STUDY ON SEEDLING DISEASES OF JACKFRUIT (*Artocarpus heterophyllus* L.) IN SELECTED AREA OF BANGLADESH AND THEIR MANAGEMENT

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STUDY ON SEEDLING DISEASES OF JACKFRUIT (*Artocarpus heterophyllus* L.) IN SELECTED AREA OF BANGLADESH AND THEIR MANAGEMENT

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CERTIFICATE

This is to certify that thesis entitled, **"STUDY ON SEEDLING DISEASES OF JACKFRUIT (*Artocarpus heterophyllus* L.) IN SELECTED AREA OF BANGLADESH AND THEIR MANAGEMENT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment 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 MOSTAFIZUR RAHMAN Registration No. 04-01322** 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 duly been acknowledged.

Dated:
Dhaka, Bangladesh

(Dr. M. Salahuddin M. Chowdhury)
Professor
Department of Plant Pathology
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DEDICATED

TO

MY BELOVED PARENTS

STUDY ON SEEDLING DISEASES OF JACKFRUIT (*Artocarpus heterophyllus* L.) IN SELECTED AREA OF BANGLADESH AND THEIR MANAGEMENT

ABSTRACT

Experiments were carried out during the period of July, 2010 to October, 2012 to study the status of seedling diseases of jackfruit and the effect of weather parameters on the incidence and severity of seedling diseases in different major growing areas of Bangladesh with development of an environment friendly disease management practice. Important plant pathogen *Phyllosticta artocarpina* and *Pseudomonas syringae pv. syringae*. were detected and identified. The incidence and severity of leaf spot and leaf blight of jackfruit seedlings were differed location to location and significant variations were observed. Correlation regression study revealed that the development of leaf spot and leaf blight diseases were correlated with temperature and rainfall but least or no effect of humidity was observed on development of these two diseases. Comparative effectiveness of BAU-biofungicide either alone or in combination with two fungicides viz. Cupravit and Bavistin were evaluated on jackfruit in the nursery. Among the treatments applied, *Trichoderma harzianum* based BAU-Biofungicide showed promising result in controlling leaf spot and leaf blight disease. BAU-Biofungicide, as an alternate to chemicals, can successfully be used as eco-friendly option.

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Dated: June, 2011 The author

Place: SAU, Dhaka.

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development of leaf spot and leaf blight diseases were correlated with temperature and rainfall but least or no effect of humidity was observed on development of these two diseases. Comparative effectiveness of BAU-biofungicide either alone or in combination with two fungicides viz. Cupravit and Bavistin were evaluated on jackfruit in the nursery. Among the treatments applied, *Trichoderma harzianum* based BAU-Biofungicide showed promising result in controlling leaf spot and leaf blight disease. BAU-Biofungicide, as an alternate to chemicals, can successfully be used as eco-friendly option.

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LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate
°C	=	Degree Centigrade
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cv.	=	Cultivar (s)
DAI	=	Days After Inoculation
DMRT	=	Duncan’s Multiple Range Test

e.g.	=	For example
et al.	=	And Others
etc.	=	Etcetera
Ag	=	Gram
Hr	=	Hour (s)
i.e.	=	That is
Kg	=	Kilogram
LSD	=	Least Significant Difference
no.		Number
PDA	=	Potato Dextrose Agar
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
t/ha	=	Ton per Hectare

UNDP	=	United Nation Development Program
$^{W}/_{V}$	=	Weight per Volume
$^{W}/_{W}$	=	Weight per Weight
wt.		Weight
BE	=	Biological efficiency
Mg	=	Milligram
Conc.	=	Concentration
&	=	And

CHAPTER 1

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* L.) is one of the most important popular and delicious fruit crops in Bangladesh (Haque, 1977). It belongs to the family Moraceae. It stands third position in respect of area (9237 ha) and second in production (1005 thousand metric tons) of fruits in Bangladesh (BBS, 2010). It is grown in Bangladesh, Phillipines Srilanka, Thiland, India, some extent in Brazil and Queensland of Australia.

Jackfruit contains many vitamins, minerals and numerous health benefits. The fruit is isoflavors, antioxidant and phytonutrients means that jackfruit has cancer fighting properties. It is also known to help cure indigestion. Bangladesh produces less than 30 percent of the fruit needed to meet the minimum daily requirements for its production. About 80 percent of families in the country consume less than the minimum recommended daily requirements of fruits. As a consequences, widespread nutritional deficiencies in vitamin 'A' and 'C' iron and other nutrients that causes debilitating illness among the population (Annonymous, 2005). Jackfruit is the major important fruit corps in Bangladesh due to their calorific and nutritive values and of their versatile used by the consumers.

Success of an orchard or homestead gardening depends on the quality of the planting material. Disease of jackfruit have been reviewed by few workers throughout the world. Seedling diseases of jackfruit play a major role in reducing yields of horticultural crops in the tropic (Ming Shen *et al*. 2001). It has been estimated that the production could be increased at least by 28% if the crop could be protected against various seedling diseases (Chowdhury, 2009). The climate of Bangladesh harbors plant pathogens and provide luxuriant environment for the growth and reproduction of large number of plant pathogens which causes hundreds of different diseases of crops (Fakir, 2001). Although a huge number of nurseries are engaged in producing seedlings, they fail to

produce quality seedlings due to lack of their knowledge about diseases. Seed after germination are liable to attack by different soil borne organisms. Even after emergence of the seedling, it could be attacked by different diseases which may produce distinct symptoms in the nursery bed or it may carry the organisms when it is transplanted in the orchard or any selected place. In severe cases, diseases cause mortality of many seedlings after plantation. For this reasons, seedlings are to be reared up with proper care in order to avoid the diseases and to ensure quality jackfruit production and increasing yield. Thus production of healthy seedlings ensures good plantation and save money, labor and energy of jackfruit gardener.

Jackfruit is grown widely in Bangladesh and it is called national fruit of the country. Seedling diseases of jackfruit species were not thoroughly investigated by researchers of Bangladesh prior to this study. However, Awasthi *et al.* (2005) observed that jackfruit mainly suffered from leaf spot (*Phyllosticta artocarpina*) and tender fruit rot (*Rhizopus artocarpi* [*Rhizopus stolonifer var. stolonifer*]). Morton (1987) stated important diseases that include pink disease, *Pelliculana (Corticium) salmonicolor,* stem rot, fruit rot and male inflorescence rot caused by *Rhizopus artocarpi*; and leafspot due to *Phomopsis artocarpina*, *Colletotrichum lagenarium*, *Septoria artocarpi*, and other fungi. Gray blight, *Pestalotia elasticola*, and rust, *Uredo artocarpi* occurred on jackfruit. Determining the effect of temperature, rainfall, leaf wetness and relative humidity on the formation, release and germination of inoculum in different pathosystems have been focused by many researchers worldwide (Rowe and Beute, 1975; Sutton, 1981; Pinkerton *et al.*, 1998; Mondal and Timmer, 2002). Understanding the disease epidemiology, effective control measures could be developed and implemented (Hopkins and McQuilken, 2000). Plant diseases play a major role in reducing yields of horticultural crops in the tropics (Pathak, 1980a; Rawal, 1990; Mariau, 2001).

So, studies on seedling diseases of jackfruit is an urgent need in the country. Therefore, attempt should put forward to study the prevalence of various diseases occuring on jackfruit seedlings in some selected nurseries of Dhaka, Gazipur, Barisal and Khagrachari. Keeping in view of the above discussion the present study was undertaken with the following objectives:

i) Survey on the seedling diseases of Jackfruit in selected nurseries of Bangladesh.
ii) Identification of causal organisms of the seedling diseases of jackfruit.
iii) Epidemiological survey on the disease prevelance of seedling diseases of jackfruit.
iv) Development of environment friendly disease management practices for the nursery disease of jackfruit.

CHAPTER 2

REVIEW OF LITERATURE

Hossain (2011) studies the nursery diseases of jackfruit in Bangladesh during the period of 2010-2011. He recorded leaf spot and leaf blight dieses in different jackfruit growing areas of Bangladesh.

Hossain *et al.* (2011) made in extensive survey on the incidence and severity of nursery diseases of jackfruit in different locations of major Jackfruit growing areas of Bangladesh. In addition they were working on isolation and identification of diseases causal organisms. Moreover, management of nursery diseases was their focal point.

Tangonan (2011) studed on diseases of jackfruit and their management. More than ten different diseases have been recorded attacking jackfruit and their distribution was generally believed to be common where this fruit tree was grown. Most of these diseases are caused by fungal pathogens and a bacterium. Neither virus nor nematode diseases were reported so far although two to three genera of nematodes were noted associated with the roots of jackfruit, their pathogencity, however, remains unclear. Control or management interventions for these diseases were included herein. A combination of one or two methods or an integrated approach has been recommended.

Chowdhury (2009) studed on the effect of weather factors on the incidence and severity of leaf spot disease of jackfruit seedling. Significant effect of temperature, relative humidity and rainfall on the incidence and severity of different diseases of jackfruit seedlings were observed. In case of leaf spot diseases of jackfruit seedlings, the highest incidence (61.08%) and severity (56.23%) were recorded during the month of October 2007 at temperature, RH and rainfall of 27.45^{0}C, 81.33% and 14.9 cm respectively. On

the other hand, lowest incidence (52.48%) and severity (29.55%) were recorded during the month of January 2008 at temperature, RH and rainfall of 18.10^{0}C, 75.33% and 2.73 cm, respectively.

Chowdhury (2009) carried out trials to determine the effect of different management practices on the severity of leaf spot diseases of jackfruit seedlings. Considering the mean disease severity, the highest severity (46.63%) was observed in T_8 (untreated control), which was significantly different from all other treatments. On the other hand, the lowest severity (8.10%) was observed in T_5 (BAU Bio-fungicide applied in soil and top dressing @ 2%), which was significantly different from all other treatments. in case of reduction of disease severity, the highest reduction (82.63%) of disease severity over control was observed in T_5 (BAU Bio-fungicide applied in soil and top dressing @ 2%) followed by 79.05% recorded in T_7 (BAU Bio-fungicide applied in soil @ 2% and Bavistin spray @ 0.2%) and the lowest reduction (43.23%) over control was observed in T_4 (BAU Bio-fungicide foliar spray @ 2%).

Pulawska *et al. (*2008). proved the presence of bacterium *Pseudomonas morsprunorum* as a causal agent of sweet cherry bacterial canker. She also evaluated the susceptibility of breeding clones of Prunus avium to bacterial canker.

Awasthi *et al.* (2005) observed that jackfruit mainly suffered from leaf spot (*Phyllosticta artocarpina*) and tender fruit rot (*Rhizopus artocarpi*).

Rawal and Saxana (1997) reported that prunning of infected twigs followed by spraying of carbendazim (0.15) or Topsin M (0.1%) or chlorothalonil (0.2%) were very much effective against leaf spot and die-back disease of jackfruit incited by *Botryodiplodia theobromae* and *Colletorichum gloeosporioides.*

Pathak (1989) reported leaf spot of jackfruit caued by *phyllosicta artocarpina*. He described the management practices of this disease and reported good control by 0.33% of perenox

Hattingh *et al*. (1989) isolated systemic Invasion *Pseudomonas syringae* from interior tissues of fruiting cherry trees; most of these trees typically had three to six cankers, but two showed no visible symptoms. Bacteria were detected as far as 20 ft from any obviously diseased tissue. The highest bacterial counts were from the trunk, roots, and lower scaffold limbs. However, of nearly 10,000 bacteria examined, fewer than 10% were identified *as Pseudomonas syringae*. In South Africa, bacteria introduced into leaves and leaf petioles during the growing season invaded leaves and shoots of plum and cherry trees and caused disease (Hattingh, 1989).

Moore (1988) reported that fixed copper compounds (such as bordeaux and copper hydroxide), streptomycin (an antibiotic), and coordination productions (such as Bravo CM) were used to control *Pseudomonas syringae* with various degrees of success. Adding spreader stickers to these bactericides had gotten longer lasting control under the cool, wet conditions of the Pacific Northwest.

Laurd and Alves (1986) observed that *Sclerotium cofficolum* was isolate from trees with foliage disease that induced severe leaf shading. inoculatin detached leaves of jackfruit proved its pathogenecity.

Tandon and Bilgrami (1957) described the attack of leaf spot disease and its symptom on jackfruit disease as recorded checking some selected trees from jackfruit garden. According to them the disease first appears on the older leaves as a change in color from brown to bark brown.

CHAPTER 3

MATERIALS AND METHODS

Four experiments were carried out throughout the study period in order to study the seedling diseases of Jackfruit. The four experiment were as follows:

i) Survey on the seedling diseases of jackfruit in selected nurseries of Bangladesh.

ii) Identification of causal organisms of the seedling diseases of jackfruit.

iii) Epidemiological survey on the prevelance of seedling diseases of jackfruit.

iv) Development of environment friendly disease management practices for the nursery disease of jackfruit.

