PREVALENCE AND MANAGEMENT OF SOME MAJOR DISEASES OF MANGO AT DINAJPUR AND THAKURGAON DISTRICT IN BANGLADESH

A Thesis

BY

Md. Mobinul Islam

Student No. 1405026

Session: 2014-2015

MASTER OF SCIENCE (M. S.)

IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

June, 2015

PREVALENCE AND MANAGEMENT OF SOME MAJOR DISEASES OF MANGO AT DINAJPUR AND THAKURGAON DISTRICT IN BANGLADESH

A Thesis

BY

Md. Mobinul Islam

Student No. 1405026

Session: 2014-2015

Submitted to

The Department of Plant Pathology

Hajee Mohammad Danesh Science and Technology University, Dinajpur

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE (M. S.)

IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

June, 2015

PREVALENCE AND MANAGEMENT OF SOME MAJOR DISEASES OF MANGO AT DINAJPUR AND THAKURGAON DISTRICT IN BANGLADESH

A Thesis

By

Md. Mobinul Islam

Student No. 1405026

Session: 2014-2015

Approved as to the style and content by:

_____

Professor Dr. S. M. Emdadul Hassan

Supervisor

_____

Professor Dr. SK. Md. Mobarak Hossain

Co-supervisor

_____

Professor Dr. SK. Md. Mobarak Hossain

Chairman, Examination Committee

&

Chairman

Department of Plant Pathology

Hajee Mohammad Danesh Science and Technology University, Dinajpur

June, 2015

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, Who has enabled me to complete this thesis for the degree of MS in Plant Pathology.

The author expresses his heartfelt respect, deepest sense of gratitude, sincere appreciation and immerse indebtedness to his research supervisor, Dr. S. M. Emdadul Hassan, Professor, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his scholastic guidance, continuous supervision, constructive suggestions affectionate encouragement throughout the course of research work and immense help in preparing this manuscript.

The author expresses his gratitude and indebtedness to his research co-supervisor, Dr. SK. Md. Mobarak Hossain, Professor, Department of Plant Pathology, HSTU, Dinajpur for his creative suggestions, helpful advice, necessary corrections and sincere co-operation in preparing this thesis.

It is a great opportunity for the author to express his sincere appreciation and deep sense of gratitude to beloved teacher Prof. Dr. SK. Md. Mobarak Hossain, Chairman, Department of Plant Pathology, HSTU, Dinajpur for their sympathetic co-operation and constant encouragement.

The author expresses his deepest and sincere gratitude to Dr. M. Mamunur Rashid, Professor, Dr. A. T. M. Safiqul Islam, Professor, Dr. Md. Mohidul Hasan, Associate Professor, Md. Shamim Hasan, Assistant Professor, Department of Plant Pathology, HSTU, Dinajpur for inspiration and valuable suggestions during the study period and research work.

It is a great pleasure for the author to express his deep sense of gratitude to Dr. Md. Ismail Hossain, Professor, BAU, Mymensingh for providing necessary facilities of the research work and allocation of field.

The author extends his thanks to all the staff of the Department of Plant pathology, HSTU, Dinajpur, for their help and co-operation during the study period.

The author is very grateful and regards to all friends, younger and elder brothers Nur haque, Purobi, Rakhi, Shiuli, Minara, Raju, Kaeys, Forid, Alal, Rakib, Shazon, Mannan and Nazrul as well as well wishes for their enthusiasm and direct and indirect helps during the period of research work.

Finally the author expresses his profound respect to his beloved parents, Md. Mafidul Islam and Jubily Begum, Brother, Md. Faridul Islam, Sister, Most. Papia Akter, relative and well-wishers for their blessing, sacrifices, constant inspiration, advice, love, affection and moral support in completion of higher education.

June, 2015 The Author

ABSTRACT

The experiments were conducted in different mango orchards of Dinajpur and Thakurgaon districts in Bangladesh under the Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University during April, 2014 to April, 2015 on prevalence and management of mango diseases. Altogether, seven different diseases viz. anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot were recorded. All the diseases were common in both regions but these varied from orchard to orchard. Among the diseases, severity of anthracnose (22.67%), die-back (17.67%), powdery mildew (37.17%), red rust (17.75%) and bacterial leaf blight (44.33%) were found major problem in Thakurgaon districts. In Dinajpur district, anthracnose (18.54%), sooty mold (22.08%), bacterial leaf blight (21.04%) and bacterial leaf spot (11.50%) were found the highest severity. Efficacy of fungicides and fungicide with insecticides viz. Indofil M-45 and Indofil M-45 with Confidor 70 WG respectively, were evaluated and found that Indofil M-45 with Confidor 70 WG were good effect in controlling anthracnose, die-back, sooty mold, red rust and bacterial leaf spot. Indofil M-45 was also found effective in controlling anthracnose, die-back, powdery mildew, red rust and bacterial leaf spot disease.

Keywords: Mango, Location, Disease severity, Chemical control

CONTENTS

CONTENTS (CONTD.)

LIST OF TABLES

LIST OF TABLES (CONTD.)

LIST OF PLATES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Mango (*Mangifera indica L.*) is one of the most important, popular nutritious fruits grown in the tropical and subtropical countries of the world as well as in Bangladesh. It belongs to the family Anacardiaceae and has been cultivated for more than 4000 years ago (Candole, 1984). The mango is considered as a popular fruit in our country. It is cultivated commercially in a number of countries of the world. The main mango producing countries are India, China, Pakistan, Mexico, Brazil, Haiti and Philipines including Bangladesh. India is the largest producers (Salunkhe and Desai 1984). In India, mango cultivated over an area of 2309 thousand hectares with an annual production of 15026 thousand metric tons (FAO, 2011). Approximately 66% production of mango over the world is produced in India (Jacob *et al*. 2001). China and Thailand stood at second and third position among mango producing countries in the world with 4,366 and 2,551 thousand tons and area coverage 465 and 311 thousand hectares, respectively (FAO, 2011). In Nepal, as per the agriculture statistics, the total area covered by mango was 14781 ha from which 110736 metric tons of the mango was produced (FAO, 2011). It is grown all over Bangladesh but the quality mangoes are produced in the north-western areas especially greater Rajshahi, Dinajpur and Rangpur (Karim 1985). The Food and Agriculture Organization (FAO) of the United Nations estimates worldwide production at nearly 37,043,000 tons in 2014. In Bangladesh, mango ranks second and third fruit in terms of area and production, respectively (Kobra *et al.*, 2012). In Bangladesh, 889176 metric tons of mangos are produced 67842 acre of mango orchard during the period of 2013-14 (BBS, 2014). Bangladesh import huge amount of fruits to meet up the requirement of the demand of the increasing population using a lot of foreign currency. Mango is considered as "the king of the oriental fruits" (Popenoe, 1964). It is an ideal dessert due to its comparatively low production along with its high nutritive value (Tripathi and Dubey, 2004). Besides, the minimum dietary requirement of fruit'

day/head is 85gm, whereas our availability is only 40-55gm, which is much lower than recommended daily allowance. Ripe mangoes are typically freshly consumed and used for the preparation of squash, nectar, jam, cereal flakes, custard powder, baby food, mango lather and toffee (Siddique and Scanian, 1995). A considerable quantity of both ripe and green fruits are used for making jam, jelly, squash, chutney, pickle (achar) and similar other products (Kabir, 1987).

The demand for mango fruits is increasing day by day with the increased population as well as declined in production results in scarcity every year. Disease is a major cause for lower production of mango in Bangladesh (Meah and Khan, 1987). One of the major reasons behind the low yield is diseases caused by fungi, bacteria, nematode, viruses etc**.** In Bangladesh, 18 mango diseases have been reported. Among these, nine are major and the rest are minor (Tripathi and Dubey, 2004). The diseases of mango are anthracnose, red rust, powdery mildew, malformation, bacterial leaf blight, sooty mold, bacterial leaf spot and die-back considered to be the major ones (Suchana, 2008). Dey *et al.* (2007) conducted a survey on fruit diseases of Bangladesh in 13 districts and 102 diseases were recorded in 18 fruit trees. They reported that anthracnose, powdery mildew, sooty mold, malformation and fruit rot complex is common and destructive diseases in Bangladesh. Awasthi *et al.* (2005) found four diseases of mango namely anthracnose (*Colletotrichum gloeosporioides),* leaf blight (*Macrophoma mangiferae*) and red rust (*Cephaleuros* sp.) were in orchard and two diseases namely, vegetative malformation (*Fusarium moniliformae* var. *subglutinans*) and wilt (*Fusarium* sp.) were in the nursery. These diseases are the important problems in the tropics. Although a huge number of farmers are engaged in producing mango but they fail to produce quality fruits due to lack of their knowledge about diseases and their management. For these reasons, an integrated means of controls of mango diseases viz. anthracnose, sooty mold and powdery mildew has been studied (Anonymous, 1988). There are several ways to control the diseased mentioned. Among them, chemical measure is the most effective one because of its retention, availability and broad spectrum. Eight fungicides namely Bordeaux mixture, Burgandy mixture, Dithane M-45, Antracol, Tilt 250 EC, Tri-miltox forte,

Thiovit and insecticide were used. Among the fungicides tested, anthracnose was controlled by Dithane M-45 effectively on fruits followed by Antracol. In case of sooty mold, Dithane M-45 and Tri-miltox forte were equally effective in controlling the disease. All these selected fungicides against three major diseases of mango namely anthracnose, powdery mildew and sooty mold were evaluated at Mango Research Station, Chapai Nawabganj, Bangladesh (Anonymous, 1989).

However, the occurrence and prevalence of mango diseases in different orchards are not yet studied in Dinajpur and Thakurgaon region but it is urgently needed and necessary to know the status of the disease for taking necessary steps to manage the diseases. For these reasons, mango productions are to be reared up with proper care in the orchards in order to avoid the diseases and to ensure quality mango production and increasing yield. It ensures good plantation and save money, labor and energy of the orchard owner and to save foreign currency. Keeping in view of the above discussion, the present study was undertaken in Dinajpur and Thakurgaon region with the following objectives:

i. To know the status of diseases of mango at some selected orchard

ii. To distinguish the effect of diseases in the different orchard

iii. To find out the efficacy of the treatments

CHAPTER 2

REVIEW OF LITERATURE

Mango is the most important and popular fruit species in Bangladesh. Mango plants are attacked by many diseases at all stages of plant growth. Research works are continuously going on occurrence of diseases, epidemiology and management of the diseases. In this regard, an attempt has been made to review the available literature about symptoms of mango diseases, their causal organism, disease status in different varieties and management of diseases in home and abroad.

Khan *et al.* (2015) carried out an experiment during the period of July, 2010 to April, 2012 to find out the effect of weather prevalence of seedling diseases of mango in different areas of Bangladesh. The locations were Mymensingh Dinajpur, Rajshahi and Khagrachari. Altogether, 12 nurseries in four districts of Bangladesh were surveyed and seedling diseases of mango were recorded. Incidence and severity of important diseases of mango seedling are studied under different geographical locations (viz. Mymensingh, Dinajpur, Rajshahi and Khagrachari) of Bangladesh. The effects of temperature, rainfall, and relative humidity on the incidence and severity of noted diseases were observed at the aforesaid locations of Bangladesh. The studied diseases were anthracnose, leaf spot, red rust, powdery mildew, scab, bacterial leaf blight and malformation of mango seedlings.

Kumar and Gupta (2015) conducted an extensive survey in sixty seven mango growing areas of different villages in and around the Varanasi region for the period of two successive years. The disease incidence varied from 0.00- 68.30%. The maximum disease incidence (68.30%) was recorded in the village, Adalpura of red rust disease on mango in the July of second year. Higher disease prevalence was recorded in Adalpura on Amrapali cultivar of mango i.e. 18.30% and 68.60% in both of the years, respectively. The lowest disease prevalence was found in local

cultivars of mango i.e. 2.60 % and 7.60% in the first year and the second year, respectively.

Iram *et al.* (2014) surveyed prevalence, disease incidence and severity of major post-harvest diseases (anthracnose, stem end rot) of mango in the orchards (farmer and demo block) of Punjab and Sindhu province of Pakistan and the associated fungal pathogens (*Colletotrichum* spp. and *Lasiodiplodia* spp.) were isolated through tissue segment method on general and specific media. In both provinces, diseases observed were generally the same but incidences, severity and prevalence varied according to management practices employed by individual farmers.

Guettia *et al.* (2014) surveyed different mango orchards in Côte d'Ivoire to record the incidence and severity of anthracnose on mangoes and observed that the incidence and severity of the disease seem to be influenced by climatic parameters and cultural practices. Based on white-grey colony and cylindrical conidia and the pathogenicity test, the pathogen was identified as *Colletotrichum gloeosporioides* varying on pathotypes.

Rehab *et al.* (2014) surveyed the severity of powdery mildew caused by *Oidium mangiferae* of mango during seasons 2011 and 2012 in Sharkeya, Behera, Ismailía and Giza as well as Noubareya district. The highest disease severity (%) was observed in Ismailía being (46.6%) and the lowest in Giza (23.6%). Five different fungicides namely Punch, Bayleton, Kema-Z, Colis, Billis and one Biocide (AQ 10) were used as spraying treatments to control the disease on four mango cultivars (Langara, Zebda, Alphonso and Fagri Kelan) grown at Noubareya district. Punch gave the highest efficiency in controlling the disease being (78.9 and 79.4% in 2011 and 2012, respectively) whereas AQ 10 gave the lowest efficiency (57.0 % and 55.3%).

Naqvi *et al.* (2014) observed that powdery mildew of mango caused by *Oidium mangiferae,* Bert. is one of the major plant pathological constraints in growing healthy mango orchards. Twenty-five mango varieties *i.e.* Langra, Dusehri, Ratole No.12, Fajri, Sindhri, Chaunsa Samar Bahisht, Anwar ratole, Neelam, Yakta, Tota

Pari, Sensation, Saroli, Malda, Ghulabe Khas, Chaunsa Black, Chaunsa white, Anmol, Almas, Shane Ali, Shane Mustafa, Mahmood Khan, Armughan, Zafaran, Malda Late and Early Gold were evaluated through the observation of symptoms on young inflorescence to determine the disease incidence, disease severity index and average yield of fruit. Maximum disease incidence was observed (33.33%, 26.66% and 26.66%, 26.66%) on Dusehri, Chaunsa Samar Bahisht, Malda and Ratole No.12, respectively and minimum disease incidence was (3.66% and 3.66%) noted on Almas and Sensation, respectively.

Nasir *et al.* (2014) studied symptomatology, biology, and etiology, inoculum potential, growth models and epidemiological parameters and control of powdery mildew of mango, incited by the fungus *Pseudoidium anacardii* (formerly known as *Oidium mangiferae* Berthet).

Basak (2013) studied the efficacy of Gentamicin, Erythromycin, Doxycycline, Copper sulphate and BAU-Biofungicide in management practices for controlling bacterial leaf blight disease of mango and litchi. Among the different treatments, BAU-Biofungicide was found superior that reduced 39.31% disease incidence and 48.50% disease severity when applied as foliar spray @ 2% followed by Gentamicin over control. On the other hand, in litchi BAU-Biofungicide also showed good result in decreasing incidence (17.16%) and severity (63.03%) of bacterial leaf blight disease followed by Copper sulphate over control.

Islam *et al.* (2013) reported that Bacterial leaf blight of mango caused by *Pseudomonas syringae pv. syringae* and surveyed nurseries of some selected areas viz. Dinajpur, Rajshahi, Khulna, Mymensingh and Madhupur of Bangladesh to know the status of bacterial leaf blight of mango in terms of its incidence and severity and to characterize the pathogen causing the disease.

Nafees *et al*. (2013) conducted an experiment on the effect of time of urea spray on irregular bearing of most commercial cultivars of mango (Chounsa, Dushehari and Anwar Ratool) of Pakistan. Various concentrations of low biurete urea (LBU) were sprayed in February, 2005 (before blooming) and September, 2005 (After

harvest at flower bud differentiation) and its effect on blooming of tagged shoots was studied during on year 2005. Percentage of emergence of vegetative and flowering buds on shoots emerged during on year 2005 was recorded during off-year 2006. Means and standard deviations of results reflected that there was significant effect of time and concentration of urea spray on blooming as compared to control. Significantly high blooming was recorded in off-year on plants, received 3% urea compared with control.

Sarkar and Rahim (2013) conducted an experiment to determine the effects of KNO_3 and urea in manipulating the harvesting time and increasing yield as well as quality of nine years old mango (*Mangifera indica* L.) cv. Amrapali plants. The five treatments included in the experiment were potassium nitrate at 4%, 6% and 8%; urea at 2% and 4% and the control (water spray). Foliar spraying of urea at 4% exhibited better performance in relation to terminal shoot length, number of leaves and leaf area and potassium nitrate at 4% gave superior results with respect to length and breadth of panicle and number of secondary branches per panicle compared to control. The plants sprayed with KNO_3 at 4% expressed earlier panicle appearance by 17 days as compared to delayed appearance of panicle in untreated control plants. The plants received KNO_3 at 4% produced the highest number of panicles per plant (220.67) whereas the control plants had the least number of panicles (107.67). Regardless of concentration, KNO_3 and urea manifested slightly earlier harvest (5 days) compared to control. Plants treated with KNO_3 at 4% noted the highest number of fruits per plant (136.67) compared to control (62.67). The treatment urea at 4% resulted in the biggest fruit (202.83g) and the control plants exhibited the smallest fruit (175.00g). Potassium nitrate at 4% gave maximum yield (23.14 kg/plant) as compared to minimum yield (9.12 kg/plant) in the control (water spray).

Onyeani *et al.* (2012) investigated the etiology, disease incidence and disease severity of mango fruit anthracnose in Southwestern Nigeria. Sixty percent of mango trees surveyed were found infected with anthracnose and over 34% of fruits produced on those trees were found severely infected.

Hossain (2011) studied the nursery diseases of mango in Bangladesh during the period of 2010-2011. He recorded red rust, bacterial leaf blight, anthracnose and malformation of mango seedlings in different mango growing areas of Bangladesh.

Sen *et al*. (2010) conducted a systematic investigation of the diseases and insect pests of mango plants in 24 cities and counties in Guangxi Zhuang Autonomic Region was conducted. Twenty diseases were documented, of which the most important were powdery mildew, anthracnose, bacterial black rot and blossom-end rot. Mango vesicular disease, mango malformation disease and mango red-spot disease were the first to be recorded in China. Ninety-four insect pests, from 8 orders and 38 families, were found.

Haggag (2010) reported that mango suffers from several diseases at all stages of growth. All the parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. They cause several kinds of rot, die-back, anthracnose, malformation, scab, necrosis, blotch, spots and mildew etc. This fact sheet concentrates on the symptoms of the important mango diseases, the weather conditions conducive to disease development and methods for control.

