. The severity of Anthracnose of mango observed in the month of January was 27.97% when the temperature and relative humidity were 18.45°C and 68%, respectively. The severity of Anthracnose of mango observed in the month of March was 39.52% when the temperature and relative humidity were 25.50°C and 54%, respectively. In the month of July the severity of Anthracnose of mango was 29.53% when the temperature and relative humidity were 28.50°C and 84%, respectively and in the month of October the severity of Anthracnose of mango was 52.54% while the temperature and relative humidity were 27.60°C and 78%, respectively (Figure 2).

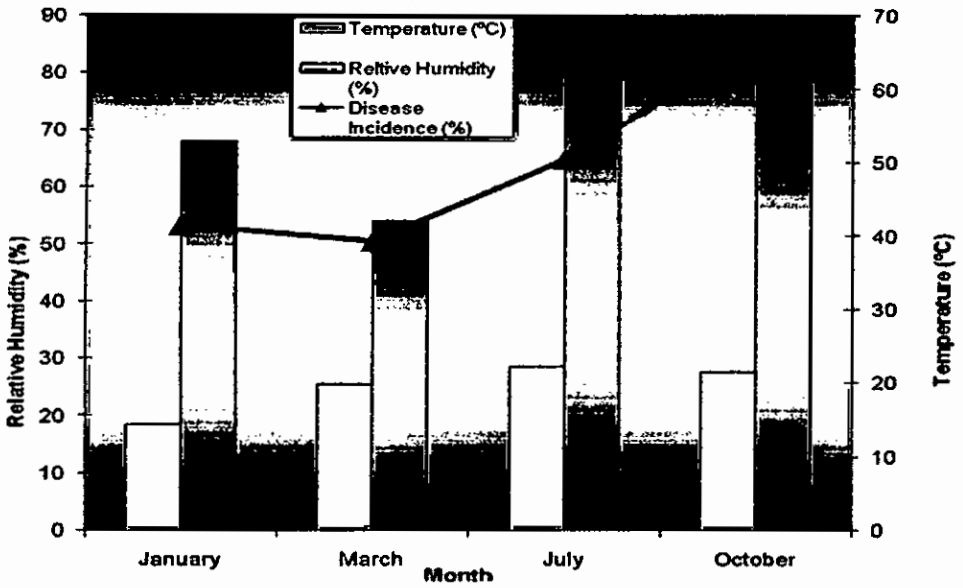


Figure 1. Effect of temperature and relative humidity on the incidence of mango Anthracnose

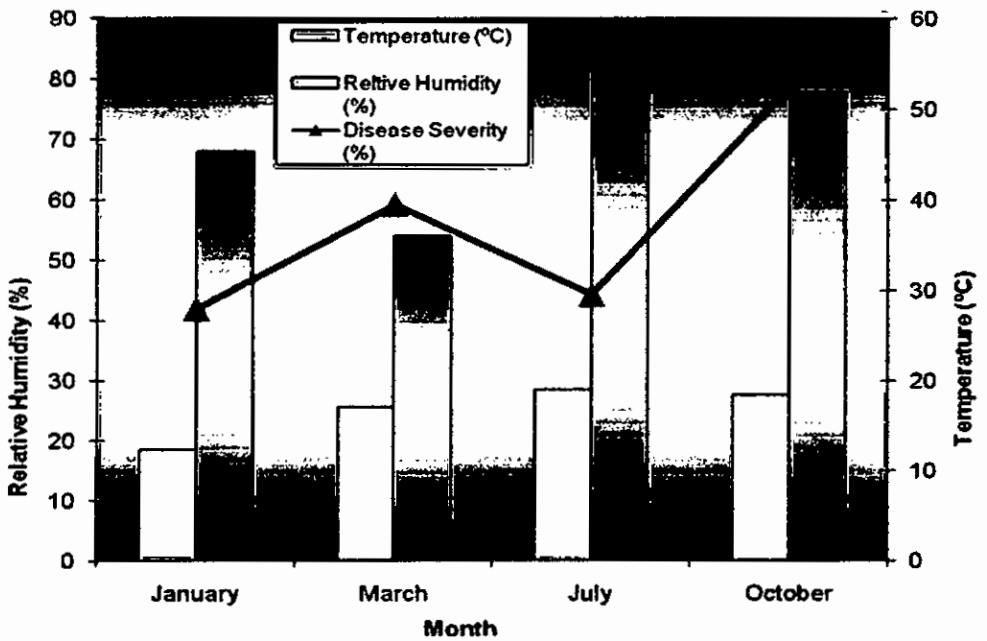


Figure 1. Effect of temperature and relative humidity on the severity mango Anthracnose

4.3.1.2. Correlation between the mango Anthracnose incidence and temperature

A positive correlation between Anthracnose incidence and temperature was observed (Figure 3). The relationship between disease incidence and temperature could be expressed by the equation $y = 1.554x + 11.273$ ($R^2 = 0.3651$), where y = disease incidence and x = temperature. The R^2 value indicated that contribution of temperature was 36.51% on the incidence of mango Anthracnose (*Colletorichum gloesporiodes*).

4.3.1.3. Correlation between mango Anthracnose severity and temperature

A positive correlation between Anthracnose severity and temperature was observed (Figure 4). The relationship between disease severity and temperature could be expressed by the equation $y = 1.683x - 4.7051$ ($R^2 = 0.4578$), where y = disease severity and x = temperature. The R^2 value indicated that contribution of temperature was 45.78% on the severity of mango Anthracnose (*Colletorichum gloesporiodes*).

4.3.1.4. Correlation between mango Anthracnose incidence and relative humidity

A positive correlation between Anthracnose incidence and relative humidity was observed (Figure 5). The relationship between disease incidence and relative humidity could be expressed by the equation $y = 0.5507x + 11.044$ ($R^2 = 0.3806$), where y = disease incidence and x = relative humidity. The R^2 value indicated that contribution of relative humidity was 38.06% on the incidence of mango Anthracnose (*Colletorichum gloesporiodes*).

4.3.1.5. Correlation between mango Anthracnose incidence and relative humidity

A positive correlation between Anthracnose severity and relative humidity was observed (Figure 6). The relationship between disease severity and relative humidity could be expressed by the equation y = 0.5729-3.2864 (R^2 = 0.4404), where y = disease severity and x = relative humidity. The R^2 value indicated that contribution of relative humidity was 44.04% on the severity of mango Anthracnose (*Colletorichum gloesporiodes*).

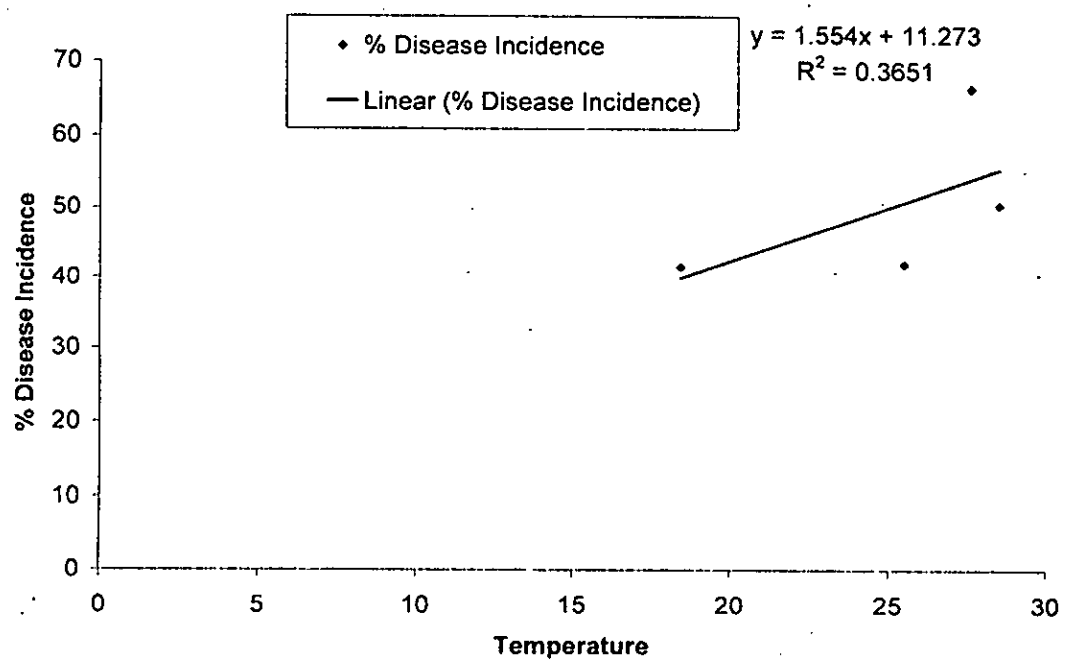


Figure 3. Linear regression analysis of the effect of monthly average temperature of investigated four months on incidence of mango Anthracnose

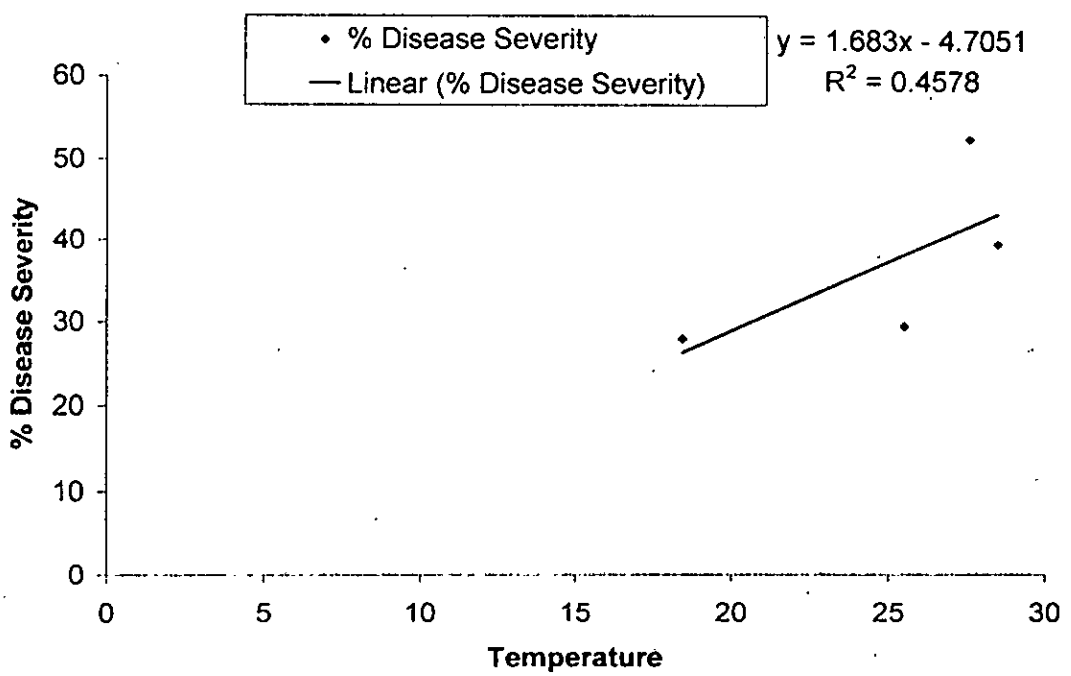


Figure 4. Linear regression analysis of the effect of monthly average temperature of investigated four months on severity of mango Anthracnose

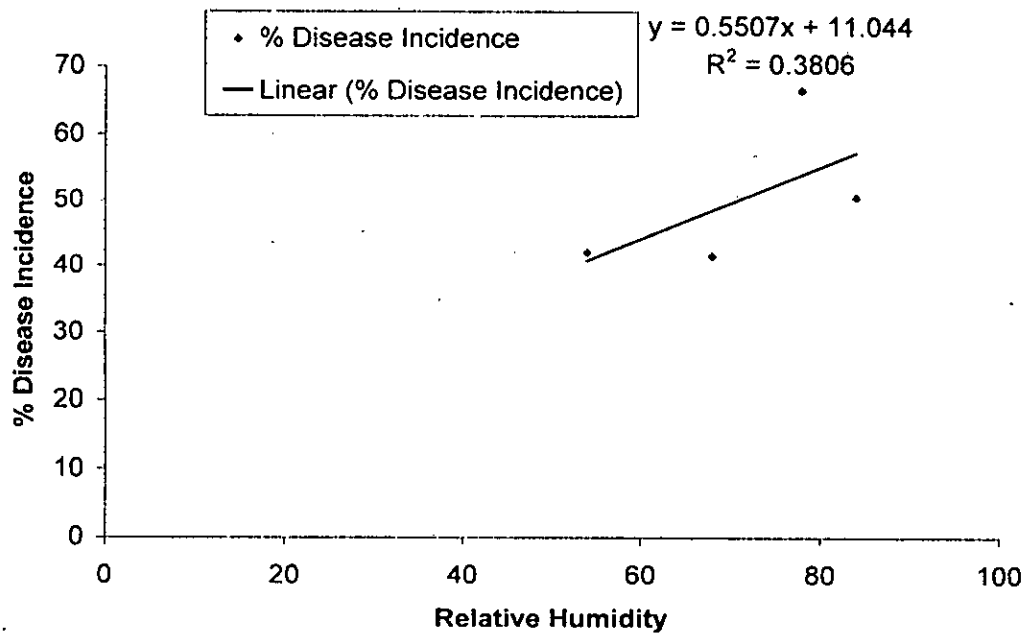


Figure 5. Linear regression analysis of the effect of monthly average relative humidity in investigated four months on incidence of mango Anthracnose