3.1. Experiment I. Survey on the seedling diseases of jackfruit in some selected nurseries of Bangladesh

3.1.1. Location of survey area

Prevalence of diseases occurring on jackfruit seedlings raised in the selected nurseries was surveyed. The experiment was carried out in eight nurseries of Dhaka, Gazipur, Khagrachari and Barisal.

3.1.2. Selection of Nursery

The eight nurseries of four districts are surveyed:

Name of District	Name of nursery
Dhaka	➢ Green orchid nursery, Agargaon ➢ Barisal nursery, Savar
Name of District	**Name of nursery**
Barisal	➢ Sarchina nursery, Barisal ➢ Riyad nursery, Barisal
Gazipur	➢ Gazipur nursery, Gazipur ➢ Laxmipur nursery, Gazipur
Khagrachari	➢ Hill Research Center, Khagrachari ➢ Ramghar nursery, Ramghar

3.1.3. Age and number of seedlings

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

Table1. Age of the jackfruit seedlings and total number of seedlings in selected eight nurseries from July, 2010 to April, 2012**.**

Nurseries	Age of the seedling (Years)	Total number of seedlings (July,2010-July,2011)	Total number of seedlings (Oct'10-Oct'11)	Total number of seedlings (Jan'11-Jan'12)	Total number of seedlings (April'11-April'12)
Green orchid nursery Agargaon, Dhaka	1	30	70	80	60

Barisal nursery Savar,Dhaka	1	60	90	90	70
Gazipur nursery Gazipur	1	70	80	90	90
Laxmipur nursery Gazipur	1	70	60	80	70
Hill Research Center Khagrachari	1	50	70	70	50
Ramghar nursery Ramghar, Khagrachari	1	50	60	50	50
Sarchina nursery Barisal	1	60	90	80	70
Riyad nursery Barisal	1	60	60	80	70

3.1.4. Observation of the symptoms

Symptoms of the diseases were studied by visual observation. Sometimes hand lens were 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 Ber and other jackfruit disease compendium.

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 following method

3.2.2.1. Moist blotter method

The pathogen associated with the diseased 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 (leaves) 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 3-4 days and examined daily for any fungal growth.

3.2.2.3. Purification

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

3.2.3. Identification of Bacteria

3.2.3.1. Preparation of Nutrient Agar

For the preparation of 1 liter NA medium at first nutrient agar (15g) was taken in the Erlenmeyer flask containing 1000 ml distilled water. Peptone (5g) and beef extract (3g) were added to flask. For mixing properly the nutrient agar was shaked thoroughly for few minutes. Then $_{P}H$ was adjusted at 7 by adding KOH. Flask was then plugged with cotton and wrapped with a piece of brown paper and tied with thread. It was then autoclaved at 121°C under 15 lbs pressure for 15 minutes. After autoclaving, the liquid medium was poured in the sterilize petridishes and solidified.

3.2.3.2. Nutrient Agar plate method

The diseased leaves were cut into small pieces from the young blighted portion. Then surface sterilized by dipping them in 0.01% $HgCl_2$ solution for 1.5 minutes and washed three times with sterile water. After surface sterilization the cut pieces were kept in a test tube containing 3-4 ml of sterile water and kept for 30 minute for bacterial streaming and get stock. From this stock 3-4 dilution were made. After prepaparing different dilution 0.1 ml of each dilution was spreaded over NA plate at three replications. The inoculated NA plates were kept in incubation chamber at 30°C. The plates were observed after 24 hr and 48 hours. Then single colony grown over NA plate was taken with loop and again streaked on another plate to get pure colony.

3.2.3.3. Gram staining

A small drop of sterile water was placed on a clean microscope slide. Part of young colony was removed, with a cold, sterile loop, from the agar medium smeared the bacteria on to the slide. The smear should be just discernible. Dried the thinly spreaded bacterial film in air without heat. Then lightly flamed the underside of the slide twice to fix the bacteria to the slide. Then the smear was

flooded with Crystal violet solution for 1 minuite. It was washed with tap water for a few seconds and excess water was removed by air. Then the smear was flooded with Iodine solution (Lugol's Iodine) for 1 min. and then washed with tap water for few seconds and excess water removed by air.

After that the smear was decolorized with 95% Ethanol for 30 seconds and again washed with tap water and dried by air. Then the smear was counterstained with 0.5% Safranine for 10 seconds and washed briefly in tap water and excess water was removed by air. Finally it was examined under microscope at 40x / 100x magnification using oil immersion.

3.3. Experiment III: Epidemiology of disease incidence and severity

3.3.1. Survey period

Altogether eight surveys were made during the period from July, 2010 to April, 2012. The First, second, third, fourth , fifth, sixth, seventh, and eighth surveys were made in July, 2010; October, 2010; January, 2011; April, 2011; July, 2011; October, 2011; January, 2012; and April, 2012 respectively.

3.3.2. Data collection during survey

During the survey in the nurseries, total numbers of jackfruit seedlings as well as number of diseased seedlings in the nurseries 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 Jackfruit seedling was determined by the following formula (Rai and Mamatha, 2005):

$$\text{Percent plant infection} = \frac{\text{Number of diseased plants}}{\text{Number of total plants observed}} \times 100$$

Percent disease incidence(PDI) of foliar diseases was determined by the following formula (Rai and Mamatha, 2005):

$$\text{Percent Disease Incidence (Leaves)} = \frac{\text{Number of diseased leaves on each plant}}{\text{Number of total leaves on each plant}} \times 100$$

Percent Disease severity (PDI) was determined by the following formula (Rai and Mamatha, 2005):

$$\text{Percent Disease Severity (Leaves)} = \frac{\text{Area of leaf tissue infected by disease}}{} \times 100$$

Total number of leaf inspected

3.3.4. Meterological data collection

Meterologial data of the experimental period were collected from Meterological Department, Agargaon, Dhaka.

3.3.5. Data analysis

Data on different parameters were analyzed in two factor randomized block design (RCBD) through computer software MSTAT-C (Anonymous 1989b). Duncan'.0s Multiple Range Test(DMRT) and Least Significant difference (LSD) test were performed to determine the level of significant differences and to separate the means within the parameters.

3.4. Eco-friendly management trial

3.4.1.Experimental site

The study was carried out at Sher-e-Bangla Agricultural University, Dhaka- 1207.

3.4.2. Experimental period

The experiment was carried out from December 2010 to November 2011

3.4.3. Preparation of nursery soil and seedlings

The substratum was prepared by mixing soil, sand and well decomposed cow dung and sterilized with 5 ml formalin (40%) diluted with 20 ml water for 4 kg soil (Dashgupta, 1988). The prepared soil was heaped in square block. After 4 days of treatment, earthen pots were filled up with the sterilized soil.. Seedling was transplanted in the earthen pots in November 2010.

3.4.4. Treatments

For the management of nursery diseases of jackfruit seven different treatments were evaluated.

The treatments were as follows:

Treatments	Dose used
T_1- BAU- Biofungicide was applied in the soil at the time of pot preparation	2%
T_2- BAU- Biofungicide was applied as foliar spray	2%
T_3 - BAU- Biofungicide was applied in the soil as well as foliar spray	2%
T_4 - Mancozeb was applied as foliar spray	0.2%
T_5 - Bavistin was applied as foliar spray	0.2%
T_6 - Cupravit was applied as foliar spray	o.2%

T_7 - Untreated control	

Fungicide solutions were prepared separately by taking requisite amount of fungicides for each dose. The fungicides were sprayed at 30 days interval during 12 months of the experimental period by hand sprayer. Precautions were taken with ploythene barrier to avoid drifting of spray materials from plant to neighbouring plants. One seedling per pot and 5 seedlings per treatment were used.

3.4.5. Experimental design and layout

The experiment was laid out in Randomized Completely Block Design (RCBD) with five replications.

3.4.6. Application of bio-agent

BAU Bio-fungicide is a formulated product of *Trichoderma harzianum*, developed by Prof. Dr. Ismail Hossain, Disease Resistance Laboratory, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh (Hossain, 2003). BAU-biofungicide was thoroughly mixed with the soil @ 6.4 g/m^2 soil (Lo *et al.*, 1996). Spraying of seedlings with BAU-biofungicide was done at one month interval during 12 months of the experimental period.

3.4.7. Data collection

The data were recorded on the following parameters at an interval of 30 days before treatment used as shown below:

a) Height of the seedlings

b) Total number of leaves/plant

c) Number of diseased plant.

d) Percent leaf area diseased for different diseases.

3.4.8. Assessment of disease incidence, severity, % disease reduction over control and % increase of height over first count

Disease incidence was assessed as percentage of plants infected with at least one leaf spot or visible symptom. Assessment of incidence and severity of the diseases of each fruit species was calculated by the following formula: Percent disease incidence (PDI) was calculated using the formula of Rai and Mamatha (2005).

$$\text{Disease reduction (PDR)} = \frac{\text{PDI in control} - \text{PDI in treatment}}{\text{PDI in control}} \times 100$$

Height increase or decrease over first count was calculated using the formula (Ali,2008)

$$\%\ \text{Height increase/decrease} = \frac{\text{Height at final count} - \text{Height at first count}}{\text{Height at first count}} \times 100$$

3.4.9. Data analysis

Data on different parameters were analyzed in two factor randomized complete block design (RCBD) through computer software MSTAT-C (Anonymous, 1989b). Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test were performed to determine the level of significant differences and to separate the means within the parameters.

CHEPTER 4

RESULTS

4.1 Survey of nursery diseases of jackfruit

Two different diseases viz. leaf spot and leaf blight of jackfruit were recorded in the survey conducted in eight nurseries of Dhaka, Gazipur, Khagrachari and Barisal.

4.2. Symptoms of diseases and identification of pathogen

4.2.1. Leaf spot of jackfruit

The disease was characterized by dark brown to brick red spot on both the leaf surfaces. These spots were later turned into grayish white centers with dark brown boundaries. Conidia cylindrical, conical, sometimes very slender, straight or curved. Conidia were one celled pyriform or even club shaped.

Plate.1A. Symtom of leaf spot on leaf of jackfruit seedling

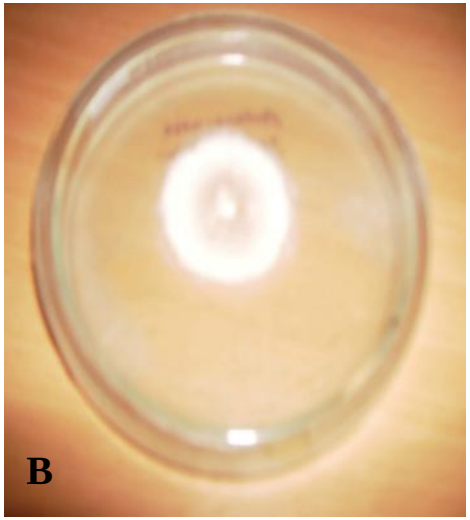

Plate. 1B. Pure culture of *Phyllosticta artocarpina*.

4.2.2. Leaf blight of jackfruit:

The disease was characterized by blighting of leaf . At later stage, the total leaf and the twig also blighted and showed die back symptom.

Plate 2. Symtom of leaf blight on jackfruit seedlings

4.3. Epidemiology of incidence and severity

4.3.1.1 Mean incidence and severity of leaf spot of jackfruit at different experimental locations of Bangladesh during July, 2010 to April, 2012

Incidence of leaf spot of jackfruit varied from location to location and that ranged from 29.44 - 50.70% (Table 2). The highest incidence (50.70%) was recorded at Dhaka and the lowest (29.44%) was recorded at Barisal. The severity of leaf pot of jackfruit also varied from location to location and that ranged from 19.26 - 41.53% (Table 2). The highest severity (41.53%) was recorded at Dhaka and the lowest (19.26%) was recorded at Barisal.

Table 2. Mean incidence and severity of leaf spot of jackfruit at different locations of Bangladesh during July, 2010 to April, 2012

Location	Leaf spot of jackfruit	
	% Disease Incidence (July, 2010-April, 2012)	% Disease Severity (July, 2010-April, 2012)
Dhaka	50.70 a	41.53 a
Gazipur	48.90 a	39.38 a
Khagrachari	36.95 b	26.67 b
Barisal	29.44 c	19.26 c
$LSD_{(p\geq0.05)}$	4.370	4.064
CV%	3.49	3.56

Each data represents the mean value of three nurseries for two consecutive years

4.3.1.2. Mean incidence and severity of leaf spot of jackfruit in different growing seasons of Bangladesh during July, 2010 to April, 2012

The incidence of leaf spot of jackfruit varied significantly from July, 2010 to April, 2012 and ranged from 31.73 - 51.79% (Table 3). The highest (51.79%) incidence was recorded in October (2010 & 2011) and the lowest (31.73%) was observed in the month of January (2011& 2012). The severity of leaf spot of jackfruit varied significantly from July, 2010 to April, 2012 and ranged from 22.43 - 41.18% (Table 3). The highest (41.18%) severity was recorded in the month of October (2010 & 2011) and the lowest (22.43%) was observed in the month of January (2011 & 2012).

