PREVALENCE AND MANAGEMENT OF SOME MAJOR DISEASES OF CITRUS AND GUAVA AT DINAJPUR AND THAKURGAON DISTRICTS

A THESIS

BY

AFIA FAHMIDA ANAMIKA

Student No. 1605378

Session: 2016-2017

MASTER OF SCIENCE

IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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DECEMBER, 2017

Dedicated
To my
Beloved Parents

ACKNOLEDGEMENT

I would like to express my profound gratefulness to the Almighty Allah for granting blessing in completing this research work.

I want to express my deepest sense of gratitude and indebtedness to my supervisor, Professor Dr. S. M. Emdadul Hassan, Department of Plant Pathology, Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh for his tremendous help, keen interest, scholastic supervision and encouragement, painstakingly and thoroughly editing the thesis and offering helpful suggestions for the improvement of the manuscript.

I must also express my deepest gratitude to my co-supervisor. Professor Dr. Sk. M. Mobarak Hossain, Department of Plant Pathology, Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh, for his cordial help and suggestions in conducting this research and also for his valuable advice an encouragement for improvement of the manuscript.

I am indebted and grateful to Professor Dr. ATM Shafiqul Islam, Head of the Department of Plant Pathology as well as other teachers of the Department of Plant Pathology, Hajee Mohammad Danesh Science & Technology University, Dinajpur, for their valuable suggestions and cooperation during laboratory work of my research.

Thanks are also due to Md. Hafizur Rahman and other staffs of the Department of Plant Pathology for their technical help during the entire period of my research.

The author expresses her deepest sense of gratitude to her beloved father Md. Faizer Rahman, mother Habiba Begum, and younger sister Madhu whose blessing, inspiration and sacrifices opened the gate and paved the way to my higher studies.

I am greatly indebted to my sister, Rukhsana Parvin who helped in different times throughout the research work. Sincere gratitude is also extended Sourov, Shuvo, Moktar, Jinat, Jebal and all of my well wishes for their direct and indirect help in completing this research work.

Thankful appreciation to Kamruzzaman Rasel for his careful typing of this manuscript in right shape.

May, 2018 *The Author*

ABSTRACT

The present study has been designed to survey the major diseases of citrus and guava in different orchards of Dinajpur and Thakurgaon district to find out their effective control measures under the supervision of Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during July, 2017 to May, 2018. Four treatments viz. Iprodione @ 2 g/L (T_1), Copper oxychloride @ 3 g/ L (T_2), Mancozeb @ 3 g/L (T_3) and Control (T_0) were applied for controlling the diseases (canker, scab, anthracnose and die-back) of citrus leaves and diseases (algal rust, anthracnose and die-back) of guava leaves recorded in orchards of Dinajpur and Thakurgaon districts. Out of tested fungicides, Iprodione was found superior in action exhibiting the lowest disease severity to control the canker (2.33%) and scab (2.33%) diseases of citrus in different orchards of Thakurgaon and Dinajpur. Disease severity of anthracnose (3.00%) was more suppressed by spraying of Copper oxycholoride. Mancozeb was effective to control die-back (3.00%) of citrus in orchards of Thakurgaon district. Disease severity of citrus was higher in orchards of Dinajpur than that of Thakurgaon in citrus regarding anthracnose and die-back but inversely for canker and scab. Scab of citrus was more suppressed than other diseases of citrus treated with Iprodione followed by other treatments in the orchards of Thakurgaon than that of Dinajpur. Copper oxychloride was more effective to control algal rust disease (2.33%) of guava. Anthracnose (3.00%) and die-back (3.00%) of guava were suppressed by Mancozeb. Disease severity of algal rust and anthracnose was higher in orchards of Dinajpur following die-back in orchards of Thakurgaon district, respectively. Algal rust of guava was more suppressed than other diseases treated with Copper oxycholoride in the orchards of Dinajpur.

Keywords: Citrus, Guava, Location, Disease severity, Chemical control

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

Fruits are special gift of Allah to man and animal world. The natural environment of Bangladesh is favorable for the production of different kinds of fruits. About 1.15% land is used for fruit cultivation in Bangladesh (Hossain, 2012). About 70% fruit are imported from abroad which create pressure to the foreign currency of Bangladesh (Hossain, 2012). Bangladesh imports about 1.58 million kg of fruit every day. According to statistics of Bangladesh bank, these fruit imports taka 10 billion annually. In the fiscal year of 2014-2015 some 1 million kg fruits were imported, while this increased to 1.27 million in 2015-2016 and 1.57 million kg in 2016-2017.

The ever increasing malnutrition problem together with the alarming rate of population in Bangladesh envisages the need to achieving accelerated productivity of both the field crops and garden crops. Although recently Bangladesh has got self-sufficiency in food crops, increase in the production of garden crops i. e. fruits and vegetables are still far behind the country's present requirement. Even the present advancement in producing field crop especially rice, has in many ways been achieved at the cost of producing other agriculture products. But for sound health and good physique, consumption of a balanced diet and adequate fruit is essential. Now only 35 g of fruits is available for a person against the daily requirement of 85g (HRDP, 1995[a]). This low consumption of fruits in association with protein and calorie deficiencies are the main reasons for wide spread malnutrition on the country. The main fruits in the country are banana, papaya, guava, litchi, mango, pineapple, lemon and other fruits as reported by BBS (2011). The country abounds with a large variety of tropical and subtropical fruits. The most widely cultivated fruits are litchi, banana, lemon, guava, papaya, and custard apple, wood apple, elephant apple Indian olive

and Indian jujube. The horticultural crops, especially fruits, are playing a vital role in crop diversification, nutrition and economy. Important fruits like mango, guava, litchi, jackfruit, citrus, ber etc. are available in Bangladesh, which can contribute in the poverty ridden economy and nutrition sector significantly (Rahim, 2009). Bangladesh produces less than 30 percent daily requirements of fruits for its population. The diseases of fruits are a major problem to the growers which affect to reduce yield much below the expectation.

It is reported that 90% people of Bangladesh have been suffering from Vitamin C deficiency (Anonymous, 1980). All such malnutrition problems could be reduced considerably through adequate consumption of fruits, especially fruits which are rich in Vitamin C and minerals, like citrus, guava, banana etc. So, widely grown two important fruit species namely citrus and guava have been selected for the study. Citrus (*Citrus limon* L.) is one of the important, popular and nutritious fruits in the world. It has a great demand due to its nutritive value, aroma and taste. It has 22mg of calcium, 0.03mg of iron and 40mg of vitamin C in hundred grams of edible portion. Many people of our country are suffering from the deficiency of some limiting vitamins like vitamin A, vitamin B and vitamin C and other important minerals like calcium, iron in their daily diet. About 91 percent people of Bangladesh are suffering from the deficiency of vitamin C. Citrus fruits are the important source of vitamin C. It also has some medicinal and digestive value too (Reuther *et al.*, 1967). Vitamin C cannot be stored in human body like others and it is needed to be taken every day in the diet. Thus, citrus fruits play an important role in human health. Jam, jelly, juice, prickle etc. are produced from them. Some of them are used in the juice industry. From the by-product of juice industries, palatable molasses is produced which is a good feed for livestock. The rind of the fruit and leaves are used for the production of oil, which is used in the cosmetics industries. The citrus fruits are also

used in the industry for production of citric acid and pectin. In Bangladesh, eight species of citrus fruits are grown. Among them, three species- lemon (*Citrus limon* L), lime (*Citrus aurantifolia* Swing) and pummel [*Citrus grandis* (L) Osbeck] are commonly cultivated in our country. Citrus is cultivated in 4,822 acre and production is 65,248 MT in recent year in Bangladesh (BBS, 2015-2016). In the Mediterranean region, around 22.5 million tons of citrus is produced on 1.066 million hectares. 2.36 million tons of citrus produced in Pakistan on 199.4 thousand hectares where India produces 8607.7 thousand MT on 923.2 thousand hectares. Compared to nearby countries, production of citrus, in Bangladesh is low due to the occurrence of diseases. More than 100 diseases are known to occur on different species of citrus in the world (Klotz, 1973). Of all the diseases occurring on citrus, die-back and canker are the major. Among the diseases, the most important diseases include the canker *(Xanthomonas axonopodis pv. citri*), scab (*Elsinoe fawcetii*) anthracnose (*Glomerella cingulata*), and die-back (*Colletotrichum gloeosporioides*). The disease breaks out widely and has become a limiting factor of citrus cultivation in many countries (Ray chaudhury *et al.* 1980; Talukder 1974 and Klotz, 1948). Canker can be effectively controlled by spraying Copper oxychioride (Ravikumer *et al.,* 2001), scab can be controlled by Mancozeb (Ran *et al.*, 2002, Singh *et al.*, 2000) and die-back can be controlled by Carbendazim, Mancozeb and Copper oxychloride (Ebenezar *et al.*, 1996), Rovral (Rahman, 2003). Miah and Fakir (1987) reported the prevalence of die-back on Elachi lemon and Kagzi lime by 89.9% and 100% respectively, in Bangladesh. About 101,000 MT of orange and mandarin orange was imported to meet domestic demand in 2011. In Bangladesh 350,000 tons of citrus fruits worth $220 million were exported (2015). Later on, 4000 tons of the fruits were exported to several countries including UK, Canada, Sweden and the Netherland and 100,000 tons of citrus fruits were exported to Russian market in last year (2015-2016).

Guava (*Psidium guajava* L.), is one of the most common fruits in tropical and sub-tropical regions of the world. . The tropical guava is best adapted to a warm climate, thriving in both humid and dry climates. It is adaptable over a wide range of climatic and soil conditions. It can be used as an important resource for local communities with potential for commercialization; boosting food and nutritional security. Guava contains moisture 80-83%; acid 2.45%; reducing sugar 3.5-4.5%; non reducing sugar 3.97-5.23%; TSS 9.73-14.23; potassium 0.48%; vitamin C 260 mg per 100 g of edible portion (Rahim, 2008). In rural areas, guava is used to supplement the daily diet or substitute exotic fruits. Guava has been found to be beneficial for people suffering from Asthma, high blood pressure, oral ulcers, scurvy, congestion of the lungs, bacterial infection etc. Guava can improve the texture of skin and help avoid skin problems. For the purpose, we can eat it raw or make wash our skin with a decoction of its immature fruits leaves. Juice of raw immature guavas decoction of guava leaves is known to bring relief in cough and cold. Guava is a popular fruit which contain a lot of vitamin A, C and iron and helps us to keep fit. Fresh fruits used salad, pudding etc. Jam, jelly, juice, pickles, ice cream can be made from guava through processing. Tea can be made from leaves of guava. Fruits are tasty to eat and satisfy the demand of vitamins and minerals in our body. The commercial cultivation of fruits can be a good source of money. It is cultivated in 8,794 acre and production is 214,308 MT in recent year in Bangladesh (BBS, 2015-16). Thailand produces 7.5 million tons of guava on 1.31 million hectares, India produces 17,650 thousand MT on 501,600 acres, and Pakistan produces 468.3 thousand tones on 58.5 thousand hectares of guava. Compared to nearby countries, production of guava, in Bangladesh is low due to the occurrence of diseases. Guava is affected by about 177 pathogens of which, 167 are fungal, 3 bacterial, 3 nematodes and one epiphyte (Misra, 2007). Among the diseases the most important diseases include the wilt disease (*Fusarium oxysporum*), algal rust (*Cephaleuros* sp.), anthracnose (*Glomerella cingulata*), dampinng off (*Rhizoctonia solani),* die-back (*Gloeosporium psidii*) and gall forming nematode, *Meloidogyne* spp. (Lim *et al*. (2003),

Dwivedi *et al*. (1994) reported disease symptoms of guava including defoliation, die-back and bark cracking. Anthracnose can be effectively controlled by spraying Rovral 50 WP (Islam, 2005; Meah and Khan, 1986), Cupravit (Anser *et al.*, 1997), Topsin M (Anser *et al.*, 1997; Hossain 1993; Rahman and Hossain, 1988), Mancozeb (Hossain, 1993; Pandey, 1988; Rahman and Hossain, 1988). Die-back can be effectively controlled by spraying Mancozeb (Thakore *et al.*, 1994) and Rovral 50 WP (Islam, 2005). Plant diseases play an important role in reducing yield of many fruit crops reported by Pathak, 1980. It has been estimated that production could be increased at least 28% if the fruit plant could be protected against diseases. Bangladesh exported 228 MT of guava and earn $1million in 2016. There are several ways to control diseases of plants but chemical means are the effective ones among them due to retention, spreading ability, penetration and their residual effect as well as easily handling for spraying.

However, the prevalence and management of diseases of citrus and guava in different orchards are not yet studied in Thakurgaon and Dinajpur region but it is urgently needed and necessary to know the status of the disease for taking necessary steps to manage the disease. For these reasons, citrus and guava productions are to be reared up with proper care in the orchard in order to avoid the diseases and to ensure quality fruit 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 in mind, the present study was undertaken with the fungicides Iprodione, Copper oxycholoride and Mancozeb in Dinajpur and Thakurgaon region with the following objectives:

i) To know the status of diseases of citrus and guava at some selected orchards at Dinajpur and Thakurgaon districts, and

ii) To find out the efficacy of the treatment against major diseases of citrus and guava

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Citrus

Citrus is a common nutritious fruit. Chemical control of foliar diseases of citrus viz. canker, scab, anthracnose and die-back with fungicides is an effective approach of citrus disease control. Some relevant literature in this aspect is reviewed in this chapter.