Udhayakumar *et al*. (2010) reported that anthracnose caused by *Colletotrichum gloeosporioides* (Penz.) Penz.and Sacc. is one of the most damaging diseases causing losses in pre and post-harvest conditions in mango. Studies were conducted to find out the favorable temperature, relative humidity and light period for the growth and conidial germination of *C. gloeosporioides* under in-vitro condition. The study indicated that the temperature of 25^0C was found to be good for the mycelial growth (89.6 mm) and conidial germination (69%). At 100% relative humidity, the mycelial growth (90 mm) and conidial germination (87%) were higher. In this context, different light periods were tested; continuous light favored the both mycelial growth and conidial germination.

Chowdhury (2009) studied the effect of different management practices on the incidence of diseases (anthracnose, red rust and powdery mildew) and stated that

the highest reduction (67.85%) of anthracnose and red rust disease incidence over control was observed in T_5 (BAU-Biofungicide applied in soil and top dressing @ 2%) followed by 64.83% recorded in T_1 (BAU-Biofungicide applied in soil @ 2%). On the other hand, the lowest reduction (46.77%) of disease incidence over control was observed in T_3 (Bavistin spray @ 0.2%).

Chowdhury (2009) carried out trials to determine the effect of different management practices on the severity of anthracnose and red rust diseases of mango seedlings. Considering the mean disease severity, the highest severity (26.10%) 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-Biofungicide 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 (68.97%) of disease severity over control was observed in T_5 (BAU-Biofungicide applied in soil and top dressing @ 2%) followed by 51.84% recorded in T_7 (BAU-Biofungicide applied in soil @ 2% and Bavistin spray @ 0.2%) and the lowest reduction (26.44%) over control was observed in T_4 (BAU-Biofungicide foliar spray @ 2%).

Chowdhury and Rahim (2009) conducted an experiment to develop an Integrated Crop Management (ICM) practice for controlling anthracnose **(***Colletotrichum gloeosporioides*) of mango with emphasis on non-chemical means and achieving higher yield. The treatments were T_1 = Pruning (P) + Weeding (W) + Spading (S) + Fertilizer application + Garlic Extract (3 times) + Irrigation (14 days interval); T_2 = P+W+S + Fertilizer application +GE (2 times) + Dithane M-45 (one time) + Irrigation (14 days interval); T_3 = P+W+S + Fertilizer application + Bagging (60 days before harvest) + Irrigation (14 days interval); T_4 = P+W+S + Fertilizer application + Dithane M-45 (3 times) + Irrigation (14 days interval) and T_5 = Control (Untreated). It was found that T_4 treated plant resulted the highest (14%) fruit retention per plant followed by T_1 (13.75%). The lowest (8.50%) was obtained from T_5 (control) at 60 DAFS. Treatments T_4 and T_1 produced the highest

percentage (94 and 92, respectively) of healthy fruits and the lowest (86%) was obtained from T_5 (control). The highest yield was obtained from T_4 and T_1 treatment (18.88 and 17.47 t/ha, respectively) and the lowest (4.48 t/ha) was found in T_5. The highest (26.50%) soluble solid was obtained from treatment T_4 followed by T_1 (25.75%) and the lowest (24.00%) was recorded from T_5. The highest disease incidence and severity was found in T_5 (66.67% and 3.00%, respectively).

Guang *et al*. (2009) investigate and identify various diseases in mango crops in main mango producing areas of Hainan Province, including Danzhou, Baisha, Changjiang, Dongfang, Ledong, and Sanya, from April, 2004 to May, 2006. According to the identification criteria of diseases and the pathogenesis, forty-two kinds of mango diseases were found in Hainan, out of which, 32 were fungal, 5 were bacterial disease, 3 were nematodes, and 2 were parasitic plants. The major severe diseases on mango crop included powdery mildew, gummosis, branch rot, stem-end rot, bacterial fruit rot, soft rot, gray mold, sooty mold, seedling blight and fruit rot. The present investigation provides an important data for construction of control measures for mango diseases and ensures the sustainable and healthy mango crop production in Hainan Province.

Mathews *et al*. (2009) tested the efficacy of fungicides viz., Carbendazim, Hexaconazole, Propioconazole, Thiophanate-methyl, Prochloraz, Thiram, Captan, Mancozeb and Copper oxychloride at 50, 25, 25, 50, 50, 750, 750, 1000 and 1000 ppm concentrations, respectively against the pathogen, *Colletotrichum gloeosporioides* using poisoned food technique. The data revealed that all the fungicides inhibited the growth of the pathogen except the non-systemic fungicide Mancozeb.

Suvarna *et al*. (2009) tested the efficacy of commonly used systemic, i.e. Carbendazim 50% WP (50 and 100 ppm), Thiophanate-methyl 70% WP (50 and 100), Propioconazole 50% EC (25 and 50 ppm) and non-systemic fungicides, i.e. Hexaconazole 25% EC (25 and 50 ppm), Mancozeb 75% WP (500 and 1000 ppm) and Copper oxychloride 50% WP (500 and 1000 ppm), was investigated in vitro

against *C. gloeosporioides [Glomerella cingulata*] isolates by poisoned food technique. All the fungicides inhibited the growth of the pathogen. A significant reduction in radial growth of the isolates at the 2 concentrations of the tested fungicides was observed compared to the control. These results showed variation in the degree of sensitivity to the different fungicides among the isolates. All the isolates were classified under highly sensitive to sensitive categories both at 50 and 100 ppm concentrations for Carbendazim. The same results were observed with Thiophanate-methyl at 50 and 100 ppm and Propioconazole at 25 and 50 ppm concentrations. Isolates Cg2, Cg6, Cg10, Cg13, Cg19, and Cg20 exhibited moderate resistance to Hexaconazole at 25 and 50 ppm concentrations. Cg9 was resistant to Mancozeb and Cg12 was resistant to Copper oxychloride at 500 ppm and moderately resistant at 1000 ppm. The non-systemic fungicides Mancozeb and Copper oxychloride were less effective than the systemic fungicides.

Oosthuyse (2008) found that the effects of foliar spray application of $KN0_3$, low biuret urea, GA_3 (a gibberellin), CPPU (a synthetic cytokinin) and NAA (a synthetic auxin) on fruit retention, average fruit weight and yield at harvest, and monetary return taking currently obtained prices into account were evaluated. Applications were made while the trees were in flower or subsequently, just prior to the commencement of fruit drop. The effects of a foliar application of Wuxal® - boron at flowering and of panicle pruning were additionally evaluated. Of the treatments applied during flowering, $KN0_3$ application was the only treatment to noticeably increase fruit retention, average fruit mass, yield and monetary return. Of the treatments applied after flowering, application of CPPU + GA_3, NAA, or NAA + GA_3 noticeably increased fruit retention, yield and monetary return. Increases in return realized were in the order of 19 to 33%.

Sarker (2008) studied the comparative efficacies of BAU-Biofungicide with four different fungicides viz. Amister, Tilt 250 EC, Bavistin and Dithane M-45 on incidence of anthracnose of four varieties of mango (Gopalbhog, Langra, Amropali and Seedless). There was a wide variation in incidence of anthracnose under different treatments. In 1st counting incidence of anthracnose was the highest

(54.68%) in Amropali under Dithane M-45 and the lowest (4.68%) in seedless under Tilt 250 EC spray schedule. In 2nd counting, the incidence of anthracnose was found the highest (57.88%) and the lowest (5.14%) in Amropali under Dithane M-45 and in seedless under BAU-Biofungicide, respectively. Incidence of anthracnose in 3rd, 4th, 5th and 6th counting's were highest in Gopalbhog under control and lowest in seedless where BAU-Biofungicide was sprayed. From the findings, it is evident that incidence of anthracnose increased up to 93.78% in seedless under control, while maximum reduction (57.02%) of incidence of anthracnose was observed in seedless under Dithane M-45 followed by BAU-Biofungicide (51.95%).

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

Diedhiou *et al.* (2007) conducted an experiment on mango production in Senegal takes place over the two seasons of dry and humid conditions between April and November. The increasing demand for fresh mangoes has led to an increase in land area allocated to that crop. Mango production suffers, however, from fruit rotting due to post-harvest diseases during ripening. These diseases reduce the fruit quality and cause severe losses. A survey was carried out in 2004 to detect fungi involved in post-harvest rot of mangoes (cv. Kent) produced in the Niayes area of Senegal in relation with the production practices and the climatic conditions. The results showed that at first harvest during the dry season, a broader species range of fungi including *Alternaria* sp., *Botryodiplodia theobromae*, *Dothiorella* sp., *Aspergillus niger* and non-identified fungi were responsible for mango rotting. The fruits harvested during the humid season, however, were more heavily infested but a smaller number of fungal agents were involved; *Colletotrichum gloeosporioides* and secondarily *Phoma mangiferae* played the main role. The cultural practices played an important role on mango infection whereby orchard sanitation and particularly cleaning and pruning reduced the infection rates. Orchards with no care, in contrast, yielded the most heavily infested mango samples. In addition, the

harvest practice of inversion of fruits in soil for sap elimination increases contamination with pathogenic fungi.

Hossain (2007) applied Dithane M-45, Bavistin, Rovral, Cupravit and Tilt in controlling anthracnose of mango. Out of these chemicals, Bavistin and Tilt were recorded as superior over others.

Ko *et al*. (2007) stated that a leaf spot disease was found in mango orchards of Taiwan since 2001. Now, the disease was observed throughout Taiwan in moderate to severe form, thus affecting the general health of mango trees and orchards. Initial symptoms were small, yellow-to-brown spots on leaves. Later, the irregularly shaped spots (from a few millimetres to a few centimetres in diameter) turned white to grey and coalesced to form larger grey patches. Lesions had slightly raised dark margins. On mature lesions, numerous black acervuli, measuring 290-328 micro m in diameter, developed on the grey necrotic areas. Single conidial isolates of the fungus were identified morphologically as *Pestalotiopsis mangiferae* and were consistently isolated from the diseased mango leaves on acidified PDA medium. Upon conducting pathogenicity tests, the symptoms described above were observed on all inoculated leaves, while uninoculated leaves remained completely free from symptoms. Resolutions from the inoculated leaves consistently yielded *P. mangiferae*. This is thought to be the first report of grey leaf spot disease affecting mango in Taiwan.

Mortuza (2007) tested the performance of two fungicides (Bavistin and Tilt) and one hormone Naphthalene Acetic Acid (NAA) for controlling vegetative malformation of mango in grafts of four varieties viz. BARI Aam-1, BARI Aam-2, BARI Aam-3 and khirsapati. The lowest disease incidence (2.49%) as well as the highest disease reduction (80.11%) as compared with the unsprayed plants was noted in plant sprayed with Planofix. Bavistin and Tilt controlled 73.72 and 62.38% disease, respectively. The lowest disease incidence (1.77%) was recorded in BARI Aam-2, sprayed with Planofix followed by BARI Aam-3 (91.90 %)

sprayed with Planofix (1.90%). The highest disease incidence (16.66%) was noted in BARI Aam-3 grafts.

Rivas and Carrizals (2007) stated currently the most important pathologies of mango in Monagas State, Venezuela, are the spots on the foliage, flower and fruits caused by anthracnose (*Collelotrichum gloesporioides Penz*). It has been noted that the implementation of a spraying program containing fungicides, is the most viable practice to manage the disease. The fungicides were Benlate WP, Funcloraz 40 CE and Amistar xtra. Test showed that the fungicides Funcloraz and Amistar achieved the best anthracnose control on harvested fruits.

Sundravadana *et al.* (2006) observed that anthracnose caused by *Colletotrichum gloeosporioides* is one of the most damaging diseases causing flower set reduction and yield losses in mango. Application of fungicide was one of the approaches to control the disease. In this study, the efficacy of Azoxystrobin, one of the Strobilurin class fungicides, was evaluated both in vitro and in vivo conditions. In in-vitro tests, Azoxystrobin completely inhibited mycelial growth of *C. gloeosporioides*. In field experiment, Azoxystrobin at 1, 2, and 4 ml/L significantly suppressed the development of both panicle and leaf anthracnose. Mango trees treated with Azoxystrobin produced more fruits compared to control and showed no phytotoxicity.

Tiwari *et al*. (2006) studied the resistance of 44 mango cultivars to powdery mildew caused by *Oidium mangifera* in an experiment conducted in Madhya Pradesh, India during 2000-01 and 2002-03. Powdery mildew incidence ranged from 0 to 75%. Cultivars Baigan phalli, Barbalia, Dabari, Dilpasand, Khirama, Nagarideeh, Oloor and Totapari were highly resistant to the pest, recording 0% incidence of powdery mildew, whereas cv. Aamrpali was the most susceptible, recording 75% incidence of the disease.

Awasthi *et al*. (2005) observed the prevalence of different diseases of some major fruit crops. On mango, four diseases, namely anthracnose (*Colletotricum*

gloeosporioides, Glomerella cingulata), leaf blight (*Phoma glomerata*) and red rust (*Cephaleuros* sp.), were found to occur in the orchard.

Nizamani *et al. (*2005) surveyed different mango (*Mangifera indica [Mangifera indica*]) orchards at Tando Qaiser, Tandojam, Village Karim Dad Khaskheli, Arbab Nahiyoon, Mureed Sipio and Khesano Mori, Pakistan, to estimate the incidence of tip die-back disease. The maximum disease incidence was obtained on Langra cultivar (52.0%) at Tando Qaiser, followed by Tandojam (48.0%). The minimum disease incidence was recorded on Siroli cultivar (16.0%) at Khesano mori. The overall mean disease incidence on Langra (28.0-52.0%) was followed by that on Chaunsa (24.0-44.0%), Sindhri (16.0-36.0%) and Siroli cultivars (16.0-28.0%). The disease severity recorded on Langra was (63.33-81.66%), followed by Chaunsa (60.0-75.0%), Sindhri (11.66-25.0%) and Siroli (7.66-15.0%), respectively.

Pawar *et al*. (2004) tested the effects of different fungicides (Mancozeb at 0.10, 0.15 and 0.25%; Copper Oxychloride at 0.25%; Copper Hydroxide at 0.25; and Carbendazim at 0.10%) in controlling mango cv. Ratna diseases in 1998 in Maharashtra, India. The fungicides 0.1% Carbendazim 75 WP and 0.1% Carbendazim liquid were the most effective in controlling anthracnose [*Glomerella cingulata*] and red rust [*Cephaleuros virescens*] disease of mango compared to the other fungicide treatments. However, for controlling pink disease, 0.25% Copper oxychloride 50 WP was the most effective fungicide. The new formulations of Mancozeb and Carbendazim in liquid or WP form have a broad spectrum effect, thus can be used as common treatment for control of anthracnose, pink and red rust diseases in mango.

Stovold and Dirou (2004) recommended for the application of fungicide Prochloraz and Mancozeb for controlling anthracnose at every three weeks and copper fungicide for controlling bacterial black spot at every three weeks. They also mentioned that Azoxystrobin (Amistar WG) could be included in the spray schedule to improve control of anthracnose.

Willis and Mabunda (2004) evaluated the efficacy of low copper-content products for the control of bacterial black spot (BBS, *Xanthomonas campestris* pv. *mangiferae indicae*) and post-harvest diseases of mango. Four copper products and an untreated control were evaluated on one hectare of Keitt mangoes in the Mooketsi area, Limpopo Province, South Africa during the 2003/04 season. Fruit loss due to bacterial black spot was monitored weekly from December onwards and the total fruit loss due to disease was determined for the season for each treatment. Fruit samples were taken for shipment simulation and evaluated for post-harvest diseases and disorders. Nordox (Cuprous oxide at 100 g/100 litres) was as effective as Copper oxychloride (300 g/100 litres) for the control of bacterial black spot, while Kocide (Copper hydroxide at 225 g/100 litres) and Cu protect (Copper acetate at 500 ml/100 litres) were significantly less effective. Copper oxychloride, Kocide and Nordox were equally effective in controlling anthracnose (caused by *Glomerella cingulata*) as well as stem-end rot and soft brown rot (both caused by *Botryosphaeria* spp., formerly known as *Nattrassia mangiferae*). Nordox resulted in half, the amount of Copper being applied to the orchard in one season.

Okigbo and Usuinde (2003) observed the incidence of fungal leaf spot diseases on mango (*Mangifera indica)* in Southeastern Nigeria and application of a biological control measure was investigated. The survey proved that the incidence of leaf spot diseases was the 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* and *Macrophoma mangiferae* were isolated from leaf spots. Other fungi, *Fusariella* spp., which are well known saprophytes of dead plant materials, and the fungus *Meliola* sp., were also isolated from diseased leaves. 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* NCIB 3610, isolated from soil under a mango tree, inhibited *P. mangiferae, B. theobromae* and *M. mangiferae* by 57%, 61% and

58%, respectively on agar plates. Also, in *in-vivo* experiments, the symptoms were considerably reduced in the field by the application of the antagonist. The importance of the biological control method for rural mango farmers is emphasized.

Akhter *et al*. (2002) conducted an experiment to control anthracnose of mango with three fungicides viz. Shincar 500 SC (Carbendazim at 100 ml/100 litre) of water (LW), Bavistin 50 DF (Carbendazim, 100g/100 LW) and Topas 100 EC (Penconazole, 50ml/100 LW) on mango cv. Dosari at Sandspur Multan, Pakistan. Among the fungicides, Bavistin 50 DF showed the best result in reducing the disease incidence significantly.

Colon-Garay *et al.* (2002) reported that *Colletotrichum gloeosporioides (Glomerella cingulata*) caused anthracnose in various tropical crops including mango. 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.

Jianguo *et al*. (2002) found that antagonistic micro-organisms reduce the incidence of anthracnose disease (caused by *Colletotricum gloeosporioides*) on mango. The result indicated that the pathogen suppressive substances produced by the antagonistic micro-organisms and the increase in enzyme activity in host leaves reduced disease activity.

Singh and Varma (2002) found that some15 to 20 year old mango cv. Dushehari trees were sprayed separately with Dinocap, Tridemorph, Wettable sulfur, Carbendazim and Thiophanate-methyl in a field experiment conducted in New Delhi, India to control powdery mildew caused by *Oidium mangiferae*. The fungicidal spray schedule was worked out based on the occurrence of key weather factors. Two sprays with wettable sulfur WP at 0.2%, Dinocap EC at 0.05%, Carbendazim WP at 0.1%, Tridemorph EC at 0.1% or Thiophanate-methyl WP at 0.1% at 15 days interval, after the occurrence of high humidity and low

temperature for 4-5 days in disease prone areas effectively controlled the disease. Cost-benefit ratio was higher in Sulfur treatment followed by Carbendazim.