Table 3. Mean incidence and severity of leaf spot of jackfruit during July, 2010 to April, 2012 of Bangladesh

Time of data collection	leaf spot of jackfruit	
	% Disease Incidence (July, 2010-April, 2012)	% Disease Severity (July, 2010-April, 2012)
July	36.90 c	27.78 c
October	51.79 a	41.18 a
January	31.73 d	22.43 d
April	45.58 b	35.46 b
$LSD_{(p\geq0.05)}$	4.228	3.297
CV%	4.52	3.56

. Each data represents the mean value of three nurseries for two consecutive years

4.3.1.3. Mean incidence and severity of leaf spot of jackfruit during different growing seasons at different experimental location

Incidene of leaf spot of jackfruit varied significantly from season to season as well as location to location and that ranged from 17.78 - 61.11% (Table 4). The highest (61.11%) incidence of leaf spot of jackfruit recorded in the month of October (2010 & 2011) at Dhaka followed by in the month of october (2010 & 2011) at Gazipur (59.44%). The lowest (17.78%) incidence was observed in the month of January(2011&2012)at Barisal. The severity of leaf spot of jackfruit 10.50 - 51.57%. The highest (51.57%) severity of leaf spot observed in the month of October(2010 & 2011) at Dhaka followed by in the month of October (2010 &2011) at Gazipur (59.44%) while the lowest (10.50%) was recorded in the month of January (2011 & 2012) at Barisal.

Table 4. Mean incidence and severity of leaf spot of jackfruit during growing seasons at different experimental locations of Bangladesh

Location	Time of data collection	Leaf spot of jackfruit	
		% Disease Incidence	% Disease Severity

		(July, 2010-April, 2012)	(July, 2010-April, 2012)
Dhaka.	July	46.66 c	37.43 c
	October	61.11 a	51.57 a
	January	40.03 e	30.83 d
	April	55.00 b	46.29 b
Gazipur	July	44.38 cd	34.84 c
	October	59.44 a	50.15 a
	January	39.10 ef	29.44 d
	April	52.67 b	43.09 b
Khagrachari	July	31.55 gh	23.00 e
	October	46.61 c	34.37 c
	January	30.00 h	18.95 fg
	April	39.66 e	30.38 d
Barisal	July	25.00 i	15.87 g
	October	39.99 de	28.62 d
	January	17.78 j	10.50 h
	April	35.00 fg	22.07 ef
$LSD_{(p\geq0.05)}$		4.228	3.297

CV(%)	3.49	3.56

Each data represents the mean value of three nurseries for two consecutive years

4.3.2.1. Mean incidence and severity of leaf blight of jackfruit at different experimental locations of Bangladesh during July, 2010 to April, 2012

Incidence of leaf blight of jackfruit varied from location to location and that ranged from 19.71 - 34.29% (Table 5). The highest (34.29%) incidence was recorded at Dhaka followed by incidence of leaf blight at Gazipur (33.40%) and the lowest (19.71%) was recorded at Khagrachari. The severity of leaf blight of jackfruit varied from location to location and that ranged from 14.57 - 30.27% (Table 5). The highest (30.27%) severity was recorded at Dhaka followed by severity of leaf blight at Gazipur (29.03%) and the lowest (14.57%) was recorded at Khagrachari.

Table 5. Mean incidence and severity of leaf blight of jackfruit at different locations of Bangladesh during July, 2010 to April, 2012

Location	Leaf blight of jackfruit	
	% Disease Incidence (July, 2010-April, 2012)	% Disease Severity (July, 2010-April, 2012)
Dhaka	34.29 a	30.27 a
Gazipur	33.40 a	29.03 a
Khagrachari	19.71 c	14.57 c
Barisal	26.77 b	21.63 b

$LSD_{(p\geq0.05)}$	4.050	4.194
CV%	5.62	4.72

Each data represents the mean value of three nurseries for two consecutive years

4.3.2.2. Mean incidence and severity of leaf blight of jackfruit in different growing seasons of Bangladesh during July 2010 to April 2012

The incidence of leaf blight of jackfruit varied significantly from July, 2010 to April, 2012 and ranged from 3.21 - 44.17% (Table 6). The highest (44.17%) incidence was recorded in April (2011 & 2012) and the lowest (3.21%) was observed in the month of January (2011& 2012). The severity of leaf blight of jackfruit varied significantly from July, 2010 to April, 2012 and ranged from 1.27 - 38.59 % (Table 6). The highest (38.59%) severity was recorded in the month of April (2011 & 2012) and the lowest (1.27%) was observed in the month of January (2011 & 2012).

Table 6. Mean incidence and severity of leaf blight of jackfruit during July, 2010 to April, 2012 of Bangladesh.

Time of data	Leaf blight of jackfruit

collection	% Disease Incidence (July, 2010-April, 2012)	% Disease Severity (July, 2010-April, 2012)
July	37.00 b	31.38 b
October	29.80 c	24.27 c
January	3.21 d	1.27 d
April	44.17 a	38.59 a
$LSD_{(p\geq0.05)}$	4.681	3.287
CV%	5.62	4.72

Each data represents the mean value of three nurseries for two consecutive years

4.3.2.3. Mean incidence and severity of leaf blight of jackfruit during different growing seasons at different experimental locations of Bangladesh

Incidene of leaf blight of jackfruit varied significantly from season to season as well as location to location and that ranged from 0.00 - 53.28% (Table 7). The highest (53.28%) incidence of leaf blight of jackfruit recorded in the month of April (2011 & 2012) at Dhaka followed by in the month of April (2011 & 2012) at Gazipur (51.73%). There is no incidence was observed in the month of January (2011 & 2012) at Dhaka and in the month of January (2011 & 2012) at Gazipur. The lowest incidence was found in the month of

January (2011&2012) at khagrachuri and Barisal. The severity of leaf blight of jackfruit also varied significantly from season to season as well as location to location and that ranged from 0.00 - 48.13 %. The highest (48.13.%) severity of leaf blight of jackfruit observed in the month of April (2011 & 2012) at Dhaka followed by in the month of April (2011 & 2012) at Gazipur (46.45%). The disease severity was absent in the month of January (2011 & 2012) at Dhaka and Gazipur.

Table 7. Mean incidence and severity of leaf blight of jackfruit seedlings during growing seasons at different experimental locations of Bangladesh

Location	Time of data collection	leaf blight of jackfruit	
		% Disease Incidence (July, 2010-April, 2012)	% Disease Severity (July, 2010-April, 2012)
Dhaka.	July	44.44 b	39.08 b
	October	39.48 bcd	33.89 c
	January	o.oo i	0.00 h
	April	53.28 a	48.13 a
Gazipur	July	43.56 b	38.03 b
	October	38.33 cd	31.66 cd
	January	0.00 i	0.00 h
	April	51.73 a	46.45 a
Khagrachari	July	25.00 f	19.09 f
	October	17.56 g	11.97 g
	January	5.157 h	1.74 h
	April	31.11 e	25.46 e

Barisal	July	35.00 de	29.36 d
	October	23.80 f	19.56 f
	January	7.66 h	3.340 h
	April	40.55 bc	34.30 c
$LSD_{(p\geq0.05)}$		4.681	3.287
CV(%)		5.62	4.72

Each data represents the mean value of three nurseries for two consecutive years

4.3.2.4. Effect of weather components on the incidence and severity of leaf spot of jackfruit seedling during July, 2010 to April, 2012

The incidence of leaf spot of jackfruit was influenced by average temperature, relative humidity and rainfall. The highest incidence (51.79%) was recorded in Oct (2010 & 2011) when the average temperature, relative humidity and rainfall were 29.07°C, 80.85% and 6.54 cm, respectively. On the other hand, lowest incidence (31.73%) was recorded in January (2011 & 2012) having average temperature, relative humidity and rainfall 17.67°C, 74.90% and 0.56 cm, respectively. In the month of April (2010 & 2011) the incidence was 45.58% when the temperature, relative humidity and rainfall were 21.0°C, 70.72% and 3.68 cm, respectively and in the

month of July (2010 & 2011) the incidence was 36.9% while the temperature, relative humidity and rainfall were 30.08°C, 82.45% and 6.53 cm, respectively.

The severity of leaf spot of jackfruit was influenced by average temperature, relative humidity and rainfall. The highest severity (41.18%) was recorded in Oct (2010 & 2011) when the average temperature, relative humidity and rainfall were 29.07°C, 80.85% and 6.54 cm, respectively. On the other hand, lowest severity (22.43%) were recorded in January (2011 & 2012) having average temperature, relative humidity and rainfall 17.67°C, 74.90% and 0.56 cm, respectively. In the month of April (2010 & 2012) the severity was 35.46% when the temperature, relative humidity and rainfall were 21.0°C, 70.72% and 3.68 cm, respectively and in the month of July (2010 & 2011) the severity was 27.78% while the temperature, relative humidity and rainfall were 30.08°C, 82.45% and 6.53 cm, respectively (Fig. 1).

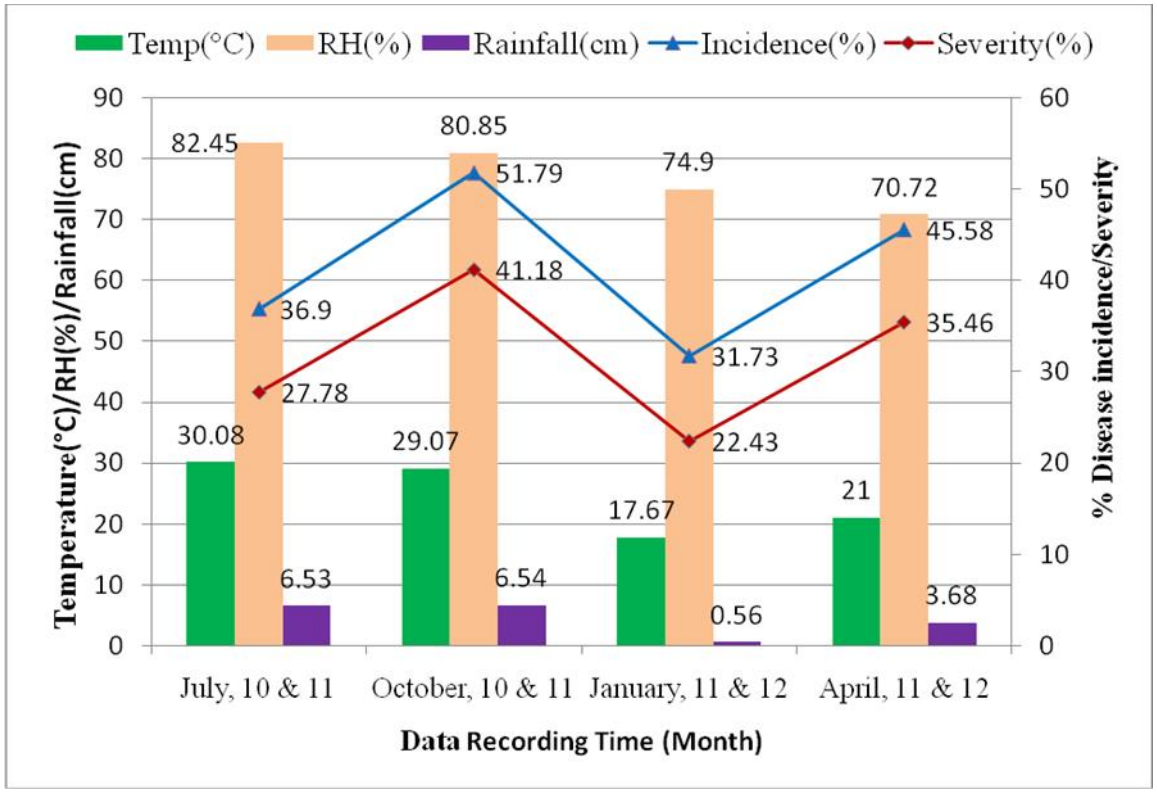

Fig .1. Effect of different weather factors on the incidence and severity of leaf spot of jackfruit seedling during July, 2011 to April, 2012

4.3.2.4.a. Relation between leaf spot disease incidence and severity of jackfruit seedlings with temperature

A positive correlation between leaf spot disease incidence and severity with temperature was observed. The relationship between disease incidence and temperature could be expressed by the equation $Y= 0.665 X + 25.22$ (R^2 =0.205), where X = temperature and Y

= disease incidence. Here, the R^2 value indicates that the contribution of temperature was 20.50% on the incidence of leaf spot of jackfruit. On the other hand, the relationship between disease severity and temperature could be expressed by the equation Y= 0.645X +15.92 (R^2 =0.225), where X = temperature and Y= disease severity. Here, the R^2 value indicates that the contribution of temperature was 22.50% on the severity of leaf spot of jackfruit.