Bacterial disease of citrus

Citrus canker

Hossain (2011) studied the nursery diseases of citrus in Bangladesh during the period of 2010-2011. He recorded canker disease in different citrus growing areas of Bangladesh.

Sarao *et al.* (2011) observed citrus canker, a disease of orange trees are a highly contagious disease with serious economic losses. Citrus canker, affects grapefruit, lemon, lime and orange trees, entering through wounds and natural openings called stomata. Rain, overhead watering and flooding can spread the canker from one tree to another. People can also spread the disease on hands, tools and clothing. Symptoms appear on leaves, where they take the form of blister-like brownish lesions with oily margins; on fruit; where they resemble crusty scabs and are often haloed with yellow; and on branches, where they resemble gray bumps. The distinctive raised appearance of the lesions can help to distinguish them from damage caused by hail and cold temperatures, and can help to confirm a diagnosis of citrus canker.

Awasthi *et al.* (2005) conducted a survey of different orchards, nurseries and markets during January 2002 to August 2003 in new alluvial plains of West Bengal, India. They

found the prevalence of different diseases of some major fruit crops. On citrus, twig blight (*Phytophthora* sp.) and canker *(Xanthomonas campestris pv. citri (X. axonopodis pv. citri*) are the major problems in the nursery and orchard.

Gottwald (2005) stated that citrus canker can be a serious disease where rainfall and warm temperatures are frequent during periods of shoot emergence and early fruit development. This is especially the case where tropical storms are prevalent. Citrus canker is mostly a leaf-spotting and fruit rind-blemishing disease. But if conditions are highly favorable for infection, severe infections cause defoliation, shoot, dieback and fruit drop.

Kaiser *et al. (*2005) reported that canker (*Xanthomonas axonopodis* pv. *citri*) and greening (Mycoplasmal disease) in citrus and mosambi were endemic disease in West Bengal.

Bal and Dhiman (2005) observed that citrus canker (*Xanthomonas axonopodis* pv. *citri*) was serious diseases in Kinnow mandarin nursery plants. The highest incidence of citrus canker (73.3%) was recorded during the second week of September and both diseases showed a positive correlation with temperatures relative humidity and rain fall. The period from July to September was identified as the most conducive for the development of citrus canker. The nursery should be provided with the required protection against this disease during the period.

Verniere *et al.* (2003) studied the Asiatic citrus canker (ACC) and found expression of symptom depend on temperature where as relative humidity had no effect on disease suppression.

Das (2002) reported that *Xanthomonas axonopoides* pv. *citri* causing citrus canker. This pathogen was collected from acid lime (*Citrus aurantifolia*) rough lemon (*C. macrophylla*)

and trifoliate orange (*Swingle citrumelo*) from Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. India to determine the pathogen variability in the bacteria. Inoculation of the bacterial isolates resulted in 1-75% canker severity in acid lime and 1-25% canker severing in both rough lemons.

Taylor *et al.* (2002) reported that citrus canker, caused by *Xanthomonas axonopoidis* pv. *citri* was eradicated from New Zealand in 1972 but continues to be a biosecurity threat to the citrus industry here. In this study evaluated and adapted molecular diagnostic procedures for the detection of exotic phytopathogenic bacteria. These method were used to identify the bacteria isolated from the canker-like symptoms observed on citrus leaves in kerikeri and allowed the elimination of *Xanthomonas axonopoides* pv. *citri* as the causal agent and symptoms of the irregular sunken, spots developed on the leaves.

Ye *et al.* (2001) reported that, citrus canker (*Xanthomonas axonopodis* pv. *citri*) an important disease of pummel, attacks young leaves and summer shoots. Small yellow spots appear first on the leaf blade then become corky and grey with stripes at the center. Symptoms on infected fruits are similar to those on damaged leaves and shoots.

FU and XU (2001) showed that citrus canker (*Xanthomonas axonopodis* pv. *citri)* appeared in late April and early May; the rampart period being mid May to early June.

Ravikumar *et al.* (2001) evaluated four antibiotics (streptomycin sulfate, streptocycline, bacterimycin and paushamycin) along with 2 fungicides (Copper oxychloride and Bordeaux mixture) against citrus canker (caused by *Xanthomonas axonopodis* pv. *citri*) of acid lime (*citrus aurantifolia*) during kharif 1999-2000, in Bijapur, Kamataka, India. The results showed that streptomycin sulfate (500 ppm) sprayed either alone or in combination with Copper oxychloride (2000 ppm) was very effective in reducing the disease severity (2.23-2.5l number of lesions per fruit) followed by combination

spray of streptocycline (500 ppm) + Copper oxychloride (2000 ppm) (3.22) compared to the control (8.29). The highest yield (577 fruits per tree) was recorded in combination treatment of streptomycin sulfate (500 ppm) + Copper oxychloride.

Kale *et al.* (1994) observed the effects of foliar sprays to citrus canker of Kagzi lime caused by *Xanthomonas campestris* pv. *citri* in Maharashtra, India. He used 100 ppm streptocycline + 0.1% Copper oxychloride. Sprays were applied at intervals of 7, 15 and 21 days and the most cost effective chemical control was achieved by spraying at intervals of 7 to 15 days.

Whiteside *et al.* (1988) stated that citrus canker found in dryer, more temperate areas in South West Asia and the Middle East. It occurs the countries such as Iran, Iraq, Oman, Saudi Arabia, United Arab Emirates and Yemen. They reported that citrus canker occurs primarily in tropical and sub-tropical climates where considerable rainfall accompanies warm temperatures but it can also occur in drier climates. Citrus canker becomes a serious disease when wet weather conditions occur during the periods of shoot emergence. It severely affects on lemons and to a lesser extent on Mexican lime, sour orange and pummel in Argentina, Paraguay and Uruguay.

Aiyappa (1958) stated that mandarin and sweet orange are less commonly affected by canker diseases.

Fungal diseases of citrus

Scab disease of citrus

Hossain (2011) studied the nursery diseases of citrus in Bangladesh during the period of 2010-2011. He recorded scab disease in different citrus growing areas of Bangladesh.

Chowdhury (2009) studied on the effect of weather factors on the incidence and severity of scab disease of citrus seedling. Significant effect of temperature, relative humidity and rainfall on the incidence and severity of different diseases of citrus seedlings were observed. In case of scab disease of citrus seedlings, the highest incidence (57.53%) and severity (45.43%) were recorded during the month of July, 2007 at temperature, RH and rainfall of 28.87^{0}C, 85.67% and 62.60 cm, respectively. On the other hand, lowest incidence (21.12%) and severity (14.37%) were recorded during the month of April 2008 at temperature, RH and rainfall of 28.53 ^{0}C, 67.67% and 4.93cm, respectively.

Bal and Dhiman (2005) observed that citrus scab (*Elsinoe fawcettii*) was serious disease in Kinnow mandarin nursery plants. The highest incidence of citrus scab (66.6%) was recorded during the second week of September and both diseases showed a positive correlation with temperatures relative humidity and rain fall. The period from July to September was identified as the most conducive for the development of citrus scab. The nursery should be provided with the required protection against this disease during the period.

Agosthini (2003) conducted an experiment on citrus scab (*Elsinoe fawcettii*) and found external blemishes on citrus fruit, reducing acceptability of the fruit for the fresh market. In laboratory studies, rough lemon seedlings and grapefruit seedlings were inoculated with conidia of *E. fawcettii* and exposed to a range of temperatures and durations of leaf wetness. Scab was most severe at temperatures from 23.5 to 27°C and much less severe at 17, 20, 30, or 32°C. Leaf wetness duration of 4 hr was sufficient for some infection, but 12h of leaf wetness were needed for maximum infection with scab. In field studies, grapefruit seedlings with new shoots were placed beneath trees weekly and disease severity was evaluated in relation to environmental factors. Scab severity increased

sharply with an increase in total weekly rainfall, leaf wetness durations of greater than 80h per week and average temperatures above 22°C.

Huang and Huang (2002) reported that approximately 50% of fruits from Nanfengmiju trees were damaged by citrus scab (*Elsinoe fawcettii*). The main reasons were annual applications of multiple fungicides and unfavorable weather conditions (Much rainfall and high humidity and frost damage). Control was possible by spraying spring buds of 0.5 mm long with Bordeaux mixture followed by 2 sprayings of Bordeaux mixture between August and October (2000 ppm) compared to the untreated control (465 fruit per tree).

Ran *et al.* (2001) sprayed the pesticides Mancozeb M-45, Carbendazim, Topsin M (Thiophanatemethyl) and Pyridaben in a citrus orchard at different concentrations to control citrus diseases and citrus rust mite. Spraying were applied at different stages. The results showed that the best control of citrus scab was achieved by spraying a 600-times solution of 80% M-45 when the shoots were 2 cm long then twice more at two days intervals (total of 3 times). Spraying a 600-times solution of 80% M-45 after flower fall and again at intervals of 15 days (total of 4 times) gave good control of citrus black spot. Also spraying a 500-600 times solution of M-45 wettable powder gave good control of rust mite its effect could last for 30 days.

Tyson *et al.* (2000) conducted an experiment on citrus scab (*Elsinoe fawcettii*) in New Zealand and briefly discussed with regard to the disease symptom, disease cycle, disease severity, chemical control and fungicide resistance against scab.

Singh *et al.* (2000) conducted an experiment to management of citrus scab. They used Blitox-SO (Copper oxychloride), Bordeaux mixture, Derosal (Carbendazim) Chlorothalonil and lndofil M-45 (Mancozeb) at l000 ppm each were tested against the pathogen (*Elsinoe fawcettii*) in vitro culture resulting in 81.1, 88.0, 77.2, 76.6 and 64.4%

growth inhibition of the pathogen over untreated control respectively. Blitox-SO at 0.3%. Bordeaux mixture at l% Derosal at 0.2% Chlomthalonil at 0.2% and Indofil M-45 at 0.3% reduced the disease incidence in the field by 47.8, 69.5, 46.2, 50.4 and 40.4% over control respectively. *Trichoderma viride, T. rersei* and *Epicoccum purpurascens* showed antibiosis whereas *Trichoderma harzianum* and *E. purpurascens* reduced the disease incidence in the field on spraying by 17.8 and l0% respectively out of 64 citrus species / cultivars screened under natural conditions in the field Indofil M-45 were free from infection, 4 tolerant, 7 moderately susceptible, 4 susceptible and 5 highly susceptible with 0-10%, 11-20%, 21-30% and above 30% disease index respectively.

Huang (1999) reported that citrus scab (*Elsinoe fawcettii*) attacked the expanded leaves of spring shoots of Satsuma mandarian and started to attack the fruitlets in mid-late May in Jiangxi, China. During the autumn, if the temperature and humidity are favorable, it attacks the young shoots and fruitlets causing up to 65.9-72.2% fruit let drop.

Singh *et al.* (1998) conducted an experiment on the development of citrus scab. They collected total of 505 scab-infected rough lemon leaves in the Indian Punjab to test the epidemiology and survival of *E fawcettii*. Disease was shown to be initiated during August when the mean atmospheric temperature, relative humidity and rainfall were 29.8°C, 75% and 2.5 mm, respectively. A decrease in temperature and an increase in relative humidity in September favored the further development of the disease. The fungus was shown to survive on susceptible citrus species as dormant mycelium or conidia.

Timmer *et a1.* (1992) reported that scab symptoms could appear on leaves as early as 4 days after infection. The disease started as small, pale orange, usually somewhat circular, elevated spots. As the leaves developed, these infections became well-defined warts or protuberances on one side of the leaf, often with a conical depression on the opposite side.

The lesions might be single or irregularly grouped. The crests of these wan-like growths usually became covered with a scabby, corky tissue pale in color, but sometimes dark if colonized by other fungi. The infected spots often run together and covered large areas with a corky scab growth. Badly infected leaves became crinkled, distorted and stunted having very little resemblance to normal foliage. The characteristic effects of the scab disease on twigs were the development of small masses of similar corky outgrowths on the surfaces. Scab symptoms on fruit could appear 7 days after infection. The disease started on the fruit by forming irregular scabby spots or cracked masses, which vary from cream-colored to pale yellow in young fruits to drab or olive-gray with age. Fruits severely attacked when very young often became misshapen, with predominant warty projections or conical growths extending from the surface, especially on Temples. On grapefruit, infected areas tend to flatten out, resembling wind scar injury. On tangelos, lemons and sour orange, the scabby areas were at the tip of blister-shaped projections on the rind.

Tripathi and Srivustava (1992) conducted an experiment on the effect of meteorological factors for the development of citrus scab. They found a correlation between the development of citrus scab disease caused by *Spaceloma fawcettii [Elsinoe fawcettii]* in Srinagar, India, and the three most important environmental factors (humidity, rainfall and temperature). Although the disease on leaves and fruits appeared during summer (April-June), little progress was observed during these months. With the onset of the rainy season (July-September) the infection progressed well and was seldom exposed to severe conditions. A definite correlation was observed among the disease intensities on various cultivars of citrus and meteorological factors. The relative humidity of the area had a positive significant effect on the disease development; whereas rainfall showed a positive non-significant effect and temperature had a negative non-significant effect.