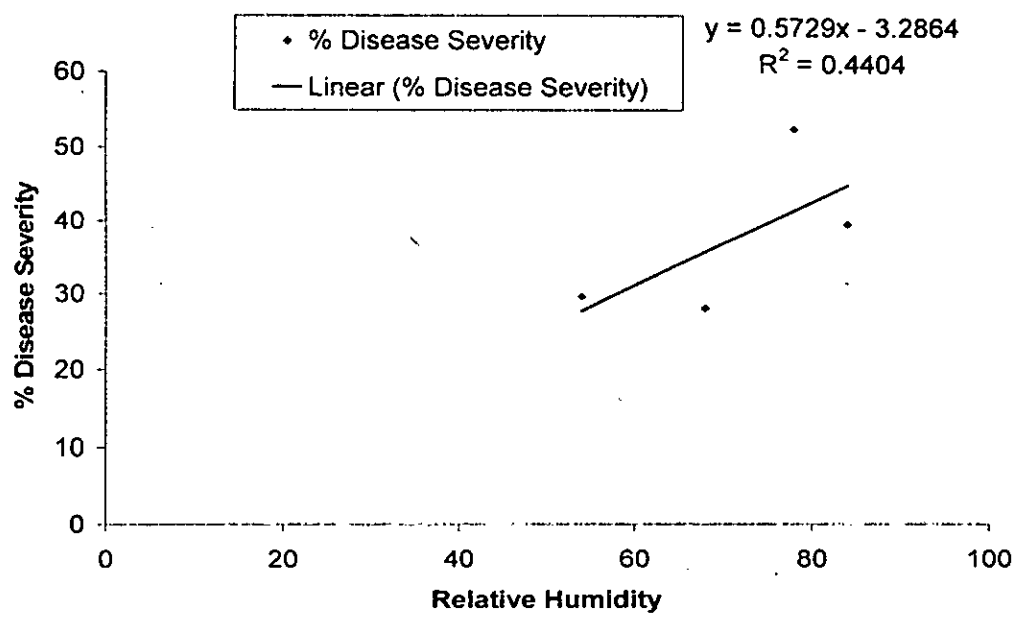


Figure 6. Linear regression analysis of the effect of monthly average relative humidity in investigated four months on severity of mango Anthracnose

4.3.2. Incidence and severity of Powdery mildew of mango

In the month of January, 2007 the incidence of Powdery mildew of mango varied significantly from 29.10-41.57% with respect to nurseries surveyed. The highest incidence (41.57%) was recorded at Liza Nursery, Gulshan, Dhaka followed by BRAC Nursery, Dhaka (33.80%) while the lowest incidence (29.10%) was observed in Borishal Nursery Savar (Table 3). The severity of Powdery mildew of mango also varied significantly from 22.63-36.27% with respect to nurseries. The highest severity (36.27%) was recorded at Liza Nursery Gulshan, Dhaka followed by BRAC Nursery, Dhaka (28.84%). The lowest severity (22.63%) was observed in BRAC Nursery, Manikgong followed by Borishal Nursery Savar (22.98) (Table 3).

In the month of March, 2007 the incidence of Powdery mildew of mango varied significantly from 44.08-56.70% with respect to nurseries surveyed. The highest incidence (50.00%) was recorded at BRAC Nursery Manikgong followed by Liza Nursery Gulshan Dhaka (47.49%) while the lowest incidence (44.08%) was observed in BRAC Nursery Dhaka (Table 3). The severity of Powdery mildew of mango also varied significantly from 27.82-61.61% with respect to nurseries. The highest severity (61.61%) was recorded at Liza Nursery Gulshan, Dhaka followed by Borishal Nursery, Savar (42.37%). The lowest severity (27.82%) was observed in BRAC Nursery Manikgonj (Table 3).

Table 3. Incidence and severity of Powdery mildew of mango in five different surveyed nurseries of Dhaka and Manikgonj districts from January to October, 2007

Name of the Nursery	January		March		July		October	
	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)
Bonayon Nursery Ashulia	32.91b	25.29c	44.86b	35.25c	42.66b	26.53b	-	-
Borishal Nursery Savar	29.10b	22.98cd	44.57b	42.37b	56.33a	27.31b	-	-
Liza Nursery Gulshan Dhaka	41.57a	36.27a	47.49b	61.61a	59.90a	28.12b	-	-
BRAC Nursery Dhaka	33.80b	28.84b	44.08b	35.49c	43.49b	25.51b	-	-
BRAC Nursery Manikgong	32.80b	22.63d	56.70a	27.82d	35.04c	34.37a	-	-
CV%	8.49	3.43	4.56	3.72	2.78	4.82	-	-
LSD	5.44	2.55	4.09	4.131	3.62	3.75	-	-
Level of Significance	0.05	0.01	0.05	0.01	0.01	0.01		

Means followed by same letter significantly different at 1% or 5% level of significance.

- = Disease was not found.

In the month of July, 2007 the incidence of Powdery mildew of mango varied significantly from 35.04-59.90% with respect to nurseries surveyed. The highest incidence (59.90%) was recorded at Liza Nursery Gulshan Dhaka followed by Borishal Nursery Savar (56.33%) while the lowest incidence (35.04%) was observed in BRAC Nursery Manikgong (Table 3). The severity of Powdery mildew e of mango also varied significantly from 25.51-34.37% with respect to nurseries. The highest severity (34.37%) was recorded at BRAC Nursery, Manikgonj followed by Liza Nursery Gulshan Dhaka (28.12%). The lowest severity (25.51%) was observed in BRAC Nursery Dhaka (Table 3).

4.3.2.1. Effect of temperature and relative humidity on the incidence and severity of Powdery mildew of mango

The incidence of Powdery mildew of mango was influenced by temperature and relative humidity. The incidence of Powdery mildew of mango observed in the month of January was 35.33% when the temperature and relative humidity were 18.45°C and 68%, respectively. The incidence of Powdery mildew of mango observed in the month of March was 50.39% when the temperature and relative humidity were 25.50°C and 54%, respectively and in the month of July the incidence of Powdery mildew of mango was 47.47% when the temperature and relative humidity were 28.50°C and 84%, respectively. No disease was observed in the month of October (Figure 7).

The severity of Powdery mildew of mango was influenced by average temperature and average relative humidity. The severity of Powdery mildew of mango observed in the month of January was 29.45% when the temperature and relative humidity were 18.45°C and 68%, respectively. The severity of Powdery mildew of mango observed in the month of March was 29.94% when the temperature and relative humidity were 25.50°C and 54%, respectively and in the month of July the severity of Powdery mildew of mango was 44.72% while the temperature and relative humidity were 28.50°C and 84%, respectively. No disease was observed in the month of October (Figure 8).

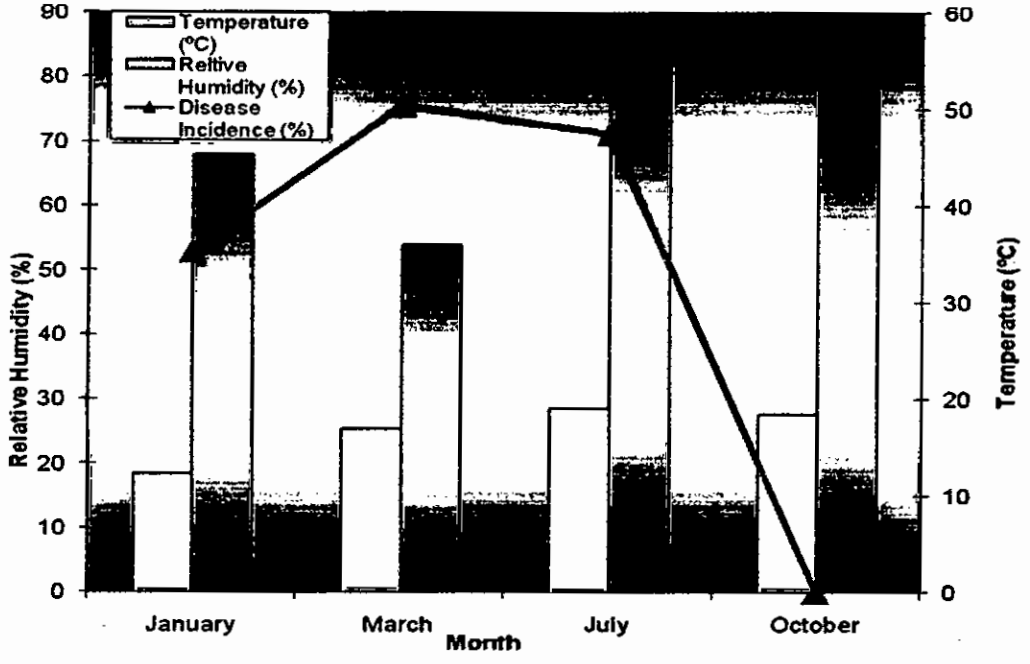


Figure 7. Effect of temperature and relative humidity on the incidence and of mango Powdery mildew

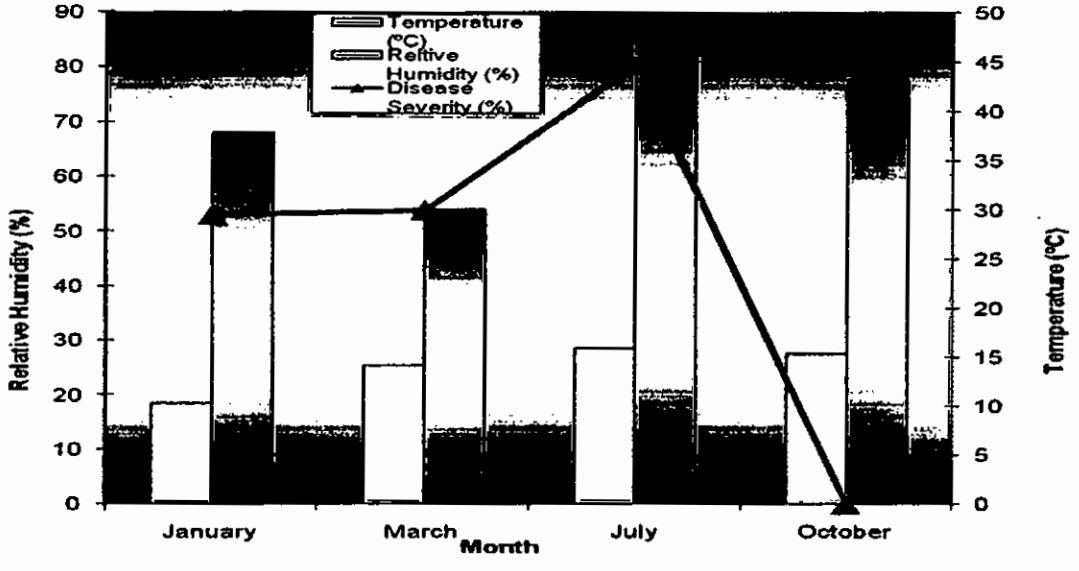


Figure 8. Effect of temperature and relative humidity on the severity of mango Powdery mildew

4.3.2.2. Correlation between the mango Powdery mildew incidence and temperature

A significant and positive correlation between Powdery mildew incidence and temperature was observed (Figure 9). The relationship between disease incidence and temperature could be expressed by the equation y = 1.3739x +11.271 (R^2 = 0.7877**), where y = disease incidence and x = temperature. The R^2 value indicated that contribution of temperature was 78.77% on the incidence of mango Powdery mildew (*Oidium mangiferae*).

4.3.2.3. Correlation between the mango Powdery mildew severity and temperature

A positive correlation between Powdery mildew severity and temperature was observed (Figure 10). The relationship between disease severity and temperature could be expressed by the equation y = 0.4273x +24.385 (R^2 = 0.0645), where y = disease severity and x = temperature. The R^2 value indicated that contribution of temperature was 6.45% on the severity of mango Powdery mildew (*Oidium mangiferae*).

4.3.245. Correlation between the mango Powdery mildew incidence and relative humidity

A negative correlation between Powdery mildew incidence and relative humidity was observed (Figure 11). The relationship between disease incidence and relative humidity could be expressed by the equation y = -0.0771x +49.689 (R^2 = 0.0.021),

where y = disease incidence and x = relative humidity. The R^2 value indicated that no contribution of relative humidity on the incidence of mango Powdery mildew (*Oidium mangiferae*).