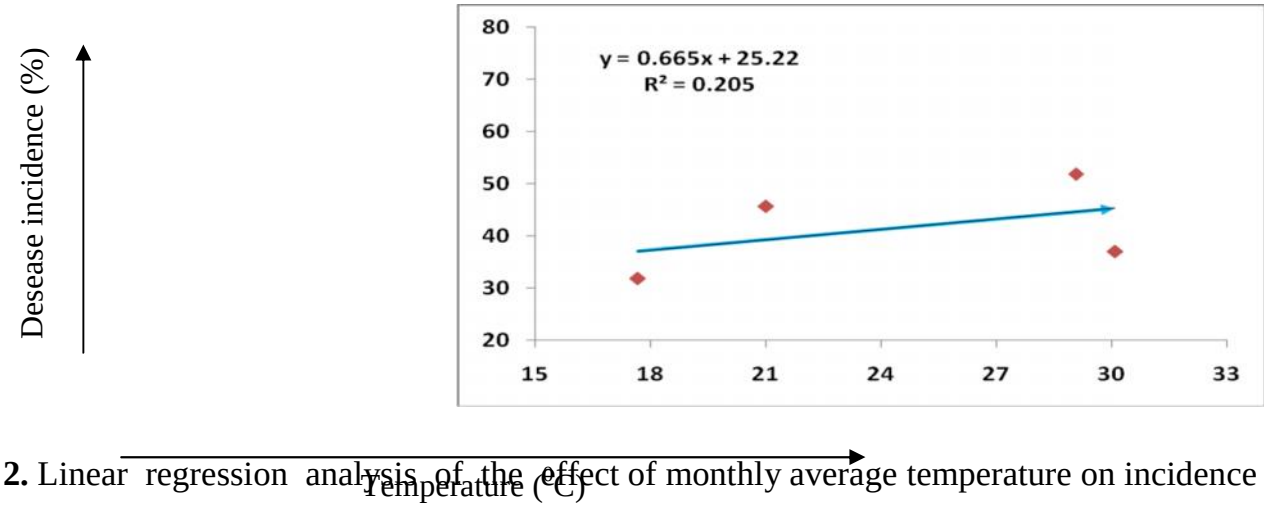

Fig. 2. Linear regression analysis of the effect of monthly average temperature on incidence of leaf spot of jackfruit during July, 2011 to April, 2012

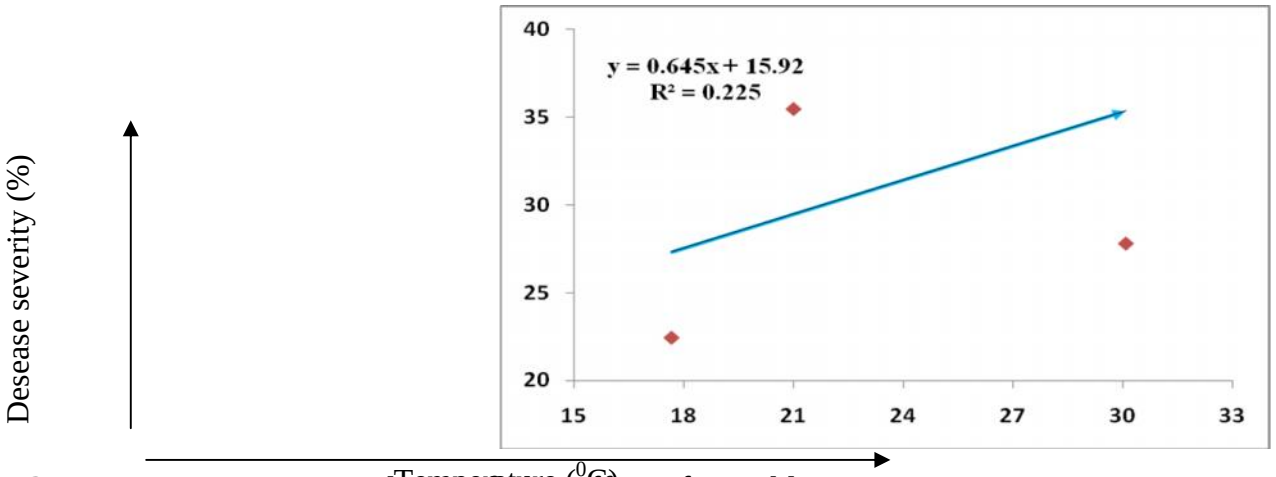

Fig. 3. Linear regression analysis of the effect of monthly average temperature on severity of leaf spot of jackfruit during July, 2011 to April, 2012

4.3.2.4.b. Relation between leaf spot disease incidence and severity of jackfruit seedlings with relative humidity

A positive correlation between leaf spot disease incidence and severity with relative humidity was observed. The relationship between disease incidence and relative humidity could be expressed by the equation Y= 0.107X – 33.23 (R^2 =0.004), where X = relative humidity and Y = disease incidence. Here, the R^2 value indicates that the contribution of relative humidity was 0.40% on the incidence of leaf spot of jackfruit. On the other hand, the relationship between disease severity and relative humidity could be expressed by the equation Y= 0.789X - 38.36 (R^2 =0.152), where X = relative humidity and Y = disease severity. Here, the R^2 value indicates that the contribution of relative humidity was 15.2% on the severity of leaf spot of jackfruit.

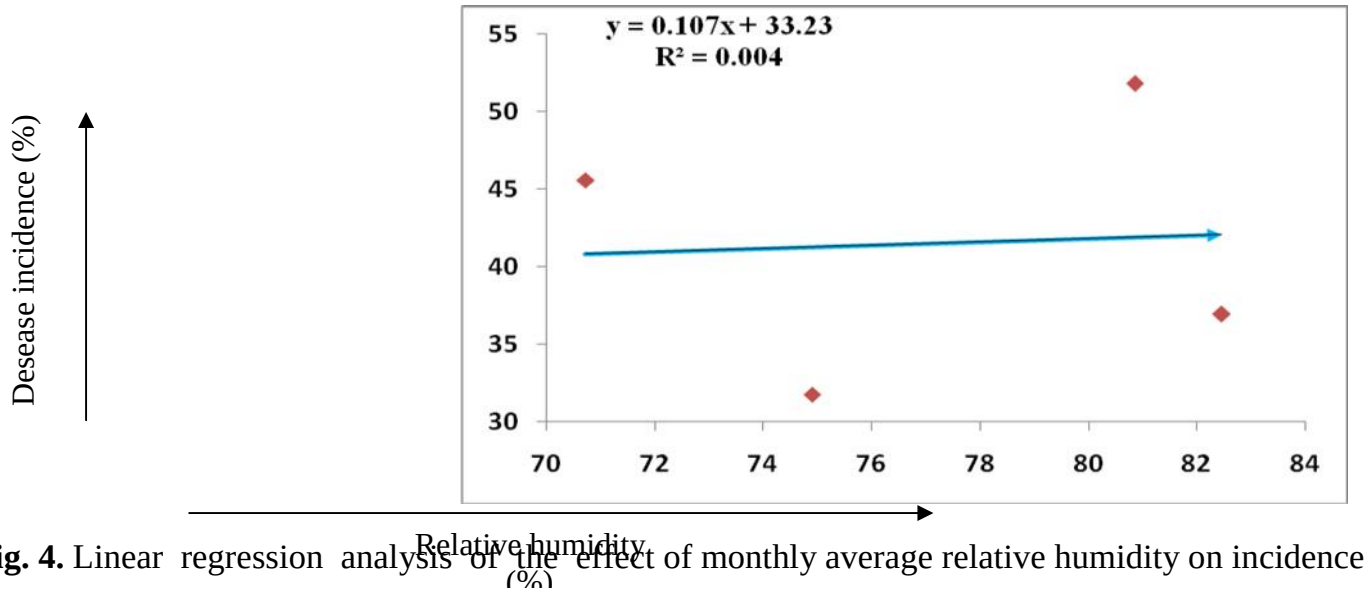

Fig. 4. Linear regression analysis of the effect of monthly average relative humidity on incidence of leaf spot of jackfruit during July, 2011 to April, 2012

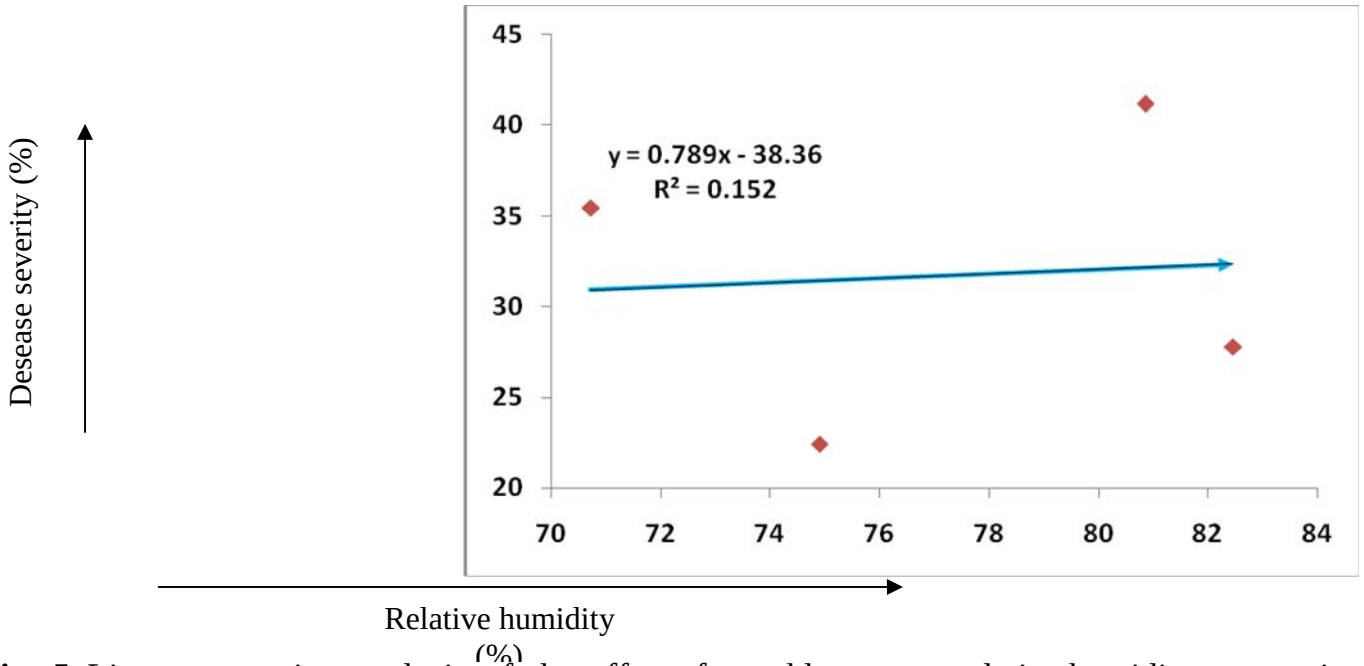

Fig. 5. Linear regression analysis of the effect of monthly average relative humidity on severity of leaf spot of jackfruit during July, 2011 to April, 2012

4.3.2.4.c. Relation between leaf spot disease incidence and severity of jackfruit seedlings with rainfall

A positive correlation between leaf spot disease incidence and severity with rainfall was observed. The relationship between disease incidence and rainfall could be expressed by the equation Y= 1.921X + 33.18 (R^2 =0.376), where X = rainfall and Y = disease incidence. Here, the R^2 value indicates that the contribution of rainfall was 37.6% on the incidence of leaf spot of jackfruit. On the other hand, the relationship between disease severity and rainfall could be expressed by the equation Y= 1.840X+ 2 (R^2 =0.353),

where X = rainfall and Y = disease severity. Here, the R^2 value indicates that the contribution of rainfall was 35.3% on the severity of leaf spot of jackfruit.