Whiteside (1990) conducted 3 years trial with 4 fungicides namely Dithianon and 2 Sterol inhibiting fungicides, Diniconazole and Difenoconazole to evaluate them against citrus scab caused by *Elsinoe fawcettii* in Florida, USA. They showed that Dithianon performed better than Copper fungicide treatments, recommended at the time of these field trials. However, Difenoconazole usually gave better control of scab than Dithianon. Where spray treatments were delayed until after some fruit had become infected, Difenoconazole reduced scab severity even more than Captafol (no longer available) because of its unique ability to inhibit the further development of existing pustules.

Anthracnose & die-back disease of citrus

Hossain and Roy (2006) isolated *Colletotrichum gloeosporioides*, *Fusarium solani*, *Botryodiplodia theobromae* as the causal agents of dieback of citrus.

Rahman (2003) worked on the effect of fungicides on citrus die-back. He observed that Rovral at 250 ppm spray solution at 10 days interval 4 times gave excellent control of die-back of citrus.

Ebenezar *et al.* (1996) observed effect of chemicals to prevent die-back of acid lime caused by *Colletotrichum gloeosporioides* in India (Tamil Nadu). They used 7 fungicides like Carbendazim, Mancozeb, Copper oxychloride, Zineb, Captafol, Bordeaux mixture and Aurafungin for testing their efficacy. All the fungicides reduce die-back of acid lime. The treatments which are used to control the disease with l% Bordeaux mixture being the most effective followed by 0.l% Carbendazim and 0.8% Bordeaux mixture.

Broadbent *et al*. (1980) claimed that citrus dieback was to be caused by a mycoplasma like organism in Australia.

Raychaudhuri *et al*. (1980) observed that numerous agents including greening virus were involved in the causal complex of the devastating citrus dieback diseases occurring in India.

Talukder (1974) listed die-back or wither-tip caused by *Colletotrichum gloeosporioides* as one of the major disease of citrus occurring in Bangladesh.

Singh and Kapoor (1971) isolated *Colletotrichum gloeosporioides* from the diseased as well as healthy twigs of dieback affected citrus plants. In the pathogenicity test, they found the fungus most pathogenic to Kagzi lime among several citrus species including lemon.

Singh *et al*. (1971) showed that fungi such as *C. gloeosporioides* and *Fusarium* species in combination with citrus greening may be important in die-back, to which lemons are more susceptible than the orange.

Sharma and Sharma (1969) identified certain toxic metabolites (S-metabolites) produced by *Colletotrichum gloeosporioides* causing citrus dieback, a widely prevailing diseases in the northern India.

Knorr *et al.* (1957) described the symptoms of die-back of citrus in details. According to them the symptoms of the disease starts from the tips and extends for some distance down the limb ending in a sharp line. The whole twig, branch or trunk may often become affected. Barks of the affected twig develop a reddish-brown color and become dotted with small innumerable black structures-the fruiting bodies of the fungus. The drying symptoms progress slowly, leaves on the affected twigs turn yellow, wilt and drop. Gumming may occur at the junction between the healthy and diseased tissues. Fruiting bodies of the fungi are found on the dead barks.

Peralta (1949) reported a peculiar form of citrus die-back from Malta. The disease was characterized by its rapid on-set a complete absence of root symptoms and rapid death. The fungus isolated from the affected twig was *Colletitrichum gloeosporioides*.

Klotz and Stewart (1948) observed the occurrence of fruit stem die-back on orange and grapefruit in California. The disease was characterized by dying up to the fruit stem, starting near the fruit bottom and extending a few inches to 3 ft.

Bates (1936) observed a localized outbreak of twig, die-back of young premier orange trees caused by *Colletotrichum gloeosporioides* in southern Rhodesia.

Smith (1936) observed that die-back or Wither-tip or anthracnose of citrus a commonly occurring disease in Jamaica was prevalent in one of the districts of the country in 1935. The fungus *Colletotrichum gloeosporioides* was found to be the most commonly associated with the disease.

Burger (1924) reported that the damage of citrus due to die-back disease of an obscure etiology specially on light and sandy soils in Florida. During I923 in Saint Lucia, West lndies, a die-back of lime trees (*Citrus medica var acida* syn. *Citrus aurantifolia*) characterized by yellowing and falling of the leaves, casting fruit, browning of the young tips of the branches and subsequent extension to a main branch and drying up, was associated with poor soil almost without exception.

Guava

Guava is considered as a popular and nutritious fruit species in Bangladesh. And, from a research and development point of view, it is found to be attacked by different diseases. The diseases of guava seedlings have been studied in Bangladesh to a limited extent. In this chapter an attempt has been made to review the available literature about symptoms of diseases of guava, their causal organisms, diseases status and their management.

Algal rust disease of guava

Hossain *et al.* (2011) studied the nursery diseases of guava in Bangladesh during the period of 2010-2011. He recorded leaf blight and algal rust in different guava growing areas of Bangladesh.

Pathak (1989) reported the alga, *Cephaleuros virescens* Kunze that caused severe damage to leaves and fruits of guava. On leaves, the spots may vary from specks to big patches. The pathogen was extended between cuticle and epidermis and penetrated the epidermal cell.

Fungal diseases of guava

Chowdhury *et al*., (2011) studied the seedling diseases of guava and effect of temperature, rainfall and humidity on the prevalence of anthracnose (*Colletotrichum gloeosporioides*) in the nurseries of Bangladesh during 2005-2008. Important plant pathogens viz. *Colletotrichum gloeosporioides* and *Fusarium oxysporum* were detected and identified. Incidence and severity of anthracnose of guava varied significantly from season to season as well as from location to location and was also positively correlated with temperature, rainfall and relative humidity.

Chowdhury (2009) studied on the effect of weather factors on the incidence and severity of anthracnose of guava seedling. Significant variations of the incidence and severity of different diseases of guava seedlings due to variations of the temperature, relative humidity and rainfall were observed in different data recording times. In case of anthracnose diseases of guava seedlings, the highest incidence (20.00%) and severity (16.19%) were recorded in July 2007 at temperature, RH and rainfall of 28.87 ^{0}C, 85.67 ^{0}C and 62.60 cm, respectively. On the other hand, no incidence (0.00%) was recorded in January 2008 at temperature, RH and rainfall of 18.10 ^{0}C, 75.33% and 2.73 cm, respectively.

Islam (2005) worked on the effect of different cultural and chemical treatments on the management of anthracnose, die-back and leaf spot of guava. He found that Rovral 50 WP (0.2%) at 30 days interval control the above mentioned diseases effectively.

Lim *et al*. (2003) studied diseases of guava including distribution, importance and control of guava (*Psidium guajava*) diseases, together with characteristics and production of the fruit. Important diseases include anthracnose (*Glomerella cingulata*), damping-off fungus (*Rhizoctonia solani*), guava wilt disease (caused by *Fusarium oxysporum* f. sp. *psidii* among others) and the gall-forming nematode, *Meloidogyne* spp. Postharvest rots can be caused by a variety of microorganisms including *Cylindrocladium, Lasiodiplodia, Mucor* and *Rhizopus* species.

Wahid (1999) tested five isolations of *C. gloeosporioides* for their ability to grow on PDA. Enzymatic activity of these isolates was significantly different as well as their sensitivity towards Rovral [Iprodione].

Ansar *et al.* (1997) investigated the cause of control of guava branch decline in Pakistan. They found *C. gloeosporioides* as the main causal agent for decline of guava. *Fusarium*

oxysporum was also isolated from disease twigs. When both the fungi were present together then they acted synergistically and rapidly cause decline. Good control to the disease was obtained by combined use of Topsin M (Thiophanate methyl) and the Cupravit (Antagonist).

Dwivedi *et al.* (1994) reported that disease incidence in guava orchards from 3.9 to 30%. Symptoms included defoliation, die-back and bark cracking. Among the associated pathogens, *Fusarium solani, F. oxysporum* and *F. oxysporum f. sp. psidii* pre-dominated in all seasons.

Thakore *et al.* (1994) treated die-back affected plant with Biltox-SO (Copper oxychloride), Dithane M-45 (Mancozeb) and Macuprex (Cupranneb + Bordeaux). They found all fungicides were effective against the disease. Then they used 500, 1000 and 2000 ppm for each fungicides. They observed that 2000 ppm was most effective dose against the disease for all the fungicides.

Hossain (1993) conducted several years trial with seven fungicides, namely Bordeaux mixture (4: 4: 40), Zineb (2g/L), Topsin M-70 WP (1g/L), Dithane M-45 (2g/L), Bavistin (1g/L), Morestin (1g/L) and Daconil (1g/L), to evaluate them against anthracnose disease of guava at Agricultural Research Station, Khagrachari during kharif season of 1986 and 1987. He was concluded that Topsin M and Dithane M-45 are best in controlling anthracnose disease in guava.

Rahman and Hossain (1988) evaluated Bavistin (0.l%), Bordeaux mixture (5: 5: 50), Cupravit (0.2%), Dithane M-45 (0.2%) and Topsin M (02%) against guava anthracnose under field condition at Sarupkati on sarupkati variety. The chemicals were applied 4 times at 5 days interval [beginning at flower bud in initiation, at full blooming, at fruit setting] and 5 days after the 3rd spray. Severity of disease was recorded l0 days after the

final spray Topsin M and Dithane M-45 sprayed at flower bud initiation significantly reduced fruit infection (40% over control).

Pandey (1988) reported that, *Colletotrichum gloesporioides* and *Pestalotia psidii* were found in guava to be the dominant pathogens causing *in vitro,* Benomyl and Mancozeb gave the maximum inhibition of spore germination and germ tube length in *Colletotrichum gloesporioides* and Benomyl was most effective against *P. psidii.* The effects of 3 concern of 2 and 4 fungicides were tested in the rainy and winter seasons, respectively, Benomyl was most effective against the pathogens, and appeared to have the least effect on phylloplane fungi. Greatest decreases in the number of fungal species colonizing leaves were observed after treatment with Mancozeb.

Meah and Khan (1987) recorded five diseases of guava in the orchards where anthracnose was found in high intensity in some parts of the country.

Kabir and Meah (1987) sprayed guava plant, in Horticulture base, Keyotkhali in 1986 prior to symptoms appearance with Dithane M-45, Topsin M, Cupravit, Dithane Z-78 and Rovral FLO. They found an excellent control of the fruit infection with 5 sprays of Topsin M (0.2%), Rovral FLO (0.2%) and Dithane Z-78 (0.3%).

Meah and Khan (1986) worked on Bavistin, Rovral WP, Dithane M-45 and Topsin M in vitro against *Colletotrichum gloeosporioides* the cause of fruit rot of guava. They observed that Bavistin (0.2%), Rovral WP (0.2%) and Topsin M (0.2%) were effective in inhibiting the mycelial growth of the test fungus.

Tandon and Singh (1969) observed the symptoms of anthracnose of guava caused by *Gloeosporioides psidii* at Sharanpur. The appearance of spots on fruits were especially during the rainy season. Small spots of pin head size fruit appeared on the unripe fruits

inocula gradually enlarged and attained a size of 5-6 mm in diameter. The spots were dark brown to black in color, sunken, circular and bore minute. Several spots coalesced to form bigger lesions. The infected area in the unripe fruits was corky and harder than the healthy portion area often developed crakes in case of severe infection. On ripe fruits, the infection caused softening of issues and lesions attained a diameter of 10 to 20 mm. According to them, symptoms appeared on leaves, twigs and fruits. On leaves, ashy grey necrotic lesions appeared at the tip or on the margin which bore fruiting bodies. The tender twigs when infected gave "wither-tip" appearance dying from the tip downwards.

Tandon (1967) reported *Gloeosporium psidii, Phomopsis psidii, Botryodiplodia theobrome* and *Pestalotia psidii* on guava. He further mentioned that the latter two pathogens caused greater damage.

Mathur and Singh (1959) observed in all orchard near Kota, Rajasthan State, India, guava branches suffered from die-back, drying and defoliation, generally in association with *Hendesonula toruloidea*. No pycnidia was found in nature or obtained in culture.

Gupta *et al.* (1955) started that *Botryodiplodia theobromae* is one of the most serious pathogen of mulberry plant. It causes die-back and attack many plantation crop like pear, rose, mango, guava etc.

Tandon and Agarwala (1954) made a detailed study of the wilt and die-back of guava in Allahabad caused by *Gloeosporium psidii*. They reported total or partial death of the trees without fruiting, these ripen fruits bearing pinkish masses of acervuli. In June and July only old twigs were affected, but in August, the young shoots began to die-back. Severity of the disease continued to increase up to the beginning of October. In a severe case flowering was prevented and under conditioned favorable for development of the disease, the main trunk was affected. The cool season of January to March and the dry summer

weather from April to June prevented the spread of infection. Field and Laboratory pathogenicity tests during both the rainy season and the summer showed that the fungus readily attacked young shoots, injured, young leaves, flowers and fruits.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site

The experiment was conducted in three citrus, three guava orchards of Dinajpur and three citrus, three guava orchards of Thakurgaon district in Bangladesh. In Dinajpur district, six orchards of farmers were selected that located between 25 N latitude and 88.23 E longitude and about 37.5m above sea level. Six orchards in Thakurgaon district were selected that located between 26 N latitude and 88.46 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 facilitates and suitable to conduct agro forest as well as other field research. The selected orchards were many varieties of citrus and guava plants with different ages. Disease of citrus and guava were taken consideration by observing their symptoms and signs.