4.3.2.5. Correlation Study between the mango Powdery mildew severity and relative humidity

A significant negative correlation between Powdery mildew severity and relative humidity was observed (Figure 12). The relationship between disease severity and relative humidity could be expressed by the equation y = -0.4803x +67.683 (R^2 = 0.6902**), where y = disease severity and x = relative humidity. The R^2 value indicated that no contribution of relative humidity was 69.02% on the severity of mango Powdery mildew (*Oidium mangiferae*).

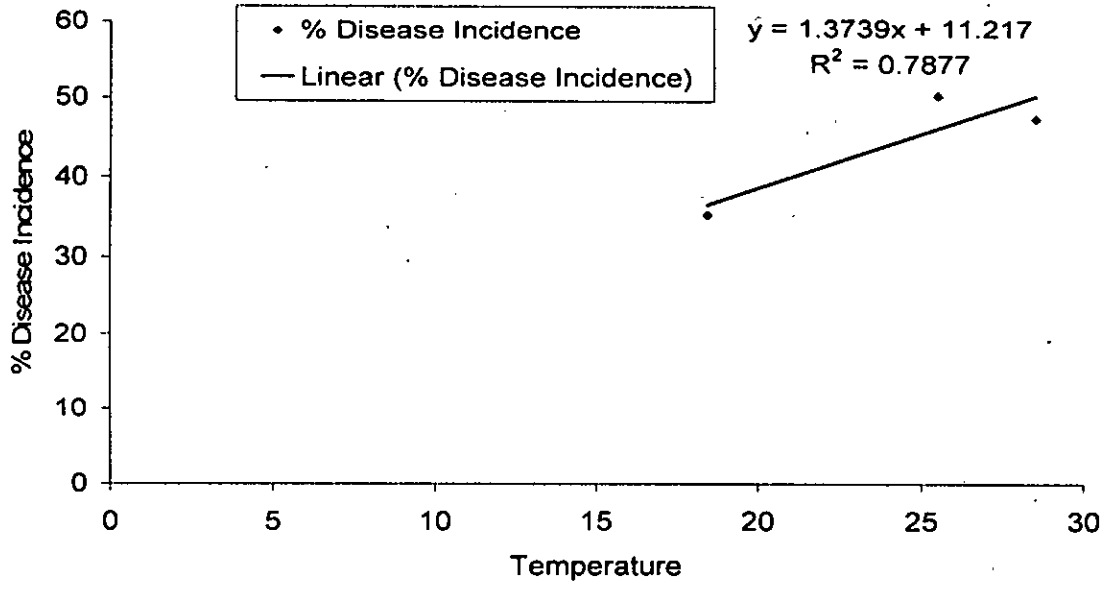


Figure 9. Linear regression analysis of the effect of monthly average temperature of associated four months on incidence of mango Powdery mildew

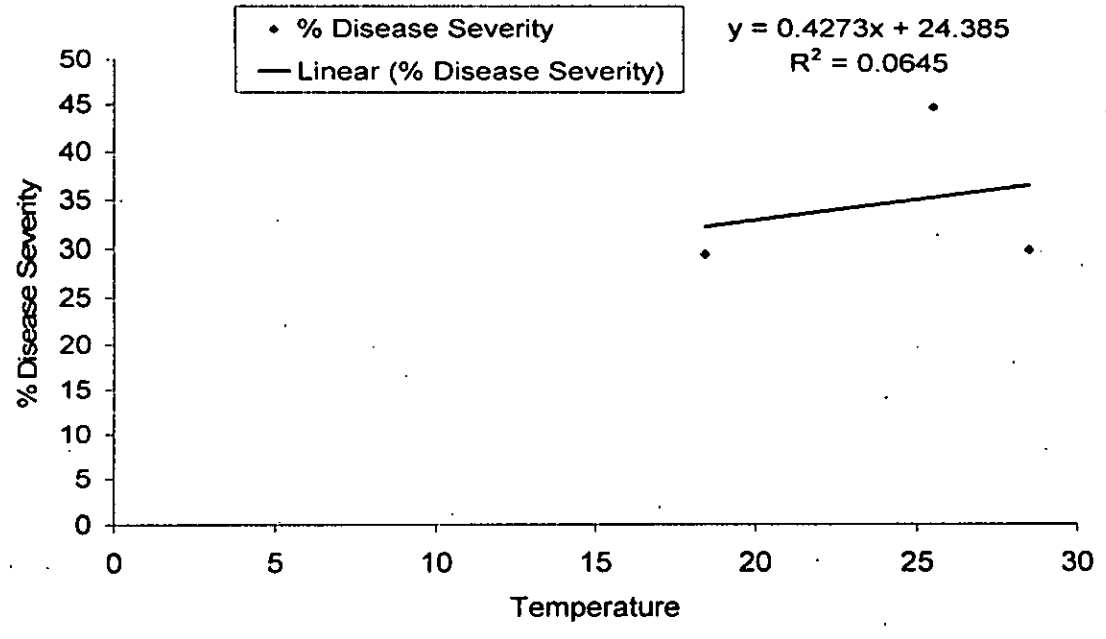


Figure 10. Linear regression analysis of the effect of monthly average temperature of associated four months on severity of mango Powdery mildew

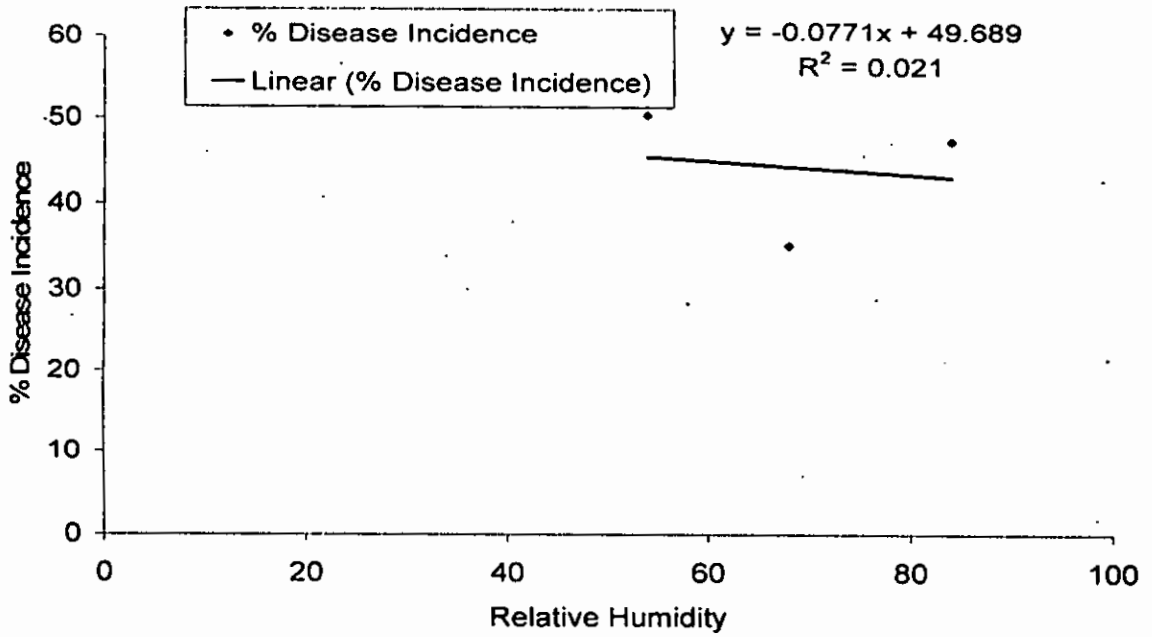


Figure 11. Linear regression analysis of the effect of monthly average relative humidity of associated four months on incidence of mango Powdery mildew

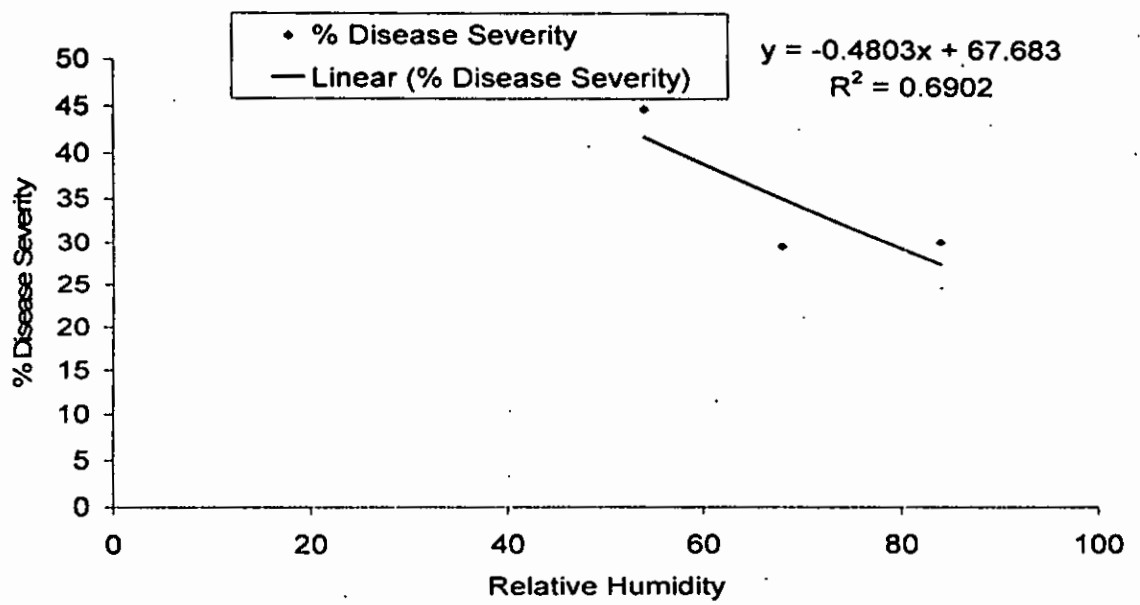


Figure 12. Linear regression analysis of the effect of monthly average relative humidity of associated four months on severity of mango Powdery mildew

4.3.3. Incidence and severity of Red rust of mango

In the month of January, 2007 the incidence of Red rust of mango varied significantly from 18.81-24.50% with respect to nurseries surveyed. The highest incidence (24.50%) was recorded at BRAC Nursery Manikgong followed by Liza Nursery Gulshan Dhaka (23.25%) while the lowest incidence (18.81%) was observed BRAC Nursery Dhaka (Table 4). The severity of Red rust of mango also varied significantly from 9.93-13.43% with respect to nurseries. The highest severity (13.43%) was recorded at BRAC Nursery Manikgong followed by Liza Nursery Gulshan Dhaka (11.80%). The lowest severity (10.01%) was observed in BRAC Nursery Dhaka; followed by Bonayon Nursery Ashulia (11.05%) (Table 4).

In the month of March, 2007 the incidence of Red rust of mango varied significantly from 39.69-47.57% with respect to nurseries surveyed. The highest incidence (47.57%) was recorded at Bonayon Nursery Ashulia, Dhaka followed by BRAC Nursery Dhaka (46.98%) and BRAC Nursery Manikgong (46.10%) while the lowest incidence (39.69%) was observed in Liza Nursery Gulshan Dhaka (Table 4). The severity of Red rust of mango also varied significantly from 26.28-33.39% with respect to nurseries. The highest severity (33.39%) was recorded at Bonayon Nursery Ashulia followed by BRAC Nursery Manikgong (33.11%). The lowest severity (26.28%) was observed in Liza Nursery Gulshan Dhaka (Table 4).

Table 4. Incidence and severity of mango Red rust in five different surveyed nurseries of Dhaka and Manikgonj districts from January, 2007 to October, 2007

Name of the Nursery	January		March		July		October	
	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)	Disease Incidence (%)	Disease Severity (%)
Bonayon Nursery Ashulia	18.97b	11.05b	47.57a	33.39a	26.13c	9.977c	-	-
Borishal Nursery Savar	19.65b	9.933b	43.95ab	31.49a	37.61a	14.59a	-	-
Liza Nursery Gulshan Dhaka	23.25a	11.80ab	39.69b	26.28b	30.38b	12.04b	-	-
BRAC Nursery Dhaka	18.81b	10.01b	46.98a	27.96b	24.28c	9.824c	-	-
BRAC Nursery Manikgong	24.50a	13.43a	46.10a	33.11a	25.97c	12.45b	-	-
CV%	7.11	10.12	6.08	5.27	6.92	6.82	-	-
LSD(0.05)	2.815	2.143	5.136	3.023	3.761	1.513	-	-

Means followed by same letter significantly different at 5% level of significance.

- = Disease was not found.

In the month of July, 2007 the incidence of Red rust of mango varied significantly from 24.28-37.61% with respect to nurseries surveyed. The highest incidence (37.61%) was recorded at Borishal Nursery Savar followed by Liza Nursery Gulshan Dhaka (30.38%) while the lowest incidence (24.28%) was observed in BRAC Nursery Dhaka (Table 4). The severity of Red rust of mango also varied significantly from 9.82-14.59% with respect to nurseries. The highest severity (14.59%) was recorded at Borishal Nursery Savar followed by Liza Nursery Gulshan Dhaka (12.04%). The lowest severity (9.82%) was observed in BRAC Nursery Dhaka (Table 4).