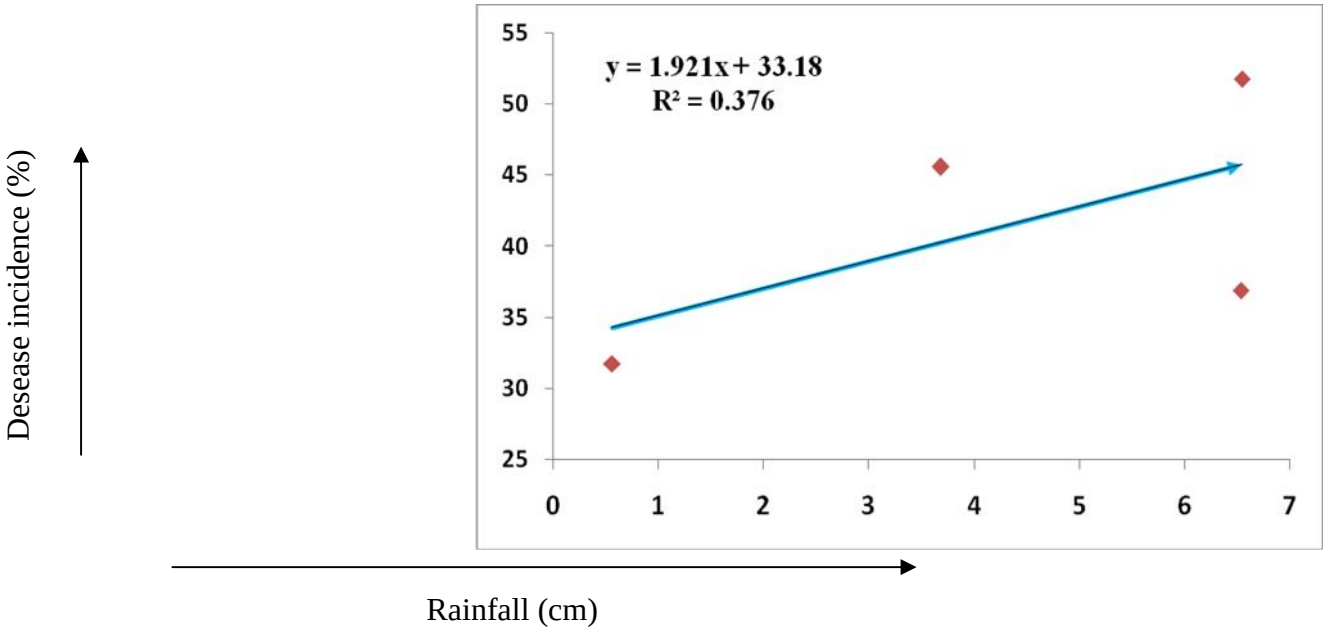

Fig . 6. Linear regression analysis of the effect of monthly average rainfall on incidence of leaf spot of jackfruit during July, 2011 to April, 2012

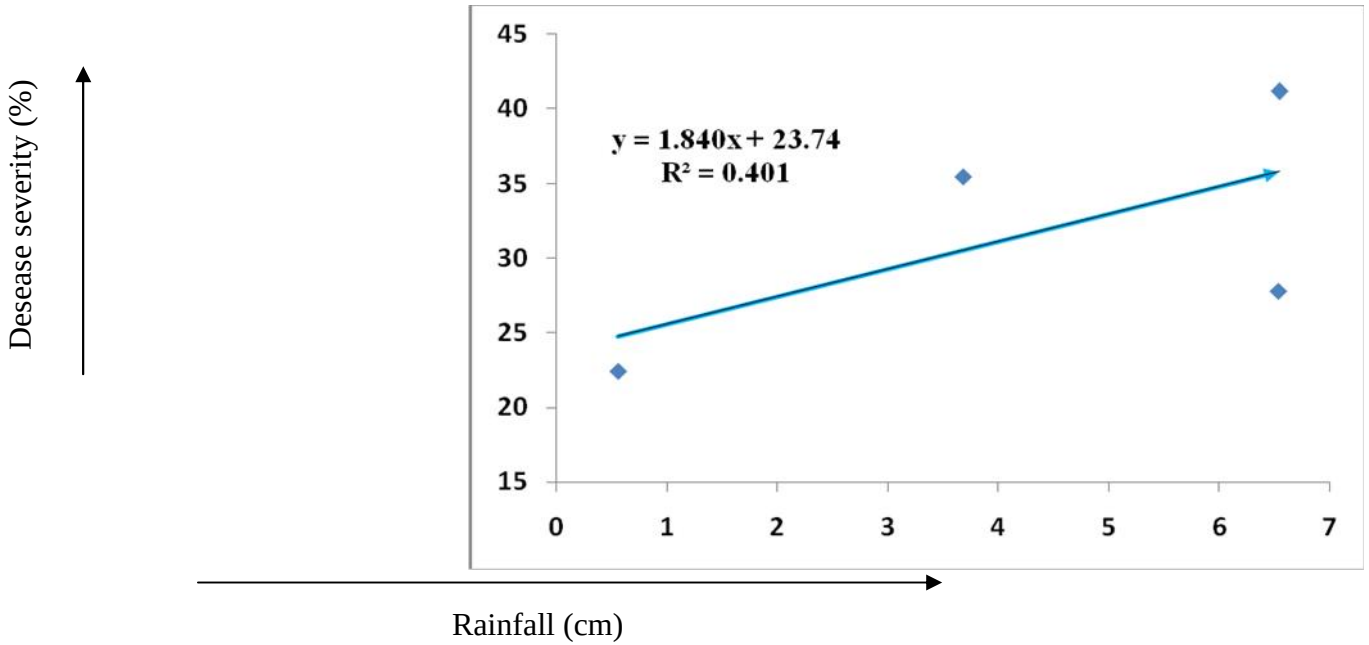

Fig . 7. Linear regression analysis of the effect of monthly average rainfall on severity of leaf spot of jackfruit during July, 2011 to April, 2012

4.3.2.5. Effect of weather components on the incidence and severity of leaf blight of jackfruit seedling during July, 2011 to April, 2012

The incidence of leaf blight of jackfruit was influenced by average temperature, relative humidity and rainfall. The highest incidence (44.17%) was recorded in April (2011 & 2012) when the average temperature, relative humidity and rainfall were 21°C, 70.72% and

3.68 cm, respectively. On the other hand, lowest incidence (8.86%) was recorded in January (2011 & 2012) having average temperature, relative humidity and rainfall 17.67°C, 74.90% and 0.56 cm, respectively. In the month of July (2010 & 2011) the incidence was 37% when the temperature, relative humidity and rainfall were 30.08°C, 82.45% and 6.53 cm, respectively and in the month of October (2010 & 2011) the incidence was 29.8% while the temperature, relative humidity and rainfall were 29.07°C, 80.85% and 6.54 cm, respectively.

The severity of leaf blight of jackfruit was influenced by average temperature, relative humidity and rainfall. The highest severity (38.59%) was recorded in April (2011 & 2012) when the average temperature, relative humidity and rainfall were 21°C, 70.72% and 3.68 cm, respectively. On the other hand, lowest severity (6.858%) were recorded in January (2011 & 2012) having average temperature, relative humidity and rainfall 17.67°C, 74.90% and 0.56 cm, respectively. In the month of July (2010 & 2012) the severity was 31.38% when the temperature, relative humidity and rainfall were 30.08°C, 82.45% and 6.53 cm, respectively and in the month of October (2010 & 2011) the severity was 24.27% while the temperature, relative humidity and rainfall were 29.07°C, 80.85% and 6.54 cm, respectively (Fig 8.)

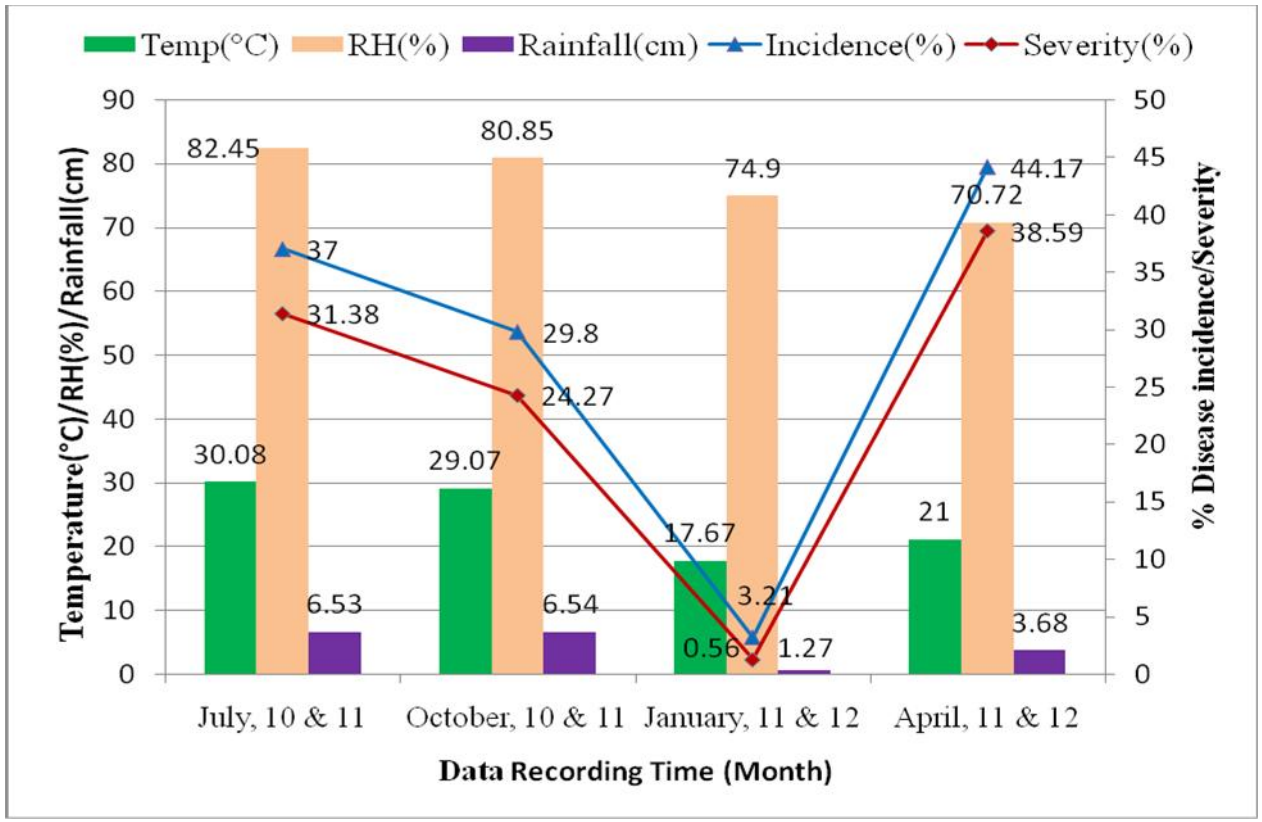

Fig. 8. Effect of different weather factors on the incidence and severity of leaf blight of jackfruit seedling during July, 2011 to April, 2012

4.3.2.5.a. Relation between leaf blight disease incidence and severity of jackfruit seedlings with temperature

A positive correlation between leaf blight disease incidence and severity with temperature was observed. The relationship between disease incidence and temperature could be expressed by the equation Y= 1.544X + 9.217 (R^2 =0.275), where X = temperature and Y = disease incidence. Here, the R^2 value indicates that the contribution of temperature was 27.9% on the incidence of leaf blight of jackfruit. On the other hand, the relationship between disease severity and temperature could be expressed by the equation Y= 1.321X – 8.440 (R^2 =0.247), where X = temperature and Y = disease severity. Here, the R^2 value indicates that the contribution of temperature was 24.7% on the severity of leaf blight of jackfruit.