3.2. Period of experiments

The experiment was conducted for one year starting from the month of July, 2017 and end to May, 2018.

3.3. Topography and soil

The topography of land was medium high and soil was clay and texture having pH around 5.5 to 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 6.2 and the color of the soil was dark grayish brown to dark yellowish brown (Uddin *et al*. 2012).

3.4. Intercultural operation

Intercultural operations of citrus and guava i.e. weed control, spading, training and pruning were done by 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 treatment.

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

3.5.1. Selection of citrus orchard in Dinajpur

Citrus orchard of farmer was selected in three different locations of Dinajpur Sadar Upazila with the help of Upazila Sub-Assistant Agriculture Officer. Detailed of locations and farmers were as follows:

Sl. No. of orchard	Name of the farmer	Location /village	Total plants in the orchard	Age of the plants (years)	Selected plants (no.)
1	Polo	Pulhat	500	2	12
2	Solayman	Basher hat	1500	2	12
3	Sofikul	Basher hat	1000	2	12

3.5.2. Selection of citrus orchard in Thakurgaon

Citrus orchard of farmer was selected in three different locations of Thakurgaon Sadar Upazila with the help of Upazila Sub-Assistant Agriculture Officer. Detailed of locations and farmers were as follows:

Sl. No. of orchard	Name of the farmer	Location /village	Total plants in the orchard	Age of the plants (years)	Selected plants (no.)
4	Harun	Teliapara	500	2	12
5	Babu	Choto khochabari	1500	2	12
6	Salman	Boro khochabari	500	2	12

3.5.3. Selection of plants

The plants were selected from the orchard in Thakurgaon and Dinajpur districts as mentioned previously. From each orchard, 12 plants were selected randomly for the study which represent three replications in each treatment.

3.5.4. Experimental design

The experiment was carried out in Randomized Completely Block Design (RCBD) with two factorial experiment having three replications where location in one factor and treatments in another factor.

3.5.5. Fertilizer and manure application

Manure and fertilizer in orchards of Thakurgaon and Dinajpur was applied shown below:

Application of manure and fertilizer in citrus orchard (kg/ha)

Name of the Fertilizers and manure	/ha
Cow dung	12kg
Boron	1.0g
Urea(U)	90gm
Tripple Super Phosphate(TSP)	90gm
Murate of Potash(MOP)	100gm
Zn	4.0g

Source: Bangladesh Agricultural Research Council (BARC) for medium soil type in 2015

3.6. Severity of guava disease of some selected guava plants in different orchards of Dinajpur and Thakurgaon

3.6.1. Selection of guava orchard in Dinajpur

Guava orchard of farmer was selected in three different locations of Dinajpur Sadar Upazila with the help of Upazila Sub-Assistant Agriculture Officer. Detailed of locations and farmers were as follows:

Sl. No. of orchard	Name of the farmer	Location /village	Total plants in the orchard	Age of the plants (years)	Selected plants (no.)
1	Abdul Hannan	Pulhat	1500	3	12
2	Hossan	Basherhat	500	3	12
3	Hamidur	Basherhat	500	3	12

3.6.2. Selection of guava orchard in Thakurgaon

Guava orchard of farmer was selected in three different locations of Thakurgaon Sadar Upazila with the help of Upazila Sub-Assistant Agriculture Officer. Detailed of locations and farmers were as follows:

Sl. No. of orchard	Name of the farmer	Location /village	Total plants in the orchard	Age of the plants (years)	Selected plants (no.)
4	Eidu	Teliapara	1000	3	12
5	Jodu	Choto khochabari	1000	3	12
6	Kawsar	Boro khochabari	500	3	12

3.6.3. Selection of plants

The plants were selected from the orchard in Thakurgaon and Dinajpur districts as mentioned previously. From each orchard, 12 plants were selected randomly for the study which represent three replications in each treatment.

3.6.4. Experimental design

The experiment was carried out in Randomized Completely Block Design (RCBD) with two factorial experiment having three replications where location in one factor and treatments in another factor.

3.6.5. Fertilizer and manure application

Manure and fertilizer in orchards of Thakurgaon and Dinajpur was applied shown below:

Application of manure and fertilizer in guava orchard (kg/ha)

Name of the Fertilizers and manure	/ha
Cow dung	15kg
Sulfur	9gm
Urea(U)	138gm
Tripple Super Phosphate(TSP)	70gm
Murate of Potash(MOP)	150gm

Source: Bangladesh Agricultural Research Council (BARC) for medium soil type in 2015

3.7. Treatments

For management of citrus and guava diseases, four different treatments were applied as foliar spray at 30 days interval. The treatments were as follows:

T_0 = Control

T_1 = Spraying of Iprodione @ 2g/L

T_2 = Spraying of Copper oxychloride @ 3g/L

T_3 = Spraying of Mancozeb @ 3g/ L

3.7.1. Preparation of Iprodione solution (2g/L)

'Rovral 50 WP' was the trade name of Iprodione which is marketed by Bayer Crop Science Ltd. Rovral 50 WP had the Iprodione concentration 50%. So, to prepare Iprodione solution (2g/L), Rovral 50 WP (16g) was taken in a 8L bucket and water was added up to the mark. The material was then stirred properly until the mixing was complete. As a result, 2g/L Iprodione solution was prepared.

3.7.2. Preparation of Copper oxychloride solution (3g/L)

'Cupravit' was the trade name of Copper oxychloride which is marketed by SAM Agro. Chemical, Dhaka. Cupravit had the Copper oxychloride concentration 50%. So, to prepare

Copper oxychloride solution (3g/L), Cupravit (24 g) was taken in a 8 L bucket and water was added up to the mark. The material was then stirred properly until the mixing was complete. As a result, 3g/L Copper oxychloride solution was prepared.

3.7.3. Preparation of Mancozeb solution (3g/ L)

'Dithane M-45'was the trade name of Mancozeb which is marketed by Dow Agro Sciences company product. Dithane M-45 had the Mancozeb concentration 75%. So, to prepare Mancozeb solution (3g/L), Dithane M-45 (24 g) was taken in a 8 L bucket and water was added up to the mark. The material was then stirred properly until the mixing was complete. As a result, 3g/L Mancozeb solution was prepared.

3.7.4. Application of spray solution

Required amount of spray solution of Iprodione**,** Copper oxychloride and Mancozeb prepared as mentioned above were sprayed on the selected plants. The test chemicals were sprayed fifth times at 30 days interval. The first spray was done at 1st July, 2017. 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.

3.8. Assessment of disease severity on citrus plants

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).

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

3.8.1. Identification of diseases on citrus plants

Symptoms of the diseases were identified by comparing its symptom. Only the top diseases of citrus were considered for the study.

3.8.2. Identification of diseases on guava plants

Symptoms of the diseases were identified by comparing its symptom. Only the top diseases of guava were considered for the study.

3.8.3. Data recording times

Each plant was observed carefully to collect the data on disease severity. Data on disease severity was recorded five times at one month interval. The first time data was recorded at 1st July, 2017 and the second time data was recorded at 1st August. In this way last data was recorded at 1st November, 2017. The time of data collection was determined on the basis of time of fungicide application during the growing season.

3.8.4. Data recorded on citrus plants

The data were recorded five times on the following parameters at an interval of one month starting from July, 2017:

1) Severity of canker disease

2) Severity of scab disease

3) Severity of anthracnose disease

4) Severity of die-back phase

3.8.5. Data recorded on guava plants

The data were recorded five times on the following parameters at an interval of one month starting from July, 2017:

1) Severity of algal rust disease

2) Severity of anthracnose disease

3) Severity of die-back phase

3.8.6. Weather and climate

The climate of the experimental area was 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 kharif season.

3.9. Statistical analysis

Data on various parameters were subjected to analysis of variance following MSTATC computer program and the means were compared by New Duncan's Multiple Range Test (DMRT).

CHAPTER 4

RESULTS

CHAPTER 4

RESULTS

Disease severity of citrus and guava was determined and their management was studied by different experiments in the various orchards of Dinajpur and Thakurgaon districts of Bangladesh. Altogether four diseases of citrus viz. canker, scab, anthracnose and die-back and three diseases of guava viz. algal rust, anthracnose and die-back were recorded.

4.1. Symptoms of citrus diseases

The symptoms of different diseases of citrus as observed in the field were as follows:

4.1.1. Canker

Citrus canker is a disease affecting *Citrus* species caused by the bacterium *Xanthomonas axonopodis pv. citri*. Infection causes lesions on the leaves, stems, and fruit of citrus trees, including lime, oranges, and grapefruit. Plants infected with citrus canker have characteristic lesions on leaves, stems, and fruit with raised, brown, water-soaked margins, usually with a yellow halo or ring effect around the lesion. Older lesions have a corky appearance, still in many cases retaining the halo effect. Canker significantly affects the vitality of citrus trees, causing leaves and fruit to drop prematurely.

Plate 1. Canker disease symptoms on citrus leaves

4.1.2. Scab

Lemon scab is a serious disease of all lemon varieties. Lemon scab is caused by the fungus *Sphaceloma fawcettii var. scabiosa.* The characteristics symptoms of the disease was observed as raised, irregular corky spots on leaves and fruits. No disease symptoms were observed on flowers. The disease first noticed as small, somewhat raised spots and then became irregular corky on leaves and fruits. The spots ranged from a few millimeters to one centimeter in diameter. Badly infected leaves became crinkled and stunted. The spots were found more often on the lower surface of leaves than on the upper surface. Several spots coalesced together to form large patches of corky out growth.

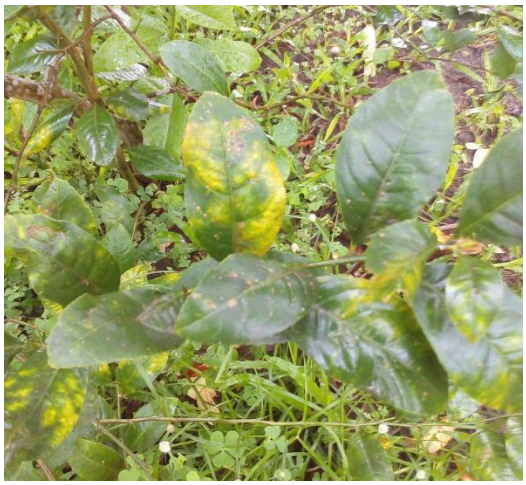

Plate 2. Scab disease symptoms on citrus leaves

4.1.3. Anthracnose

Anthracnose of citrus is caused by the fungus *Glomerella cingulata.* Leaves display more or less circular spots of light tan color with a prominent purple margin. The center of these spots gradually turn grayish and, in the later phases of the infection, it may show tiny dispersed black flecks. Tissues injured by environmental factors (such as insect damage or otherwise inflicted lesions) are more susceptible to the colonization by the anthracnose fungus. Fruits that have previously been injured by other agents like sunburn, chemical

burn, pest damage, bruising, or unfavorable storage conditions, are particularly prone to develop anthracnose. Fruit symptoms are firm and dry, brown to black spots of 1.5 mm or slightly greater diameter. The spore masses growing on the lesions are usually brown to black, but under humid conditions, they can turn pink to salmon. Several spots coalesced together to form large patches. In case of severe infection, the twig will be distorted.

Plate 3. Anthracnose disease symptoms on citrus leaves

4.1.4. Die-back phase

Causal organisms of die-back of citrus are *Colletotrichum gloeosporioides*, *Fusarium solani* and *Botryodiplodia theobromae*. The plant begins to die backwards form the top of a branch. Young shoots, leaves and fruits are readily attacked, while they are still tender. The greenish color of the growing tip is changed to dark brown and later to black necrotic areas extending backwards. The fungus develops from the infected twigs and then petiole and young leaves which may drop down or fall leaving the dried twigs without leaves.

Plate 4. Die-back symptoms on citrus leaves

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after one month of fungicide application. The highest (6.00%) severity of canker was observed in orchard 2 and the lowest severity ranges of canker was (5.00%) observed in orchard 1 which was statistically similar to orchard 3. The highest and the lowest severity ranges of scab disease were 7.25% to 6.25% (Table 1). The highest (7.25%) severity was observed in orchard 2 and the lowest (6.25%) disease severity was recorded in orchard 3 which was statistically similar to orchard 1. Similarly, the highest severity (8.50%) of anthracnose was observed in orchard 3 and the lowest severity (6.50%) was observed in orchard 2 which was statistically similar to orchard 1. In case of die-back, the highest severity (8.25%) was observed in orchard 3 and lowest severity (7.00%) was observed in orchard 1 and orchard 2 (Table 1).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after one month of fungicide application. The highest (5.50%) severity was observed in orchard 4 and orchard 5 and the lowest severity ranges of canker was (5.25%) observed in orchard 6. The highest (6.25%) severity of scab was observed in orchard 5 and the lowest (5.75%) disease severity was recorded in orchard 6. Similarly,

the highest severity (6.75%) of anthracnose was observed in orchard 4 and orchard 6 and the lowest severity (5.50%) was observed in orchard 5. In case of die-back, the highest severity (6.75%) was observed in orchard 6 and lowest severity (6.25%) was observed in orchard 4 (Table 1).