Tiwari and Singh (1999) conducted an experiment at Regional Agricultural Research Station, Sarakanda, Farm, Biluspure, India in different mango cultivars. They found that 23 mango cultivars were resistant to red rust.

Xie and Xie (1999) studied the symptoms of anthracnose of mango and its control. They described that 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, dried and infected flower clusters, turned black and rotted. Infected fruits were abnormal in shape, becoming black and then dropping. Spraying with Chlorothalonil, Carbendazim or Topsin-M (Thiophanate-methyl) during the flowering and fruit growing period controlled the disease.

Akhter *et al*. (1998) reported that Topsin-M, Mancozeb, Propineb and Benomyl were the most effective in controlling anthracnose disease of mango.

Simmons *et al.* (1998) stated that preharvest Calcium chloride sprays increased fruit calcium (Ca) concentrations and the number of days to eating soft at 22°C (shelf life) by 1.3 days, but caused a 5% increase in lenticel spotting, No significant effects on skin green colour at ripe, percentage dry matter (% OM) or disease were observed. Soil fertilizer applications of gypsum did not significantly affect mango fruit shelf life or quality. Altering the leaf, fruit ratios affected fruit mass, Calcium (Ca), Magnesium (Mg) and Potassium (K) concentrations, shelf life, % OM, disease, skin colour, and external chilling injury. Water stressing mango fruit during different stages of development and growth affected fruit Ca, Mg and K concentrations, % OM, disease, skin colour, chilling injury, fruit cuticle thickness, fruit growth rates and final fruit mass by reducing cell number or size. Pulp Ca concentrations had poor correlations with fruit shelf life in all trials. Stronger relationships were found between fruit shelf life and % DM.

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

Verma and Kumar (1998) tested the efficacy of five fungi toxicants for controlling powdery mildew (*Oidium mangiferae*) of mangoes in Ludhiana, India Punjab. Triadimefon (Bayleton) gave the best control followed by Sulfur (Sulfex), Dinocap (Karanthane) and Carbendazim (Bavistin).

Hussein (1997) studied leaf of mango and found that leaf spot severity increased with increasing period after artificial inoculation of these pathogens.

Reza and Mortuza (1997) suggested for using two foliar sprays with Kumulus DF (0.2%) followed by Tilt 250 EC (0.05%) against powdery mildew disease resulted higher fruit retention of mango.

Reza and Kader (1996) conducted a survey program to record the prevalence of different diseases of mango in Chapai Nawabganj district, Bangladesh during June 1996. They found that Khirsapat, Mohanada and Kalia were free from anthracnose on leaves and shoots and Lata mombai was susceptible to red rust. The variety Gopalbhog was severely infected by anthracnose and Fazli was susceptible to red rust at Horticulture Base Kallyanpur, Chapai Nswabganj.

Ahmed *et al.* (1995) evaluated various fungicides against dieback disease in mango caused by *Botryodiplodia theobromae*. They observed that Benomyl (0.5 g/l) and Thiophanate-methyl gave effective control against this disease. They also observed that Propiconazole (Tilt) was least effective in reducing disease severity.

Reza and Kader (1995) tested six fungicides viz. Tilt 250 EC (0.05%), Dithane M-45(0.2%), Macuprex (0.2%), Thiovit (0.2) and Bavistin (0.1%) to control anthracnose and stem end rot of mango in Chapai Nawabganj district, Bangladesh and found that Bavistin was effective to control anthracnose disease and Tilt was the best for the control of stem end rot.

Visser (1995) conducted a detached leaf bio-assay to determine the efficacy of the bactericidal chemicals in eradicating the bacterial leaf spot population established on mango leaf surface. Epiphytic populations of the pathogen on the mango leaves were significantly reduced, but not eradicate from the leaf surfaces with the chemical used. He found Copper sulphate, the most successful followed by Ethanol, Dichlorophen, Copper ammonium carbonate, Quanternay ammonium compound, Copper oxychloride and Mancozeb.

Dulvi and Sardeshpande (1993) conducted an experiment with *Cephaleuros virescens* on mango and found that the alga significantly increased the total sugar content of diseased leaf, but decreased chlorophyll content. He reported that Copper oxychloride, Bordeaux mixture, Fytalon and Copper sulphate were effective in controlling the pathogen up to two months but Bordeaux mixture and Copper sulphate solution had appreciable effect checking the pathogen for long time and Copper sulphate solutions had no effect on mango leaves.

Anonymous (1990) recorded the occurrence and severity of various diseases of mango throughout the year in the orchards of Chapai Nawabganj and Rajshahi (Kajla). It was observed that anthracnose, sooty mold and powdery mildew were pre-dominant diseases in the orchard of served area; the highest incidence of anthracnose was observed in the variety of Aswina (37.16%) and Gootee (37.8%) in Chapai Nawabganj district and the lowest was in the variety Kuapahari in the same district.

Gupta *et al.* (1990) conducted an experiment to control red rust disease of mango with fungicides and reported that the solution of Copper sulphate @0.4, 0.6, and

0.8% did not show any injurious effects on mango leaves even after two sprays given at an interval of one month.

Mortuza (1990) recorded the occurrence and severity of various diseases of mango from January, 1990 to June, 1990 in different orchard of Chapai Nawabganj and Rajshahi districts. Different diseases and severity were recorded; infected leaves and panicles were measured at every two month. Red rust, a new disease (*Cephaleures virescence*) was recorded. Other recorded diseases were anthracnose (*Colletotrichum gloeosporioides*), sooty mold (*Capnodium ramosum*), powdery mildew (*Oidium mangiferae*), die-back (*Diplodia natalensis*) 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.

Micvkenzie (1988) carried out trails to determine the efficacy of Propaconazole (Tilt 250EC) for the control of powdery mildew on mango. In the trail, which compared Propaconazol to Triadimenfon, Pyrazophos and Bupirimate, there was heavy attack of powdery mildew and 9% of the panicles were attacked with 45% of their surface covered the fungus. The level of control was 96, 97, 84 and 81% for Propiconazole, Triadimefon, Pyrazophos and Bupirimate, respectively.

Sardeshpande (1988) experimented with red rust of mango at Regional Farm Research Station, Vengurla, Sindhudrug and observed the incidence of *Cephaleuros* on 160 varieties of mango.

Burhan (1987) found that *Botryodiplodia theobromae* caused dieback in young mango seedlings with blackening and necrosis of the tap root. On older plants, dieback twig blight and blackening of the stem were followed by stem canker necrosis and root necrosis.

Peterson (1986) reported that anthracnose (*Colletotrichum gloeosporioides , 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. Mangiferae indicae*) and powdery mildew (*Oidium mangiferae*) were the major diseases aspects of etiology and epidemiology.

Prakash and Singh (1980) experimented with control of red rust of mango. They tested some chemicals (Boedeaux mixture, Fytalon, Cupravit etc) and obtained good control of *Cephaleuros virescens*.

Pathak (1980) stated that 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 speeded from tip of inflorescence and covered the floral axis, young leaves and stems. In addition, he mentioned that they onset of die-back became evident by discoloration and darkening of the bark some disease from the tip. The dark area advanced and young, green twigs started withering first at the base and then extending towards along the veins of leaf edges. The latter bearded cluster of spores appears at the apex. Cells of both the types of hairs and mature spore were brown colored. After shedding of spores and hairs, a creamy-white mark of the alga remained at the original rust spot.

Singh (1968) described the symptoms of anthracnose of mango. Numerous oval or irregular brown spots of different sizes were formed on the leaves. These spots had their origin at the tip or on any other portion of the margin or center of the leaf. Under humid or dam atmospheric conditions, these spots increased at a first pace and formed elongated narcotic areas, which when old, become ruptured. Young leaves were most susceptible of this infection. If the petioles were affected they turned grey or black, the leaves fall down, became dry, and were ultimately shed prematurely, leaving a black scar on the twig. The tips of very young branches were the first to show the symptoms. Black and necrotic areas were formed on the affected twigs, which began to dry out from the tip downwards. At this stage, the leaves on the twigs shaded, leaving it bare; the tip subsequently showed blackening and finally dried up.

Singh (1968) described the symptoms of bacterial leaf spot of mango. In the initial stage, tiny water-soaked dark brown spots appeared on leaves. Later on the spots gradually increased in area and became 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 Singh 1978, also stated that anthracnose mostly affected the tender parts of the tree on a young shoots, leaves, panicles, flowers and fruits. The symptoms varied according to the plant parts infected. Dark brown necrotic areas were appeared on the leaves with elongated black necrotic patches on the twigs.

According to Singh (1968) initially the spots of red rust disease on mango leaves are greenish-gray in color and velvety in texture, but latter on surface bears reddish hair like structure which gives in the characteristics red-rust appearance. The algal spots are circular to irregular in shape slightly and with usually a diameter of 2mm, though in some case it may be as much as 1cm. A number of such spots may be formed on the upper surface of the leaf blade.

Suit and Ducharme (1946) observed that the red rust alga attracts foliage, barks and twigs of the mango plants. They also observed that, the barks become thickened, the twigs enlarged and remain stunted, and the foliage become spares and finally dries up in serious infections.

Suit and Ducharme (1946) reported that Copper sulphate sprays were quite effective in killing the red rust alga of citrus.

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site

The experiment was conducted in ten orchard of Dinajpur and Thakurgaon district in Bangladesh. In Dinajpur district, 5 orchards of farmers located between 25 ^{0} N latitude and 88.23 ^{0} E longitude and about 37.5m above the sea level was selected. Other five orchards in Thakurgaon district were selected that located between 26 ^{0} N latitude and 88.46 ^{0} E longitude and about 37.5m above the sea level. The orchard was selected far from the road side to minimize the side effects. All the orchards were well protected by the brick boundary or wicker fence. The minimum distance of the boundary from the present experimental site was kept about 5 m for minimizing boundary effects. The orchards were well ventilated with irrigation and drainage facilities and suitable to conduct agro forest as well as other field research. The orchards selected were many varieties of mango plants with different ages. The present investigation was done in different mango orchards. Disease of mango on inflorescence and fruits were not considered for the study as because the mango has alternate bearing habit. Only the leaves and twigs disease were taken consideration by observing their symptoms and signs.

3.2. Periods of experiments

The experiment was conducted for twelve months starting from the month of May-2014 and ending at April-2015.

3.3. Topography and soil

The topography of land was medium high and soil was clay loam in texture having pH around 5.5 - 6.5 and soil color was dark gray due to rich in organic matter content in Dinajpur district. In Thakurgaon district, the topography of land was medium high and the texture of the soils varied from clay loam to sandy loam

having pH around 5.4 to 6.26 and the color of the soil was dark grayish brown to dark yellowish brown (Uddin *et al*. 2012).

3.4. Intercultural operation

Intercultural operations were done by the orchard owner as a regular and routine work. Irrigation of the plants was also done by them as a routine work during the study period. Any other treatments were not applied during the study period without selected treatments.

3.5. Severity of mango disease of some selected mango plants in different orchards of Dinajpur and Thakurgaon

3.5.1. Selection of orchard in Dinajpur

Mango orchard was selected with the help of Upazilla Sub-Assistant Agriculture Officer. Mango orchard of farmer was selected in five different locations of Dinajpur Sadar Upzilla. Detailed of the locations and farmers were as follows:

No. of Orchard	Name of the farmer's	Location/ Village	Total plants in the orchard	Plants age (years)	Selected plants (No.)
Orchard 1	Md. Jaman Uddin	Raipur	90	5-7	12
Orchard 2	Dr. Md. Zonab Ali	Shulibalter	50	8-10	12
Orchard 3	Md. Wajed Ali	Shulibalter	60	5-7	12
Orchard 4	Md. Majid Mia	Shulibalter	85	8-10	12
Orchard 5	Kripanonda Roy	Amoir	55	6-7	12

3.5.2. Selection of orchard in Thakurgaon

Mango orchard of farmer was selected in five different locations of Thakurgaon Sadar Upzilla with the help of Upazilla Sub-Assistant Agriculture Officer. Detailed of the locations and farmers were as follows-

No. of Orchard	Name of the farmer's	Location/ Village	Total plants in the orchard	Plants age (years)	Selected plants (No.)
Orchard 1	Md. Kalu Mia	Madarganj	120	5-7	12
Orchard 2	Md. Kalu Mia	Madarganj	110	8-10	12
Orchard 3	Forhad Hossain	Madarganj	90	5-7	12
Orchard 4	Forhad Hossain	Madarganj	85	8-10	12
Orchard 5	Md. Poigam Ali	Arazi	75	8-10	12

3.5.3. Selection of plants

The plants were selected from the orchard in Dinajpur and Thakurgaon district as mentioned previously. From each orchard, twelve plants were selected randomly for the study which represents four replications in each treatment.

3.5.4. Fertilizer and manure application

Firstly, all of cowdung, $ZnSO_4$, boric acid, half of urea, TSP and MP were applied in soil around the base of mango tree by using of spade in October, 2014 before the initiation of flowering. Then, rest of urea, TSP and MP were applied in soil around plant by same process at the time of February to middle of the March, 2015. Amount of doses of cowdung and fertilizers are shown-

Application of manures and fertilizers in mango orchard (g/plant)

Name of the fertilizers and manure	First Dose (g/plant)	Second Dose (g/plant)
Cow-dung	8000	0
Urea	250	250
TSP	230	230
MP	75	75
Zypsum	250	250
$ZnSO_4$	17.5	0
Boric acid	35.5	0

Source: Bangladesh Agricultural Research Council (BARC) for 4-8 years old plant in 2005

3.6. Treatments

For management of mango diseases, three different treatments were applied as foliar spray at 30 days interval. The treatments were as follows:

T_0 = Control

T_1 = Spraying of Indofil M-45@ 0.2%

T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

3.6.1. Preparation of Indofil M-45 solution ($0.2\%/2gL^{-1}$)

Indofil M-45 (40g) was taken in a 20L bucket and water was added up to the mark. The material was then stirred properly until the mixing was complete. As a result, 0.2% Indofil M-45 solution was prepared. Eight plants were sprayed with 20 L spray solution.

3.6.2. Preparation of Confidor 70 WG solution ($0.02\%/0.2gL^{-1}$)

Confidor 70 WG (4g) was taken in a 20L bucket and water was added up to the mark. The material was then stirred properly until the mixing was complete. As a result, 0.02% Confidor 70 WG solution was prepared. Four plants were sprayed with 20 L prepared solution.

3.6.3. Application of spray solution

Required amount of spray solution of Indofil M-45 and Confidor 70 WG were prepared as mentioned above were sprayed on the selected plants. The test chemicals were sprayed thrice at 30 days interval. The first spray was done at 1st October 2014. Freshly prepared solution was used as spray solution. Adequate precautions were taken to avoid drifting spray materials from one plant to another. Special attention was taken to complete the coverage of the plants with the spray solution. In control treatment, only fresh water was sprayed at every time of chemical spray.

3.7. Assessment of disease severity

Disease severity was defined as the percentage of leaf area diseased. Disease severity was assessed and expressed as the mean disease severity per plant. Disease severity was calculated using the following formula of Johnston (2000).

$$\text{Percent disease severity} = \frac{\text{Area of leaf tissue infected by disease}}{\text{Total area of leaf}} \times 100$$

3.7.1. Identification of diseases on mango plants

Branches of selected mango plants were carefully observed and symptoms of the diseases were recorded following the description of Pathak (1980), Peterson (1986), Singh (1998) and Ploez *et al*. (1994). Observation of disease was done four times starting from October, 2014 and ending at April, 2015. Only the major diseases of mango on leaves and twigs were considered.

3.7.2. Data recording times

Assessment of the disease severity of each plant was observed at four month of growing season during the period of October, 2014 to April, 2015. The dates of collection of data were at the first week of every month after treatment. The time of data collection was determined on the basis of time of pesticide application during the growing season.

3.7.3. Data recorded

The Data were recorded four times on the following parameters at an interval of one months starting from October, 2014.

a) Severity of anthracnose disease
b) Severity of die-back disease
c) Severity of powdery mildew disease
d) Severity of sooty mold disease
e) Severity of red rust disease
f) Severity of bacterial leaf blight disease
g) Severity of bacterial leaf spot disease

3.7.4. Weather and climate

The climate of the experimental area is sub-tropical in nature and six distinct seasons. Hot and humid conditions occur in rainy season with high rainfall. Scanty rainfall and plenty of sunshine prevailing during Rabi season. Details of the meteorological data regarding temperature, rainfall and relative humidity during the period of experiment were collected from the weather stations located at Dinajpur and Thakurgaon district was presented in Appendix 1 and Appendix 2, respectively.

3.8. Analysis of data

Data on different parameter were analyzed through computer software MSTAT-C (Anonymous, 1989). 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 parameter.

CHAPTER 4

RESULTS

Diseases of mango their severity was determined and their management was studied by different experiments in the various orchard of Dinajpur and Thakurgaon district in Bangladesh. Altogether seven different diseases viz. anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot were recorded. The symptoms of different diseases as observed in the field were as follows:

4.1. Anthracnose

The disease developed on all the tender parts of the plant. It was found serious especially on tender twigs, leaves and tender stems. Symptoms on leaves were small, dark brown spots, which coalesced to form irregular lesions. The centers of old lesions were dried and fallen out. Sometimes only the edges of the leaves were attacked; their margins darken, dried up, fall out, giving the leaf a rugged appearance and also resulted in twig die-back.

Plate 1. Anthracnose symptoms on mango leaf

4.2. Die-back

The disease was characterized by drying of twigs and branches followed by complete defoliation, which gives the tree an appearance of scorching by fire. Die-back became evident by discoloration and darkening of the bark. The dark area

advances and young green twigs start withering first at the base and then extending outwards along the veins of leaf edges. The affected leaf turns brown and its margins roll upwards. Finally the twig or branch dies, shrivels and falls. In old branches, brown streaking of vascular tissue was found on splitting it longitudinally.

Plate 2. Die-back symptoms on mango twig

4.3. Powdery mildew

The characteristics symptoms found were the white superficial powdery fungal growth on leaves stalk and under surface of young infected leaves. Severe infection of young leaves were exhibited distorted growth and appeared bluish mauve to brown , particularly where the mycelia collapsed or was rubbed away and finally premature leaf drop. On mature leaves, the spots were turned purplish brown, as the white fungal mass eventually disappears.