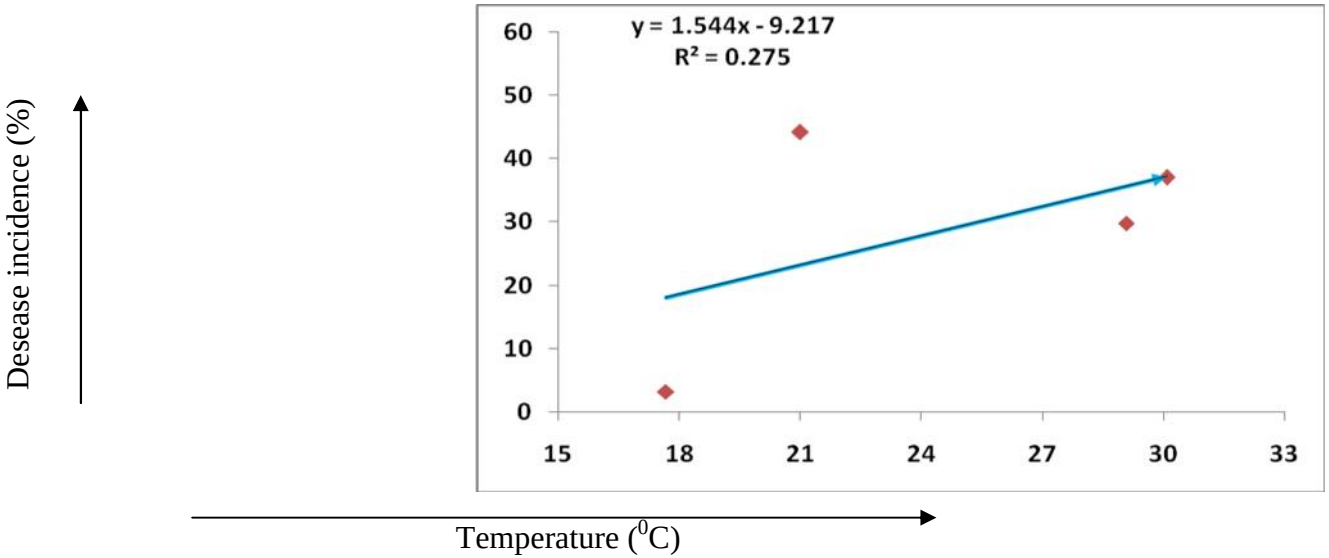

Fig. 9. Linear regression analysis of the effect of monthly average temperature on incidence of leaf blight of jackfruit during July, 2011 to April, 2012

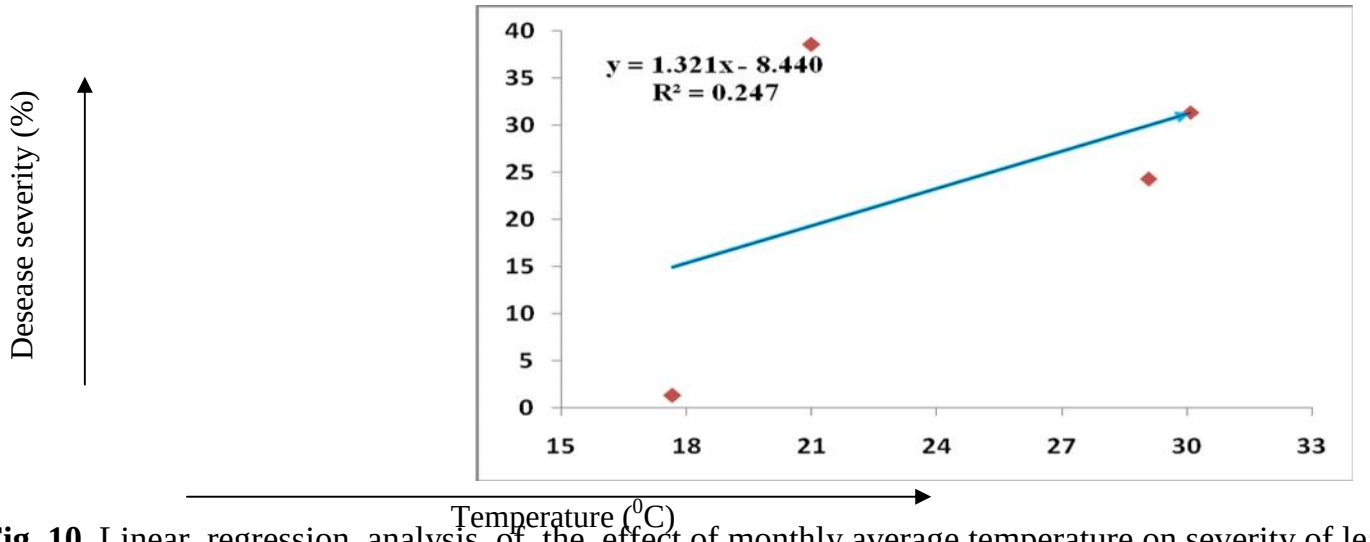

Fig. 10. Linear regression analysis of the effect of monthly average temperature on severity of leaf blight of jackfruit during July, 2011 to April, 2012

4.3.2.5.b. Relation between leaf blight disease incidence and severity of jackfruit seedlings with relative humidity

A positive correlation between leaf blight disease incidence and severity with relative humidity was observed. The relationship between disease incidence and relative humidity could be expressed by the equation $Y= 0.067X + 23.29$ (R^2 =0.000), where X = relative humidity and Y = disease incidence. Here, the R^2 value indicates that the contribution of relative humidity was 0.0% on the incidence of leaf blight of jackfruit. On the other hand, the relationship between disease severity and relative humidity could be

expressed by the equation Y= 0.789X – 38.36 (R^2 =0.152), where X = relative humidity and Y = disease severity. Here, the R^2 value indicates that the contribution of relative humidity was 15.2% on the severity of leaf blight of jackfruit.

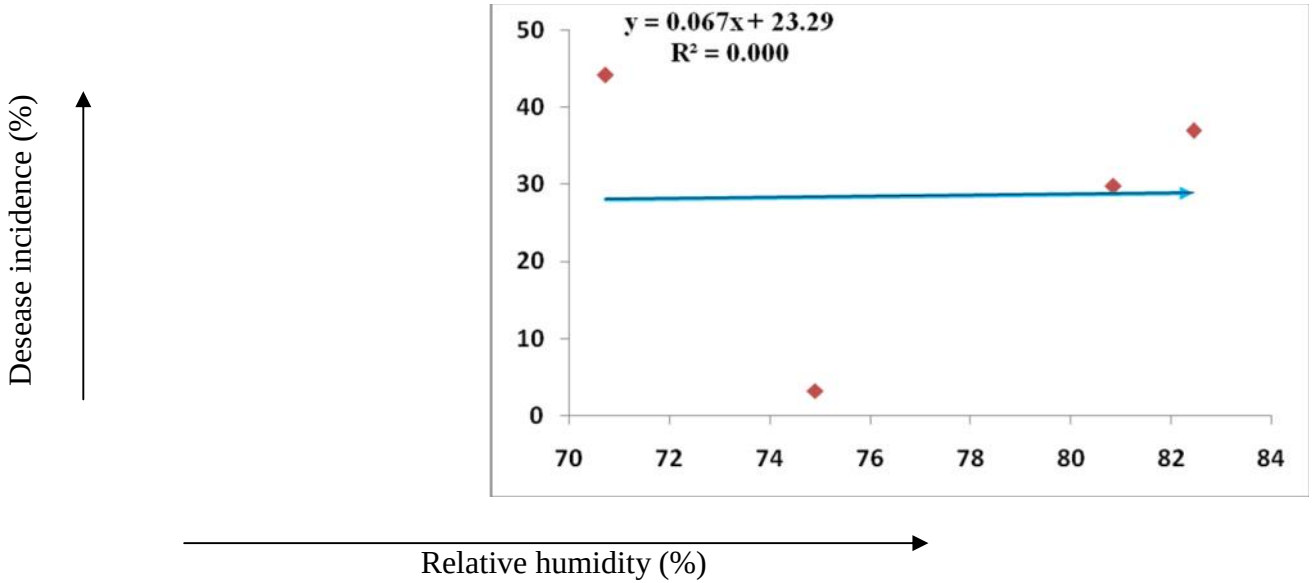

Fig. 11. Linear regression analysis of the effect of monthly average relative humidity on incidence of leaf blight of jackfruit during July, 2011 to April, 2012

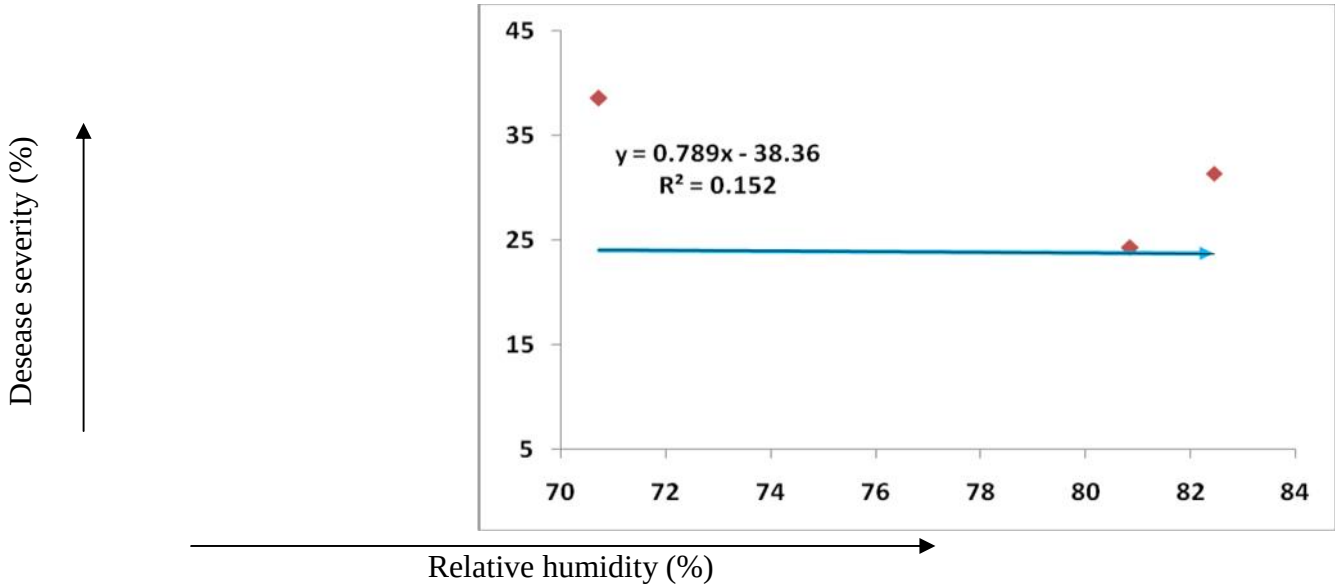

Fig. 12. Linear regression analysis of the effect of monthly average relative humidity on severity of leaf blight of jackfruit during July, 2011 to April, 2012

4.3.2.5.c. Relation between leaf blight disease incidence and severity of jackfruit seedlings with rainfall

A positive correlation between leaf blight disease incidence and severity with rainfall was observed. The relationship between disease incidence and rainfall could be expressed by the equation $Y= 4.381X + 9.584$ ($R^2 =0.487$), where X = rainfall and Y = disease incidence. Here, the R^2 value indicates that the contribution of rainfall was 48.7% on the incidence of leaf blight of jackfruit. On the other hand, the relationship between disease severity and rainfall could be expressed by the equation $Y= 3.819X + 7.348$ ($R^2 =0.453$),

where X = rainfall and Y = disease severity. Here, the R^2 value indicates that the contribution of rainfall was 45.3% on the severity of leaf blight of jackfruit.

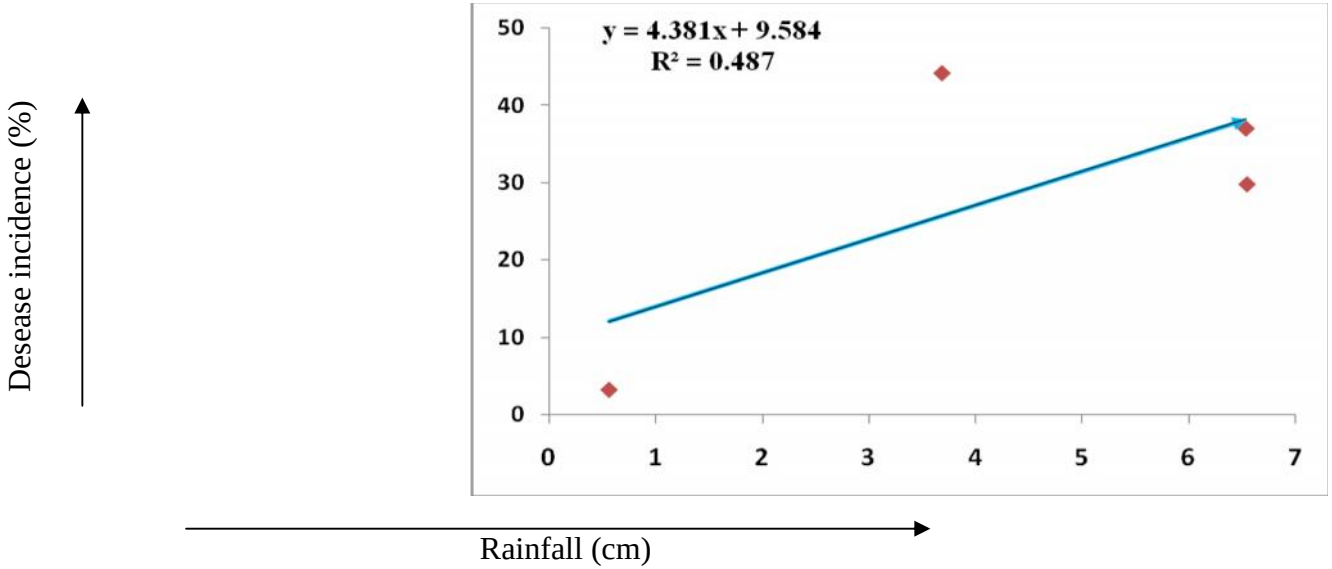

Fig 13. Linear regression analysis of the effect of monthly average rainfall on incidence of leaf blight of jackfruit during July, 2011 to April, 2012