4.3.3.1. Effect of temperature and relative humidity on the incidence and severity of Red rust of mango

The incidence of Red rust of mango was influenced by average temperature and average relative humidity. The incidence of mango Red rust observed in the month of January was 21.65% when the temperature and relative humidity were 18.45°C and 68%, respectively. The incidence of Red rust of mango observed in the month of March was 43.59% when the temperature and relative humidity were 25.50°C and 54%, respectively and in the month of July the incidence of Red rust of mango was 30.94% while the temperature and relative humidity were 28.50°C and 84%, respectively. No disease was observed in the month of October (Figure 13).

The severity of Red rust of mango was influenced by average temperature and average relative humidity. The severity of mango Red rust observed in the month of January was 11.68% when the temperature and relative humidity were 18.45°C and 68%, respectively. The severity of Red rust of mango observed in the month of March was 30.10% when the temperature and relative humidity were 25.50°C and 54%, respectively and in the month of July the severity of Red rust of mango was 12.20% while the temperature and relative humidity were 28.50°C and 84%, respectively. No disease was observed in the month of October (Figure 14).

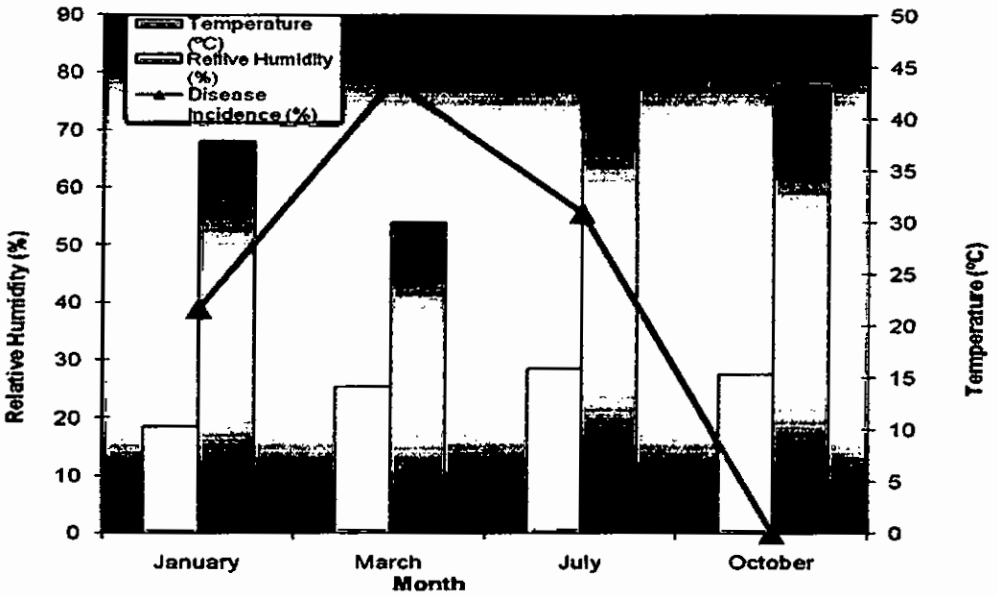


Figure 13. Effect of temperature and relative humidity on the incidence of mango Red rust

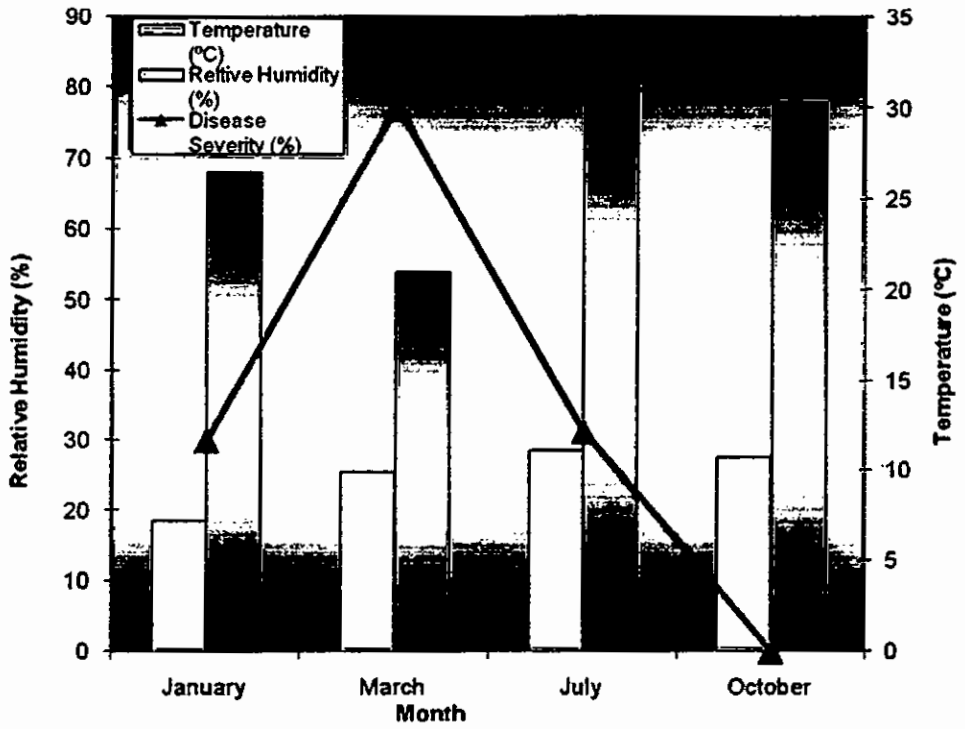


Figure 14. Effect of temperature and relative humidity on the severity of mango Red rust

4.3.3.2. Correlation between the mango Red rust incidence and temperature

A positive correlation between Red rust incidence and temperature was observed (Figure 15). The relationship between disease incidence and temperature could be expressed by the equation y = 1.3155x +6.2957 (R^2 = 0.3798), where y = disease incidence and x = temperature. The R^2 value indicated that contribution of temperature was 37.98% on the incidence of mango Red rust (*Cephaleuros virescens*).

4.3.3.3. Correlation between the mango Red rust severity and temperature

A positive correlation between Red rust severity and temperature was observed (Figure 16) in case of mango Red rust. The relationship between disease severity and temperature could be expressed by the equation y = 0.5101x +5.6767 (R^2 = 0.063), where y = disease severity and x = temperature. The R^2 value indicated that contribution of temperature was 6.30% on the severity of mango Red rust (*Cephaleuros virescens*).

4.3.3.4. Correlation between the mango Red rust incidence and relative humidity

A negative correlation between Red rust incidence and relative humidity was observed (Figure 17). The relationship between disease incidence and relative humidity could be expressed by the equation y = -0.3979x +59.39 (R^2 = 0.2942), where y = disease incidence and x = relative humidity. The R^2 value indicated that contribution of relative humidity was 29.42% on the incidence of mango Red rust (*Cephaleuros virescens*).

4.3.3.5. Correlation between the mango Red rust severity and relative humidity

A negative correlation between Red rust severity and relative humidity was observed (Figure 18). The relationship between disease severity and relative humidity could be expressed by the equation $y = -0.5818x + 57.945$ ($R^2 = 0.693^*$), where y = disease severity and x = relative humidity. The R^2 value indicated that contribution of relative humidity was 69.30% on the severity of mango Red rust (*Cephaleuros virescens*).

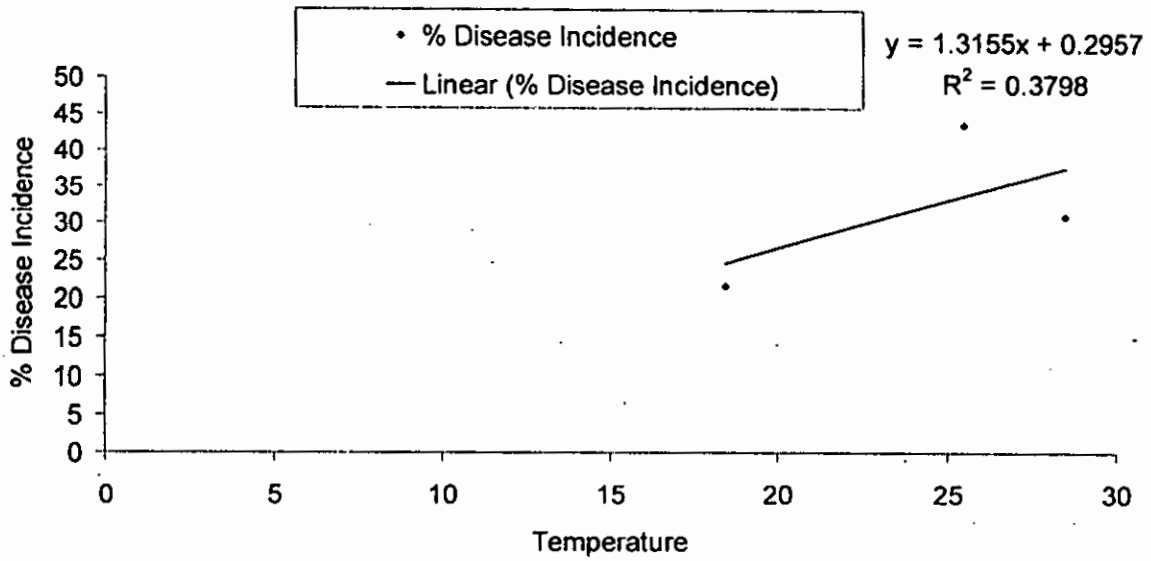


Figure 15. Linear regression analysis of the effect of monthly average temperature of associated four months on incidence of mango Red rust

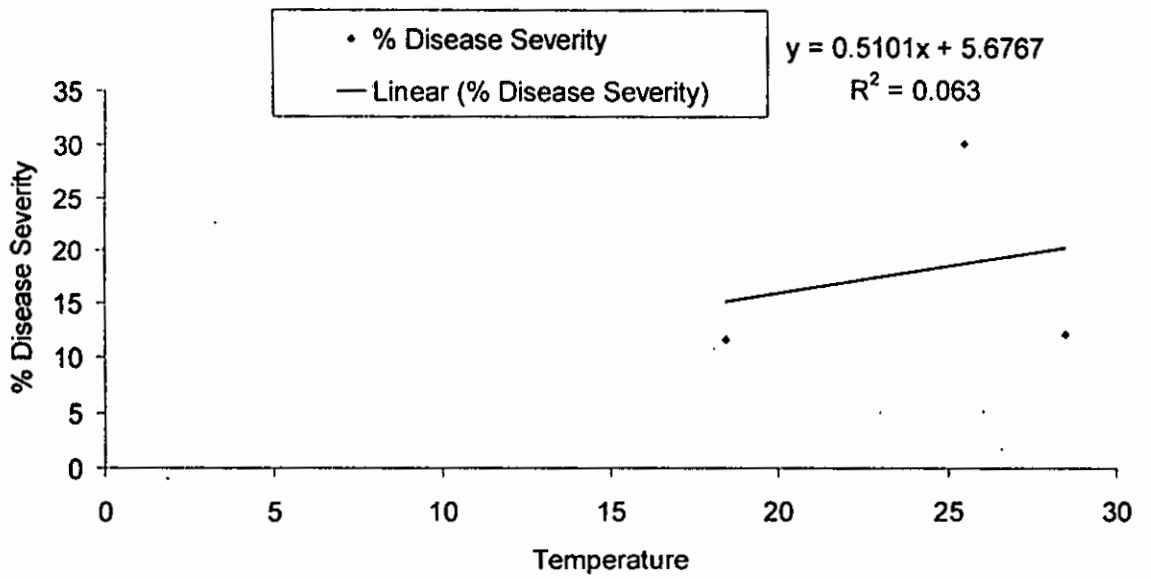


Figure 16. Linear regression analysis of the effect of monthly average temperature of associated four months on severity of mango Red rust