Table 1. Effect of location on disease severity of citrus after one month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur				Orchard	Thakurgaon			
	Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
1	5.00 a	6.50 a	7.25 b	7.00 a	4	5.50 a	6.00 a	6.75 a	6.25 a
2	6.00 a	7.25 a	6.50 b	7.00 a	5	5.50 a	6.25 a	5.50 a	6.50 a
3	5.50 a	6.25 a	8.50 a	8.25 a	6	5.25 a	5.75 a	6.75 a	6.75 a
LSD	1.26	1.36	1.20	1.30	LSD	1.15	1.20	1.21	1.20
CV %	27.09	24.11	19.07	20.70	CV%	25.15	23.57	22.54	21.88

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after one month of fungicide application in response of treatments (Table 2). The highest (6.00%) disease severity of canker was recorded in T_2 and the lowest severity of canker was (5.00%) recorded in T_3. The highest disease severity of scab disease (8.00%) was observed in T_0 and the lowest severity ranges (5.33%) was observed in T_1. Similarly, the highest severity (8.33%) of anthracnose was observed in T_0 and the lowest severity (6.67%) was observed in T_1 and T_3. In case of die-back the highest severity (8.33%) was observed in T_0 and lowest severity (6.67%) was observed in T_1 and T_3 (Table 2).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after one month of fungicide application in response of treatments (Table 2). The highest (6.33%) disease severity of canker was recorded in T_2

and the lowest severity of canker was (5.00%) recorded in T_0 and T_1. The highest disease severity of scab disease (6.67%) was observed in T_1 and the lowest severity ranges (6.00%) was observed in T_0. Similarly, the highest severity (6.67%) of anthracnose was observed in T_0 and T_1. The lowest severity (5.67%) was observed in T_3. In case of die-back, the highest severity (7.67%) was observed in T_1 and the lowest severity (5.00%) was observed in T_2 (Table 2).

Table 2. Effect of treatment on disease severity of citrus after one month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur				Thakurgaon			
	Canker	Scab	Anthracnose	Die-back	Canker	Scab	Anthracnose	Die-back
T_0	5.33 a	8.00 a	8.33 a	8.33 a	5.00 a	6.00a	6.67 a	7.33ab
T_1	5.67 a	5.33 b	6.67 b	6.67 b	5.00 a	6.67a	6.67 a	7.67 a
T_2	6.00 a	6.67ab	8.00 ab	8.00ab	6.33 a	5.33a	6.33 a	5.00 c
T_3	5.00 a	6.67ab	6.67 b	6.67 b	5.33 a	6.00a	5.67 a	6.00bc
LSD	1.46	1.57	1.38	1.50	1.33	1.38	1.40	1.39
CV %	27.09	24.11	19.07	20.70	25.15	23.57	22.54	21.88

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Dinajpur in response of location and treatment effects were recorded after one month of fungicide application (Table 3). The highest (7.00%) disease severity of canker was observed in orchard 2 by T_0 treatment which was statistically similar with orchard 2 by T_1 treatment as well as orchard 1 by T_2 treatment and the lowest (3.00%) canker disease severity was recorded in orchard 1 by T_0 treatment. The lowest (5.00%) scab disease

severity was recorded in orchard 2 by treatment T_1 which is similar to orchard 3 by treatment T_1 and orchard 1 by treatment T_3, respectively and the highest (9.00%) disease severity of scab was observed in orchard 2 by treatment T_0. The severity of anthracnose varied significantly according to the location and treatment of the experiment. The highest (10.00%) disease severity of anthracnose was observed in orchard 3 by T_2 treatment and the lowest (5.00%) anthracnose disease severity was recorded in orchard 2 by T_1 treatment. The highest (10.00%) disease severity of die-back was observed in orchard 3 by T_2 treatment and the lowest (5.00%) die-back disease severity was recorded in orchard 1 by T_1 treatment which was statistically similar with orchard 2 by T_3 treatment (Table 3).

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Thakurgaon in response of location and treatment effects were recorded after one month of fungicide application (Table 3). The highest (7.00%) disease severity of canker was observed in orchard 4 and orchard 6 by T_2 treatment and the lowest (4.00%) canker disease severity was recorded in orchard 6 by T_0 treatment. The highest (8.00%) scab disease severity was recorded in orchard 6 by treatment T_1 and orchard 5 by treatment T_3 and the lowest (5.00%) disease severity of scab was observed in orchard 6 by treatment T_0 and orchard 5 by treatment T_1 and orchard 4 and orchard 6 by treatment T_2 and orchard 4 and orchard 6 by treatment T_3. The highest (8.00%) disease severity of anthracnose was observed in orchard 6 by T_0 treatment and orchard 6 by T_1 treatment and orchard 6 by T_1 treatment. The lowest (5.00%) anthracnose disease severity was recorded in orchard 5 by T_0 treatment and orchard 5 by T_1 treatment and orchard 6 by T_2 treatment and orchard 4 by T_3 treatment. The highest (10.00%) disease severity of die-back was observed in orchard 4 by T_2 treatment and the lowest (5.00%) die-back disease severity was recorded in orchard 4 by T_0 treatment and orchard 6 by T_1 treatment and orchard 4 and orchard 5 and orchard 6 by T_2 treatment and orchard 4 by T_3 treatment (Table 3).

Table 3. Interaction effect of location and treatment on disease severity of citrus after one month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur				Orchard	Thakurgaon			
		Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
T_0	1	3.00 c	8.00ab	8.00 abc	9.00ab	4	5.00ab	7.00ab	7.00 ab	5.00 b
	2	7.00 a	9.00 a	8.00 abc	8.00ab	5	6.00ab	6.00ab	5.00 b	8.00 a
	3	6.00 ab	7.00ab	9.00 ab	8.00ab	6	4.00 b	5.00 b	8.00 a	9.00 a
T_1	1	5.00abc	6.00ab	7.00 bcd	5.00 c	4	5.00ab	7.00ab	7.00 ab	10.00 a
	2	7.00 a	5.00b	5.00 d	8.00ab	5	5.00ab	5.00 b	5.00 b	8.00 a
	3	5.00abc	5.00 b	8.00 abc	7.00bc	6	5.00ab	8.00 a	8.00 a	5.00 b
T_2	1	7.00 a	7.00ab	7.00 bcd	7.00bc	4	7.00 a	5.00 b	8.00 a	5.00 b
	2	6.00 ab	7.00ab	7.00 bcd	7.00bc	5	5.00ab	6.00ab	6.00 ab	5.00 b
	3	5.00abc	6.00ab	10.00 a	10.00a	6	7.00 a	5.00 b	5.00 b	5.00 b
T_3	1	5.00abc	5.00b	7.00 bcd	7.00bc	4	5.00ab	5.00 b	5.00 b	5.00 b
	2	4.00 bc	8.00ab	6.00 cd	5.00 c	5	6.00ab	8.00 a	6.00 ab	5.00 b
	3	6.00 ab	7.00ab	7.00 bcd	8.00ab	6	5.00ab	5.00 b	6.00 ab	8.00 a
LSD		2.52	2.72	2.40	2.60	LSD	2.31	2.40	2.42	2.41
CV %		27.09	24.11	19.07	20.70	CV%	25.15	23.57	22.54	21.88

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after two month of fungicide application. The highest (6.75%) severity was observed in orchard 2 and the lowest severity ranges of canker was (5.75%) observed in orchard 1 which was statistically similar to orchard 3. The highest (7.50%) severity was observed in orchard 2 and the lowest (6.75%) disease severity was recorded in orchard 3 which was statistically similar to orchard 1. Similarly, the highest severity

(8.75%) of anthracnose was observed in orchard 3 which was statistically similar to orchard 1 and the lowest severity (6.50%) was observed in orchard 2. In case of die-back, the highest severity (8.75%) was observed in orchard 3 and lowest severity (7.25%) was observed in orchard 1 which was statistically similar to orchard 2 (Table 4).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after two month of fungicide application. The highest (5.75%) severity was observed in orchard 4 orchard 5 and the lowest severity ranges of canker was (5.50%) observed in orchard 6. The highest (6.75%) severity of scab was observed in orchard 5 and the lowest (6.25%) disease severity was recorded in orchard 4 and orchard 6. Similarly, the highest severity (7.00%) of anthracnose was observed in orchard 4 and orchard 6. The lowest severity (6.00%) was observed in orchard 5. In case of die-back, the highest severity (7.25%) was observed in orchard 6 and lowest severity (6.75%) was observed in orchard 4 (Table 4).

Table 4. Effect of location on disease severity of citrus after two month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur				Orchard	Thakurgaon			
	Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
1	5.75 a	7.25 a	8.00 a	7.25 b	4	5.75 a	6.25 a	7.00 a	6.75 a
2	6.75 a	7.50 a	6.50 b	7.75 ab	5	5.75 a	6.75 a	6.00 a	7.00 a
3	6.00 a	6.75 a	8.75 a	8.75 a	6	5.50 a	6.25 a	7.00 a	7.25 a
LSD	1.21	1.34	1.46	1.37	LSD	1.27	1.24	1.22	1.42
CV %	23.15	22.13	22.32	20.48	CV%	26.56	22.86	21.65	23.98

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after two month of fungicide application in response of treatments

(Table 5). The highest (6.67%) disease severity of canker was recorded in T_0 and T_2 and the lowest severity of canker was (5.33%) recorded in T_3. The highest disease severity of scab disease (9.33%) was observed in T_0 and the lowest severity ranges (5.67%) was observed in T_1. Similarly, the highest severity (9.33%) of anthracnose was observed in T_0 and the lowest severity (6.67%) was observed in T_1. In case of die-back the highest severity (10.67%) was observed in T_0 and lowest severity (6.33%) was observed in T_3 (Table 5).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after three month of fungicide application in response of treatments (Table 5). The highest (7.00%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (5.00%) recorded in T_1. The highest disease severity of scab disease (7.67%) was observed in T_0 and the lowest severity ranges (5.33%) was observed in T_2. Similarly, the highest severity (7.33%) of anthracnose was observed in T_0 and the lowest severity (5.67%) was observed in T_3. In case of die-back, the highest severity (9.33%) was observed in T_0 and lowest severity (5.00%) was observed in T_2 (Table 5).

Table 5. Effect of treatment on disease severity of citrus after two month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur				Thakurgaon			
	Canker	Scab	Anthracnose	Die-back	Canker	Scab	Anthracnose	Die-back
T_0	6.67 a	9.33 a	9.33 a	10.67 a	7.00 a	7.67 a	7.33 a	9.33 a
T_1	6.00 a	5.67 b	6.67 b	6.67 bc	5.00 b	6.67ab	6.67 ab	7.67 b
T_2	6.67 a	7.00 b	8.00 ab	8.00 b	5.33 b	5.33 b	7.00 ab	5.00 c
T_3	5.33 a	6.67 b	7.00 b	6.33 c	5.33 b	6.00 b	5.67 b	6.00 c
LSD	1.40	1.55	1.69	1.59	1.47	1.43	1.41	1.64
CV %	23.15	22.13	22.32	20.48	26.56	22.86	21.65	23.98

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Dinajpur in response of location and treatment effects were recorded after two month of fungicide application (Table 6). The highest (8.00%) disease severity of canker was observed in orchard 2 by T_0 treatment and the lowest (5.00%) canker disease severity was recorded in orchard 1 by T_0 treatment. The lowest (5.00%) scab disease severity was recorded in orchard 2 by treatment T_0 which is similar to orchard 3 by treatment T_1 and orchard 1 by treatment T_3, respectively and the highest (10.00%) disease severity of scab was observed in orchard 1 by treatment T_0 and orchard 2 by treatment T_0. The highest (10.00%) disease severity of anthracnose was observed in orchard 1 by T_0 treatment and orchard 3 by T_0 treatment and orchard 3 by T_2 treatment. The lowest (5.00%) anthracnose disease severity was recorded in orchard 2 by T_1 treatment. The highest (12.00%) disease severity of die-back was observed in orchard 1 by T_0 treatment and the lowest (5.00%)

die-back disease severity was recorded in orchard 1 by T_1 treatment and orchard 2 by T_3 treatment (Table 6).

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Thakurgaon in response of location and treatment effects were recorded after two month of fungicide application (Table 21). The highest (8.00%) disease severity of canker was observed in orchard 5 by T_0 treatment and the lowest (5.00%) canker disease severity was recorded in orchard 4, orchard 5 and orchard 6 by T_1 treatment and orchard 4 and orchard 5 by T_2 treatment and orchard 5 and orchard 6 by T_3 treatment. The highest (8.00%) scab disease severity was recorded in orchard 4 and 5 by treatment T_0 and orchard 6 by treatment T_1 and orchard 5 by T_3 treatment. The lowest (5.00%) disease severity of scab was observed in orchard 5 by treatment T_1 and orchard 4 and orchard 6 by treatment T_2 and orchard 4 and orchard 6 by treatment T_3. The highest (8.00%) disease severity of anthracnose was observed in orchard 6 by T_0 treatment and orchard 6 by T_1 treatment and orchard 4 by T_2 treatment. The lowest (5.00%) anthracnose disease severity was recorded in orchard 5 by T_1 treatment and orchard 5 by T_3 treatment. The highest (11.00%) disease severity of die-back was observed in orchard 6 by T_0 treatment and the lowest (5.00%) die-back disease severity was recorded in orchard 6 by T_1 treatment and orchard 4, orchard 5 and orchard 6 by T_2 treatment and orchard 4 and orchard 5 by T_3 treatment (Table 6).