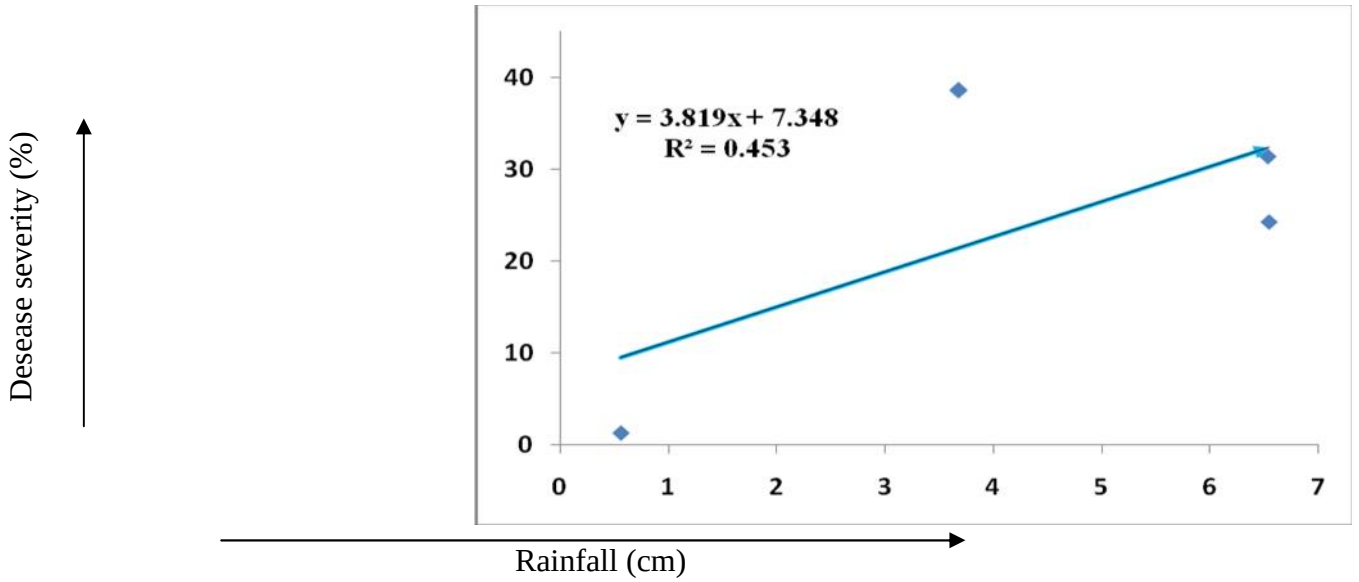

Fig 14. Linear regression analysis of the effect of monthly average rainfall on severity of leaf blight of jackfruit during July, 2011 to April, 2012

4.4.1. Effect of different management practices on the height of jackfruit seedlings

Significant variations on height increase over first count were found under different management practices (Table 8). The maximum height 106.00 cm that increased by 52.75% over control was recorded in treatment T_3 (BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%). The minimum 31.87 cm height increase over first count and the lowest increase by 11.96% over control

was observed in T_6 (Cupravit was applied as foliar spray @ 0.2%) which is statistically similar in treatment T_4 (Mancozeb was applied as foliar spray @ 0.2%).

4.4.2. Effect of management practices on the incidence of leaf spot disease of jackfruit

All the treatments significantly reduced the disease of jackfrut seedlings over control (Table 9). Out of all the treatments applied except T_7 (untreated control), the highest incidence (70.00–100.00%) was observed in the month of August, 2011 and September, 2011. The lowest incidence (0.00 – 36.27%) were observed in the month of January and February. Considering the mean incidence, the highest incidence (68.07%) was recorded in T_7 (untreated control), which was statistically different from all other treatments. On the other hand, the lowest disease incidence (47.28) was recorded in T_3(BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%). Incase of percent reduction of disease incidence over control due to application of different management practices, the highest reduction (30.54%) over control was observed in T_3(BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%) lowest reduction (12.68%)over control was observed in T_4 (Mancozeb was applied as foliar spray @ 0.2%.)

4.4.3. Effect of management practices on the severity of leaf spot disease

of jackfruit

All the treatments significantly reduced the sverity of disease of jackfrut seedlings over control (Table 10). Out of all the treatments applied except T_7 (untreated control) the highest **s**everity (4.80-13.32 %) was observed in the month of August 2011 and September2011. The lowest severity (0.59-3.06%) were observed in the month of December, March and April. except T_7 (Untreated control)there is no severity is found in the month of January and February. Considering the mean severity , the highest severity (6.83%) was recorded in T_7 (untreated control), which was statistically different from all other treatments. On the other hand, the lowest disease sverity (3.32%) was recorded in T_1(BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%). Incase of percent reduction of disease sverity over control due to application of different management practices, the highest reduction (51.39%) over control was observed in T_1(BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%) and the lowest reduction (32.94%)over control was observed in T_6 (Cupravit was applied as foliar spray @ 0.2%).

4.4.4. Effect of management practices on the incidence of leaf blight disease of jackfruit

All the treatments significantly reduced the disease of jackfrut seedlings over control (Table 11). Out of all the treatments applied the highest incidence were observed in the month of August 2011 and April 2011. The lowest incidence were observed in the month of March 2011and september2011. Considering the mean incidence, the highest incidence (20.73%) was recorded in T_7 (untreated control), which was statistically different from all other treatments. On the other hand, the lowest disease incidence (7.18%) was recorded T_6(Cupravit was applied as foliar spray @ 0.2%) which is statistically similar in treatment T_3

(BAU- Biofungicide was applied in the soil at the time of pot preparation and foliar spray@ 2%). Incase of percent reduction of disease incidence over control due to application of different management practices, the highest reduction (65.36%) over control was observed in T_6(Cupravit was applied as foliar spray @ 0.2%) and lowest reduction (25.37%)over control was observed in T_1(BAU-Biofungicide was applied in the soil at the time of pot preparation @ 2%)

4.4.5. Effect of management practices on the severity of leaf blight disease of jackfruit

All the treatments significantly reduced the sverity of disease of jackfrut seedlings over control (Table 12). Out of all the treatments applied except T_7 (untreated control) the highest severity (10.08 %) was observed in the month of March, 2011. There is no severity is found in the month of December, January , February, May ,June, July, October and November. Considering the mean severity , the highest severity (2.71%) was recorded in T_7 (untreated control), which was statistically different from all other treatments. On the other hand, the lowest disease sverity (0.92%) was recorded in T_6 (Cupravit was applied as foliar spray @ 0.2%) T_1(BAU-Biofungicide was applied in the soil at the time of pot preparation @ 2%) and T_3. Incase of percent reduction of disease sverity over control due to application of different management practices, the highest reduction (66.05%) over control was observed in T_6 (Cupravit was applied as foliar spray @ 0.2%). and lowest reduction (22.50%) over control was observed in T_1(BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%)

CHAPTER V

DISCUSSION

A survey was conducted in eight nurseries under four district of Bangladesh viz. Green orchid nursery, Barisal nursery, Gazipur nursery, Laxmipur nursery, Sarchina nursery, Riyad nursery, Hill Research Center and Ramghar nursery during the period of July, 2010 to April, 2012. Seedling diseases of jackfruit were recorded namely leaf spot and leaf blight. In the study of jackfruit seedlings both fungal and bacterial diseases were observed. These diseases were recorded as a common disease in all the growing areas surveyed. The diseases in the present study were identified by observing the symptoms on the seedlings during survey and determination of presence of fungi was made either directly by preparation of slides and examining them under compound microscope or indirectly by isolation to agar culture following keys outline by Sing (1978), Pathak (1989), Peterson (1986) and Awasthi (2005). In the present study the pathogen isolated from leaf spot was *Phyllosticta artocarpina.* The pathogen has been reported by many researchers throughout the world [Awasthi *et al.* (2005), Pathak (1989) and Hossain *et al.* (2011)]. Chowdury, (2009) also stated that the leaf spot disease caused by the pathogen *Colletorichum gloeosporioides.* The leaf blight disease caused by systemic invation of *Pseudomanas syringe* stated by Moore (1988) and Hattingh *et al.* (1989).

The prevalence of the recorded two diseases on jackfruit seedlings varied in respect of nursery and location. Similar variation in prevalence of seedling diseases in respect of nursery and location was recorded by Fraser (1959). Chowdhury (2009) studied seedling disease in different growing regions of Bangladesh and observed that the incidence and severity of leaf spot disease varied location to location. These variations may be due to effect of environment of different agro-ecological zone. The highest incidence and severity of leaf spot were recorded at Dhaka. This high prevalence may be due to environmental effect of that particular agro-ecological zone. The lowest incidence and severity were recorded at Barisal. Incidence and sverity of recorded in leaf spot was the most prominent while the leaf blight had the least occurrence

The effects of temperature, rainfall and relative humidity on the incidence and severity of noted diseases of jackfruit seedlings in selected location were observed. The climate of Bangladesh is characterized by high temperature, heavy rainfall, and often excessive humidity with fairly marked seasonal variations (Anonymous, 1995). ANOVAs, correlation and linear regression analysis were performed to determine the relationship between different components of climatic factor (temperature, relative humidity and rainfall) and the incidence as well as severity of seedling disease of jackfruit. Gilligan (1986) observed that ANOVAs has been the fundamental method used by Plant Pathologist to determine the correlation between the prevalence and environmental parameters. Determining the effects of temperature, rainfall and relative humidity on the incidence and severity of disease in different pathosystems has been focused by many researchers worldwide (Rowe and Beute, 1975; Sutton, 1981; Pinkerton *et al.*, 1998; MacHardy *et al.*, 2001; Mondal and Timmer, 2002; Rawal, 2005; Chowdhury, 2009; Hossain, 2011).

In the present study diseases were recorded eight particular times during the period of two years survey from July, 2010 to April, 2012. Prevalence (incidence and severity) of leaf spot were found to be increased in the month of October and April while the disease decreased in the month of January and July. Correlation regression analysis of prevalence of leaf spot disease along with generalized environmental parameters revealed that this increase and decrease were due the effect of temperature and rainfall. A positive correlation was observed between prevalence of leaf spot with temperature and rainfall. With the increase of temperature and rainfall both the incidence and severity increased significantly but in case of relative humidity least or no effect on leaf spot disease. The prevalence (incidence and disease severity) of leaf blight of seedlings of jackfruit was observed in the month of July and April and the lowest prevalence (incidence and disease severity) observed in the month of January and October. A positive correlation was observed between prevalence leaf blight with temperature and rainfall. With the increase of temperature and rainfall both the incidence and severity increased significantly. But least or no effect on relative humidity for incidence and severity of leaf blight disase The result of the present study found that the leaf spot and blight was negligible in colder season than that of warmer seasons. The present study also supported by the previous workers [Tangonan (2011); Tandon and Baligrami (1957); and Chowdhury (2009)]. Chowdhury (2009) reported that humidity and rainfall played more important role in the development of diseases than by temperature.

Comparative effectiveness of BAU-Biofungicide and three other fungicides viz. Mancozeb, Bavistin and Cupravit were evaluated on seedling diseases in the nursery. Significant effect of different management practices on incidence, severity and plant height were observed. Employment of control measures resulted in gradual decrease of the incidence and severity of diseases over untreated control. In case of plant height, the maximum height increase was recorded by appiying BAU-Biofungicide in the soil as well as foliar spry. Enhancement of seedling germination and vigor by using *Trichoderma harzianum* or *Trichoderma* based

formulations have been studied and reported by many workers around the world [Mamatha *et al*. (2000); Chowdhry (2009) and Hossain (2011)]. The highest reduction of incidence of leaf spot was observed in applying BAU-Biofungicide in the soil as well as foliar spray @ 2% while highest reduction of severity over control was observed in application of BAU biofungicide at the time of pot preparation. Mancozeb also given significant result for decrease the severity of leaf spot disease. Pathak (1989) reported leaf spot of jackfruit disease good control by 0.33% of perenox.

Performance of Cupravit was found best in controlling incidence and severity of leaf blight disease while treatment BAU biofungicide showed statistically similar effect to fight against the disease. Chowdhury (2009) also reported the performance of BAU biofungicide in controlling nursery diseases in Bangladesh. This new ecofriendly means of disease control may be incorporated in the management of nursery diseases in Bangladesh.

CHAPTER VI

SUMMARY AND CONCLUSION

Jackfruit (*Artocarpus heterophyllus* L.) is one of the most popular fruit of Bangladesh. Jackfruit seedlings are vulnerable to attack by various diseases in Bangladesh, but least concrete information regarding their distribution, incidence, severity, epidemiology and management is available. Therefore, the present study has been designed to study the occurrence and prevalence of seedling diseases of jackfruit and to study the correlation of disease development with environmental parameters in eight nurseries in four selected districts namely, Dhaka, Gazipur, Barisal and Khagrachari and to study the effective management strategies of the diseases.