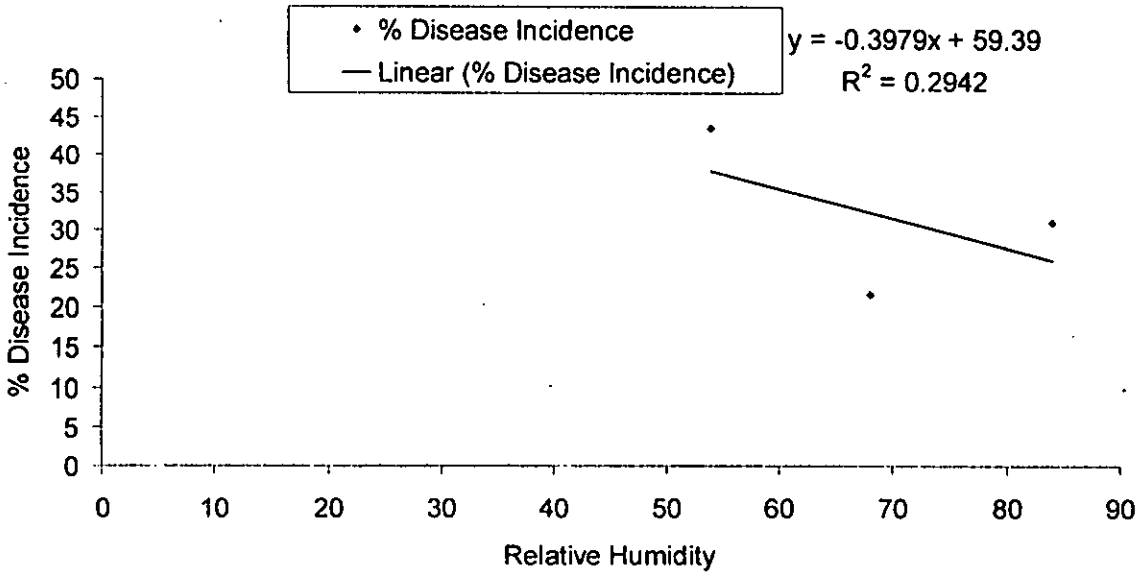


Figure 17. Linear regression analysis of the effect of monthly average relative humidity of associated four months on incidence of mango Red rust

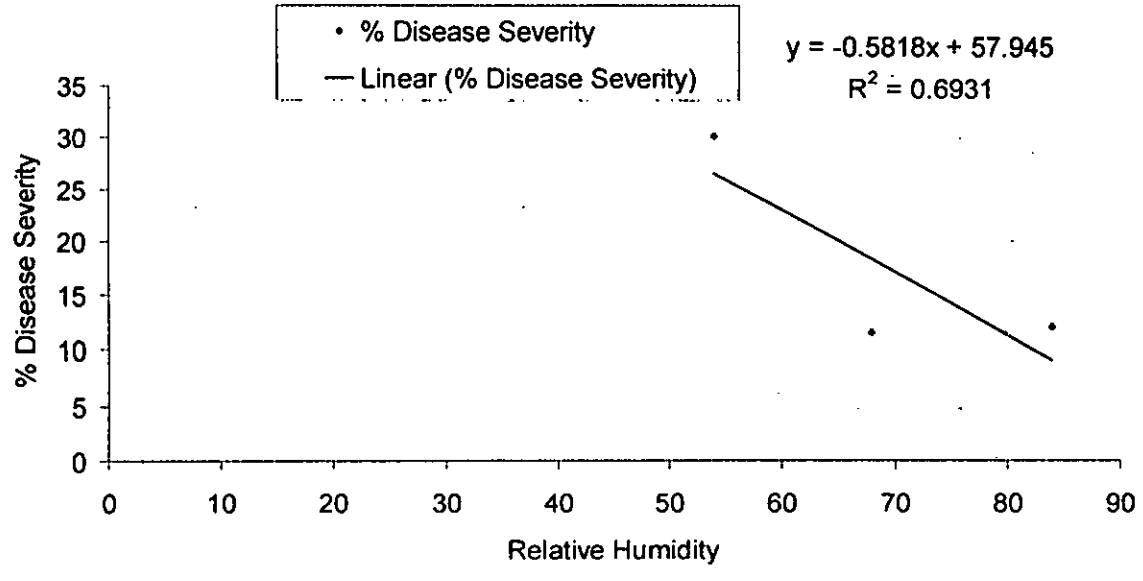


Figure. 18. Linear regression analysis of the effect of monthly average relative humidity of associated four months on severity of mango Red rust

4.3.4. Incidence and severity of Alternaria Leaf Spot of mango

In the month of January, 2007 the incidence of Alternaria leaf spot of mango varied significantly from 37.50-52.55% with respect to nurseries surveyed. The highest incidence (52.55%) was recorded at Borishal Nursery Savar followed by BRAC Nursery, Dhaka (44.62%) while the lowest incidence (37.50%) was observed Liza Nursery Gulshan Dhaka (Table 5). The severity of Alternaria leaf spot of mango also varied significantly from 22.17-29.45% with respect to nurseries. The highest severity (29.45%) was recorded at Borishal Nursery Savar followed by BRAC Nursery, Dhaka (27.61%) while the lowest severity (22.17%) was observed in Bonayon Nursery Ashulia; followed by Liza Nursery Gulshan Dhaka (22.72%) (Table 5).

In the month of March, 2007 the incidence of Alternaria leaf spot of mango varied significantly from 42.87-48.89% with respect to nurseries surveyed. The highest incidence (42.87%) was recorded at Liza Nursery Gulshan, Dhaka followed by Bonayon Nursery Ashulia (48.89%) while the lowest incidence (42.87%) was observed in Borishal Nursery Savar (Table 5). The severity of Alternaria Leaf Spot of mango also varied significantly from 27.20-35.74% with respect to nurseries. The highest severity (35.74%) was recorded at BRAC Nursery, Dhaka followed by Liza Nursery Gulshan (33.83%) while the lowest severity (27.20%) was observed in Borishal Nursery Savar (Table 5).

Table 5. Incidence and severity of mango Alternaria leaf spot in five different surveyed nurseries of Dhaka and Manikgonj districts from January to October, 2007

Name of the Nursery	January		March		july		October	
	Disease Incidence	Disease Severity	Disease Incidence	Disease Severity	Disease Incidence	Disease Severity	Disease Incidence	Disease Severity
Bonayon Nursery Ashulia	38.36c	22.17d	48.89a	33.63a	49.66a	32.19a	53.59a	40.77a
Borishal Nursery Savar	52.55a	29.45a	42.87b	27.20b	45.83b	35.90a	53.22a	39.31ab
Liza Nursery Gulshan Dhaka	37.50c	22.72cd	49.03a	33.83a	49.36a	34.20a	50.30b	37.21b
BRAC Nursery Dhaka	44.62b	27.61ab	45.80ab	35.74a	46.89b	34.88a	46.93c	38.36ab
BRAC Nursery Manikgong	39.40c	25.58bc	43.44b	32.84a	44.98b	33.09a	50.08b	36.28b
CV%	6.14%	4.42	3.70%	6.37	2.53	7.28	3.04	4.00
LSD	4.91	3.09	3.20	3.91	2.25	4.67	2.91	2.892
Level of Significance	0.05	0.01	0.05	0.05	0.05	0.05	0.05	0.05

Means followed by same letter significantly different at 1% or 5% level of significance.

In the month of July, 2007 the incidence of Alternaria leaf spot of mango varied significantly from 44.98-49.66% with respect to nurseries surveyed. The highest incidence (49.66%) was recorded at Bonayon Nursery Ashulia followed by Liza Nursery Gulshan Dhaka (49.36%) while the lowest incidence (44.98%) was observed BRAC Nursery Manikgong (Table 5). The severity of Alternaria leaf spot of mango also varied significantly from 32.19-35.90% with respect to nurseries. The highest severity (35.90%) was recorded at Borishal Nursery Savar followed by Liza Nursery Gulshan Dhaka (34.88 %) while the lowest severity (32.19 %) was observed in Bonayon Nursery Ashulia followed by BRAC Nursery Manikgong (33.09%) (Table 5).

In the month of October, 2007 the incidence of Alternaria leaf spot of mango varied significantly from 46.93-53.59% with respect to nurseries surveyed. The highest incidence (53.59%) was recorded at Bonayon Nursery Ashulia followed by Borishal Nursery Savar (50.30%) while the lowest incidence (46.93%) was observed in BRAC Nursery Dhaka (Table 5). The severity of Alternaria Leaf Spot of mango also varied significantly from 36.28-40.77% with respect to nurseries. The highest severity (40.77%) was recorded at Bonayon Nursery Ashulia followed by BRAC Nursery Dhaka (38.36%) while the lowest severity (36.28%) was observed in BRAC Nursery Manikgong (Table 5).

4.3.2.1. Effect of temperature and relative humidity on the incidence and severity of Alternaria leaf spot of mango

The incidence of Alternaria leaf spot of mango was influenced by temperature and relative humidity. The incidence of Alternaria leaf spot of mango observed in the month of January was 45.02% when the temperature and relative humidity were 18.45°C and 68%, respectively. The incidence of Alternaria leaf spot of mango observed in the month of March was 45.88% when the temperature and relative humidity were 25.50°C and 54%, respectively. In the month of July the incidence of Alternaria leaf spot of mango was 46.84% while the temperature and relative humidity were 28.50°C and 84%, respectively. In the month of October the incidence of Alternaria leaf spot of mango was 50.84% while the temperature and relative humidity were 27.60°C and 78% respectively (Figure 19).

The severity of Alternaria leaf spot of mango was influenced by average temperature and average relative humidity. The severity of Alternaria leaf spot of mango observed in the month of January was 25.81% when the temperature and relative humidity were 18.45°C and 68%, respectively. The severity of Alternaria leaf spot of mango observed in the month of March was 31.47% when the temperature and relative humidity were 25.50°C and 54%, respectively. In the month of July the severity of Alternaria leaf spot of mango was 34.52% while the temperature and relative humidity were 28.50°C and 84%, respectively and in the month of October the severity of Alternaria leaf spot of mango was 38.38% while the temperature and relative humidity were 27.60°C and 78%, respectively (Figure 20).

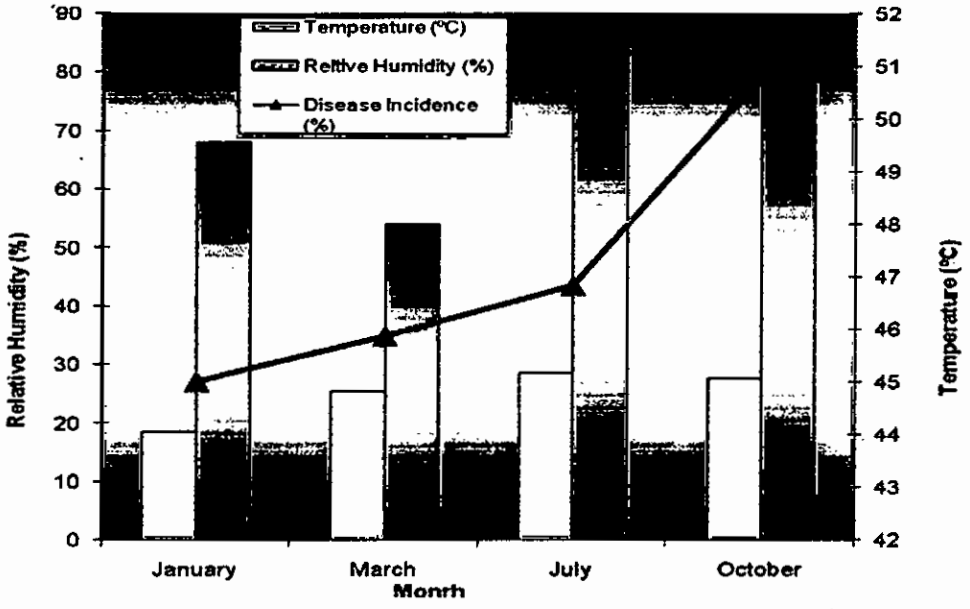


Figure 19. Effect of temperature and relative humidity on the incidence of mango Alternaria leaf spot

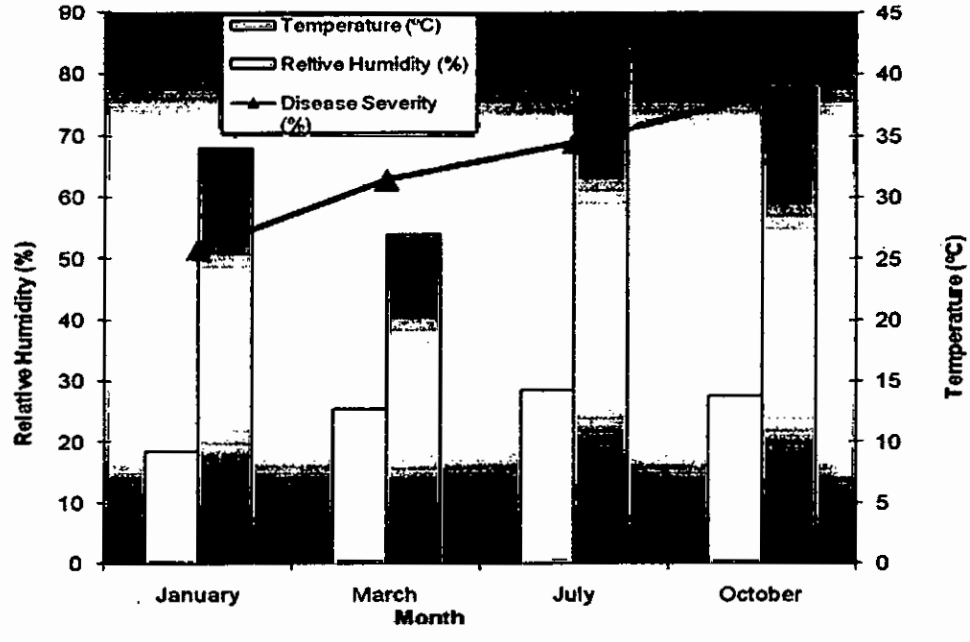


Figure 20. Effect of temperature and relative humidity on the severity of mango Alternaria leaf spot

4.3.4.2. Correlation between the mango Alternaria leaf spot incidence and temperature

A positive correlation between Alternaria leaf spot disease incidence and temperature was observed (Figure 21). The relationship between disease incidence and temperature could be expressed by the equation y = 0.3508x +38.364 (R^2 = 0.3876) where y = disease incidence and x = temperature. The R^2 value indicated that contribution of temperature were 38.76% on the incidence of mango Alternaria leaf spot (*Alternaria alternata*).