Plate 3. Powdery mildew symptoms on mango leaf

4.4. Sooty mold

The disease is common in the orchards where mealy bug, scale insects and hoppers are not controlled efficiently. The disease in the field is recognized by the presence of a black sooty mold on the leaf surface. In severe cases, the trees turn completely black due to the presence of mold over the entire surface of twigs and leaves. The severity of infection depends on the honey dew secretion of the above insects. Honey dews secretions from insects stick to the leaf surface and provide necessary medium for fungal growth. Although, the fungus causes no direct damage, the photosynthetic activity of the leaf is adversely affected.

Plate 4. Sooty mold symptoms on mango leaf

4.5. Red rust

The rusty red spots were found mainly on leaves and sometimes on petioles and young twigs. Initially the spots were found circular greenish grey in color and velvety in texture. Later they turned reddish-brown and bearded hair-like structure which gave the characteristic red rust appearance. The spots observed were roughly circular and slightly elevated and sometimes coalesce to from a larger,

irregular spot. At mature stage spores and hairs were shedding which give a creamy white mark at the original rust spot.

Plate 5. Red rust symptoms on mango leaf

4.6. Bacterial leaf blight

The symptoms of the disease are characterized by a rapid enlargement of necrotic lesions in buds and leaves. Mango buds, leaves, and stems are all predisposed to infection, but fruit lesions have not been detected. Disease symptoms comprise necrosis of vegetative and flower buds and bud failure before bud break. Necrotic lesions in buds occasionally outspread to the leaf petiole through the stem. This disease can affect most parts of the plant including the trunk, branches, shoots, buds, flowers, leaves and fruit. Generally, a white creamy gum exudes from necrotic lesions on buds, stems, and less frequently on petioles. Lesions on leaves start as interveinal, angular, water-soaked spots (1 to 3 mm in diameter) that coalesced, becoming dark brown to black with distinctive reddish brown margins.

Plate 6. Bacterial leaf blight symptoms on mango leaf

4.7. Bacterial leaf spot

Bacterial leaf spot was observed on leaves, petioles and tender twigs. Groups of minute, water soaked lesions were appeared towards the tip of the leaf and surface of the leaf which turned brown to black in color. These spots were surrounded by chlorotic halo and delimited by leaf veins. Large necrotic patches were also found which is formed by coalescing of several spots. These patches were sometimes dry up, often rough and raised due to heavy bacterial exudation. In severe infection, leaves lamina usually fall down.

Plate 7. Bacterial leaf spot symptoms on mango leaf

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur were recorded after one month of pesticide application and were presented in Table 1. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (18.54%) severity of anthracnose was observed in orchard 1 which was followed by orchard 2, 4 and 3, respectively. On the other hand, the lowest (3.39%) severity of anthracnose was observed in orchard 5. The die-back disease of mango was also varied significantly according to location. The ranges of severity were 0.41% to 7.10%. The highest severity of die-back was found on orchard 1 which was followed by orchard 3, 2 and 4, respectively. On the contrary, the lowest die-back severity was found in orchard 5. The severity of powdery mildew was significantly varied with the location. The highest (7.91%) severity of powdery mildew was observed in orchard 2 which was followed by orchard 3, 1 and 4, respectively. And the lowest (0.47%) severity of powdery mildew was observed in orchard 5. The sooty mold disease severity was significantly varied with the location. The highest (22.08%) severity was found in orchard 2 and 4, respectively followed by orchard 3 and the lowest (3.33%) severity of sooty mold was observed in orchard 5. In case of red rust, severity was also significantly varied with location. The highest (3.06%) severity of red rust was observed in orchard 2 and the lowest (0.01%) was in orchard 4 which was statistically significant with orchard 5. On the contrary, the bacterial leaf blight was found significant variation with different locations. The highest (21.04%) severity was observed in orchard 1 which was statistically similar with orchard 3, 4 and 2, respectively. On the other hand, the lowest (4.58%) severity of bacterial leaf blight was observed in orchard 5. Finally, the bacterial leaf spot severity was observed significantly varied according to location. The highest and the lowest severity ranges of bacterial leaf spot were 11.50% to 4.33%. The highest severity was observed in orchard 3 which was followed by orchard 1, 2 and 4, respectively. The lowest severity was observed in orchard 5.

Table 1. Effect of locations of Dinajpur on disease severity of mango after one month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	18.54 a	7.10 a	0.83 c	18.21 b	2.75 b	21.04 a	9.08 bc
Orchard 2	16.92 b	4.31 c	7.91 a	22.08 a	3.06 a	20.17 a	10.08 b
Orchard 3	13.25 d	6.20 b	3.75 b	18.58 b	1.20 c	20.33 a	11.50 a
Orchard 4	14.08 c	1.20 d	0.79 cd	22.08 a	0.01 d	20.25 a	8.75 c
Orchard 5	3.39 e	0.41 e	0.47 d	3.33 c	0.01 d	4.58 b	4.33 d
CV %	7.62	12.12	14.39	8.19	17.66	7.57	14.96

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of treatments were recorded after one month of pesticide application and were presented in Table 2. The effects of treatments were significantly varied in anthracnose diseases. The highest (16.44%) disease severity was recorded in T_0. The lowest (11.15%) disease severity was observed in T_1. T_2 was used resulted lower (0.01%) disease severity. In case of die-back disease, the effects of treatments were significantly varied. The highest (4.56%) disease severity was observed in T_0 and the lowest (2.95%) was in T_2. In case of powdery mildew disease, the treatments effects varied significantly. The severity range was 4.53% to 1.90%. The highest disease severity was observed in T_0 treatment. The lowest severity was observed on T_2 which was statistically similar with T_0. In sooty mold disease, the treatments were significantly varied. The highest (21.77%) severity was found in T_0 treatment. The lowest (13.70%) disease severity was observed in T_2. Red rust disease severity was shown significantly variation in treatment effects. The highest (1.65%) disease

severity was observed in T_0. The lowest disease severity was 1.30% and 1.25% which was statistically similar and found in T_1 and T_2, respectively. The treatment effect in bacterial leaf blight severity was significantly varied. The highest (19.77%) severity was found in T_0. The lowest (15.93%) disease severity was statistically similar with the treatment T_1. In case of bacterial leaf spot, the treatment effect was significantly varied. The maximum (10.80%) disease severity was observed in T_0 and the minimum (0.01%) severity was observed in T_1.

Table 2. Effect of treatments on disease severity of mango after one month of pesticide application in Dinajpur

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	16.44 a	4.56 a	4.53 a	21.77 a	1.65 a	19.77 a	10.80 a
T_1	11.15 c	4.03 b	1.90 c	15.10 b	1.30 b	16.13 b	7.20 c
T_2	12.13 b	2.95 c	1.82 b	13.70 c	1.25 b	15.93 b	8.25 b
CV%	14.39	8.19	12.12	7.57	7.62	17.66	14.96

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of location and treatment effects were recorded after one month of pesticide application and were presented in Table 3. The severity of anthracnose was varied significantly according to the location and treatment of the experiment. The highest (24.75%) severity of anthracnose was recorded in orchard 1 with T_0 treatment and the

lowest (1.68%) disease severity was recorded in orchard 5 with T_1 treatment. The lowest (0.01%) die-back disease was observed in orchard 3 with T_2 treatment, in orchard 4 with T_1 treatment and orchard 5 with T_1 and T_2 treatment, respectively and the highest (10.50%) disease severity of die-back was observed in orchard 1 with T_0 treatment which was statistically similar with orchard 3 accompanied by T_0 treatment. The powdery mildew severity significantly varied with the location and treatment effects. The highest (11.25%) severity was found in orchard 3 with T_0 treatment. There lowest (0.01%) disease was observed in orchard 1 with T_1 and T_2 treatment, orchard 3 with T_1 and T_2 treatment, orchard 4 with T_1 and T_2 treatment and in orchard 4 with T_1 and T_2 treatment, respectively. In case of sooty mold, disease severity was significantly varied. The highest (34.00%) severity was recorded in orchard 3 with control (T_0) treatment. The lowest (3.37%) severity was observed in orchard 5 with T_2 treatment. Red rust disease severity was observed significantly varied with location and treatment. The lowest (0.01%) severity was observed in orchard 3 with T_2 treatment, orchard 4 and 5 with T_1, T_2 and T_0 treatment, respectively. The highest (4.25%) severity was recorded in orchard 2 with T_0 treatment. The severity of bacterial leaf blight was significantly varied with different location and treatment. The highest (25.25%) severity was recorded in orchard 2 which was statistically similar with orchard 3, 4 and 1 with T_0 treatment and orchard 4 with T_1 treatment, respectively. The lowest (1.62%) severity was observed in orchard 5 with T_1 treatment. Bacterial leaf spot disease severity was significantly varied with location and treatment. The highest (19.00%) severity was recorded in orchard 3 with T_0 treatment. On the other hand, the lowest (3.35%) severity was observed in orchard 5 with T_1 treatment.

Table 3. Effect of location and treatments on disease severity of mango after one month of pesticide application in Dinajpur

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	T_0	24.75 a	10.50 a	2.50 d	21.63 d	3.57 b	25.00 a	9.00 cd
	T_1	15.88 d	3.56 f	0.01 f	20.00 de	1.92 f	20.00 b	9.25 cd
	T_2	15.00 de	7.25 c	0.01 f	13.00 g	2.75 c	18.13 b	9.00 cd
Orchard 2	T_0	20.00 c	6.37 d	10.00 b	26.00 c	4.25 a	25.25 a	12.25 b
	T_1	16.00 d	1.43 h	9.50 b	21.25 d	2.25 ef	16.00 c	12.00 b
	T_2	14.75 def	5.12 e	4.25 c	19.00 e	2.68 cd	19.25 b	6.00 ef
Orchard 3	T_0	13.50 efg	10.25 a	11.25 a	34.00 a	2.35 de	25.25 a	19.00 a
	T_1	13.00 g	8.37 b	0.01 f	13.50 g	1.25 g	19.50 b	8.00 cde
	T_2	13.22 fg	0.01 i	0.01 f	8.25 h	0.01 h	16.25 c	7.50 de
Orchard 4	T_0	22.25 b	1.25 h	2.37 d	31.50 b	0.01 h	25.25 a	10.00 c
	T_1	7.25 h	0.01 i	0.01 f	18.50 e	0.01 h	23.50 a	8.25 cd
	T_2	12.75 g	2.37 g	0.01 f	16.25 f	0.01 h	12.00 d	8.00 cde
Orchard 5	T_0	3.62 i	1.25 h	1.43 e	4.50 i	0.01 h	7.12 e	4.75 fg
	T_1	1.68 j	0.01 i	0.01 f	2.12 j	0.01 h	1.62 g	3.75 g
	T_2	4.87 i	0.01 i	0.01 f	3.37 ij	0.01 h	5.00 f	4.50 fg
CV %		14.39	8.19	12.12	7.57	7.62	17.66	14.96

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur were recorded after two month of pesticide application and were presented in Table 4. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (5.16%) severity of anthracnose was observed in orchard 2 which was followed by orchard 1, 3 and 4, respectively. On the other hand, the lowest (1.33%) severity of anthracnose was found in orchard 5. The die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot were also varied significantly according to the location. The maximum die-back severity (5.33%) was found in orchard 3 and minimum (0.01%) was in orchard 5. The powdery mildew disease severity ranged found 6.00% to 0.75%. The highest severity was observed in orchard 3 and the lowest was in orchard 4 which was statistically similar with orchard 5. The maximum (13.75%) sooty mold disease severity was observed in orchard 2 which was followed by orchard 1, 3 and 5, respectively. The lowest (0.01%) severity was found in orchard 4. In case of red rust, the highest (2.16%) severity was observed in orchard 3 which was statistically similar with orchard 2. In orchard 4 lowest (0.01%) red rust diseases was found. The maximum (2.50%) severity of bacterial leaf blight was found in orchard 2 which was statistically similar with orchard 1. The minimum (1.66%) severity was found in orchard 4 which was statistically similar with orchard 5. On the contrary, the highest (7.00%) severity of bacterial leaf spot was obtained in orchard 4 and the lowest (1.66%) was found in orchard 1, statistically similar with orchard 5.

Table 4. Effect of locations of Dinajpur on disease severity of mango after two month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	3.58 c	3.08 c	3.16 c	5.16 b	0.25 b	2.16 ab	1.66 d
Orchard 2	5.16 a	3.91 b	4.75 b	13.75 a	2.08 a	2.50 a	5.08 b
Orchard 3	4.33 b	5.33 a	6.00 a	5.41 b	2.16 a	2.10 b	3.58 c
Orchard 4	3.50 c	2.91 c	0.75 d	0.01 d	0.01 c	1.66 c	7.00 a
Orchard 5	1.33 d	2.08 d	0.91 d	1.66 c	0.29 b	1.70 c	1.66 d
CV %	19.87	17.71	16.32	16.19	18.98	21.90	15.43

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of treatments were recorded after two month of pesticide application and were presented in Table 5. The effects of treatments was significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot diseases. The maximum (4.20%) anthracnose severity was observed in T_0 treatment followed by T_1. The minimum (2.95%) severity was found in T_2 treatment. The die-back disease severity was observed with higher (3.65%) in control (T_0) treatment and which was statistically similar with T_1 and T_2 treatment. In case of powdery mildew disease, the highest (4.20%) severity was obtained in T_0 treatment whereas the lowest (2.20%) severity was found in T_1 treatment. In sooty mold disease, the maximum (6.30%) severity was found in T_0 treatment and the minimum (4.30%) was found in T_1 treatment. The highest (1.07%) red rust disease severity was observed in T_0 treatment and the lowest (0.85%) was obtained in T_2 treatment which was statistically similar with T_1 treatment. In bacterial leaf blight, the maximum (2.65%)

severity was observed in T_0 treatment and the minimum (1.32%) in T_1 treatment. T_0 treatment was treated in bacterial leaf spot the maximum (4.70%) severity was exhibited and the minimum (0.01%) was found in T_1 treatment.

Table 5. Effect of treatments on disease severity of mango after two month of pesticide application in Dinajpur

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	4.20 a	3.65 a	4.20 a	6.30 a	1.07 a	2.65 a	4.70 a
T_1	3.60 b	3.35 a	2.20 c	4.30 c	0.95 b	1.32 c	3.15 c
T_2	2.95 c	3.40 a	2.95 b	5.00 b	0.85 b	2.11 b	3.55 b
CV %	19.87	17.71	16.32	16.19	18.98	21.90	15.43

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of location and treatment effects were recorded after two month of pesticide application and were presented in Table 6. The severity of anthracnose and die-back were varied significantly according to the location and treatment of the experiment. The maximum (5.75%) severity of anthracnose was recorded in orchard 2 which was statistically similar with orchard 4 and 3 with T_0 treatment. The lowest (0.01%) anthracnose disease was found in orchard 5 with T_2 treatment. The highest (6.00%) severity of die-back was observed in orchard 3 with T_0 treatment and the lowest

(0.01%) was found in orchard 4 with T_2 treatment which was statistically similar with orchard 5 with T_1 and T_0 treatment. The powdery mildew severity significantly varied with the location and treatment. The maximum (7.50%) severity was found in orchard 3 with T_0 treatment. The lowest (0.01%) severity was observed in orchard 4 and 5 with T_1 treatment. Sooty mold disease was observed significantly varied with location and treatment. The highest (16.75%) disease severity was recorded in orchard 2 with T_0 treatment. The lowest (0.01%) sooty mold was observed in orchard 4 with T_0, T_1 and T_2 treatment, orchard 5 with T_1 treatment, respectively. In case of red rust, bacterial leaf blight and bacterial leaf spot, disease severity was significantly varied. The maximum (2.75%) red rust disease severity was recorded in orchard 2 with T_0 treatment. The lowest (0.01%) red rust was observed in orchard 1 with T_1 and T_2 treatment, orchard 4 with T_0, T_1 and T_2 treatment and orchard 5 with T_1 and T_2 treatment, respectively. The highest (3.50%) disease severity of bacterial leaf spot was recorded in orchard 2 with T_0 treatment. Bacterial leaf blight lowest (0.01%) was observed in orchard 4 with T_1 treatment. The maximum (8.00%) bacterial leaf spot was recorded in orchard 4 with T_0 treatment and the minimum (1.00%) was found in orchard 1 with T_1 treatment and which was statistically similar in orchard 5 with T_1 and T_2 treatment.

Table 6. Effect of location and treatments on disease severity of mango after two month of pesticide application in Dinajpur

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	T_0	4.50 bcd	4.25 bc	4.50 d	6.25 de	0.75 f	3.00 ab	2.00 ef
	T_1	2.75 ef	2.00 gh	2.50 f	4.25 fg	0.01 g	1.50 f	1.00 g
	T_2	3.50 de	3.00 def	2.50 f	5.00 ef	0.01 g	2.00 def	2.00 ef
Orchard 2	T_0	5.75 a	4.00 c	6.25 b	16.75 a	2.75 a	3.50 a	7.50 ab
	T_1	5.50 ab	4.00 c	3.50 e	13.25 b	1.50 e	1.75 ef	4.00 d
	T_2	4.25 cd	3.75 cd	4.50 d	11.25 c	2.00 cd	2.25 cde	3.75 d
Orchard 3	T_0	4.75 abc	5.00 b	7.50 a	6.50 d	2.50 ab	2.50 bcd	6.00 c
	T_1	4.00 cd	5.00 b	5.00 cd	4.00 fg	1.75 de	1.75 ef	2.25 ef
	T_2	4.25 cd	6.00 a	5.50 c	5.75 de	2.25 bc	2.05 cdef	2.50 e
Orchard 4	T_0	5.00 abc	3.50 cde	1.25 g	0.01 i	0.01 g	2.75 bc	8.00 a
	T_1	2.75 ef	2.75 efg	0.01 h	0.01 i	0.01 g	0.01 g	7.00 b
	T_2	2.75 ef	2.50 fgh	1.00 g	0.01 i	0.01 g	2.25 cde	6.00 c
Orchard 5	T_0	2.25 f	2.25 fgh	1.50 g	3.00 gh	0.87 f	2.00 def	2.00 ef
	T_1	1.75 f	2.25 fgh	0.01 h	0.01 i	0.01 g	1.62 ef	1.50 fg
	T_2	0.01 g	1.75 h	1.25 g	2.00 h	0.01 g	1.50 f	1.50 fg
CV %		19.87	17.71	16.32	16.19	18.98	21.90	15.43

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur were recorded after three month of pesticide application and were presented in Table 7. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (0.74%) severity was recorded in orchard 5, statistically similar with orchard 1 and 2 and the lowest (0.01%) severity was found in orchard 3. The die-back disease of mango was varied significantly according to the location. The maximum (0.68%) severity was observed in orchard 2 and the minimum (0.01%) die-back was found in orchard 4 and 5. The severity of powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) were significantly varied with the location. The powdery mildew severity was ranges 2.58% to 0.11%. The highest (2.58%) severity was recorded in orchard 3 and the lowest (0.11%) was found in orchard 4 which was statistically similar with orchard 5. The maximum (2.72%) disease severity of sooty mold was observed in orchard 2 and the minimum (0.01%) severity was found in orchard 4. In red rust, the maximum (1.19%) severity was found in orchard 3 and the minimum (0.01%) was found in orchard 1. The highest (0.50%) severity of BLB was recorded in orchard 1, statistically similar with orchard 2. And the lowest (0.25%) was found in orchard 3, statistically similar with orchard 5. In BLS disease, the maximum (2.20%) severity was found in orchard 4 and the minimum (0.40%) was found in orchard 1 which was statistically similar with orchard 5.