Four experiments were carried out throughout the study period from July, 2010 to April, 2012. The diseases were identified based on matching the observed symptoms in the infected plant. The diseases also identified by observing the symptoms on the seedlings during survey and determination of presence of fungi was made either directly by preparation of slides and examining them under compound microscope or indirectly by isolation to agar culture.

Two different disease were recorded in jackfruit seedlings during the survey period under four different geographical location viz. Dhaka, Gazipur, Barisal and Khagrachari and the effect of temperature, relative humidity and rainfall on incidence and severity of identified diseases. Incidence and severity of leaf spot and leaf blight varied from location to location and time to time. The highest incidence and severity of leaf spot were recorded in the month of October (2010&2011) at Dhaka . The lowest incidence and severity of leaf spot were observed in January (2011&2012) at Barisal.

Significant variations were observed in the incidence and severity under the variation of weather parameters. The intermittent addition and defoliation of leaves during different period of year responsible for significant reduction of disease incidence and severity.

Effectiveness of BAU-Biofungicide and two other fungicides viz. Cupravit and Bavistin were evaluated on seedling diseases of jackfruit in the nursery. Significant effect of different management practices in relation to incidence, severity and plant height were observed. Among the treatment applied, *Trichoderma harzianum* based BAU-Biofungicide showed the promising result in controlling the leaf spot and leaf blight disease as well as increase in plant height. Use of Cupravit and Bavistin also reduced the incidence of incidence and severity over control.

Therefore, the present study on the occurrence of seedling disease in the nursery revealed that all the diseases studied are related to the temperature, relative humidity and rainfall. Other parameters of epidemiology viz. leaf wetness period, vapor presure deficit, sunshine hour, microclimatic parameters including canopy temperature, relative humidity etc, should be critically evaluated to 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 fight against the disease at minimum effort.

From the findings of the present study it may be concluded that use of BAU-biofungicide should be incorporated in the nursery disease management system that is a most important alternative to the hazardous chemical fungicides.

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Table 8. Effect of different management practices on seedling height of jackfruit during the growing period of December 2010 to November 2011

Treatments	% Height (cm) of jackfruit seedling													
	Dec. 2010	January 2011	Feb. 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	Sep. 2011	Oct. 2011	Nov. 2011	Height (cm) increase from initial count	% Height (cm) increase or decrease over control
T_1	63.0 bc	66.4 abc	66.8 b	72.8 ab	75.4 ab	78.0 ab	81.0 a	85.2 ab	88.4 a	91.8 ab	94.4 ab	97.4ab	35.16bc	21.15
T_2	63.4 abc	68.8 ab	70.8 ab	72.6 ab	75.0 ab	77.6 ab	76.6 a	84.4 ab	87.4 a	89.6 ab	93.0 ab	97.4ab	34.28bcd	17.50
T_3	58.8 c	61.8 c	65.2 b	68.4 b	71.8 b	76.6 ab	82.6 a	89.2 ab	94.8 a	98.6 a	102.6 a	106.0a	44.33a	52.75
T_4	64.40ab	66.8 abc	68.6 b	70.6 b	73.0 b	76.0 ab	78.6 a	84.00 ab	89.2 a	91.6 ab	93.6 ab	96.4ab	33.17cd	14.30
T_5	63.6 abc	65.8 bc	68.6 b	71.4 ab	74.8 ab	77.6 ab	80.6 a	87.40	93.0 a	96.2 ab	100.2 a	104.2a	38.91b	34.07

T_6	68.8 a	72.8 a	76.4 a	78.8 a	81.6 a	83.4 a	85.6 a	90.8 a	95.2 a	97.4 ab	99.6 ab	101.0b	31.87cd	9.82
T_7	65.0 ab	66.4 abc	68.8 b	71.2 ab	73.0 b	74.0 b	76.2 a	79.6 b	85.6 a	87.2 b	89.4 b	91.6b	29.02d	
$LSD_{(0.05)}$	5.038	5.992	6.338	6.981	7.600	7.600	8.969	8.899	9.130	9.431	9.565	10.02	4.989	
CV(%)	6.04	6.85	7.01	7.40	7.77	7.50	8.57	7.95	7.73	7.75	7.62	7.72	10.84	

Data represent the mean value of 5 replications

T_1= BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%
T_2= BAU- Biofungicide was applied as foliar spray @ 2%
T_3= BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%
T_4 = Mancozeb was applied as foliar spray @ 0.2%
T_5 = Bavistin was applied as foliar spray @ 0.2%
T_6 = Cupravit was applied as foliar spray @ 0.2%,
T_7 = Untreated control

Table 9. Effect of different management practices on incidence of leaf spot disease of jackfruit during the growing period of December 2010 to November 2011

Treatments	% disease incidence													
	December 2010	January 2011	February 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	September 2011	October 2011	November 2011	Mean	% reduction over control
T_1	30.87 c	0..00 b	0.00 b	25.33c	30.87c	34.00bc	70.00bc	80.00b	91.33b	91.33 b	100.0a	71.33 b	52.09e	23.47
T_2	60.67 a	0..00 b	0..00 b	41.3ab	47.33b	52.67 a	80.00 a	70.0 c	80.00 d	82.00 c	91.33b	80.27 a	57.13b	16.07
T_3	34.00 c	0..00 b	0..00 b	36.67b	36.67c	41.33 b	72.00 b	60.67d	70.00 e	75.33 d	80.00c	60.67 c	47.28f	30.54
T_4	36.67 c	0..00 b	0..00 b	41.33ab	47.33b	60.0 a	65.33 c	80.00b	91.33 b	80.00 cd	91.33b	71.33 b	55.39cd	12.68
T_5	34.00 c	0..00 b	0..00 b	42.60ab	47.33b	52.67 a	70.00bc	80.00b	85.33 c	91.33 b	100.0a	71.33 b	56.22bc	17.40
T_6	52.67 b	0..00 b	0..00 b	41.33ab	30.87c	30.87 c	70.00bc	80.00b	72.00 e	100 a	91.33b	80.27 a	54.11 d	20.22
T_7	30.87 c	33.07a	36.27 a	47.33 a	60.67a	60.67 a	80.00 a	91.33a	100.00a	91.33 b	100.0a	85.33 a	68.07 a	
$LSD_{(0.05)}$	5.586	0.4023	0.6053	7.217	8.099	7.968	5.919	5.344	5.312	5.882	3.705	6.336	1.615	
CV (%)	4.79	2.89	4.00	6.27	6.45	5.75	2.80	2.36	2.16	2.31	1.36	2.92	0.99	

Data represent the mean value of 5 (five) replications

T_1= BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%

T_2= BAU- Biofungicide was applied as foliar spray @ 2%
T_3= BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%
T_4 = Mancozeb was applied as foliar spray @ 0.2%
T_5 = Bavistin was applied as foliar spray @ 0.2%
T_6 = Cupravit was applied as foliar spray @ 0.2%
T_7=Untreatedcontrol

Table 10. Effect of different management practices on severity of leaf spot disease of jackfruit during the growing period of December 2010 to November 2011

Treatments	% Disease sverity													
	December 2010	January 2011	February 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	September 2011	October 2011	November 2011	Mean	% reduction over control
T_1	0.82bc	0.00b	0.00b	0.72e	2.80d	3.12c	4.10g	5.62cd	5.96de	5.71e	6.92f	4.02f	3.32g	51.39
T_2	1.10a	0.00b	0.00b	0.80de	3.23b	2.14e	5.89d	4.44e	5.84e	7.14d	8.13d	5.05c	3.65d	46.55
T_3	0.59d	0.00b	0.00b	0.93c	2.64de	3.08c	5.68e	4.64e	6.12d	7.98c	6.72g	4.90d	3.61e	47.14
T_4	0.90b	0.00b	0.00b	0.72e	2.14f	2.600d	4.79f	5.52d	4.80f	7.12d	7.36e	5.77b	3.48f	49.00
T_5	0.73c	0.00b	0.00b	0.87cd	3.04c	3.17c	6.67c	5.88c	7.82c	7.56cd	10.21c	5.12c	4.26c	38.06
T_6	1.11a	0.00b	0.00b	1.14b	2.54d	3.50b	7.12b	7.71b	8.05b	8.58b	11.04b	4.23e	4.58b	32.94
T_7	1.06a	2.06a	2.51a	3.06a	5.16a	6.12a	8.09a	10.32a	12.12a	11.08a	13.32a	7.14a	6.83a	
$LSD_{(0.05)}$	0.09230	0.09230	0.02919	0.09230	0.1846	0.09230	0.1846	0.2919	0.1846	.4615	0.1599	0.1305	0.02919	
CV (%)	1.71	4.84	4.91	2.32	2.30	0.80	1.03	1.62	0.90	1.99	1.57	0.94	0.50	

Data represent the mean value of 5 (five) replications

T_1= BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%

T_2= BAU- Biofungicide was applied as foliar spray @ 2%
T_3= BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%
T_4 = Mancozeb was applied as foliar spray @ 0.2%
T_5 = Bavistin was applied as foliar spray @ 0.2%
T_6 = Cupravit was applied as foliar spray @ 0.2%,
T_7 = Untreated control

Table 11. Effect of different management practices on incidence of leaf blight disease of jackfruit during the growing period of December 2010 to November 2011

Treatments	% Disease incidence													
	December 2010	January 2011	February 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	September 2011	October 2011	November 2011	Mean	% reduction over control
T_1	0.00	0.00	0.00	71.87a	62.14b	0.00	0.00	0.00	51.60b	0.00d	0.00	0.00	15.47b	25.37
T_2	0.00	0.00	0.00	0.0e	41.53c	0.00	0.00	0.00	41.53c	41.33b	0.00	0.00	10.37d	50.00
T_3	0.00	0.00	0.00	0.0 e	33.33d	0.00	0.00	0.00	20.93d	32.00c	0.00	0.00	7. 53 f	63.67
T_4	0.00	0.00	0.00	41.53c	33.33d	0.00	0.00	0.00	43.07c	36.00bc	0.00	0.00	12.83c	38.10
T_5	0.00	0.00	0.00	62.14b	41.53c	0.00	0.00	0.00	0.00e	0.00d	0.00	0.00	8.63e	58.36
T_6	0.00	0.00	0.00	21.07d	33.33d	0.00	0.00	0.00	0.00e	36.00bc	0.00	0.00	7.18f	65.36
T_7	0.00	0.00	0.00	61.67b	78.87a	0.00	0.00	0.00	65.27a	50.00a	0.00	0.00	20.73a	
$LSD_{(0.05)}$				3.196	3.606				4.705	6.665			0.5982	
CV (%)				2.97	2.73				5.07	8.18			1.74	

Data represent the mean value of 5 (five) replications

T_1= BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%
T_2= BAU- Biofungicide was applied as foliar spray @ 2%
T_3= BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%
T_4 = Mancozeb was applied as foliar spray @ 0.2%
T_5 = Bavistin was applied as foliar spray @ 0.2%
T_6 = Cupravit was applied as foliar spray @ 0.2%
T_7 = Untreated control

Table 12. Effect of different management practices on disease severity of leaf blight disease of jackfruit during the growing period of December 2010 to November 2011

Treatments	% Disease sverity										
	December 2010	January 2011	February 2011	March 2011	April 2011	May 2011	June 2011	July 2011	August 2011	September 2011	C 2
T_1	0.00	0.00	0.00	10.08a	8.84a	0.00	0.00	0.00	7.35b	o.oof	0
T_2	0.00	0.00	0.00	0.00 e	6.19 b	0.00	0.00	0.00	6.28 c	4.21 c	0
T_3	0.00	0.00	0.00	0.00 e	4.65 d	0.00	0.00	0.00	3.58 d	3.13 e	0
T_4	0.00	0.00	0.00	6.01 c	4.94bcd	0.00	0.00	0.00	5.95 c	4.53 b	0
T_5	0.00	0.00	0.00	8.24 b	7.88 a	0.00	0.00	0.00	0.00 e	0.00 f	0
T_6	0.00	0.00	0.00	3.07d	4.84cd	0.00	0.00	0.00	0.00e	3.45d	0
T_7	0.00	0.00	0.00	8.14 b	1.196	0.00	0.00	0.00	9.78 a	5.82 a	0
$LSD_{(0.05)}$				0.5910	6.62				0.9855	0.1599	
CV (%)				3.97					7.16	1.81	

Data represent the mean value of 5 (five) replications

T_1= BAU- Biofungicide was applied in the soil at the time of pot preparation @ 2%
T_2= BAU- Biofungicide was applied as foliar spray @ 2%
T_3= BAU- Biofungicide was applied in the soil as well as foliar spray @ 2%
T_4 = Mancozeb was applied as foliar spray @ 0.2%
T_5 = Bavistin was applied as foliar spray @ 0.2%
T_6 = Cupravit was applied as foliar spray @ 0.2%
T_7 = Untreated control