4.3.4.3. Correlation between the mango Alternaria leaf spot severity and temperature

A significant positive correlation between Alternaria leaf spot disease severity and temperature was observed (Figure 22). The relationship between disease severity and temperature could be expressed by the equation y = 1.0563x +6.1248 (R^2 = 0.8211*) where y = disease severity and x = temperature. The R^2 value indicated that contribution of temperature were 82.11% on the severity of mango Alternaria leaf spot (*Alternaria alternata*).

4.3.4.4. Correlation between the mango Alternaria leaf spot incidence and relative humidity

A positive correlation between Alternaria leaf spot disease incidence and relative humidity was observed (Figure 23). The relationship between disease incidence and relative humidity could be expressed by the equation y = 0.0962x +40.306 (R^2

= 0.2521) where y = disease incidence and x = relative humidity. The R^2 value indicated that contribution of relative humidity were 25.21% on the incidence of mango Alternaria leaf spot (*Alternaria alternata*).

4.3.4.5. Correlation between the mango Alternaria leaf spot severity and relative humidity

A positive correlation between Alternaria leaf spot disease severity and relative humidity was observed (Figure 24). The relationship between disease severity and relative humidity could be expressed by the equation y =9.2035x +18.09 (R^2 = 0.2530) where y = disease severity and x = relative humidity. The R^2 value indicated that contribution of relative humidity were 25.30% on the severity of mango Alternaria leaf spot (*Alternaria alternata*).

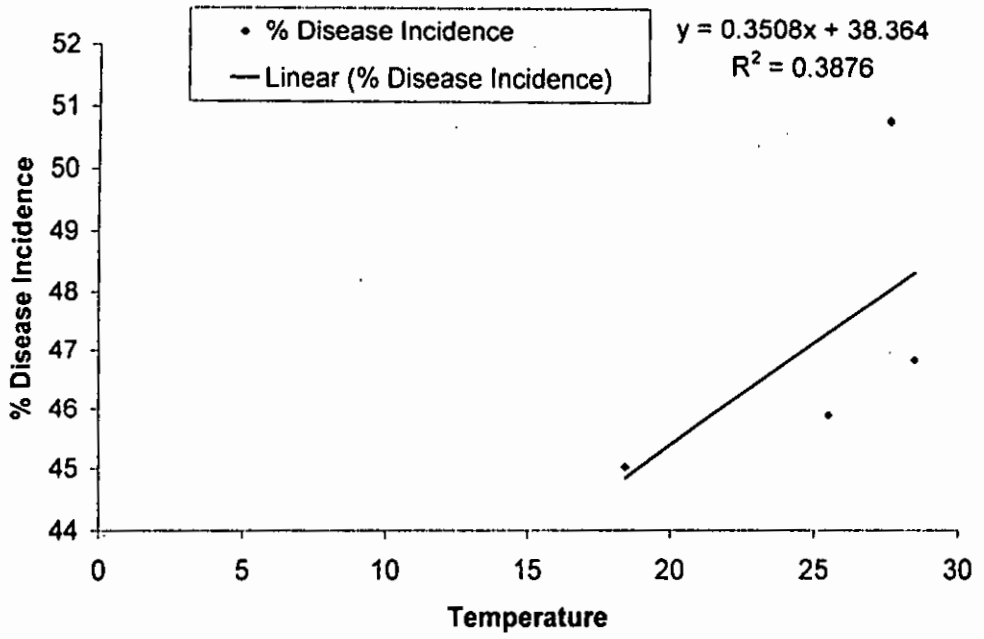


Figure 21. Linear regression analysis of the effect of monthly average temperature of associated four months on incidence of mango Alternaria leaf spot

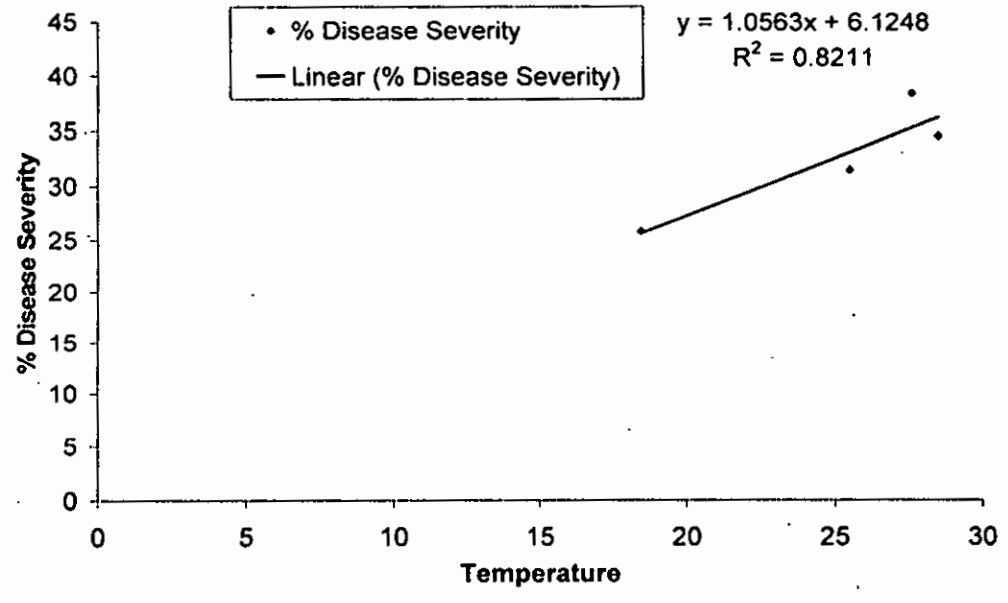


Figure 22. Linear regression analysis of the effect of monthly average temperature of associated four months on severity of mango Alternaria leaf spot

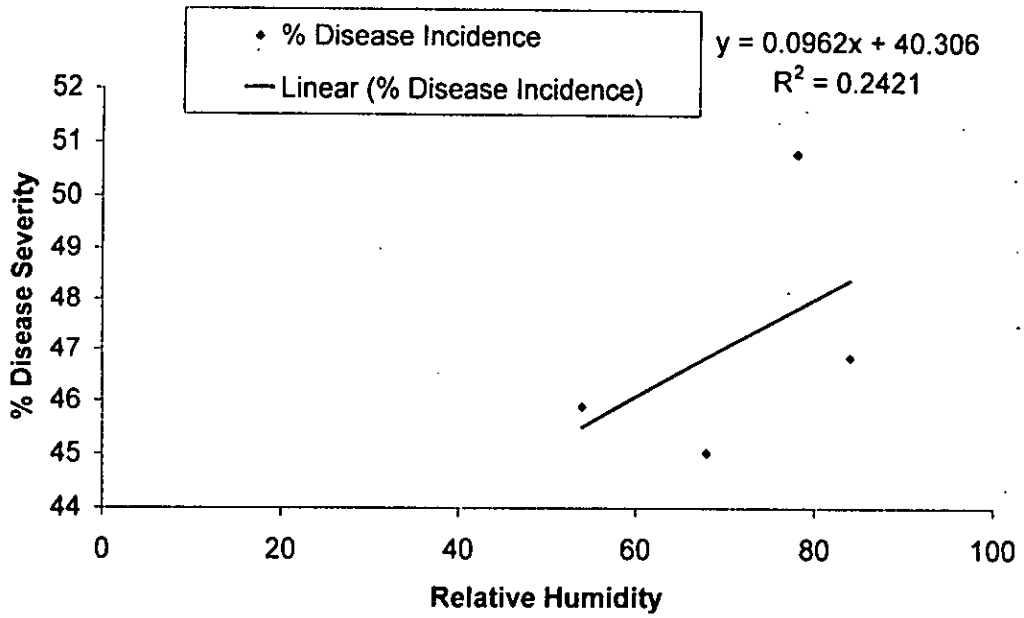


Figure 23. Linear regression analysis of the effect of monthly average relative humidity of associated four months on incidence of mango Alternaria leaf spot

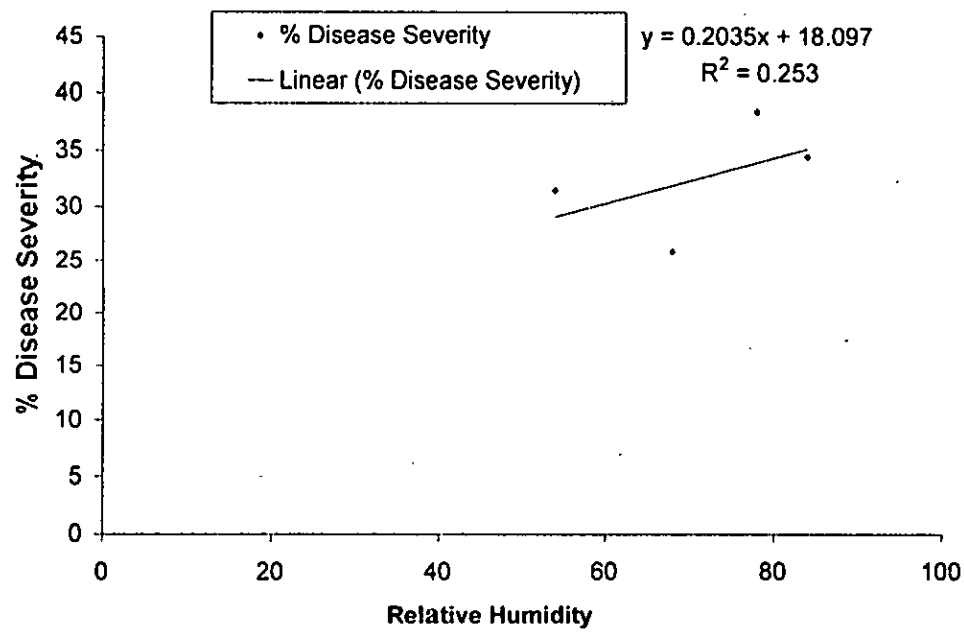


Figure 24. Linear regression analysis of the effect of monthly average relative humidity of associated four months on severity of mango Alternaria leaf spot

4.3.5. Average disease incidence and severity of the six diseases recorded in five nurseries from January to October

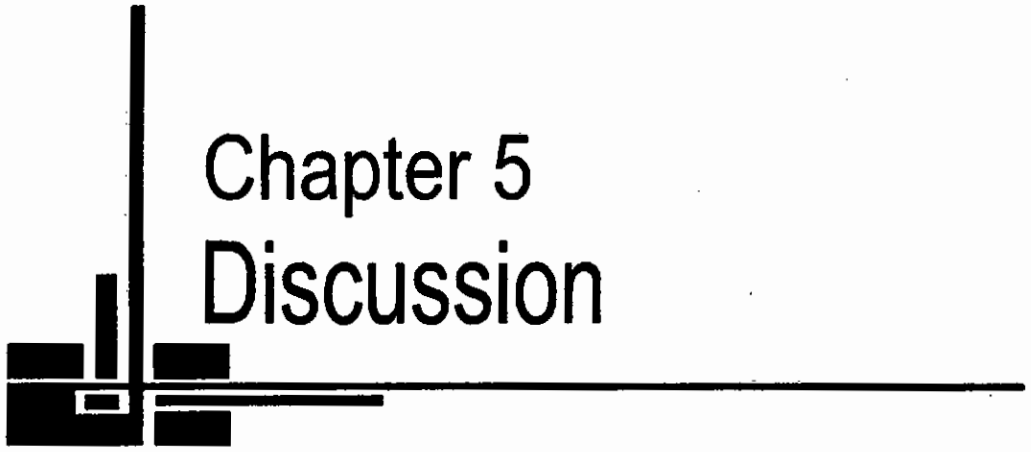
The average incidence of diseases viz. Anthracnose, Alternaria leaf spot, Powdery mildew, Red rust, Sooty mould and Bacterial leaf spot was observed from January to October were 50.14%, 47.14%, 33.30%, 24.05%, 10.50% and 9.75%, respectively and the corresponding average disease severity were 37.39%, 32.55%, 26.03%, 13.50%, 10.95% and 10.12% respectively.