Table 7. Effect of locations of Dinajpur on disease severity of mango after three month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	0.71 a	0.11 b	0.72 c	0.89 c	0.01 d	0.50 a	0.40 d
Orchard 2	0.69 ab	0.68 a	1.90 b	2.72 a	0.30 c	0.48 a	0.99 c
Orchard 3	0.01 c	0.06 c	2.58 a	1.69 b	1.19 a	0.25 c	1.57 b
Orchard 4	0.60 b	0.01 d	0.11 d	0.01 e	0.97 b	0.39 b	2.20 a
Orchard 5	0.74 a	0.01 d	0.11 d	0.46 d	0.29 c	0.28 c	0.45 d
CV %	18.71	18.60	16.84	21.09	22.25	18.25	20.24

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of treatments were recorded after three month of pesticide application and were presented in Table 8. The effects of treatments was significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (1.10%) severity of anthracnose was observed in T_0 treatment. The lowest (0.25%) severity was recorded in T_1 treatment, statistically similar with the T_2 treatment. The maximum die-back (0.42%) was obtained in T_0 treatment and the minimum (0.01%) was observed in T_1 treatment. The highest (1.55%) powdery mildew was recorded in T_0 treatment whereas the lowest (0.81%) severity was found in T_1 treatment, statistically similar with the T_2 treatment. In sooty mold, the maximum (1.75%) severity was observed in T_0 treatment and the minimum (0.67%) was found in T_2 treatment. The maximum (0.76%) severity was exhibited in T_0 treatment and the minimum (0.31%) was in T_2 treatment in case of red rust diseases. BLB severity was the highest (0.77%) in T_0 treatment and lowest

(0.14%) was found in T_1 treatment. Higher (1.54%) severity was found in T_0 treatment and lower 0.50% in T_2 treatment in case of BLS diseases.

Table 8. Effect of treatments on disease severity of mango after three month of pesticide application in Dinajpur

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	1.10 a	0.42 a	1.55 a	1.75 a	0.58 b	0.77 a	1.54 a
T_1	0.25 b	0.01 c	0.81 b	1.04 b	0.76 a	0.14 c	1.33 b
T_2	0.29 b	0.09 b	0.90 b	0.67 c	0.31 c	0.24 b	0.50 c
CV %	18.71	18.60	16.84	21.09	22.25	18.25	20.24

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of location and treatment effects were recorded after three month of pesticide application and were presented in Table 9. The severity of anthracnose was varied significantly according to the location and treatment of the experiment. The highest (2.00%) severity of anthracnose was recorded in orchard 5 with T_0 treatment and the lowest (0.01%) was observed in orchard 3 with T_0, T_1 and T_2 treatment and orchard 5 with T_1 treatment, respectively. The maximum (1.57%) severity of die-back was observed in orchard 2 with T_0 treatment and the minimum (0.01%) was observed in

orchard 1 with T_1 and T_2, orchard 2 with T_1, orchard 3 withT_1 and T_2, orchard 4 with T_0, T_1 and T_2 and orchard 5 with T_0, T_1 and T_2 treatment, respectively. The powdery mildew severity significantly varied with the location and treatment. The maximum (3.50%) severity was found in orchard 3 with T_0 treatment and the minimum (0.01%) powdery mildew severity was found in orchard 4 and 5 with T_1 and T_2 treatment. Sooty mold, red rust, BLB and BLS were varied significantly with the location and treatment. The highest (4.00%) sooty mold was recorded in orchard 2 with T_0 treatment and the lowest (0.01%) was observed in orchard 4 with T_0, T_1 and T_2 treatment, orchard 5 with T_2 treatment, respectively. The highest (2.00%) disease severity of red rust was recorded in orchard 4 with T_0 treatment and the lowest (0.01%) was observed in orchard 1 with T_0, T_1 and T_2, orchard 2 with T_1 and orchard 5 with T_2 treatment. In BLB, the maximum (1.12%) severity was found in orchard 1 with T_0 treatment and the minimum (0.01%) was found in orchard 1, 3 and 5 with T_1 treatment. The highest (3.25%) disease severity of BLS was obtained in orchard 4 with T_0 treatment and the lowest (0.17%) was obtained in orchard 5 with T_2 treatment which was statistically similar with orchard 1 with T_1 and T_2 treatment, orchard 5 with T_1 treatment, respectively.

Table 9. Effect of location and treatments on disease severity of mango after three month of pesticide application in Dinajpur

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	T_0	1.17 b	0.35 c	1.07 e	1.80 d	0.01 h	1.12 a	0.60 ef
	T_1	0.20 e	0.02 e	0.52 f	0.32 gh	0.01 h	0.01 i	0.20 g
	T_2	0.77 c	0.01 e	0.57 f	0.55 fg	0.01 h	0.40 ef	0.42 fg
Orchard 2	T_0	1.15 b	1.57 a	2.50 b	4.00 a	0.75 d	0.95 b	1.67 c
	T_1	0.70 c	0.01 e	1.55 d	2.75 b	0.01 h	0.30 fg	0.65 ef
	T_2	0.22 de	0.47 b	1.67 d	1.42 e	0.15 gh	0.20 gh	0.65 ef
Orchard 3	T_0	0.02 f	0.20 d	3.50 a	2.15 c	1.50 b	0.50 de	2.72 b
	T_1	0.01 f	0.02 e	2.00 c	1.55 de	1.10 c	0.01 i	1.32 d
	T_2	0.01 f	0.01 e	2.25 bc	1.37 e	0.97 c	0.25 gh	0.67 ef
Orchard 4	T_0	1.20 b	0.01 e	0.32 f	0.01 h	2.00 a	0.57 d	3.25 a
	T_1	0.37 d	0.01 e	0.01 g	0.01 h	0.50 e	0.40 ef	2.75 b
	T_2	0.25 de	0.01 e	0.01 g	0.01 h	0.42 ef	0.20 gh	0.60 ef
Orchard 5	T_0	2.00 a	0.01 e	0.35 f	0.82 f	0.57 e	0.70 c	0.85 e
	T_1	0.01 f	0.01 e	0.01 g	0.57 fg	0.30 fg	0.01 i	0.32 fg
	T_2	0.22 de	0.01 e	0.01 g	0.01 h	0.01 h	0.15 h	0.17 g
CV %		18.71	18.60	16.84	21.09	22.25	18.25	20.24

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2% , T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur were recorded after four month of pesticide application and were presented in Table 10. The effects of location were significantly varied in anthracnose disease. The highest (1.41%) severity of anthracnose was observed in orchard 4 which was statistically similar with orchard 1 and 2. On the other hand, the lowest (0.20%) severity of anthracnose was observed in orchard 5. The die-back disease of mango was also varied significantly according to location. The maximum (0.26%) die-back severity was recorded in orchard 2 and the minimum (0.01%) was found in orchard 3, 4 and 5. The severity of powdery mildew was significantly varied with the location. The highest (3.75%) severity of powdery mildew was observed in orchard 3 which was followed by orchard 1, 2 and 4. And the lowest (1.04%) powdery mildew severity was observed in orchard 5. The sooty mold disease severity was significantly varied with the location. The highest (4.66%) severity was found in orchard 3 and the lowest (0.41%) severity of sooty mold was observed in orchard 4. In case of red rust, severity was also significantly varied with location. The highest (2.50%) red rust severity was observed in orchard 3 and the lowest (0.01%) disease was found in orchard 1. On the contrary, the bacterial leaf blight was found significant variation with different location. The highest (1.19%) severity was observed in orchard 2. On the other hand, the lowest (0.15%) severity of bacterial leaf blight was observed on orchard 3. Finally, the bacterial leaf spot severity was observed significantly varied according to location. The highest and the lowest severity of bacterial leaf spot were 2.36% to 0.46%. The highest severity was observed in orchard 4 which was followed by orchard 2, 5 and 3. The lowest was observed in orchard 1.

Table 10. Effect of locations of Dinajpur on disease severity of mango after four month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	1.26 a	0.06 b	1.88 b	2.55 c	0.01 e	0.60 c	0.46 d
Orchard 2	1.26 a	0.26 a	1.87 b	4.16 b	0.48 d	1.19 a	1.71 b
Orchard 3	0.36 b	0.01 c	3.75 a	4.66 a	2.50 a	0.15 e	0.93 c
Orchard 4	1.41 a	0.01 c	1.70 b	0.41 e	1.08 c	0.75 b	2.36 a
Orchard 5	0.20 c	0.01 c	1.04 c	1.13 d	1.25 b	0.41 d	0.94 c
CV %	20.74	31.62	15.68	14.43	19.73	22.80	21.20

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of treatments were recorded after four month of pesticide application and were presented in Table 11. The effects of treatments were significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (1.99%) severity of anthracnose was observed in T_0 treatment. The lowest (0.07%) severity was recorded in T_2 treatment. The maximum (0.20%) die-back was obtained in T_0 treatment and the minimum (0.01%) disease was observed in T_1 and T_2 treatment. The highest (3.67%) powdery mildew was recorded in T_0 treatment whereas the lowest (1.01%) severity was found in T_2 treatment. In sooty mold, the maximum (4.20%) severity was observed in T_0 treatment and the minimum (1.33%) was found in T_2 treatment. Higher (2.11%) severity was resulted in T_0 treatment and the lower (0.45%) was in T_2 treatment which was statistically similar with T_1 treatment in case of red rust disease. BLB severity was recorded higher (1.42%) in T_0 treatment and the lower (0.10%) was

found in T_2 treatment. The highest (2.10%) severity was found in T_0 treatment and the lowest (0.45%) in T_2 treatment in case of BLS diseases.

Table 11. Effect of treatments on disease severity of mango after four month of pesticide application in Dinajpur

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	1.99 a	0.20 a	3.67 a	4.20 a	2.11 a	1.42 a	2.10 a
T_1	0.64 b	0.01 b	1.46 b	2.23 b	0.58 b	0.34 b	1.29 b
T_2	0.07 c	0.01 b	1.01 c	1.33 c	0.45 b	0.10 c	0.45 c
CV %	20.74	31.62	15.68	14.43	19.73	22.80	21.20

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Dinajpur in response of location and treatment effects were recorded after four month of pesticide application and were presented in Table 12. The effects of location and treatments was significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (3.00%) severity of anthracnose was recorded in orchard 1 with T_0 treatment which was statistically similar with orchard 4 with T_0 treatment and the lowest (0.01%) severity was observed in orchard 2 with T_2 treatment, orchard 3 with T_1 and T_2 treatment, orchard 4 with T_2 treatment and orchard 5 with T_1 and T_2 treatment, respectively. The

maximum (0.80%) severity of die-back was observed in orchard 2 and the minimum (0.01%) severity was observed in orchard 1, 3, 4 and 5 with T_0, T_1 and T_2, respectively. The maximum (6.50%) severity of powdery mildew was found in orchard 3 with T_0 treatment and the minimum (0.01%) was found in orchard 4 and 5 with T_2 treatment. The highest (7.50%) sooty mold was recorded in orchard 3 with T_0 treatment and the lowest (0.01%) was observed in orchard 4 with T_1 and T_2 treatment, orchard 5 with T_2 treatment, respectively. The highest (4.00%) disease severity of red rust was recorded in orchard 3 with T_0 treatment and the lowest (0.01%) disease was observed in orchard 1 with T_0, T_1 and T_2, orchard 2 with T_2, orchard 4 with T_1 and orchard 5 with T_2 treatment. In BLB, the maximum (2.25%) severity was found in orchard 2 with T_0 treatment and the minimum (0.01%) severity was found in orchard 1 with T_1, orchard 2 with T_2, orchard 3 with T_1, T_2, orchard 4 with T_2 and orchard 5 with T_1 and T_2 treatment, respectively. The highest (4.50%) disease severity of BLS was obtained in orchard 4 with T_0 treatment and the lowest (0.01%) severity was observed in orchard 1, 3 and 5 with T_2 treatment, respectively.

Table 12. Effect of location and treatments on disease severity of mango after four month of pesticide application in Dinajpur

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 1	T_0	3.00 a	0.20 b	2.87 cd	4.00 c	0.01 e	1.30 c	0.92 f
	T_1	0.42 e	0.01 c	0.77 i	2.00 e	0.01 e	0.01 e	0.47 g
	T_2	0.37 e	0.01 c	2.00 ef	1.67 ef	0.01 e	0.50 d	0.01 h
Orchard 2	T_0	2.50 b	0.80 a	2.75 d	6.25 b	1.30 d	2.25 a	2.10 b
	T_1	1.30 cd	0.01 c	1.30 gh	3.25 d	0.15 e	1.32 c	2.00 bc
	T_2	0.01 f	0.01 c	1.57 fg	3.00 d	0.01 e	0.01 e	1.05 ef
Orchard 3	T_0	1.10 d	0.01 c	6.50 a	7.50 a	4.00 a	0.45 d	1.80 bc
	T_1	0.01 f	0.01 c	3.25 c	4.50 c	1.50 d	0.01 e	1.00 ef
	T_2	0.01 f	0.01 c	1.50 g	2.00 e	2.00 c	0.01 e	0.01 h
Orchard 4	T_0	2.75 ab	0.01 c	4.00 b	1.25 f	2.75 b	1.87 b	4.50 a
	T_1	1.50 c	0.01 c	1.12 ghi	0.01 g	0.01 e	0.37 d	1.37 de
	T_2	0.01 f	0.01 c	0.01 j	0.01 g	0.27 e	0.01 e	1.22 def
Orchard 5	T_0	0.62 e	0.01 c	2.25 e	2.00 e	2.50 b	1.25 c	1.62 cd
	T_1	0.00 f	0.01 c	0.87 hi	1.40 f	1.25 d	0.01 e	1.20 ef
	T_2	0.01 f	0.01 c	0.01 j	0.01 g	0.01 e	0.01 e	0.01 h
CV %		20.74	31.62	15.68	14.43	19.73	22.80	21.20

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon were recorded after one month of pesticide application and were presented in Table 13. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (22.67%) severity of anthracnose was observed in orchard 8 which was followed by orchard 10, 7 and 9, respectively. On the other hand, the lowest (12.75%) severity of anthracnose was observed in orchard 6. The die-back disease of mango was also varied significantly according to the location. The highest (17.67%) severity of die-back was found on orchard 9 and the lowest (3.25%) was found in orchard 10. The severity of powdery mildew was significantly varied with the location. The highest (37.17%) severity of powdery mildew was observed in orchard 8 and the lowest (4.04%) was observed in orchard 10. The sooty mold disease severity was significantly varied with the location. The highest (12.00%) severity was found in orchard 7 which was statistically similar with orchard 6 and followed by orchard 8 and the lowest (3.16%) severity of sooty mold was observed in orchard 9 which was statistically similar with orchard 10. In case of red rust, severity was also significantly varied with location. When red rust disease was observed in orchard 7, the highest (17.75%) severity was found and the lowest (3.33%) was observed in orchard 10. On the contrary, the bacterial leaf blight was found significant variation with different locations. The highest (44.33%) severity was observed in orchard 9 and the lowest (8.41%) severity of bacterial leaf blight was observed in orchard 6. Finally, the bacterial leaf spot severity was observed significantly varied according to location. The highest and the lowest severity of bacterial leaf spot were 8.41% to 3.16%. The highest severity was observed in orchard 9 which was followed by orchard 8 and 10. The lowest (0.01%) was observed in orchard 6 which was statistically similar with orchard 7.

Table 13. Effect of locations of Thakurgaon on disease severity of mango after one month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	12.75 e	12.08 c	27.33 c	11.58 a	16.57 b	8.41 e	3.16 d
Orchard 7	16.67 c	10.67 d	30.25 b	12.00 a	17.75 a	13.38 d	3.33 d
Orchard 8	22.67 a	14.25 b	37.17 a	6.16 b	13.58 c	34.83 b	6.75 b
Orchard 9	14.00 d	17.67 a	26.33 d	3.16 c	17.00 b	44.33 a	8.41 a
Orchard 10	19.92 b	3.25 e	4.04 e	3.16 c	3.33 d	18.83 c	4.25 c
CV %	4.16	4.57	2.14	8.62	3.99	2.59	7.84

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of treatments were recorded after one month of pesticide application and were presented in Table 14. The effects of treatments were significantly varied in anthracnose diseases. The highest (19.70%) disease severity was recorded in T_0. The lowest (15.60%) disease severity was observed in T_2. In case of die-back disease, the effects of treatments were significantly varied. The highest (12.60%) disease severity was observed in T_0 and the lowest (10.52%) was in T_2. In case of powdery mildew disease, the treatments effects varied significantly. The severity range was from 25.60% to 24.63%. The highest disease severity was observed in T_0 treatment. The lowest severity was observed in T_2 which was statistically similar to T_1. In sooty mold disease, the treatments were significantly varied. The highest (8.80%) severity was found in T_0 which was statistically similar with T_1 treatment. The lowest (4.40%) disease severity was observed in T_2. Red rust disease severity was shown significant

variation in response of treatment. The highest (14.19%) disease severity was observed in T_0 which was control treatment. The lowest (13.10%) disease severity was found in T_2. The treatment effect in bacterial leaf blight severity was significantly varied. The highest (26.17%) severity was found in T_0. The lowest (21.45%) disease severity was recorded in T_1. In case of bacterial leaf spot, the significant variation was observed in the treatment. Higher (6.10%) disease severity was observed in control treatment and lower (4.70%) disease severity was observed in T_2 treatment which was statistically similar with T_1 treatment.