Table 6. Interaction effect of location and treatment on disease severity of citrus after two month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur				Orchard	Thakurgaon			
		Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
T_0	1	5.00 b	10.00 a	10.00 a	12.00 a	4	7.00 ab	8.00 a	7.00 ab	7.00 bc
	2	8.00 a	10.00 a	8.00 ab	10.00 ab	5	8.00 a	8.00 a	7.00 ab	10.00 ab
	3	7.00 ab	8.00 ab	10.00 a	10.00 ab	6	6.00 ab	7.00 ab	8.00 a	11.00 a
T_1	1	6.00 ab	7.00 b	7.00 ab	5.00 c	4	5.00 b	7.00 ab	7.00 ab	10.00 ab
	2	7.00 ab	5.00 b	5.00 b	8.00 bc	5	5.00 b	5.00 b	5.00 b	8.00 abc
	3	5.00 b	5.00 b	8.00 ab	7.00 bc	6	5.00 b	8.00 a	8.00 a	5.00 c
T_2	1	7.00 ab	7.00 b	8.00 ab	6.00 c	4	5.00 b	5.00 b	8.00 a	5.00 c
	2	7.00 ab	7.00 b	6.00 b	8.00 bc	5	5.00 b	6.00 ab	7.00 ab	5.00 c
	3	6.00 ab	7.00 b	10.00 a	10.00 ab	6	6.00 ab	5.00 b	6.00 ab	5.00 c
T_3	1	5.00 b	5.00 b	7.00 ab	6.00 c	4	6.00 ab	5.00 b	6.00 ab	5.00 c
	2	5.00 b	8.00 ab	7.00 ab	5.00 c	5	5.00 b	8.00 a	5.00 b	5.00 c
	3	6.00 ab	7.00 b	7.00 ab	8.00 bc	6	5.00 b	5.00 b	6.00 ab	8.00 abc
LSD		2.42	2.69	2.93	2.75	LSD	2.55	2.48	2.44	2.84
CV %		23.15	22.13	22.32	20.48	CV%	26.56	22.86	21.65	23.98

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

T_0 = Control

T_1 = Spraying of Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after three month of fungicide application. The highest (6.25%) severity was observed in orchard 2 and the lowest severity ranges of canker was (5.50%) observed in orchard 1 which was statistically similar to orchard 3. The highest and the lowest severity ranges of scab disease were 7.50% to 6.50% (Table 7). The highest (7.50%) severity was observed in orchard 2 and the lowest (6.50%) disease severity was recorded in orchard 3 which was statistically similar to orchard 1. Similarly, the highest severity (7.75%) of anthracnose was observed in orchard 3 and the lowest severity

(6.50%) was observed in orchard 1. In case of die-back, the highest severity (8.00%) was observed in orchard 2 and orchard 3 and lowest severity (7.25%) was observed in orchard 1 (Table 7)

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after three month of fungicide application. The highest (6.50%) severity was observed in orchard 5 and the lowest severity ranges of canker was (6.00%) observed in orchard 4 and orchard 6. The highest (6.50%) severity of scab was observed in orchard 6 and the lowest (6.00%) disease severity was recorded in orchard 4. Similarly, the highest severity (7.50%) of anthracnose was observed in orchard 5 and the lowest severity (6.25%) was observed in orchard 4 and orchard 6. In case of die-back, the highest severity (8.50%) was observed in orchard 5 and lowest severity (6.75%) was observed in orchard 4 (Table 7).

Table 7. Effect of location on disease severity of citrus after three month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur				Orchard	Thakurgaon			
	Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
1	5.50 a	7.25 a	6.50 a	7.25 a	4	6.00 a	6.00 a	6.25 a	6.75 b
2	6.25 a	7.50 a	7.50 a	8.00 a	5	6.50 a	5.75 a	7.50 a	8.50 a
3	5.75 a	6.50 a	7.75 a	8.00 a	6	6.00 a	6.50 a	6.25 a	8.00 ab
LSD	1.30	1.31	1.32	1.26	LSD	1.20	1.24	1.26	1.42
CV %	26.19	21.88	21.51	19.22	CV%	23.06	23.98	22.35	21.57

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after three month of fungicide application in response of treatments (Table 2). The highest (9.33%) disease severity of canker was recorded in T_0

and the lowest severity of canker was (4.67%) recorded in T_1.The highest disease severity of scab disease (13.33%) was observed in T_0 and the lowest severity ranges (4.67%) was observed in T_1. Similarly, the highest severity (13.00%) of anthracnose was observed in T_0 and the lowest severity (4.67%) was observed in T_1. In case of die-back the highest severity (15.33%) was observed in T_0 and lowest severity (5.00%) was observed in T_1 and T_3 (Table 8).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after three month of fungicide application in response of treatments (Table 8). The highest (11.67%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (4.00%) recorded in T_1. The highest disease severity of scab disease (10.00%) was observed in T_0 and the lowest severity ranges (4.67%) was observed in T_2 and T_3. Similarly, the highest severity (11.67%) of anthracnose was observed in T_0 and the lowest severity (5.00%) was observed in T_1, T_2 and T_3. In case of die-back the highest severity (15.00%) was observed in T_0 and lowest severity (4.67%) was observed in T_2 (Table 8).

Table 8. Effect of treatment on disease severity of citrus after three month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur				Thakurgaon			
	Canker	Scab	Anthracnose	Die-back	Canker	Scab	Anthracnose	Die-back
T_0	9.33 a	13.33 a	13.00 a	15.33 a	11.67 a	10.00 a	11.67 a	15.00 a
T_1	4.67 b	4.67 b	4.67 b	5.00 b	4.00 b	5.00 b	5.00 b	6.00 b
T_2	5.00 b	5.00 b	5.67 b	5.67 b	4.33 b	4.67 b	5.00 b	4.67 b
T_3	4.33 b	5.33 b	5.67 b	5.00 b	4.67 b	4.67 b	5.00 b	5.33 b
LSD	1.50	1.52	1.53	1.46	1.39	1.43	1.46	1.63
CV %	26.19	21.88	21.51	19.22	23.06	23.98	22.35	21.57

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Dinajpur in response of location and treatment effects were recorded after one month of fungicide application (Table 9). The highest (7.00%) disease severity of canker was observed in orchard 2 by T_0 treatment which was statistically similar with orchard 2 by T_1 treatment and the lowest (3.00%) canker disease severity was recorded in orchard 1 by T_0 treatment. The lowest (5.00%) scab disease severity was recorded in orchard 2 by treatment T_1 which is similar to orchard 3 by treatment T_1 and orchard 1 by treatment T_3, respectively and the highest (9.00%) disease severity of scab was observed in orchard 2 by treatment T_0. The highest (10.00%) disease severity of anthracnose was observed in orchard 3 by T_2 treatment and the lowest (5.00%) anthracnose disease severity was recorded in orchard 2 by T_1 treatment. The highest (10.00%) disease severity of die-back was observed in orchard 3 by T_2 treatment and the lowest (5.00%) die-back disease

severity was recorded in orchard 1 by T_1 treatment which was statistically similar with orchard 2 by T_3 treatment (Table 9).

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Thakurgaon in response of location and treatment effects were recorded after one month of fungicide application (Table 9). The highest (10.00%) disease severity of canker was observed in orchard 4 and orchard 6 by T_0 treatment. The lowest (3.00%) canker disease severity was recorded in orchard 5 by T_1 treatment. The highest (10.00%) scab disease severity was recorded in orchard 4, orchard 5 and orchard 6 by treatment T_0. The lowest (4.00%) disease severity of scab was observed in orchard 5 by treatment T_1 and orchard 5 by treatment T_2 and orchard 4 by treatment T_3. The highest (15.00%) disease severity of anthracnose was observed in orchard 5 by T_0 treatment. The lowest (5.00%) anthracnose disease severity was recorded in orchard 4, orchard 5 and orchard 6 by T_1 treatment and orchard 4, orchard 5 and orchard 6 by T_2 treatment and orchard 4, orchard 5 and orchard 6 by T_3 treatment. The highest (20.00%) disease severity of die-back was observed in orchard 5 by T_0 treatment and the lowest (4.00%) die-back disease severity was recorded in orchard 4 by T_2 treatment and orchard 5 by T_3 treatment (Table 9).

Table 9. Interaction effect of location and treatment on disease severity of citrus after three month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur				Orchard	Thakurgaon			
		Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
T_0	1	8.00 ab	15.00 a	11.00 b	16.00 a	4	10.00b	10.00 a	10.00 b	10.00 c
	2	10.00 a	15.00 a	15.00 a	15.00 a	5	15.00 a	10.00 a	15.00 a	20.00 a
	3	10.00 a	10.00 b	13.00 ab	15.00 a	6	10.00 b	10.00 a	10.00 b	15.00 b
T_1	1	5.00 c	5.00 c	4.00 c	4.00 b	4	5.00 c	5.00 b	5.00 c	8.00 cd
	2	5.00 c	4.00 c	4.00 c	6.00 b	5	3.00 c	4.00 b	5.00 c	5.00 e
	3	4.00 c	5.00 c	6.00 c	5.00 b	6	4.00 c	6.00 b	5.00 c	5.00 e
T_2	1	5.00 c	5.00 c	6.00 c	5.00 b	4	4.00 c	5.00 b	5.00 c	4.00 e
	2	6.00 bc	5.00 c	5.00 c	6.00 b	5	4.00 c	4.00 b	5.00 c	5.00 e
	3	4.00 c	5.00 c	6.00 c	6.00 b	6	5.00 c	5.00 b	5.00 c	5.00 e
T_3	1	4.00 c	4.00 c	5.00 c	4.00 b	4	5.00 c	4.00 b	5.00 c	5.00 e
	2	4.00 c	6.00 c	6.00 c	5.00 b	5	4.00 c	5.00 b	5.00 c	4.00 e
	3	5.00 c	6.00 c	6.00 c	6.00 b	6	5.00 c	5.00 b	5.00 c	7.00 de
LSD		2.59	2.62	2.64	2.52	LSD	2.41	2.47	2.52	2.83
CV %		26.19	21.88	21.51	19.22	CV%	23.06	23.98	22.35	21.57

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

T_0 = Control

T_1 = Spraying of Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after four month of fungicide application. The highest (6.50%) severity was observed in orchard 2 and the lowest severity ranges of canker was (5.75%) observed in orchard 1 which was statistically similar to orchard 3. The highest (8.00%) severity was observed in orchard 1 and the lowest (6.75%) disease severity was recorded in orchard 3. Similarly, the highest severity (10.00%) of anthracnose was observed in orchard 3 and the lowest severity (6.50%) was observed in orchard 1. In case of die-back,

the highest severity (8.50%) was observed in orchard 2 and lowest severity (7.50%) was observed in orchard 1 (Table 10).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after four month of fungicide application. The highest (7.25%) severity was observed in orchard 5 and the lowest severity ranges of canker was (5.25%) observed in orchard 6. The highest (7.00%) severity of scab was observed in orchard 4 and orchard 6. The lowest (6.75%) disease severity was recorded in orchard 4. Similarly, the highest severity (8.25%) of anthracnose was observed in orchard 5. The lowest severity (6.75%) was observed in orchard 6. In case of die-back, the highest severity (9.25%) was observed in orchard 5 and lowest severity (7.00%) was observed in orchard 4 (Table 10).

Table 10. Effect of location on disease severity of citrus after four month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur				Orchard	Thakurgaon			
	Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
1	5.75 a	8.00 a	6.50 b	7.50 a	4	6.25 ab	7.00 a	7.00 b	7.00 b
2	6.50 a	7.75 a	9.25 a	8.50 a	5	7.25 a	6.75 a	8.25 a	9.25 a
3	6.25 a	6.75 a	10.00 a	8.25 a	6	5.25 b	7.00 a	6.75 b	8.25 a
LSD	1.32	1.49	1.41	1.36	LSD	1.23	1.26	1.22	1.22
CV %	25.25	23.41	19.45	19.83	CV%	23.26	21.54	19.61	17.61

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after four month of fungicide application in response of treatments (Table 11). The highest (13.33%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (3.67%) recorded in T_2 and T_3. The highest disease severity of scab disease (18.33%) was observed in T_0 and the lowest severity ranges (3.67%) was observed in T_1. Similarly, the highest severity (21.67%) of anthracnose was observed in T_0

and the lowest severity (4.00%) was observed in T_1. In case of die-back, the highest severity (20.00 %) was observed in T_0 and lowest severity (4.00%) was observed in T_1 and T_3 (Table 11).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after four month of fungicide application in response of treatments (Table 11). The highest (15.00%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (3.00%) recorded in T_3.The highest disease severity of scab disease (15.00%) was observed in T_0 and the lowest severity ranges (4.00%) was observed in T_2 and T_3. Similarly, the highest severity (16.67%) of anthracnose was observed in T_0 and the lowest severity (4.00%) was observed in T_1. In case of die-back, the highest severity (20.00%) was observed in T_0 and lowest severity (4.00%) was observed in T_2 (Table 11).