4.3.6. Average temperature and relative humidity of Dhaka and Manikgonj from January to October 2007

The average maximum, minimum as well as mean temperature and relative humidity of each month during the experimental period have been recorded and are presented in Table 6.

Table 6. Average temperature and relative humidity of Dhaka and Manikgonj from January to October, 2007

Month	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Average Temperature (^{0}C)	Average Relative Humidity (%)
January	24.4	12.4	18.45	68
March	31.4	19.6	25.50	54
July	31.4	25.7	28.50	84
October	31.4	23.8	27.6	78



Chapter 5
Discussion

CHAPTER 5

DISCUSSION

In the present study six diseases namely Alternaria leaf spot, Anthracnose, Powdery mildew, Sooty mould, Red rust and Bacterial leaf spot were recorded in five nurseries under two districts-Dhaka and Manikgonj. Out the diseases four were fulgal viz. Alternaria leaf spot, Anthracnose, Powdery mildew and Sooty mould; one algal - Red rust and one bacterial - Bacterial leaf spot. The six diseases recorded in the present study have also been reported on mango seedlings from different countries of the world (Singh, 1968; Ploetz *et al.*,1994 and Meah and Khan, 1983). Suchana (2008) recorded all the diseases enumerated by the present author except Alternaria leaf spot. Thus Alternaria leaf spot appears to be a new recorded seedling disease of mango in the country.

The diseases recorded in the present study were identified by observing the symptoms associated attempts were made to detect the casual organism of the respective disease by isolation and identification of the pathogens associated with the infected seedlings through preparation of slides and examining them under compound microscope. Microscopic examination of the seedling affected by Alternaria leaf spot, Anthracnose, Powdery mildew and Red rust revealed that respectively three pathogenic fungi *Alternaria alternata, Colletotrichum gloeosporioides* and *Oidium mangiferae and* an alga *Cephaleuros virescens* were associated with the diseases in the study. Two pathogenic fungi - *Colletotrichum gloeosporioides* and *Alternaria alternata* were isolated respectively from

Alternaria leaf spot and Anthracnose infected tissues. Ploetz *et al.* (1994) reported that Alternaria leaf spot, Anthracnose, Powdery mildew and Red rust were caused by *Alternaria alternata, Colletotrichum gloeosporioides, Oidium mangiferae* and *Cephaleurous virescencs*, In another study Awasthi *et al.* (2005) and Mortuza (1990), found that Anthracnose, Powdery mildew and Red rust were caused by *Colletotrichum gloeosporioides, Oidium mangiferae, Cephaleurous virescencs* but they did not described Alternaria leaf spot and its pathogen.

No pathogen could be isolated or detected from the sooty mould and Bacterial leaf spot affected seedlings. Due to time constant Kock's Postulates could not be conducted to confirm the pathogenic potentiall of the isolated or detected pathogen from the diseased seedlings.

In Bangladesh nine diseases including five observed by the present author, were recoded by Suchana (2008), based only on symptoms. No attempt was made by her to isolate the causal organism of the diseases and prove its pathogenisity. The pathogens of the entire six diseases encountered in the present study were identified as the causes by workers from different mango growing countries of the world. Therefore, further critical study are needed to determine the cause(s) of the seedling diseases of mango recorded in Bangladesh.

Of the six diseases four diseases viz. Alternaria leaf spot, Anthracnose, Powdery mildew, Red rust were found to occur in all the five nurseries at the two selected locations. On the other hand Sooty mould were not found in Liza nursery, BRAC nursery, Bonayon nursery located in the Dhaka district similarly Bacterial leaf spot could not be recorded in Liza nursery and BRAC nursery.

The prevalence of the recorded six diseases varied independently of each other with respect to nursery and its location. Similar variation in prevalence of seedling diseases was recorded by Suchana (2008), Mortuza (1990) Reza, Anonymous (1990) and Kader (1996a) in Bangladesh.

As regard to incidence of the six diseases recorded in the present study, Anthracnose was the most pre-dominant (50.14%) followed by Alternaria leaf spot (47.14%), Powdery mildew (33.29%), Red rust (24.06%) while Bacterial leaf spot (9.25%) had the least occurrence. When disease severity was concerned Anthracnose (37.39%) was the prevalent disease followed by Alternaria leaf spot (32.55%), Powdery mildew (26.02%) and Sooty mould (10.95%), in this case also Bacterial leaf spot had the lowest prevalence.

In the present study, the diseases were recorded four times during the period of ten month survey from January to October. During the survey period prevalence of Anthracnose and Alternaria leaf spot was found to increase with the increase in time. Thus, the lowest prevalence (Incidence and Severity) of Anthracnose and Alternaria leaf spot diseases were recorded in January (48.49% and 27.97%) and (42.49% and 25.51%) and higher in October (66.57% and 52.54%) and (50.82% and 38.39%). The temperature and relative humidity was observed in January was 18.45^{0}C and 68% respectively and in October it was 27.60^{0}C and 78% respectively. A positive correlation was observed between prevalence of Anthracnose with temperature and relative humidity. With the increase of

temperature and relative humidity both the incidence and severity increased significantly. Statistical analysis shows that the contribution of temperature and relative humidity collectively around 74.57% on incidence and 89.82% on severity of mango Anthracnose. The other factors may influence the prevalence of the disease; it might be amount of rainfall, hours of rainfall or relative humidity. Ekbote, *et al.,* (2001) observed that high prevalence of mango Anthracnose prevailed at high relative humidity (78-90%) and temperature (22-28^{0}C). Ploetz *et al.,* (1994) also found that 70-90% relative humidity and 22-28°C temperature helps to develop the mango Anthracnose disease. A similar trend of effect of temperature and relative humidity on the incidence and severity of Alternaria leaf spot of mango was observed in the present study. The growth and development of *Alternaria alternata* is influenced by temperature and relative humidity. Statistical analysis shows that the contribution of temperature and relative humidity collectively around 62.97% on incidence and nearly 100% on severity of mango Alternaria leaf spot. This findings strongly supported by Ploetz *et al.,* (1994) stated that a minimum of 350 hr of relative humidity over 80% is needed for Alternaria leaf spot disease development.

The highest prevalence (Incidence and Severity) of Red rust observed in the month of March while the temperature and relative humidity were 25.25^{0}C and 54% respectively. No disease was observed in the month of October while October is characterized high temperature and low relative humidity. However Ploetz *et al.,* (1994) observed that a wet and humid environment within the tree canopy is

conducive for spread and establishment of alga (*Cephaleurous virescencs*). The negative trend may be described by the pattern of rainfall of our country in the season of monsoon. Since total amount of rainfall is concentrated in the month of July to October and high relative humidity prevails in those months. Thise high rainfall may washed out the superficially attached Zoospores on the leaves as a result no prevalence of Red rust was observed in the month of October. The highest prevalence (Incidence and Severity) of Powdery mildew observed in the month of March while the temperature and relative humidity were 25.25^{0}C and 54% respectively. No disease was observed in the month of October. This result is in accordance with the findings of Akhtar *et al.*, (1999) and Ploetz *et al.*, (1994). Akhtar *et al.*, (1999) observed 40-60% relative humidity and 25^{0}C is favorable for conidia development of *Oidium*. Ploctz *et al.*, (1994) observed that Conidia germination of Powdery mildew takes 5-6 hr at 23°C temperature and 20% relative humidity, but optional disease development occurs in the diurnal range of 10-30°C and 50-80% relative humidity.

Therefore, the present study on the occurrence of seedling diseases in the nursery reviles that all the diseases studied are highly related to the temperature and relative humidity. Other parameters of epidemiology viz. total amount of rainfall in the growing period, leaf wetness period, vapor presser deficit, sunshine hour, microclimatic parameters including canopy temperature, relative humidity etc. should be critically evaluated to have better understanding of disease development, Further, these parameters have profound effects on over wintering formation,

germination and development of inoculam in different pathosystem and these should be critically studied for each host-pathogen system to find out the most appropriate time to combat the disease at minimum effort.

Chapter 6
Conclusion

CHAPTER 6

SUMMARY AND CONCLUSION

Mango seedlings suffer from various diseases in Bangladesh, but least concrete information regarding their distribution, incidence, severity and epidemiology in Dhaka and Manikgonj is available. Therefore, an attempt has been made to study the occurrence and prevalence of seedlings diseases of mango and to study the correlation between temperature and relative humidity with the development of Disease in selected nurseries of Dhaka and Manikgonj.

Three experiments were carried out throughout the study period from January to October, 2007. A total of 1360 seedlings in five selected nurseries were surveyed. Six different diseases viz. Alternaria leaf spot, Anthracnose, Powdery mildew, Sooty mould, Red rust and Bacterial leaf spot were recorded during the survey period in five nurseries of Dhaka and Manikgonj. The pathogen identified from the Alternaria leaf spot, Anthracnose, Powdery mildew and red rust symptoms were *Alternaria alternata, Colletotrichum gloeosporioides, Oidium mangiferae* and *Cephaleurous virescencs* respectively. Pathogen could not be isolated or detected from the sooty mould and Bacterial leaf spot affected seedlings.

The prevalence of the recorded six diseases varied independently to each other with respect to nursery and its location. Regarding the incidence of the six diseases Anthracnose was the most pre-dominant (50.14%) followed by Alternaria leaf spot (47.14%), Powdery mildew (33.29%), Red rust (24.06%) while Bacterial leaf spot (9.25%) had the least occurrence. When disease severity was concerned,

Anthracnose (37.39%) was the most prevalent disease followed by Alternaria leaf spot (32.55%), Powdery mildew (26.02%) and Sooty mould (10.95%), while Bacterial leaf spot had the lowest prevalence. The prevalence of Anthracnose and Alternaria leaf spot was found to increase with the increase of time. The highest prevalence of Alternaria leaf spot and Anthracnose were in October and lowest in January. The prevalence of Red rust and Powdery mildew were highest in March but no disease was observed in of October.

Therefore, the present study on the occurrence of seedling diseases in the nursery revealed that all the diseases were highly related to the temperature and relative humidity. Other parameters of epidemiology viz. total amount of rainfall in the growing period, leaf wetness period, vapor presser deficit, sunshine hour, microclimatic parameters including canopy temperature, relative humidity etc. should be critically evaluated to have better understanding of disease development, Further, these parameters have profound effects on over wintering formation, germination and development of inoculam in different pathosystem and these should be critically studied for each host-pathogen system to find out the most appropriate time to combat the disease at minimum effort.


References

REFERENCES

Akem, C. N. 2006. Mango anthracnose disease: present status and future research priorities, Plant-Pathology-Journal-Faisalabad, Department of Primary Industries and Fisheries, Horticulture and Forestry Science, Australia. 5(3): 266-273pp.

Akhtar, K. P., I. A. Khan, M. J., Jaskani, M. Asif and M. A. Khan. 1999. Isolation and characterization of *Fusarium moniliforme* var. *subglutinans* [*Gibberella fujikuroi* var. *subglutinans*] from malformed mango. Sultan Qaboos University Journal for Scientific Research Agricultural Sciences. 4(2): 19-25pp.

Akhtar, K. P., I. A. Khan, M. J., Jaskani, M Asif and M. A. Khan. 1999. Preventive control of powdery mildew disease if mango. Sultan Qaboos University Journal for Scientific Research Agricultural Science. 4(1):23-28

Anonymous. 1989. Manual on mango cultivation in Bangladesh. Horticulture Division. BARI and FAO/UNDP mango improvement and development [BGD/81/022]. 1p.

Anonymous. 1990. Plant Pathology Survey and monitoring of different diseases of mango. Annual Report, Division of Plant Pathology, BARI (Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 73p.

Anonymous. 2003. Catalogue on mango germplasm Vol.1. IPGRI-ADB-TFT project. Horticulture Research centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 1p.

Awasthi, D. P., S. Sarkar, N. K. Mishra and S. A. K. M. Kaisar. 2005. Disease situation of some major fruit crops in new alluvial plains of west Bengal. Environment and Ecology. **235** (Special-3): 497-499pp.

BBS. 2006. Monthly Statistical Bulletin, Bangladesh. Bangladesh Bureau of Statistics Division, Ministry of planning, Govt. of peoples' Republic of Bangladesh, Dhaka. 55p.

Bitancourt, A. A. and A. F. Jenkins. 1943. Scab of mango caused by *Elsinoe. Abs.* in Phytopathology **33**:1p.

Campbell, C. W. and R.B. Marlatt. 1986. Current status of mango malformation disease in Florida. Proc. Int. Soc. Tropical Hort. **30**: 223-226pp.

Candole, A. D. 1984. Origin of cultivated plants. Kegal Paul Trench and Co., London. 1-67pp.

Conde, B. D., R. N. Pitkethley, E. S. C. Smith, V. J. Kulkarni, k. Thiagalingam, M. I. Connelly and D.A. Hamilton. 1997. Disease notes or new records: Identification of mango scab caused by *Elisnoe mangiferae* in Australia. Australasian Plant Pathology. **26**(2): 131-132pp.