Table 14. Effect of treatments on disease severity of mango after one month of pesticide application in Thakurgaon

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	19.70 a	12.60 a	25.60 a	8.80 a	14.19 a	26.17 a	6.10 a
T_1	16.30 b	11.63 b	24.85 b	8.45 a	13.65 b	21.45 c	4.75 b
T_2	15.60 c	10.52 c	24.63 b	4.40 b	13.10 c	24.25 b	4.70 b
CV %	4.16	4.57	2.14	8.62	3.99	2.59	7.84

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of location and treatment effects were recorded after one month of pesticide application and were presented in Table 15. The severity of anthracnose was varied

significantly according to the location and treatment of the experiment. The highest (30.00%) severity of anthracnose was recorded in orchard 8 with control treatment and the lowest (5.75%) disease severity was recorded in orchard 6 with T_1 treatment. The highest (22.00%) disease severity of die-back was observed in orchard 9 with T_0 treatment and the lowest (0.01%) severity was observed in orchard 10 with T_1 treatment. The powdery mildew disease severity significantly varied with the location and treatment. The highest (41.50%) severity was found in orchard 8 with T_0 treatment and the lowest (3.12%) was observed in orchard 10 with T_2 treatment which was statistically similar with T_1 treatment. In case of sooty mold, disease severity was significantly varied. The highest (18.00%) severity was recorded in orchard 6 with T_0 treatment and the lowest (0.01%) severity was observed in orchard 8 with T_2 treatment. Red rust disease severity was varied significantly with location and treatment. The highest (21.50%) severity was recorded in orchard 9 with T_0 treatment and the lowest (0.01%) was observed in orchard 10 with T_1 treatment. The severity of bacterial leaf blight was significantly varied with different location and treatment. The highest (51.00%) severity was recorded in orchard 9 with T_0 treatment. The lowest (6.25%) severity was observed in orchard 6 with T_1 treatment. Bacterial leaf spot disease severity was significantly varied with location and treatment. The highest (9.50%) severity was recorded in orchard 9 with T_0 treatment. On the other hand, the lowest (2.25%) severity was observed in orchard 6 with T_2 treatment which was statistically similar in orchard 7 with T_1 treatment.

Table 15. Effect of location and treatments on disease severity of mango after one month of pesticide application in Thakurgaon

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	T_0	18.25 d	18.50 c	31.50 c	18.00 a	17.20 c	10.00 j	3.75 hi
	T_1	5.75 h	4.50 h	28.25 e	9.50 de	15.50 d	6.25 l	3.50 ij
	T_2	14.25 f	13.25 e	22.25 f	7.25 f	17.00 c	9.00 k	2.25 l
Orchard 7	T_0	20.00 bc	18.00 c	31.50 c	15.00 b	20.00 b	19.00 g	4.25 gh
	T_1	15.50 e	5.12 h	30.75 cd	11.00 c	15.75 d	10.00 j	2.75 kl
	T_2	14.50 ef	8.87 g	28.50 e	10.00 d	17.50 c	11.13 i	3.00 jk
Orchard 8	T_0	30.00 a	18.50 c	41.50 a	9.50 de	17.75 c	38.25 d	8.75 b
	T_1	19.00 cd	9.50 g	30.00 d	9.00 e	11.50 f	28.50 e	5.25 e
	T_2	19.00 cd	14.75 d	40.00 b	0.01 i	11.50 f	37.75 d	6.25 d
Orchard 9	T_0	20.50 b	22.00 a	39.50 b	3.50 g	21.50 a	51.00 a	9.50 a
	T_1	11.25 g	20.00 b	19.50 g	3.00 g	15.00 de	42.50 b	7.00 c
	T_2	10.25 g	11.00 f	20.00 g	3.00 g	14.50 e	39.50 c	8.75 b
Orchard 10	T_0	20.75 b	5.00 h	5.50 h	6.50 f	5.00 g	20.50 f	5.00 ef
	T_1	19.00 cd	0.01 i	3.50 i	1.25 h	0.01 h	20.00 f	4.50 fg
	T_2	20.00 bc	4.75 h	3.12 i	1.75 h	5.00 g	16.00 h	3.25 ijk
CV %		4.16	4.57	2.14	8.62	3.99	2.59	7.84

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2% , T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon were recorded after two month of pesticide application and were presented in Table 16. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (4.33%) disease severity of anthracnose was observed in orchard 8. On the other hand, the lowest (3.20%) severity of anthracnose was found in orchard 9 which was statistically similar with orchard 6 and 7. The die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot were also varied according to the location. The maximum die-back severity (4.16%) was found in orchard 8 which was statistically similar with orchard 6 and the minimum (2.25%) was observed in orchard 10. The powdery mildew disease severity ranged from 7.25% to 3.91%. The highest severity was observed in orchard 8 and the lowest in orchard 10 which was statistically similar with orchard 7. The maximum (5.91%) sooty mold disease severity was observed in orchard 7 which was statistically similar with orchard 8. The minimum (4.50%) sooty mold severity was found in orchard 6, statistically similar with orchard 10. In case of red rust, the highest (3.58%) severity was observed in orchard 8 which was statistically similar with orchard 7 and in orchard 10 the minimum (0.01%) severity was found. The maximum (2.75%) severity of bacterial leaf blight was found in orchard 6 which was statistically similar with orchard 7. The minimum (1.83%) severity was found in orchard 9. On the contrary, the highest (11.42%) severity of bacterial leaf blight was obtained in orchard 8 and the lowest (1.66%) was found in orchard 6, statistically similar with orchard 7 and 10.

Table 16. Effect of locations of Thakurgaon on disease severity of mango after two month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	3.29 c	3.91 a	5.41 c	4.50 c	1.75 c	2.75 a	1.66 c
Orchard 7	3.79 b	2.91 b	4.16 d	5.91 a	3.41 a	2.75 a	2.00 c
Orchard 8	4.33 a	4.16 a	7.25 a	5.70 a	3.58 a	2.41 b	11.42 a
Orchard 9	3.20 c	2.83 b	6.12 b	5.08 b	2.45 b	1.83 c	9.91 b
Orchard 10	3.29 c	2.25 c	3.91 d	4.75 c	0.01 d	2.29 b	1.95 c
CV %	14.50	15.14	8.91	7.71	16.64	15.99	7.30

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of treatments were recorded after two month of pesticide application and were presented in Table 17. The effects of treatments was significantly varied in anthracnose, die back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot diseases. The maximum (4.22%) anthracnose severity was observed in T_0 treatment followed by T_2. The minimum (3.05%) severity was found in T_1 treatment. The highest (4.25%) disease severity of die-back was observed in T_0 treatment and the lowest (2.65%) was observed in T_1 treatment which was statistically similar with T_2 treatment. In case of powdery mildew disease, the highest severity (6.40%) was obtained in T_0 treatment whereas the lowest (4.07%) severity was found in T_1 treatment. In sooty mold disease, the maximum (6.65%) severity was found in T_0 treatment and the minimum (4.17%) was found in T_1 treatment. The highest (3.17%) red rust disease severity was observed in T_0 treatment and the lowest (1.10%) was obtained in T_1 treatment. In bacterial leaf blight, the maximum (3.52%) severity

was observed in T_0 treatment and the minimum (1.70%) in T_1 treatment. In case of bacterial leaf spot, the maximum (8.45%) severity was observed in T_0 treatment and the minimum (3.77%) was found in T_1 treatment which was statistically similar with T_2 treatment.

Table 17. Effect of treatments on disease severity of mango after two month of pesticide application in Thakurgaon

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	4.22 a	4.25 a	6.40 a	6.65 a	3.17 a	3.52 a	8.45 a
T_1	3.05 c	2.65 b	4.07 c	4.17 c	1.10 c	1.70 c	3.77 b
T_2	3.47 b	2.75 b	5.65 b	4.75 b	2.45 b	2.00 b	3.95 b
CV %	14.50	15.14	8.91	7.71	16.64	15.99	7.30

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control

T_1 = Spraying of Indofil M-45@ 0.2%

T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of location and treatment effects' were recorded after two month of pesticide application and were presented in Table 18. The severity of anthracnose and die back were varied significantly according to the location and treatment of the experiment. The maximum (5.25%) severity of anthracnose was recorded in orchard 8 with T_0 treatment and the minimum (2.87%) severity was found in orchard 9 with T_2 treatment which was statistically similar with orchard 10 with T_1 treatment. The highest (5.75%) die-back was observed in orchard 8 with T_0 treatment and the lowest (1.25%) was

found in orchard 10 with T_2 treatment which was statistically similar with orchard 9 with T_1 treatment. The powdery mildew severity significantly varied with the location and treatment. The maximum (10.00%) severity was found in orchard 8 with T_0 treatment. The minimum (0.01%) severity was observed in orchard 10 with T_0 treatment which was statistically similar with orchard 9 with T_1 and orchard 7 with T_2 treatment. Sooty mold disease was observed significantly varied with location and treatment. The highest (7.75%) disease severity was recorded in orchard 7 with T_0 treatment and the lowest (3.25%) was recorded in orchard 10 with T_1 treatment, statistically similar with orchard 6 with T_1 and orchard 9 with T_2 treatment. In case of red rust, bacterial leaf blight and bacterial leaf spot disease severity were significantly varied. The maximum (5.00%) red rust disease severity was recorded in orchard 8 with T_0 treatment and the minimum (0.01%) severity was observed in orchard 6 with T_1 and orchard 10 with T_0, T_1 and T_2 treatment, respectively. The highest (3.75%) disease severity of bacterial leaf blight was recorded in orchard 6 and 7 with T_0 treatment which was statistically similar with orchard 9, 10 and 8 with T_0 treatment, respectively and the lowest (0.01%) was observed in orchard 9 with T_1 treatment. The maximum (17.25%) bacterial leaf spot was recorded in orchard 8 with T_0 treatment and the minimum (0.01%) was observed in orchard 6 with T_1 treatment and in orchard 7 and 10 with T_2 treatment, respectively.

Table 18. Effect of location and treatments on disease severity of mango after two month of pesticide application in Thakurgaon

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	T_0	3.75 bcd	5.00 b	6.25 d	5.50 ef	2.75 de	3.75 a	2.75 g
	T_1	3.12 cde	4.25 c	5.50 e	3.50 j	0.01 g	2.25 b	0.01 h
	T_2	3.00 de	2.50 ef	4.50 fg	4.50 gh	2.50 e	2.25 b	2.25 g
Orchard 7	T_0	4.50 b	4.00 c	5.00 ef	7.75 a	4.50 ab	3.75 a	3.75 f
	T_1	3.00 de	2.25 ef	4.00 gh	4.25 hi	1.50 f	2.25 b	2.25 g
	T_2	3.87 bc	2.50 ef	3.50 hij	5.75 de	4.25 b	2.25 b	0.01 h
Orchard 8	T_0	5.25 a	5.75 a	10.00 a	7.00 b	5.00 a	3.25 a	17.25 a
	T_1	3.25 cde	2.50 ef	4.75 f	5.12 fg	2.50 e	1.75 bc	5.50 e
	T_2	4.50 b	4.25 c	7.00 c	5.00 fg	3.25 cd	2.25 b	11.50 c
Orchard 9	T_0	3.75 bcd	3.50 cd	8.75 b	6.75 bc	3.62 c	3.50 a	15.00 b
	T_1	3.00 de	1.75 fg	3.12 ij	4.75 gh	1.50 f	0.01 d	8.75 d
	T_2	2.87 e	3.25 d	6.50 cd	3.75 ij	2.25 e	2.00 b	6.00 e
Orchard 10	T_0	3.87 bc	3.00 de	5.00 ef	6.25 cd	0.01 g	3.37 a	3.50 f
	T_1	2.87 e	2.50 ef	3.00 j	3.25 j	0.01 g	2.25 b	2.37 g
	T_2	3.12 cde	1.25 g	3.75 hi	4.75 gh	0.01 g	1.25 c	0.01 h
CV %		14.50	15.14	8.91	7.71	16.64	15.99	7.30

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2% , T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon were recorded after three month of pesticide application and were presented in Table 19. The severity of anthracnose was varied significantly according to the location of the experiment. The highest (1.93%) severity was recorded in orchard 8, statistically similar with orchard 6 and the lowest (0.15%) anthracnose disease was found in orchard 10 which was statistically similar with orchard 6, 7 and 9, respectively. The die-back disease of mango was varied significantly according to the location. The maximum (1.16%) severity was observed in orchard 7, statistically similar with orchard 8 and the minimum (0.01%) die-back severity was found in orchard 10. The severity of powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) were significantly varied with the location. The powdery mildew severity was ranged from 1.54% to 0.49%. The highest severity was recorded in orchard 6 which was statistically similar with orchard 7 and the lowest was found in orchard 10. The maximum (2.50%) disease severity of sooty mold was observed in orchard 7 and the minimum (0.70%) was observed in orchard 9. In red rust, the maximum (0.33%) severity was found in orchard 8 which was statistically similar with orchard 6 and the minimum (0.01%) was found in orchard 10. The highest (0.72%) severity of BLB was recorded in orchard 9 and the lowest (0.22%) was found in orchard 10. In BLS disease, the maximum (1.72%) severity was found in orchard 8 and the minimum (0.30%) was found in orchard 6.

Table 19. Effect of locations of Thakurgaon on disease severity of mango after three month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	0.99 ab	0.89 b	1.54 a	2.35 b	0.35 a	0.46 b	0.30 d
Orchard 7	0.42 b	1.16 a	1.43 ab	2.50 a	0.13 c	0.36 c	0.01 e
Orchard 8	1.93 a	1.12 a	1.34 b	0.94 d	0.33 a	0.33 c	1.72 a
Orchard 9	0.62 b	0.75 c	0.90 c	0.70 e	0.29 b	0.72 a	1.53 b
Orchard 10	0.15 b	0.01 d	0.49 d	1.22 c	0.01 d	0.22 d	0.75 c
CV %	16.86	16.73	18.91	11.01	21.53	22.68	12.01

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of treatments were recorded after three month of pesticide application and were presented in Table 20. The effects of treatments were significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (1.70%) severity of anthracnose was observed in T_0 treatment. The lowest (0.34%) severity was recorded in T_1 treatment. The maximum (1.47%) die-back was obtained in T_0 treatment and the minimum (0.38%) severity was observed in T_1 treatment. The highest (1.74%) powdery mildew was recorded in T_0 treatment whereas the lowest (0.68%) severity was found in T_1 treatment. In sooty mold, the maximum (2.32%) severity was observed in control treatment, T_0 and the minimum (1.04%) was found in T_2 treatment. The maximum (0.66%) severity was obtained in T_0 treatment and there were treatments T_1 and T_2 resulted in the minimum (0.01%) severity in case of red rust diseases. BLB severity was recorded higher (0.97%) in T_0 treatment and lower

(0.09%) was found in T_1 treatment. The highest (1.43%) severity was found in T_0 treatment and the lowest (0.51%) was obtained in T_2 treatment in case of BLS diseases.

Table 20. Effect of treatments on disease severity of mango after three month of pesticide application in Thakurgaon

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	1.70 a	1.47 a	1.74 a	2.32 a	0.66 a	0.97 a	1.43 a
T_1	0.34 c	0.38 c	0.68 c	1.28 b	0.01 b	0.09 c	0.64 b
T_2	0.43 b	0.50 b	1.00 b	1.04 c	0.01 b	0.20 b	0.51 c
CV %	16.86	16.73	18.91	11.01	21.53	22.68	12.01

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control
T_1 = Spraying of Indofil M-45@ 0.2%
T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of location and treatment effects were recorded after three month of pesticide application and were presented in Table 21. The severity of anthracnose was varied significantly according to the location and treatment of the experiment. The highest (3.50%) severity of anthracnose was recorded in orchard 8 with T_0 treatment and the lowest (0.01%) severity was observed in orchard 6 with T_2, orchard 7 with T_2 and in orchard 10 with T_1 and T_2 treatment. The maximum (2.25%) severity of die-back was

observed in orchard 7 with control treatment and the minimum (0.01%) was observed in orchard 10 with T_0, T_1 and T_2 treatment, respectively. The powdery mildew severity significantly varied with the location and treatment. The maximum (2.00%) severity was found in orchard 6 and 8, statistically similar with orchard 7 and 9 with T_0 treatment and the minimum (0.01%) severity was found in orchard 9 and 10 with T_1 treatment, respectively. Sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) were varied significantly with the location and treatment. The highest (2.92%) sooty mold was recorded in orchard 6, statistically similar with orchard 7 with T_0 treatment and the lowest (0.01%) was observed in orchard 8 and 9 with T_2 treatment, respectively. The highest (1.05%) disease severity of red rust was recorded in orchard 6, which was statistically similar with orchard 7 in T_0 treatment, respectively and the lowest (0.01%) severity was observed in orchard 6 with T_1 and T_2, orchard 7 with T_1 and T_2, orchard 8 with T_1 and T_2, orchard 9 with T_1 and T_2 and orchard 10 with T_0, T_1 and T_2 treatment, respectively. In case of BLB, the maximum (1.25%) severity was found in orchard 6 with T_0 treatment and the minimum (0.01%) severity was found in orchard 6 with T_2, orchard 7 with T_2, orchard 8 with T_1 and T_2 and in orchard 10 with T_1 and T_2 treatment. The highest (2.12%) disease severity of BLS was obtained in orchard 8 with T_0 treatment and the lowest (0.01%) was obtained in orchard 6 with T_1 and T_2, orchard 7 with T_0, T_1 and T_2 and in orchard 10 with T_2 treatment, respectively.