Table 11. Effect of treatment on disease severity of citrus after four month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur				Thakurgaon			
	Canker	Scab	Anthracnose	Die-back	Canker	Scab	Anthracnose	Die-back
T_0	13.33 a	18.33 a	21.67 a	20.00 a	15.00 a	15.00 a	16.67 a	20.00 a
T_1	3.67 b	3.67 b	4.00 b	4.00 b	3.67 b	4.67 b	4.00 b	4.33 b
T_2	4.00 b	4.00 b	4.33 b	4.33 b	3.33 b	4.00 b	4.33 b	4.00 b
T_3	3.67 b	4.00 b	4.33 b	4.00 b	3.00 b	4.00 b	4.33 b	4.33 b
LSD	1.52	1.72	1.63	1.57	1.42	1.46	1.41	1.41
CV %	25.25	23.41	19.45	19.83	23.26	21.54	19.61	17.61

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Dinajpur in response of location and treatment effects were recorded after four month of fungicide application (Table 12). The highest (15.00%) disease severity of canker was observed in orchard 2 by T_0 treatment which was statistically similar with orchard 3 by T_0 treatment and the lowest (3.00%) canker disease severity was recorded in orchard 3 by T_1 treatment and orchard 3 by T_1 treatment and orchard 3 by T_2 treatment. The lowest (3.00%) scab disease severity was recorded in orchard 2 by treatment T_1 which is similar to orchard 2 by treatment T_1 and orchard 1 by treatment T_3, respectively and the highest (20.00%) disease severity of scab was observed in orchard 1 by treatment T_0 and orchard 2 by treatment T_0. The highest (25.00%) disease severity of anthracnose was observed in orchard 2 by T_0 treatment and the lowest (3.00%) anthracnose disease severity was recorded in orchard 1 by T_1 treatment. The highest (20.00%) disease severity of die-back was observed in orchard 1 by T_0 treatment and orchard 2 by T_0 treatment and orchard 3 by T_0 treatment. The lowest (3.00%) die-back disease severity was recorded in orchard 1 by T_1 treatment (Table 12).

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Thakurgaon in response of location and treatment effects were recorded after four month of fungicide application (Table 12). The highest (20.00%) disease severity of canker was observed in orchard 5 by T_0 treatment. The lowest (3.00%) canker disease severity was recorded in orchard 5 by T_1 treatment and orchard 4 and orchard 5 by T_2 treatment and orchard 4, orchard 5 and orchard 6 by T_3 treatment. The highest (15.00%) scab disease severity was recorded in orchard 4, orchard 5 and orchard 6 by treatment T_0. The lowest (4.00%) disease severity of scab was observed in orchard 4 by treatment T_1 and orchard 4, orchard 5 and orchard 6 by treatment T_2 and orchard 4, orchard 5 and orchard 6 by treatment T_3. The highest (20.00%) disease severity of anthracnose was observed in

orchard 5 by T_0 treatment and the lowest (4.00%) anthracnose disease severity was recorded in orchard 4, orchard 5 and orchard 6 by T_1 treatment and orchard 4 and orchard 6 by T_2 treatment and orchard 5 and orchard 6 by T_3 treatment. The highest (25.00%) disease severity of die-back was observed in orchard 5 by T_0 treatment. The lowest (4.00%) die-back disease severity was recorded in orchard 5 and orchard 6 by T_1 treatment and orchard 4, orchard 5 and orchard 6 by T_2 treatment and orchard 4 and orchard 5 by T_3 treatment (Table 12).

Table 12. Interaction effect of location and treatment on disease severity of citrus after four month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur				Orchard	Thakurgaon			
		Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
T_0	1	10.00b	20.00a	15.00 b	20.00a	4	15.00b	15.00a	15.00b	15.00c
	2	15.00a	20.00a	25.00 a	20.00a	5	20.00a	15.00a	20.00a	25.00a
	3	15.00a	15.00b	25.00 a	20.00a	6	10.00c	15.00a	15.00b	20.00b
T_1	1	4.00 c	4.00 c	3.00 c	3.00b	4	4.00d	5.00b	4.00c	5.00d
	2	4.00 c	3.00 c	4.00 c	5.00b	5	3.00d	4.00b	4.00c	4.00d
	3	3.00 c	4.00 c	5.00 c	4.00b	6	4.00d	5.00b	4.00c	4.00d
T_2	1	5.00 c	5.00 c	4.00 c	4.00b	4	3.00d	4.00b	4.00c	4.00d
	2	4.00 c	3.00 c	4.00 c	5.00b	5	3.00d	4.00b	5.00c	4.00d
	3	3.00 c	4.00 c	5.00 c	4.00b	6	4.00d	4.00b	4.00c	4.00d
T_3	1	4.00 c	3.00 c	4.00 c	3.00b	4	3.00d	4.00b	5.00c	4.00d
	2	3.00 c	5.00 c	4.00 c	4.00b	5	3.00d	4.00b	4.00c	4.00d
	3	4.00 c	4.00 c	5.00 c	5.00b	6	3.00d	4.00b	4.00c	5.00d
LSD		2.64	2.97	2.83	2.71	LSD	2.46	2.52	2.44	2.44
CV %		25.25	23.41	19.45	19.83	CV%	23.26	21.54	19.61	17.61

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after five month of fungicide application. The highest (7.25%) severity was observed in orchard 2 and the lowest severity ranges of canker was (6.25%) observed in orchard 1 which was statistically similar to orchard 3. The highest (8.50%) severity of scab was observed in orchard 2 and the lowest (7.00%) disease severity was recorded in orchard 3. Similarly, the highest severity (10.75%) of anthracnose was observed in orchard 3 which was statistically similar to orchard 2 and the lowest severity (8.00%) was observed in orchard 1. In case of die-back, the highest severity (11.25%) was observed in orchard 1 and lowest severity (9.25%) was observed in orchard 3 (Table 13).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after five month of fungicide application. The highest (8.00%) severity was observed in orchard 5 and the lowest severity ranges of canker was (5.75%) observed in orchard 6. The highest (8.00%) severity of scab was observed in orchard 5 and the lowest (6.50%) disease severity was recorded in orchard 4. Similarly, the highest severity (8.25%) of anthracnose was observed in orchard 5 and the lowest severity (7.33%) was observed in orchard 6. In case of die-back, the highest severity (9.00%) was observed in orchard 4. The lowest severity (8.67%) was observed in orchard 6 (Table 13).

Table 13. Effect of location on disease severity of citrus after five month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur				Orchard	Thakurgaon			
	Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
1	6.25 a	8.25ab	8.00 b	11.25 a	4	6.25 b	6.50 b	7.75 a	9.00 a
2	7.25 a	8.50 a	10.25 a	10.00 ab	5	8.00 a	8.00 a	8.25 a	8.83 a
3	6.75 a	7.00 b	10.75 a	9.25 b	6	5.75 b	7.50 ab	7.33 a	8.67 a
LSD	1.19	1.29	1.50	1.75	LSD	1.010	1.060	1.458	1.200
CV %	20.83	19.30	17.83	20.33	CV%	17.90	17.08	22.15	16.04

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Dinajpur were recorded after five month of fungicide application in response of treatments (Table 14). The highest (18.33%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (2.67%) recorded in T_1 and T_3.The highest disease severity of scab disease (23.33%) was observed in T_0 and the lowest severity ranges(2.33%) was observed in T_1. Similarly, the highest severity (28.33%) of anthracnose was observed in T_0 and the lowest severity (3.33%) was observed in T_1 and T_3. In case of die-back, the highest severity (29.33%) was observed in T_0 and lowest severity (3.67%) was observed in T_1 and T_3 (Table 14).

Canker, scab, anthracnose and die-back disease severity of three citrus orchards at Thakurgaon were recorded after five month of fungicide application in response of treatments (Table 14). The highest (19.00%) disease severity of canker was recorded in T_0 and the lowest severity of canker was (2.33%) recorded in T_1. The highest disease severity of scab disease (20.00%) was observed in T_0 and the lowest severity ranges (2.67%) was observed in T_3. Similarly, the highest severity (21.67%) of anthracnose was observed in T_0 and the lowest severity (3.00%) was observed in T_2. In case of die-back, the highest

severity (25.33%) was observed in T_0 and lowest severity (3.00%) was observed in T_3 (Table 14).

Table 14. Effect of treatment on disease severity of citrus after five month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur				Thakurgaon			
	Canker	Scab	Anthracnose	Die-back	Canker	Scab	Anthracnose	Die-back
T_0	18.33 a	23.33 a	28.33 a	29.33 a	19.00 a	20.00 a	21.67 a	25.33 a
T_1	2.67 b	2.33 b	3.33 b	3.67 b	2.33 b	3.67 b	3.11 b	3.33 b
T_2	3.33 b	3.00 b	3.67 b	4.00 b	2.67 b	3.00 b	3.00 b	3.67 b
T_3	2.67 b	3.00 b	3.33 b	3.67 b	2.67 b	2.67 b	3.33 b	3.00 b
LSD	1.38	1.50	1.69	2.02	1.167	1.224	1.684	1.385
CV %	20.83	19.30	17.83	20.33	17.90	17.08	22.15	16.04

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Dinajpur in response of location and treatment effects were recorded after one month of fungicide application (Table 15). The highest (20.00%) disease severity of canker was observed in orchard 2 by T_0 treatment which was statistically similar with orchard 2 by T_0 treatment and the lowest (2.00%) canker disease severity was recorded in orchard 3 by T_1 treatment and orchard 3 by T_1 treatment. and orchard 3 by T_2 treatment. The highest (25.00%) scab disease severity was recorded in orchard 1 by treatment T_0 and orchard 2 by treatment T_0 and the lowest (2.00%) disease severity of scab was observed in orchard 2 by treatment T_1 and orchard 3 by treatment T_1 and orchard 1 by treatment T_3. The highest (30.00%) disease severity of anthracnose was observed in orchard 2 by T_0 treatment and

orchard 3 by T_0 treatment and the lowest (2.00%) anthracnose disease severity was recorded in orchard 1 by T_2 treatment and orchard 1 by T_3 treatment. The highest (35.00%) disease severity of die-back was observed in orchard 1 by T_0 treatment and the lowest (3.00%) die-back disease severity was recorded in orchard 1 by T_1 treatment and orchard 1 by T_3 treatment (Table 15).

Severity of canker, scab, anthracnose and die-back disease of three citrus orchards at Thakurgaon in response of location and treatment effects were recorded after one month of fungicide application (Table 15). The highest (25.00%) disease severity of canker was observed in orchard 5 by T_0 treatment and the lowest (2.00%) canker disease severity was recorded in orchard 4 and orchard 5 by T_1 treatment and orchard 5 by T_2 treatment and orchard 5 by T_3 treatment. The highest (24.00%) scab disease severity was recorded in orchard 5 by treatment T_0 and the lowest (2.00%) disease severity of scab was observed in orchard 5 by treatment T_3. The highest (25.00%) disease severity of anthracnose was observed in orchard 5 by T_0 treatment and the lowest (2.00%) anthracnose disease severity was recorded in orchard 5 by T_1 treatment. The highest (26.00%) disease severity of die-back was observed in orchard 5 by T_0 treatment and the lowest (2.33%) die-back disease severity was recorded in orchard 5 by T_3 treatment (Table 15).

Table 15. Interaction effect of location and treatment on disease severity of citrus after five month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur				Orchard	Thakurgaon			
		Canker	Scab	Anthracnose	Die-back		Canker	Scab	Anthracnose	Die-back
T_0	1	15.00 b	25.00 a	25.00 b	35.00 a	4	17.00 b	16.00 c	20.00 b	25.00a
	2	20.00 a	25.00 a	30.00 a	28.00 b	5	25.00 a	24.00a	25.00 a	26.00a
	3	20.00 a	20.00 b	30.00 a	25.00 b	6	15.00 b	20.0 b	20.00 b	25.00a
T_1	1	3.00 c	3.00 c	3.00 c	3.00 c	4	2.00 c	4.00 d	4.00 c	4.00 b
	2	3.00 c	2.00 c	3.00 c	4.00 c	5	3.00 c	3.00 d	2.00 c	3.00 b
	3	2.00 c	2.00c	4.00 c	4.00 c	6	2.00 c	4.00 d	3.33 c	3.00 b
T_2	1	4.00 c	3.00 c	2.00 c	4.00 c	4	3.00 c	3.00 d	3.00 c	4.00 b
	2	4.00 c	3.00 c	4.00 c	4.00 c	5	2.00 c	3.00 d	3.00 c	4.00 b
	3	2.00 c	3.00 c	5.00 c	4.00 c	6	3.00 c	3.00 d	3.00 c	3.00 b
T_3	1	3.00 c	2.00 c	2.00 c	3.00 c	4	3.00 c	3.00 d	4.00 c	3.00 b
	2	2.00 c	4.00 c	4.00 c	4.00 c	5	2.00 c	2.00 d	3.00 c	2.33 b
	3	3.00 c	3.00 c	4.00 c	4.00 c	6	3.00 c	3.00 d	3.00 c	3.67 b
LSD		2.38	2.56	2.92	3.50	LSD	2.021	2.120	2.917	2.399
CV %		20.83	19.30	17.83	20.33	CV%	17.90	17.08	22.15	16.04

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Disease severity of guava was determined and their management was studied by different experiments in the various orchards of Dinajpur and Thakurgaon districts of Bangladesh. Altogether three diseases of guava viz. algal rust, anthracnose and die-back were recorded.