Colon-Garay, J., L. I. Rivera-Vargas, R. McGovern and P. R. R. Del. 2002. Hypovirulent isolates of *Colletotrichum gloeosporioides* induce resistance to anthracnose in detached mango fruits and seedlings. Journal of Agriculture, University of Puerto Rico. **86**(1&2): 55-64pp.

Darvas, J. M. 1998. Malformation of mango nurseries. South African Mango Growers' Association Research Journal. **8**:7p.

Dey, T. K., Ayub, G. Mortuza and N. Sultana. 2007. Research on vegetables, spices and fruits disease management at Bangladesh Agricultural Research Institute. BARI, Joydebpur, Gazipur. 72-85pp.

Ekbote, S. D., G. M Padaganur and K. H. Anahosur. 2001. Incidence of mango anthracnose in Dharwad, Plant Pathology Newsletter, Department of Plant Pathology, University of Agricultural Sciences, Dharwad - 580 005, India. **19**: 28-30pp.

FAO, 2002. Production Year book. Statistical Series No. 163. Food and Agricultural Organization , Rome, Italy. 182p.

Fitzell, R. D. and C. M. Peak. 1984. The epidemiology of anthracnose disease of mango inoculam sources, spore production and dispersal. Ann. App.Biol. **104**:53-59pp.

Freeman, S., G.D.Klein, N. Korolev and A. Sztejnberg. 2004. Epidemiology and survival of *Fusarium mangiferae*, the causal agent of mango malformation disease, Acta-Horticulturae, Dept. of Plant Pathology, ARO, Israel. **645**: 487-491pp.

Hamid, M. and M. Jalaluddin. 2006. Recurring incidence of sooty mould of mango in Karachi and its control. International Journal of Biology and Biotechnology. **3**(3): 561-565pp.

Hussein, N. E. A. 1997. Mango leaf spot in Minia Governorate. Annals of Agricultural Science Moshtohor. **35**(4):2029-2042pp.

Islalm, M. R. 2005. An integrated approach for management of thomopsis blight and fruit rot of eggplant. A Ph.D. thesis submited to the department of plant pathology Bangladesh Agricultural University Mymensingh. 33, 41pp

Jeger, M. J., Plumbley and H.O.W. Eggins. 1988. Post harvest losses caused by anthracnose (*Colletotrichum gloeosporioides*) of tropical fruits and vegetables. Selected papers presented at the 7th International Biodeterioration Symposium, Cambridge, UK. 642-646pp.

Jianguo, R., Siliang, Y. Weihong and L. Yangrui. 2002. Study on biocontrol of mango anthracnose disease by antogonistic microorganisms. South-West China Journal of Agricultural Sciencel. **5**(4):82-85pp.

Karim, A. 1985.Post harvest problems and prospects of mango in Bangladesh Proceedings 4th National symposium of Bangladesh society for Horticultural Science. 130-137pp.

Kuo, K. C., 2001, Sensitivity of mango anthracnose pathogen, *Colletotrichum gloeosporioides*, to the fungicide prochloraz in Taiwan, Bureau of Animal and Plant Inspection and Quarantine, Council of Agriculture, Executive Yuan, Taipei, Taiwan, Proceedings of the National Science Council, Republic of China Part-B, Life Sciences, Department of Plant Protection. **25**(3): 174-179pp.

Lahav, C., A. Sztejnberg, M. Maymon, Y. Danisov, and S. Freeman. 2001. Mango malformation disease presence and identification of the casual organism Fusarium subglutinans in main branches of mature trees and saplings grafted with infected scions, and importance of sanitation treatments in orchards, Alon-Hanotea, Extension Service, Ministry of Agriculture and Rural Development, Israel. **55**(7): 301-304

Mathur, S. B and O. Kongsdal. 2003. Common Laboratory Seed Health Testing Method for Detecting Fungi. Danish Govt. Institute of Seed Pathology for Developing Countries, Copenhagen, Denmark, Published by ISTA, Switzerland. 420-430pp.

Meah, M. B. and A. A. Khan. 1987. Survey of some important and vegetable crops of Bangladesh. Ann. Prog. Rep. (1986-87). 1-28 pp.

Misra,A. K. 2001. Powdery mildew a serious disease of mango, Journal-of-Applied-Horticulture-Lucknow, Central Institute for Subtropical Horticulture, Rehmankhera, India. **3**(1): 63-68pp.

Mortuza, M. G. 1990. Survey and monitoring of disease of mango under different agro-ecological condition of Bangladesh. Annual report on Fruit Improvement (1989-90). Horticulture centre. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 45-46pp.

Mukherjee, S. K. (1958) Indian Journal of Horticulture. 16:129-134.

Okigbo, R. N. and M. I. Osuinde. 2003. Fungal leaf spot diseases of mango (*Mangifera indica*) in Southeastern Nigeria and biological control with *Bacillus subtilis*, Nigeria, Plant-Protection-Science, Department of Biological Sciences, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State. **39**(2): 70-77pp.

Pathak, V. N. 1980. Diseases of fruit crops.Oxford IBH publishing Co. New Delhi. 12-22pp.

Peterson, R. A. 1986. Mango Diseases. Prceeding of CSIRO 1st Australian Mango Research Workshop, CSRI, Cairns. 233-247pp.

Ploetz, R. C., G. A. Zentmyer, W. T. Nishizima, K. G. Rohrbach, H. D. Ohr. 1994. Compendium of Tropical Fruit Diseases, APS press, USA. 34-41pp.

Popenoe, W. 1964. Manual of Tropical and Sub-Tropical Fruits. The McMillian and Co. Ltd. N. Y. and London. 474p.

Pramanik, M. A. J. 1995. Effect of different post-harvest treatment on physico-chemical change during storage and shelf life of mango. M. S. Thesis Dept. of Hort. Bangladesh Agricultural University, Mymensingh. 1-3pp.

Reza, M. M. A. and K. A. Kader. 1996a. Germplasm evaluation of mango against major diseases.Annual report on mango improvement. Regional Horticulture Research Station, BARI, Chapai Nawabgonj. 58-62pp.

Reza, M. M. A. and K. A. Kader. 1996b. Survey and monitoring of different diseases of mango. Annual report on mango improvement. Regional Horticulture Research Station, BARI, Chapai Nawabganj. 58-62pp.

Riker, J. J. and C. J. Riker. 1921. Introduction to Phytopathological Methods, Corell University. Ithaea, New York. 129-135pp.

Rivas-Figueredo, E. and R. Edwin-Gakegne. 2001. New foliar disease of mango (*Manguifera indica* L.) in Cuba, Revista Mexicana de Fitopatologia, Universidad Agraria de La Habana, Autopista Nacional, San Jose de Las Lajas, Apartado Postal 19, La Habana, Cuba. **19**(1): 104-106pp.

Sakihara, K., 2000, Survey and evaluation of old mango trees in Ishigaki city, Okinawa, Proceedings of School of Agriculture, Kyushu Tokai University. **19**: 53-60.

Salunkhe, D. K. and B. B. Desai. 1984. Post-harvest Biotechnology of Fruit. Vol.1 CRC press, Inc.Boca raton, Florida. 77-94pp.

Siddique, A. B. and Scanlan, F.M. 1995.Nutritive value of fruits. Int. Fruit Production Manual. pp. 1-28.

Singh, I. B. 1968. The Mango, Botany, Cultivation and Utilization, Lconarrd Hill, London. 280-283pp.

Singh, R, N. 1978. Mango. Indian Council of Agricultural Research, New Delhi. 60-64pp.

Singh, Z. and B. S. Dhillon. 1987. Occurance of malformation like substances seedlings of mango (*Mangifera indica* L.). Journal of phytopathology **120**(3): 245-248pp.

Singh, R. S. 1998. Plant Disease. 7th edition. Oxford and IBH Publishing Co. New Dehli. 97-98 pp.

Suchana, R .S., 2008. Nursery Diseases of Mango and Their Management, M.S. thesis, Depertment of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 1-34 pp.

Tiwari, S. C. C., S. C. Cruz, J. G. Siqueira, M. L. C. Lima, P. C. G. C. Silva, R. A. F. Neves and C. A. Menezes. 2004. Alternative control to powdery mildew (*Erysiphe poligoni*) on mango Submedio Sao Francisco River in Brazilian semi-arid region. Acta Horticulturae **645**: 471-474pp.

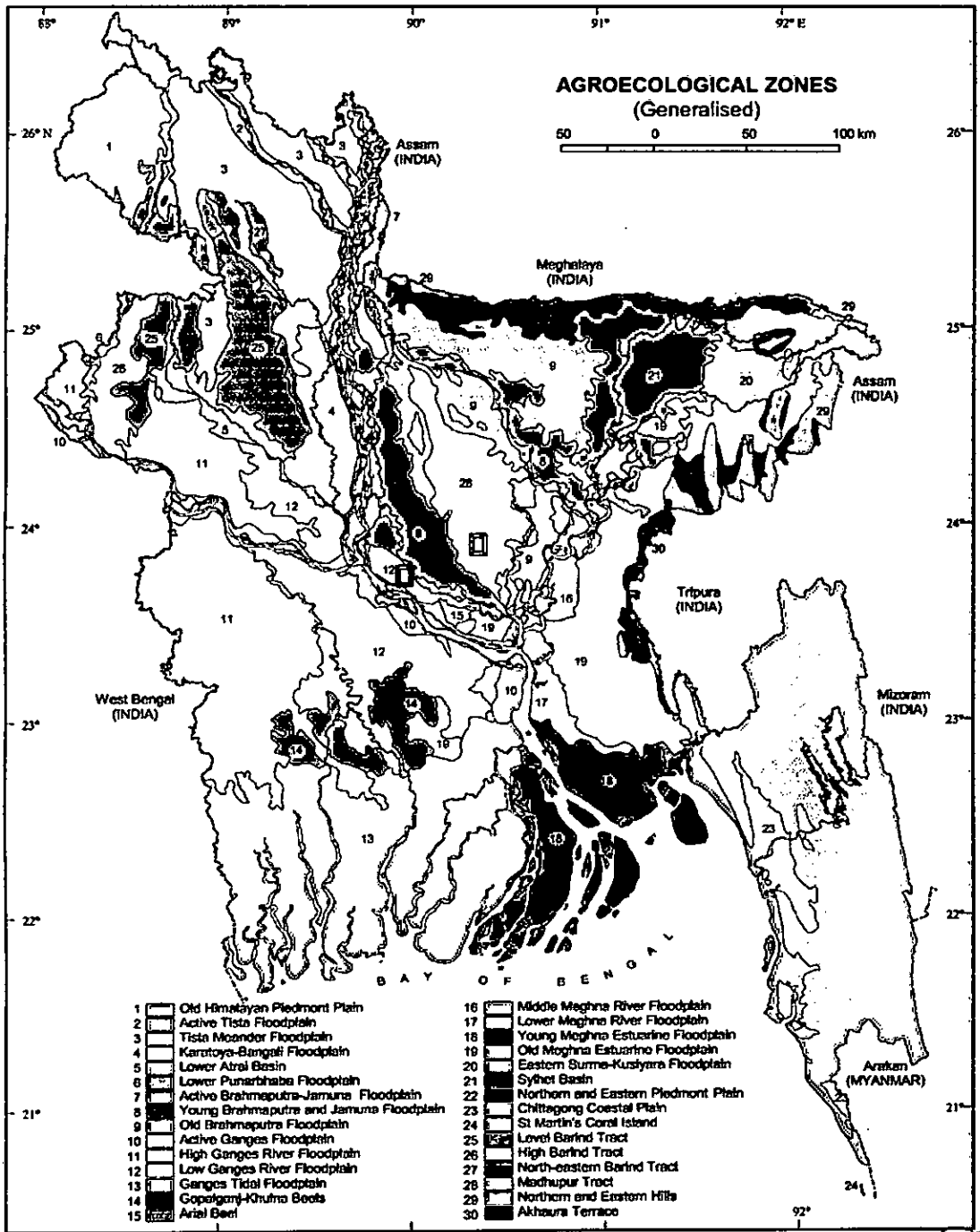
Xie, G. G. and B. Q. Xie. 1999, The occurrence of anthracnose disease of mango and its control, South-China-Fruits, Department of Horticulture, Hainan University, Haiko, Hanan, China. **28**(5): 34-35pp.

Yamashita, K. 2000. Mango production in Japan, Acta-Horticulturae, Faculty of Agriculture, Miyazaki University, Miyazaki 889-2192, Japan. **509**: 79-85

Youssef, S. A and M. Maymon. 2007. Epidemiological aspects of mango malformation disease caused by *Fusarium mangiferae* and source of infection in seedlings cultivated in orchards in Egypt, Pathology Research Institute, Agricultural Research Center, Giza, Egypt. **56**(2): 257-263

Appendiecs

Appendix 2. Location of the experimental site under study



Study Location