Table 21. Effect of location and treatments on disease severity of mango after three month of pesticide application in Thakurgaon

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	T_0	1.97 b	2.25 a	2.00 a	2.92 a	1.05 a	1.25 a	0.90 e
	T_1	1.00 d	0.15 ef	1.25 bc	2.10 c	0.01 d	0.15 d	0.01 g
	T_2	0.00 g	0.27 e	1.37 b	2.05 c	0.01 d	0.01 e	0.01 g
Orchard 7	T_0	1.10 d	2.25 a	1.97 a	2.87 ab	0.40 c	0.95 b	0.01 g
	T_1	0.17 fg	1.00 c	1.12 bc	2.00 c	0.01 d	0.15 d	0.01 g
	T_2	0.01 g	0.25 e	1.20 bc	2.65 b	0.01 d	0.01 e	0.01 g
Orchard 8	T_0	3.50 a	1.87 b	2.00 a	1.85 c	1.00 a	1.00 b	2.20 a
	T_1	0.30 ef	0.50 d	1.02 c	0.97 d	0.01 d	0.01 e	1.62 c
	T_2	2.00 b	1.00 c	1.00 c	0.01 f	0.01 d	0.01 e	1.35 d
Orchard 9	T_0	1.50 c	1.00 c	1.75 a	1.92 c	0.87 b	1.00 b	2.12 a
	T_1	0.22 f	0.25 e	0.01 e	0.20 f	0.01 d	0.15 d	1.27 d
	T_2	0.15 fg	1.00 c	0.95 c	0.01 f	0.01 d	1.02 b	1.20 d
Orchard 10	T_0	0.45 e	0.01 f	1.00 c	2.05 c	0.01 d	0.67 c	1.95 b
	T_1	0.01 g	0.01 f	0.01 e	1.12 d	0.01 d	0.01 e	0.30 f
	T_2	0.01 g	0.01 f	0.47 d	0.50 e	0.01 d	0.01 e	0.01 g
CV %		16.86	16.73	18.91	11.01	21.53	22.68	12.01

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon were recorded after four month of pesticide application and were presented in Table 22. The effects of location were significantly varied in anthracnose disease. The highest (4.65%) severity of anthracnose was observed in orchard 8 which was statistically similar with orchard 9. On the other hand, the lowest (0.01%) anthracnose severity was observed in orchard 7. The die-back disease of mango was also varied significantly according to location. The maximum (1.85%) die-back severity was recorded in orchard 8 and the minimum (0.01%) was found in orchard 7, 9 and 10, respectively. The severity of powdery mildew was significantly varied with the location. The highest (5.91%) powdery mildew severity was observed in orchard 6 which was followed by orchard 7, 8 and 10 and the lowest (0.01%) severity was observed in orchard 9.The sooty mold disease severity was significantly varied with the location. The highest (10.67%) severity was found in orchard 6 and the lowest sooty mold severity was observed in orchard 9. In case of red rust, severity was also significantly varied with location. The highest (9.25%) severity of red rust was observed in orchard 6 and the lowest (0.33%) was found in orchard 10. On the contrary, the bacterial leaf blight was found significant variation with different locations. The highest (2.66%) severity was observed in orchard 8. On the other hand, the lowest (0.91%) severity of bacterial leaf blight was observed in orchard 6. Finally, the bacterial leaf spot severity was significantly varied according to location. The highest and the lowest severity of bacterial leaf spot were 5.95% to 0.50%. The highest severity was observed in orchard 9 and the lowest was observed in orchard 6 which was statistically similar with orchard 7.

Table 22. Effect of locations of Thakurgaon on disease severity of mango after four month of pesticide application

Location	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	0.40 c	0.10 b	5.91 a	10.67 a	9.25 a	0.91 d	0.50 d
Orchard 7	0.01 d	0.01 c	5.58 b	9.58 b	6.33 b	1.25 c	0.62 d
Orchard 8	4.65 a	1.85 a	1.58 c	2.83 c	2.33 c	2.66 a	4.70 b
Orchard 9	4.41 a	0.01 c	0.01 d	0.01 d	1.16 d	2.04 b	5.95 a
Orchard 10	2.62 b	0.01 c	1.50 c	2.83 c	0.33 e	1.75 b	2.25 c
CV %	14.57	20.42	13.07	8.70	9.89	20.64	13.69

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of treatments were recorded after four month of pesticide application and were presented in Table 23. The effects of treatments were significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (3.53%) severity of anthracnose was observed in T_0 treatment. The lowest (1.57%) severity was recorded in T_2 treatment. The maximum (0.72%) die-back was obtained in T_0 treatment and the minimum (0.01%) severity was observed in T_1 treatment. The highest (5.45%) powdery mildew was recorded in T_0 treatment whereas the lowest (1.25%) severity was found in T_2 treatment. In sooty mold, the maximum (8.60%) severity was observed in T_0 treatment and the minimum (3.40%) was found in T_1 treatment which was statistically similar with T_2 treatment. The maximum (6.85%) severity was found in T_0 treatment and the minimum (1.95%) was exhibited in T_1 treatment in case of red rust disease. BLB severity was recorded higher (2.85%) in T_0 treatment and lower

(1.12%) was found in T_2 treatment which was statistically similar with T_1 treatment. In case of BLS diseases, the highest (4.05%) severity was found in T_0 treatment and the lowest (2.12%) severity was in T_1 treatment which was statistically similar with T_2 treatment.

Table 23. Effect of treatments on disease severity of mango after four month of pesticide application in Thakurgaon

Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
T_0	3.53 a	0.72 a	5.45 a	8.60 a	6.85 a	2.85 a	4.05 a
T_1	2.15 b	0.01 c	2.05 b	3.40 b	1.95 c	1.20 b	2.12 b
T_2	1.57 c	0.45 b	1.25 c	3.55 b	2.85 b	1.12 b	2.25 b
CV %	14.57	20.42	13.07	8.70	9.89	20.64	13.69

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control

T_1 = Spraying of Indofil M-45@ 0.2%

T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

Disease severity of anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot of five mango orchard of Thakurgaon in response of location and treatment effects were recorded after four month of pesticide application and were presented in Table 24. The effects of location and treatments were significantly varied in anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight (BLB) and bacterial leaf spot (BLS) diseases. The highest (6.62%) severity of anthracnose was recorded in orchard 9 with T_0 treatment and the lowest (0.01%) was observed in orchard 6 with T_1 and T_2 treatment and orchard 7

with T_0, T_1 and T_2 treatment, respectively. The maximum (3.30%) severity of die-back was observed in orchard 8 with T_0 treatment followed by orchard 8 with T_2 and orchard 6 with T_0 treatment, respectively and the minimum (0.01%) severity was observed in orchard 6 with T_1 and T_2, orchard 7 with T_0, T_1 and T_2, orchard 8 with T_1 and orchard 9 and 10 with T_0, T_1 and T_2, respectively. The maximum (10.50%) severity of powdery mildew was found in orchard 7 which was statistically similar with orchard 6 with T_0 treatment and the minimum (0.01%) was found in orchard 8 with T_2, orchard 9 with T_0, T_1 and T_2 and 10 with T_1 treatment, respectively. The highest (15.75%) sooty mold was recorded in orchard 7 with T_0 treatment and the lowest (0.01%) severity was in orchard 8 with T_1 and T_2 treatment, orchard 9 with T_0, T_1 and T_2 and in orchard 10 with T_1 treatment, respectively. The highest (16.00%) disease severity of red rust was recorded in orchard 6 with T_0 treatment and the lowest (0.01%) was observed in orchard 8 with T_1, orchard 9 with T_2 and orchard 10 with T_1 and T_2 treatment, respectively. In case of BLB, the maximum (3.75%) severity was found in orchard 8 with T_0 treatment and the minimum (0.01%) severity was found in orchard 6 with T_1 and T_2 and orchard 7 with T_1 treatment. The highest (8.25%) disease severity of BLS was obtained in orchard 9 with T_0 treatment and the lowest (0.01%) was observed in orchard 6 with T_1 and T_2 treatment and orchard 7 with T_2 treatment.

Table 24. Effect of location and treatments on disease severity of mango after four month of pesticide application in Thakurgaon

Location	Treatment	Anthracnose (%)	Die-back (%)	Powdery mildew (%)	Sooty mold (%)	Red rust (%)	Bacterial leaf blight (%)	Bacterial leaf spot (%)
Orchard 6	T_0	1.22 f	0.32 c	10.00 a	11.75 b	16.00 a	2.75 b	1.50 e
	T_1	0.01 g	0.01 d	4.75 b	11.00 c	4.75 e	0.01 f	0.01 f
	T_2	0.01 g	0.01 d	3.00 d	9.25 d	7.00 c	0.01 f	0.01 f
Orchard 7	T_0	0.01 g	0.01 d	10.50 a	15.75 a	10.00 b	2.25 bc	1.50 e
	T_1	0.01 g	0.01 d	4.00 c	6.00 g	3.50 f	0.01 f	0.37 f
	T_2	0.01 g	0.01 d	2.25 e	7.00 f	5.50 d	1.50 de	0.01 f
Orchard 8	T_0	6.07 b	3.30 a	3.25 d	8.50 e	5.25 de	3.75 a	6.00 b
	T_1	4.50 c	0.01 d	1.50 f	0.01 i	0.01 i	2.75 b	4.75 c
	T_2	3.37 de	2.27 b	0.01 g	0.01 i	1.75 g	1.50 de	3.37 d
Orchard 9	T_0	6.62 a	0.01 d	0.01 g	0.01 i	2.00 g	2.75 b	8.25 a
	T_1	3.25 de	0.01 d	0.01 g	0.01 i	1.50 gh	1.75 cd	3.50 d
	T_2	3.37 de	0.01 d	0.01 g	0.01 i	0.01 i	1.62 d	6.12 b
Orchard 10	T_0	3.75 d	0.01 d	3.50 cd	7.00 f	1.00 h	2.75 b	3.00 d
	T_1	3.00 e	0.01 d	0.01 g	0.01 i	0.01 i	1.50 de	2.00 e
	T_2	1.12 f	0.01 d	1.00 f	1.50 h	0.01 i	1.00 e	1.75 e
CV %		14.57	20.42	13.07	8.70	9.89	20.64	13.69

Each value is an average of 4 (four) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

T_0 = Control, T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% and Confidor 70 WG @0.02%

CHAPTER 5

DISCUSSION

An investigation was undertaken to find out the status of major diseases of mango and their management in the Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during May, 2014 to April, 2015. The mango orchard was selected for the study in Dinajpur and Thakurgaon district. The occurrence, severity and management of diseases were assessed at different locations with control measures in different orchards of mango plants. Disease status was investigated under natural epiphytotic conditions throughout the experimental period. The diseases were assessed based on symptoms and sign expressed on leaves and twigs at one month interval after every three spray of pesticide application. Four fungal diseases namely anthracnose, die-back, powdery mildew, and sooty mold; two bacterial diseases namely bacterial leaf blight and bacterial leaf spot; one algal disease called red rust were identified as major disease throughout the year. The finding of this study is strongly supported by Singh (1968), Suit and Ducharme (1946), Pathak (1980), Mortuza (1990), Reza and Kader (1996), Awasthi *et al.* (2005), Dey *et al.* (2007), Guang *et al.* (2009), Haggag (2010), Sen *et al.* (2010), Hossain (2011), and Khan *et al.* (2015). All these diseases of mango were recorded in different orchards of Dinajpur and Thakurgaon district in Bangladesh. All the diseases were significantly varied according to different orchards. The variation of diseases may be occur due to different cultural operations such as fertilizer application, irrigation, weeding etc. done by orchard owner (farmers) or may be due to soil texture, soil structure, planting density and canopy density that may affect the internal microclimate of orchard. Such study was also done by many scientist, viz. Diedhiou *et al.* (2007), Simmons *et al.* (1998), Nafees *et al.* (2013), Sarker and Rahim (2013) and Oosthuyse (2008).

Indofil M-45 (T_1) and Indofil M-45 with Confidor 70 WG (T_2) were applied in the experimental orchard with control (T_0) treatment for the management of these diseases. Such management was supported by some literatures viz. Chowdhury

(2009), Chowdhury and Rahim (2009), Mathews *et al.* (2009), Suvarna *et al.* (2009), Sarker (2008), Hossain (2007), Mortuza (2007), Pawar *et al.* (2004), Stovold and Dirou (2004), Akhter *et al.* (2002), and Reza and Kader (1995).

Anthracnose observed on leaves, twigs and young's branch and numerous oval irregular brown spots of different sizes were found on leaves and sometimes coalesce to cover larger area of the leaf. This is supported by Xie and Xie (1999), Janguo *et al*. (2002), Colon-Garay *et al*. (2002) and Awasthi *et al.* (2005), Sundravadana *et al.* (2006), Udhayakumar *et al*. (2010), Onyeani *et al.* (2012), and Guettia *et al.* (2014). The highest (22.67%) anthracnose severity was found in orchard 8 and (18.54%) in orchard 1. The minimum (0.01%) severity was observed in orchard 3 and 7. This study is strongly supported by Khan *et al*. (2015) and Onyeani *et al*. (2012). The highest (19.70%) severity of anthracnose was found in T_0 treatment after 1st spray of pesticide application. The lowest (0.07%) severity was found after 4th spray of T_2 treatment. Such types of management were done by Chowdhury (2009), Mathews *et al*. (2009), Hossain (2007), Sundravadana *et al.* (2006), Pawar *et al*. (2004) and Akhter *et al*. (2002).

Die-back is drying of twigs and branches followed by complete defoliation, it gives the tree an appearance of scorching by fire. The die-back disease of mango symptoms has also been observed by Burhan (1987), Mortuza (1990), Ahmed *et al*. (1995), Colon-Garay *et al.* (2002) and Haggag (2010). The disease severity was highly influenced by temperature, relative humidity and rain fall. This observation was supported by Chowdhury (2009) and Akter *et al.* (1999). The maximum (17.67%) severity has been observed in orchard 8 and the minimum (0.01%) was observed in orchard 3, 4, 5 and 7, 9, 10 after 3rd and 4th spray, respectively. The highest (12.60%) severity has been observed in T_0 treatment whereas minimum (0.01%) disease was observed at orchards 1, 3, 5 and 7, 9, 10 after 3rd and 4th spray of T_1 and T_2 treatment, respectively. Ahmed *et al*. (1995) evaluated various fungicides against die-back disease in mango caused by *Botryodiplodia theobromae*. This observation was also supported by Mortuza (1990) and Nizamani *et al*. (2005).

The powdery mildew of mango was observed in the form of whitish or grayish powdery areas on leaves and severe infection of young leaves exhibited distorted growth and finally premature leaf drop. The findings of powdery mildew of mango of the present study are in accordance with the findings of Singh (1968), Pathak (1980), Akhtar *et al*. (1999), Tiwari *et al*. (2006), Naqvi *et al.* (2014) and Nasir *et al.* (2014). The highest (37.17%) disease severity was recorded at orchard 8 in Thakurgaon district and the lowest (0.68%) was recorded in T_1 treatment after 3rd spray. This kinds of disease observation and management was also done by Khan *et al*. (2015), Rehab *et al.* (2014), Chowdhury (2009), Tiwari *et al*. (2006), Sinha and Varma (2002), Verma and Kumar (1998), Reza and Mortuza (1997) and Mortuza (1990).

The sooty mold disease in the field is recognized by the presence of a black sooty mold on the leaf surface. In severe cases, the trees turn completely black due to the presence of mold over the entire surface of twigs and leaves. These symptoms were found and supported by Anonymous (1990), Mortuza (1990), Dey *et al.* (2007) and Guang *et al.* (2009). The highest (22.08%) severity was recoded at orchard 2 and the lowest (0.67%) was observed in T_2 treatment after 3rd spray. This study is supported by Mortuza (1990).

Red rust severely infects in mango plants and it creates red rusty, circular spots mainly on leaves. Reddish brown and bearded hair like structure was also appearing on leaves. Similar symptoms were found by Suit and Ducharme (1946), Singh (1968), Pathak (1980), Mortuza (1990), Haggag (2010), Sen *et al*. (2010) and Kumar and Gupta (2015). Mortuza (1990) reported that red rust as a new disease of mango in Chapai Nawbganj and Rajshahi districts. The maximum (17.75%) red rust severity has been observed at orchard 7 in Thakurgaon district and the minimum (0.01%) disease was observed in T_1 and T_2 treatment after 3rd spray. This is supported by some researchers' like Kumar and Gupta (2015), Hossain (2011), Chowdhury (2009), Awasthi *et al*. (2005), Gupta *et al*. (1990) and Prakash and Singh (1980).

The symptoms of bacterial leaf blight disease are characterized by a rapid enlargement of necrotic lesions in buds and leaves. Generally, a white creamy gum exudes from

necrotic lesions on buds, stems, and less frequently on petioles. Lesions on leaves start as interveinal, angular, water-soaked spots (1 to 3mm in diameter) that coalesced, becoming dark brown to black with distinctive reddish brown margins. These symptoms were supported by Islam *et al*. (2013). The highest (44.33%) and (21.04%) severity has been observed in T_0 treatment at orchard 9 and in orchard 1. The lowest (0.09%) was recorded in T_1 treatment after 3rd spray. This is supported by Visser (1995), Awasthi *et al*. (2005), Hossain (2011), Basak (2013) and Islam *et al*. (2013).

Bacterial leaf spot is one of the most infectious diseases in mango plants. It was observed on leaves, petioles and tender twigs and formed groups of minute water soaked lesions on the surface of the leaf and it tuned brown to black in color. The similar symptom of bacterial leaf spot of mango have been reported by Singh (1968), Pathak (1980), Hussein (1997), Okigbo and Usuinde (2003) and Ko *et al*. (2007). The highest (11.50%) severity was found in orchard 3 and the lowest (0.45%) was found in T_2 treatment after 4th spray. This study was supported by Ko *et al*. (2007), Willis *et al*. (2004) and Visser (1995).

For the management of these seven diseases, Indofil M-45 with Confidor 70 WG (T_2) treatment showed the best result at Dinajpur and Thakurgaon district in Bangladesh.

CHAPTER 6

SUMMARY AND CONCLUSION

Mango *(Mangifera indica* L.) is very popular and delicious fruit in Bangladesh. The mango is considered as "King of the oriental fruits". Though the demand of this fruit is increasing day by day but its production in terms of area and yield is not satisfactory in comparing with other mango growing countries of the world. Management of foliar diseases of mango is neglected most of the times. As a result, most of the orchards in the country are in serious problem for the production of healthy fruits.

Therefore, the present study has been designed to survey the mango diseases in different orchards of Dinajpur and Thakurgaon district and the suitable management practices for controlling disease of mango leaves by applying three treatments viz. T_1 = Spraying of Indofil M-45@ 0.2%, T_2 = Spraying of Indofil M-45@ 0.2% with Confidor 70 WG @ 0.02% and T_0 = Control.

Altogether, seven different diseases viz. anthracnose, die-back, powdery mildew, sooty mold, red rust, bacterial leaf blight and bacterial leaf spot were recorded during the experimental period. Among the diseases, anthracnose, die-back, powdery mildew, red rust and bacterial leaf blight diseases were found major problem in Thakurgaon district, where sooty mold and bacterial leaf spot were minor problems. On the other hand, sooty mold, bacterial leaf spot, red rust, anthracnose and powdery mildew were found major problems in Dinajpur district where die-back and bacterial leaf blight were minor problems. Disease severity was influenced by different locations and which may be incorporated by weather factor, fertilizer management, different cultural management practices etc.

Efficacy of fungicide (Indofil M-45) and insecticide (Confidor 70 WG) were evaluated in different orchards of Dinajpur and Thakurgaon district. Indofil M-45 was found good in controlling die-back, powdery mildew, red rust and bacterial leaf blight. Indofil M-45 together with Confidor 70 WG was found effective in controlling anthracnose, die-back, sooty mold, red rust and bacterial leaf spot.

However, the findings of the present study pointed out that all of these seven diseases were common in Dinajpur and Thakurgaon district in Bangladesh. But the disease severity was higher in orchard of Thakurgaon than that of Dinajpur except sooty mold and bacterial leaf spot. The growers may be suggested to manage the diseases by spraying Indofil M-45 with Confidor 70 WG.

REFERENCES

Ahmed, I., A. Mahmood, K. Majeed and A. Saleem. 1995. Evaluation of various fungicides against die-back disease caused by *Diplodia natalensis (Botryodiplodia theobromae)* in mango. Pakistan J. Phytopathol. 7(2): 208-209.

Akhter, K. P., A. I. Khan and S. M. Khan. 1998. Studies on the incidence and pathogenicity of *Colletotricum gloeosporioides* Penz. causing anthracnose of mango and its chemical control. Pakistan J. Phytopathol. 10 (01): 42-44.

Akhter, M. A., I. Ahmed and A. Masud. 2002. Evaluation of agrochemicals against anthracnose of mango. Integrated plant disease management. Proceedings of 3rd National Conference of Plant Pathology, NARC, Islamabad 1-3 Oct. 2001. pp. 38-40.

Anonymous. 1988. Integrated approach to the control of mango diseases. Annual Report. Division of Plant Pathology, BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur. pp. 67-68.

Anonymous. 1989. Chemical control of mango diseases. Plant Pathology Research Annual Report (1988-89). Plant Pathology Division. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p49.

Anonymous. 1990. Survey and monitoring of different diseases of mango. Annual Report. Division of Plant Pathology, BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur. p73.

Alexander D. M. E. 1989. The mango in Australia, Common-Wealth Scientific and Industrial Research Organization, Australia. pp. 1-28.

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

BBS. 2014. Monthly statistical bulletin, Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of the Peoples' Republic of Bangladesh, Dhaka. p55.

Basak R. P. 2013. Effect of antibiotics and BAU-Biofungicide in controlling bacterial leaf blight of mango and litchi. MS Thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensigh. PP. vi.

Burhan, M. J. 1987. Outbreaks and new records. United Arab Fmirates. *Botryodiplodia* on mangoes and banana. FAO Plant Protection Bulletin. 35(1): 34.

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

Colon-Garay, J., L. I. Rivera-Vargas, R. McGovern, P. R. R. Del and R. R. del P. 2002. Hypovirulent isolates of *Colletotricum gloeosporioides* induce resistant to anthracnose in detached mango fruits and seedlings. J. Agril. the Univ. Puerto Rico. 86(1and 2): 55-64.

Chowdhury, M. S. M. 2009. Seed and seedling diseases of some selected fruits of Bangladesh. Ph.D.Thesis. Department of Plant Pathology, Bangladesh Agril. Univ. Mymensingh.

Chowdhury, M. N. A. and M. A. Rahim. 2009. Integrated crop management to control anthracnose (*Colletotrichum gloeosporioides)* of mango. J. Agric. Rural Dev. 7(1and 2): 115-120.

Dey, T. K., A. Ayub, G. Mortuza and N. Sultana. 2007. Research on vegetables, spices and fruits disease management at Bangladesh Agricultural Institute. Bakr, M. A., Ahmad, M. U. and M. A. Wadud Mian (ends.).Proc. National Workshop on ‘‘Strategic Intervention on Plant Pathological Research in Bangladesh” 11-12 February, 2007. BARI, Joydebpur, Gazipur. pp. 72-85.

Diedhiou, P. M., N. Mbaye, A. Drame, and P. I. Samb. 2007. Alteration of post-harvest diseases of mango *Mangifera indica* through production practices and climatic factors. African J. of Biotechnol. 6 (9): 1087-1094.

Dulvi, M. N. and J. S. Sardeshpande. 1993. Studies on red rust disease of mango. J. Maharastra Agril. Univ. 18 (2): 199.

FAO. 2014. Production Year Book. Statistical Series No. 163. Food and Agriculture Organization, Rome, Italy. p182.

FAO. 2011. Production Year Book. Statistical Series No. 163. Food and Agriculture Organization, Rome, Italy. p162.

Guang, L. M., L. FuXiu, L. WeiDong, L. J. Yong and X. Wei. 2009. Investigation and identification of mango diseases in Hainan Province. Gua. Agril. Sci. 40(11): 1440-1442.

Guettia, M.Y. N., N. Kouassi, H. A. Diallo, and F. R. Y. Y. Kouakou. 2014. Evaluation of anthracnose disease of mango (*Mangifera indica* L.) fruits and characterization of causal agent in Côte d'Ivoire. Intl. J. Agric. Innov. and Res. 2(6): 1008-1017.

Gupta, J. H. 1990. Chemical control of algal rust of litchi caused by *Cephaleuros virescens*. Kunze. J. Prog. Hort. 24 (1 and 2): 109-110.

Haggag, W. M. 2010. Mango disease in Egypt. Agril. And Biol. J. No. Ame. 1(3): 285-289.

Hossain, I. 2011. Nursery diseases of some selected fruit species in Bangladesh. Eco-friendly Plant Disease Management Laboratory, Dept. Plant Pathol. Bangladesh Agril. Univ, Mymensingh, Bangladesh. p24.

Hossain, I. 2007. Research on crop disease management at Bangladesh Agricultural University. Bakr, M. A.; Ahmad, M. U. and M. A. Wadud Mian (eds.). Proc. National Workshop on "Strategic Intervention on Plant Pathological Research in Bangladesh" 11-12 February, 2007. BARI, Joydebpur, Gazipur. pp. 251-282.

Hussein, N. E. A. 1997. Mango leaf spot in Minia Governorate. Annals of Agril. Sci. 35(4): 2029-2042.

Iram S., A. Rasool and I. Ahmad. 2014. Comparison of incidence, prevalence and severity of post-harvest fungal diseases in Pakistan, improved integrated management orchards and conventional practices blocks. Intl. J. Scientific and Engineering Res. 5(10): 1274-1284.

Islam S. I. A., M. R. Islam, K. M. G. Dastogeer and I. Hossain. 2013. Characterization of leaf blight pathogen, *Pseudomonas syringae* pv. s*yringae* of mango in Bangladesh. Intl. Res. J. Biol. Sci. 2(6): 39-45.

Jacob, K. K., E. A. Macrase and S. E. Hetherington. 2001. Postharvest head disinfestations treatments of mango fruits. Scientia. Hort. 89(3): 171-193.

Jianguo, R., H. Siliang, Y. Weihong and L. Yangrui. 2002. Study of biocontrol of mango anthracnose disease by antagonistic microorganisms. So. We. Chi. J. of Agril. Sci. pp. 130-137.

Johnston P. R. 2000. The importance of phylogeny in understanding of host relationships within *Colletotrichum*. In: Prusky D, Dickman MB Freeman S,eds. *Colletotrichum* host specificity, pathogenicity and host-pathogen interactions. St. Paul, Minnesota: APS. pp. 21-28.

Kabir, I. M. and M. B. Meah. 1987. Anthracnose of guava and possibility of its chemical control . 12th conference. Bang. Assoc. Adv. of Sec. 23(1): 122-123.

Karim, A. 1985. Post-harvest problems and prospect of mango in Bangladesh. Proc. 4th National symposium of Bangladesh Soc. for Hortl. Sci. pp. 130-137.

Ko, Y., K. S. Yao, C. Y. Chen and C. H. Lin. 2007. First report of gray leaf spot of mango (*Mangifera indica)* caused by *Pestalotiopsis mangiferae* in Taiwan. Plant Dis. 91(12): 1684.

Khan, M. A. H., I. Hossain, M. S. M. Chowdhury and M. U. Ahmad. 2015. Weather impact on nursery diseases of mango saplings in Bangladesh. Intl. J. Appl. Sci. Biotechnol. 3(1): 42-49.

Kobra, K., M. A. Hossain, M. A. H. Talukder and M. A. J. Bhuyan. 2012. Performance of twelve mango cultivars growing in different agro-ecological zones of Bangladesh. Bangladesh J. Agril. Res. 37(4): 691-710.

Kumar, V. and R. C. Gupta. 2015. Red rust (*Cephaleuros virescence*, kunze) of mango (*Mangifera indica*) an emerging problem in varanasi region of U.P. (India). J. of Sci. 5(2): 111-115.

Mathews, A. A., S. T. Basha, T. M. Hemalatha and N. P. E. Reddy. 2009. Evaluation of fungicides against *Colletotrichum gloeosporioides* causing mango anthracnose in-vitro study. Current Biotica. (3): 366-372.

Meah, M. B. and A. A. Khan. 1987. Survey of some important and vegetable crops of Bangladesh. Ann. Pro. Rep. (1986-87). Deptt. Plant Pathol., BAU, Mymensingh, Bangladesh. pp. 1-28.

Miah, M. M. U., M. Jahiruddin, M. F. Islam and M. S. Razia. 2005. Fertilizer recommendation guide-2005. The Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka. pp. 119-120.

Micvkenzie, D. 1988. The use of Tilt 250 EC against powdery mildew of mangoes. Sou. Afri. Mango Growers' Asso. Res. J. 8: 21-22.

Mortuza, M. G. 1990. Survey and monitoring of different diseases of mango under different agro -ecological condition of Bangladesh. Annual Report of Fruit Improvement (1989-90). Horticulture Research Centre. Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. pp. 45-46.

Mortuza, M. G. 2007. Effect of chemicals in controlling vegetative malformation of mango grafts. Research Report on Horticulture Crops (2006-07). Horti. Res. Centre. Bangladesh Agril. Res. Instt., Joydebpur, Gazipur. pp. 337-338.

Nafees, M., I. Ahmad, I. Ashraf, M. Jameel, T. hussan, and Maryam. 2013. Sustainable Production of Mango Fruit by Managing Irregular Bearing Through Foliar Spray of Urea at Critical Growth Stages. World Appl. Sci. J. 24 (10): 1368-1372.

Naqvi, S. A. H., R. Perveen, S. A. Manzoor, H. M. I. Umar, T. M. T. Iqbal, F. Liaquat, T. Majid, and A. Irshad. 2014. Evaluation of various mango varieties against the infection dynamics of powdery mildew (*Oidium mangiferae* Bert.). American J. Plant Sci. 5: 2372-2377.

Nasir M., S. M. Mughal, T. Mukhtar and M. Z. Awan. 2014. Powdery mildew of mango: A review of ecology, biology, epidemiology and management. Crop Prot. Elsevier Ltd. 64: 19-26.

Nizamani, Z. A., M. A. Pathan, M. M. Jiskani and K. H. Wagan. 2005. Studies on survey and causal agent of tip die-back disease of mango (*Mangifera indica L.)*. Pak. J. of Agril. Engl. Vate. Sci. 21(2): 17-21.

Okigbo R. N. and M. I. Usuinde. 2003. Fungal leaf spot diseases of mango (*Mangifera indica* L.) in Southeastern Nigeria and biological control with *Bacillus subtilis*. Plant Prot. Sci. 39: 70–77.

Onyeani C. A., O. Samuel, O. O. Oworu and O. Sosanya. 2012. First report of fruit anthracnose in mango caused by *Colletotrichum gloeosporioides* in Southwestern Nigeria. Intl. J. Sci. and Technol. Res. 1(4): 30-35.

Oosthuyse S.A. 2008. Effect of spray application of $KN0_3$, urea and growth regulators on the yield of Tommy Atkins mango. S. A. mango growers Assoc. year book. 13: 58-62.

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

Pawar, S. M., N. K. Chougule, P. K. Nalwandikar, and S. G. Puri. 2004. Efficacy of recommended fungicides in their modified formulations against major diseases of mango. J. of Sci. and Crop prot. 14(1): 95-99.

Peterson, R. A. 1986. Mango diseases. Proceeding of the CSIRO 1st Australian Mango Research Workshop, CSIRO, Cairns. pp. 233-247.

Ploetze, R. C., G. A. Zentmyer., W. T. Nishizima., K.G. Rohrbach and H. D. Ohr. 1994. Compendium of tropical fruit diseases, APS press. The American Phytop. Soc. pp. 34-44.

Popenoe, W. 1964. Manual of tropical and sub-tropical fruits. The McMillian and Co. Ltd. N. Y. and London. p474.

Prakash, O. and Singh, U. N. 1980. Fungicidal control of red rust of mango. India J. Mycol. Plant Pathol. 10 (2): 175-176.

Rehab, A., M. E. A. Nadia, A. Shenoudy and H. M. Anwar. 2014. Effect of powdery mildew on mango chlorophyll content and disease control. Egypt. J. Agril. Res. 92 (2): 451-463.

Reza, M. M. A. and K. A. Kader. 1995. Efficacy of pre-harvest field sprays of fungicide on the control of anthracnose and stem rot of mango. Annual Report. Reg. Horti. Res. Sta., Chapai Nawabganj. pp. 55-58.

Reza, M. M. A. and K. A. Kader. 1996. Germplasm evaluation of mango against major diseases. Annual report of mango improvement. Reg. Horti. Res. Station, BARI, Chapai Nawabgonj-63000. pp. 58-58.

Reza, M. M. A. and M. G Mortuza. 1997. Incidencee of powdery mildew of mango varieties and its control. Bangladesh J. Plant Pathol. 13(1 and 2): 37-38.

Rivas, B. A. and L. Carrizales. 2007. Chemical control of anthracnose during pre- and post-harvest in mango, in Cedeno County, Monagas State, Venezuela. Bioagro. 19(1): 19-25.

Salunkhe, D. K. and B. B. Desai. 1984. Postharvest Biotechnology of fruit. CRC press. Inc. Boca Paton Florida. 1: 77-94.

Sardeshpande, J. S. 1988. A report of the plant protection sub-committee. Regional Fruit Research Station, Vengurla, Dist. Sindhudurg. pp. 6-7.

Sarker, S. R. 2008. Nursery diseases of Mango and their management. MS. Thesis. Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. pp. 64-68.

Sarker, B. C. and M. A. Rahim. 2013. Yield and quality of mango (*Mangifera indica* L.) as influenced by foliar application of potassium nitrate and urea. Bangladesh j. Agril. Res. 38(1): 145-154.

Sen, C.Y., H. G. Di, L. Wei, M. Y. Long, Z. J. An and P. J. Ji. 2010. A preliminary survey of mango plant diseases in Guangxi Zhuang Autonomic Region. Chinese Bulletin of Entomology 47(5): 994-1001.

Siddique, A. B. and F. M. Scanlan. 1995. Nutritive values of fruits. Intl. Fruit Production Manual. pp. 1-288.

Simmons, S. L., P.J. Hofmant, A.W. Whiley and S.E. Hetherington.1998. Effects of pre-harvest calcium sprays and fertilizers, leaf : fruit ratios, and water stress on mango fruit quality. Australian Centre for International Agricultural Research (ACIAR). Proceedings of an International Workshop held at Chiang Mai, Thailand 22-23 May 1997. Canberra, ACIAR Proceedings No. 81. p166.

Singh, L. B. 1968. The mango, botany, cultivation and utilization. Leonard Hill. pp. 280-283.

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

Singh, P. and A. Varma. 2002. Chemical management of mango powdery mildew. An. Plant Prot. Sci. 10(2): 291-294.

Suchana, R. S. 2008. Nursery diseases of mango and their management, M. S. Thesis, Department of Plant Patholgy, Bangladesh Agril. Univ. Mymensingh. pp. 1-34.

Suit, R. F. and E. P. Ducharme. 1946. The *Cephaleuros* disease of citrus. J. Citrus in India. 27: 3.

Stovold, G. E. and J. F. Dirou. 2004. Fungicide management program to control mango anthracnose. NSW Cen. for Tro. Horti., Alsto. UK.

Sundravadana, S., Alice, D., Kuttalam, S., and Samiyappan, R. 2006. Control of mango anthracnose by Azoxystrobin. Tunisian J. Plant Prot. 1: 109-114.

Suvarna, J., S. T. Basha, T. M. Hemalatha and N. P. E. Reddy. 2009. Efficacy of fungicides against *Colletotrichum gloeosporioides* causing mango anthracnose. In. J. of Plant Prot. 37(1/2): 201-203.

Tiwari, R. K. S. and J. Sing. 1999. Scientific Horticulture. Regional Agricultural Research Station, Sarkanda Farm Bilaspure, India. p14.

Tiwari, R. K. S., A. Singh, M. L Rajput and R. K. Bisen. 2006. Relative susceptibility of mango varieties to powdery mildew caused by *Oidium mangiferae*. Advances in Plant Sci. 19(1): 181-183.

Tripathi, P. and N. K. Dubey. 2004. Exploitation of natural products as an alternative strategy to control post-harvest fungal rotting of fruit and vegetables. Post-harvest Biol. Technol. 32: 235–245.

Uddin, M. J., M. K. Hasan, A. S. M. Mohiuddin, S.U. Ahmed and M. M. Hassan. 2012. Study on some soils of the himalayan piedmont plain of Bangladesh. J. Asiat. Soc. Bangladesh, Sci. 38(2): 199-206.

Udhayakumar, R. and S. U. Rani. 2010. Effect of certain factors favouring the mycelial growth and conidial germination of *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. Intl. J. Plant Prot. 3(1): 20-22.

Visser, A. A. 1995. Effects of bactericides on bacterial black spot of mangoes. M. Sc. Thesis. University of Pretoria, South Africa.

Verma, K. S. and D. Kumar. 1998. Management of powdery mildew of mango. Plant Disease Res. 13(2): 190-192.

Willis, A. and R. S. Mabunda. 2004. Copper, alternatives for the control of bacterial black spot further progress. Res. J. Sou. Afri. Man. Gro. Asso. 24: 61-62.

Xie, G. G. and B. Q. Xie. 1999. The occurrence of anthracnose disease of mango and its control. South China Fruits. 28(5): 34-35.

Appendix 1

Weather data

Table 1. Month-wise air temperature, relative humidity and rainfall from October, 2014 to April, 2015, Dinajpur district

Month	Air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
October, 2014	34.90	24.25	29.58	88.5	20.15
November, 2014	29.55	16.20	22.87	87.15	0
December, 2014	24.28	12.45	18.36	89.5	0
January, 2015	23.08	11.42	17.25	71.25	0.30
February, 2015	25.10	13.20	19.15	68.7	5.04
March, 2015	30.53	17.05	23.79	68.2	01.86
April, 2015	34.90	21.07	27.99	65.82	02.70

Source: Rajbari Weather Station, Dinajpur Sadar, Dinajpur

Appendix 2

Table 2. Month-wise air temperature, relative humidity and rainfall from October, 2014 to April, 2015, Thakurgaon district

Month	Air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
October, 2014	34.0	23.8	28.9	88.34	15.0
November, 2014	28.0	15.2	21.6	89.69	0
December, 2014	25.0	10.0	17.5	89.98	0
January, 2015	22.08	11.22	16.65	89.90	0.54
February, 2015	22.70	12.40	17.55	86.68	4.0
March, 2015	29.25	16.18	22.72	77.25	1.0
April, 2015	33.30	20.44	26.87	72.78	7.4

Source: BADC Weather Station, Hajee Para, Thakurgaon