4.2. Symptoms of guava diseases

The symptoms of different diseases of guava as observed in the field were as follows:

4.2.1. Algal rust

Cephaleuros virescens is the causal organism of algal rust. Algal infects immature guava leaves during early spring flush. Minute, shallow brown velvety lesions appear on leaves specially on leaf tips, margins or areas near the mid vein and as the disease progresses, the lesions enlarge to 2-3 mm in diameter. On immature fruits the lesions are nearly black. As fruits enlarge, lesions get sunken and get cracked frequently on older blemishes as a result of enlargement of fruits, lesions are usually smaller than leaf spots. They are darkish green to brown or black to color.

Plate 5. Algal rust disease symptoms on guava leaves

4.2.2. Anthracnose

Anthracnose of guava is caused by the fungus *Glomerella cingulata.* Leaves display more or less circular spots of light tan color with a prominent purple margin. The center of these spots gradually turn grayish and, in the later phases of the infection, it may show tiny dispersed black flecks. Tissues injured by environmental factors (such as insect damage or otherwise inflicted lesions) are more susceptible to the colonization by the anthracnose fungus. Fruits that have previously been injured by other agents like sunburn, chemical burn, pest damage, bruising, or unfavorable storage conditions, are particularly prone to develop anthracnose. Fruit symptoms are firm and dry, brown to black spots of 1.5 mm or slightly greater diameter. The spore masses growing on the lesions are usually brown to black, but under humid conditions, they can turn pink to salmon. Several spots coalesced together to form large patches. In case of severe infection, the twig will be distorted.

Plate 6. Anthracnose disease symptoms on guava leaves

4.2.3. Die-back phase

The causal organism of die-back of guava is *Gloeosporium psidii*. The plant begins to die backwards form the top of a branch. Young shoots, leaves and fruits are readily attacked, while they are still tender. The greenish color of the growing tip is changed to dark brown and later to black necrotic areas extending backwards. The fungus develops from the infected twigs and then petiole and young leaves which may drop down or fall leaving the dried twigs without leaves.

Plate 7. Die-back symptoms on guava leaves

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after one month of fungicide application. The highest (7.50%) severity was observed in orchard 1 and the lowest severity ranges of algal rust was (5.50%) observed in orchard 2. The highest (8.75%) severity of anthracnose was observed in orchard 3 and the lowest (5.00%) disease severity was recorded in orchard 2. In case of die-back, the highest severity (6.00%) was observed in orchard 2 and lowest severity (5.00%) was observed in orchard 1 and orchard 3 (Table 16).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after one month of fungicide application (Table 16). The highest (7.75%) severity was observed in orchard 4 and the lowest severity ranges of algal rust was (6.25%) observed in orchard 6. The highest (6.75%) severity of anthracnose was observed in orchard 5 and the lowest (5.50%) disease severity was recorded in orchard 4. In case of die-back, the highest severity (6.75%) was observed in orchard 5 and lowest severity (6.00%) was observed in orchard 6 (Table 16).

Table 16. Effect of location on disease severity of guava after one month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur			Orchard	Thakurgaon		
	Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
1	7.50 a	7.50 a	5.50 a	4	7.75 a	5.50 a	6.50 a
2	5.50 b	5.00 b	6.00 a	5	6.75 ab	6.75 a	6.75 a
3	6.50 ab	8.75 a	5.50 a	6	6.25 b	6.50 a	6.00 a
LSD	1.095	1.37	1.23	LSD	1.25	1.24	1.15
CV %	19.91	22.89	25.66	CV%	21.36	23.34	21.23

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after one month of fungicide application in response of treatments (Table 17). The highest (7.00%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (5.67%) recorded in T_2. The highest disease severity of anthracnose disease (7.67%) was observed in T_0 and T_3. The lowest severity ranges of anthracnose (6.33%) was observed in T_2. Similarly, the highest severity (7.00%) of die-back was observed in T_0 and the lowest severity (4.67%) was observed in T_3 (Table 17).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after one month of fungicide application in response of treatments (Table 17). The highest (7.67%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (6.33%) recorded in T_2 and T_3. The highest disease severity of anthracnose disease (6.67%) was observed in T_0, T_1 and T_3. The lowest severity ranges of anthracnose (5.00%) was observed in T_2. Similarly, the highest severity (7.00%) of die-back was observed in T_3 and the lowest severity (5.67%) was observed in T_1 (Table 17).

Table 17. Effect of treatment on disease severity of guava after one month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur			Thakurgaon		
	Algal rust	Anthracnose	Die-back	Algal rust	Anthracnose	Die-back
T_0	7.00 a	7.67 a	7.00 a	7.67 a	6.67 a	6.33 a
T_1	5.67 a	6.67 a	5.33 b	7.33 a	6.67 a	5.67 a
T_2	6.67 a	6.33 a	5.67 ab	6.33 a	5.00 b	6.67 a
T_3	6.67 a	7.67 a	4.67 b	6.33 a	6.67 a	7.00 a
LSD	1.27	1.585	1.421	1.44	1.43	1.33
CV %	19.91	22.89	25.66	21.36	23.34	21.23

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Dinajpur in response of location and treatment effects were recorded after one month of fungicide application (Table 18). The highest (8.00%) disease severity of algal rust was observed in orchard 1 by T_0 treatment and orchard 3 by T_3 treatment. The lowest (5.00%)

algal rust disease severity was recorded in orchard 2 by T_1 treatment and orchard 3 by T_1 treatment and orchard 2 by T_2 treatment. The highest (9.00%) anthracnose disease severity was recorded in orchard 1 by treatment T_1 and the lowest (5.00%) disease severity was observed in orchard 2 by treatment T_2 and orchard 2 by T_3 treatment. The highest (7.00%) disease severity of die-back was observed in orchard 1, orchard 2 and orchard 3 by T_0 treatment and orchard 2 by T_1 treatment and orchard 3 by T_2 treatment. The lowest (4.00%) die-back disease severity was recorded in orchard 3 by T_1 treatment and orchard 3 by T_3 treatment (Table 18).

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Thakurgaon in response of location and treatment effects were recorded after one month of fungicide application (Table 18). The highest (10.00%) disease severity of algal rust was observed in orchard 4 by T_1 treatment. The lowest (5.00%) algal rust disease severity was recorded in orchard 6 by T_1 treatment and orchard 5 by T_2 treatment and orchard 4 by T_3 treatment. The highest (8.00%) anthracnose disease severity was recorded in orchard 5 by treatment T_0 and orchard 6 by treatment T_1. The lowest (5.00%) disease severity was observed in orchard 4 by treatment T_0 and orchard 4, orchard 5 and orchard 6 by T_2 treatment. The highest (8.00%) disease severity of die-back was observed in orchard 5 by T_2 treatment. The lowest (5.00%) die-back disease severity was recorded in orchard 5 by T_0 treatment and orchard 4 and orchard 6 by T_1 treatment and orchard 6 by T_2 treatment (Table 18).

Table 18. Interaction effect of location and treatment on disease severity of guava after one month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur			Orchard	Thakurgaon		
		Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
T_0	1	8.00 ab	7.00 abcd	7.00a	4	9.00ab	5.00b	7.00ab
	2	6.00 bc	6.00 bcd	7.00a	5	7.00bcd	8.00a	5.00b
	3	7.00 abc	10.00 a	7.00a	6	7.00bcd	7.00ab	7.00ab
T_1	1	7.00 abc	9.00 ab	5.00 ab	4	10.00 a	5.00 b	5.00 b
	2	5.00 c	4.00 d	7.00 a	5	7.00bcd	7.00 ab	7.00 ab
	3	5.00 c	7.00 abcd	4.00 b	6	5.00 d	8.00 a	5.00 b
T_2	1	9.00 a	6.00 bcd	5.00 ab	4	7.00bcd	5.00 b	7.00 ab
	2	5.00 c	5.00 cd	5.00 ab	5	5.00 d	5.00 b	8.00 a
	3	6.00 bc	8.00 abc	7.00 a	6	7.00bcd	5.00 b	5.00 b
T_3	1	6.00 bc	8.00 abc	5.00 ab	4	5.00 d	7.00 ab	7.00 ab
	2	6.00 bc	5.00 cd	5.00 ab	5	8.00abc	7.00 ab	7.00 ab
	3	8.00 ab	10.00 a	4.00 b	6	6.00 cd	6.00 ab	7.00 ab
LSD		2.19	2.75	2.46	LSD	2.50	2.47	2.31
CV %		19.91	22.89	25.66	CV%	21.36	23.34	21.23

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after two month of fungicide application (Table 19). The highest (7.25%) severity was observed in orchard 1 and the lowest severity ranges of algal rust was (6.00%) observed in orchard 2. The highest (10.50%) severity of anthracnose was observed in orchard 3 and the lowest (6.75%) disease severity was recorded in orchard 2.

In case of die-back, the highest severity (7.50%) was observed in orchard 3 and lowest severity (6.25%) was observed in orchard 1 and orchard 2 (Table 19).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after two month of fungicide application (Table 19). The highest (7.25%) severity was observed in orchard 4 and the lowest severity ranges of algal rust was (5.50%) observed in orchard 6. The highest (6.25%) severity of anthracnose was observed in orchard 5 and orchard 6. The lowest (5.25%) disease severity was recorded in orchard 4. In case of die-back, the highest severity (6.75%) was observed in orchard 6 and lowest severity (5.75%) was observed in orchard 4 (Table 19).

Table 19. Effect of location on disease severity of guava after two month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur			Orchard	Thakurgaon		
	Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
1	7.25 a	8.25 b	7.25 a	4	7.25 a	5.25 a	5.75 a
2	6.00 a	6.75 c	6.25 a	5	7.00 a	6.25 a	6.00 a
3	6.75 a	10.50 a	7.50 a	6	5.50 b	6.25 a	6.75 a
LSD	1.45	1.30	1.4	LSD	1.32	1.43	1.15
CV %	25.48	18.09	24.08	CV%	23.76	28.49	22.09

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after two month of fungicide application in response of treatments (Table 20). The highest (9.33%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (5.33%) recorded in T_1. The highest disease severity of anthracnose disease (11.67%) was observed in T_0. The lowest severity ranges of

anthracnose (6.67%) was observed in T_2. Similarly, the highest severity (10.00%) of die-back was observed in T_0 and the lowest severity (5.33%) was observed in T_3 (Table 20).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after two month of fungicide application in response of treatments (Table 20). The highest (9.00%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (5.00%) recorded in T_2. The highest disease severity of anthracnose disease (8.33%) was observed in T_0. The lowest severity ranges of anthracnose (4.33%) was observed in T_3. Similarly, the highest severity (8.67%) of die-back was observed in T_0 and the lowest severity (5.00%) was observed in T_2 (Table 20).

Table 20. Effect of treatment on disease severity of guava after two month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur			Thakurgaon		
	Algal rust	Anthracnose	Die-back	Algal rust	Anthracnose	Die-back
T_0	9.33 a	11.67 a	10.00 a	9.00 a	8.33 a	8.67 a
T_1	5.33 b	7.00 c	6.33 b	6.67 b	5.33 b	5.00 b
T_2	6.00 b	6.67 c	6.33 b	5.00 c	4.33 b	5.33 b
T_3	6.00 b	8.67 b	5.33 b	5.67 bc	5.67 b	5.67 b
LSD	1.66	1.50	1.65	1.53	1.65	1.33
CV %	25.48	18.09	24.08	23.76	28.49	22.09

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Dinajpur in response of location and treatment effects were recorded after two month of fungicide application (Table 21). The highest (9.00%) disease severity of algal rust was

observed in orchard 1 by T_2 treatment and the lowest (5.00%) algal rust disease severity was recorded in orchard 2 by T_1 treatment and orchard 3 by T_1 treatment and orchard 2 by T_2 treatment. The highest (15.00%) anthracnose disease severity was recorded in orchard 3 by treatment T_0 and the lowest (5.00%) disease severity was observed in orchard 2 by treatment T_1 and orchard 2 by T_2 treatment. The highest (12.00%) disease severity of die-back was observed in orchard 3 by T_0 treatment. The lowest (5.00%) die-back disease severity was recorded in orchard 3 by T_1 treatment and orchard 2 by T_2 treatment and orchard 1 and 2 by T_3 treatment (Table 21).

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Thakurgaon in response of location and treatment effects were recorded after one month of fungicide application (Table 21). The highest (10.00%) disease severity of algal rust was observed in orchard 4 by T_1 treatment. The lowest (5.00%) algal rust disease severity was recorded in orchard 6 by T_1 treatment and orchard 5 by T_2 treatment and orchard 4 by T_3 treatment. The highest (8.00%) anthracnose disease severity was recorded in orchard 5 by treatment T_0 and orchard 6 by treatment T_1. The lowest (5.00%) disease severity was observed in orchard 4 by treatment T_0 and orchard 4, orchard 5 and orchard 6 by T_2 treatment. The highest (8.00%) disease severity of die-back was observed in orchard 5 by T_2 treatment. The lowest (5.00%) die-back disease severity was recorded in orchard 5 by T_0 treatment and orchard 4 and orchard 6 by T_1 treatment and orchard 6 by T_2 treatment (Table 21).

Table 21. Interaction effect of location and treatment on disease severity of guava after two month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur			Orchard	Thakurgaon		
		Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
T_0	1	8.00 ab	10.00 bc	10.00 ab	4	10.00 a	8.00 ab	9.00 ab
	2	6.00 bc	10.00 bc	8.00 bc	5	9.00 ab	9.00 a	7.00 bc
	3	7.00 abc	15.00 a	12.00 a	6	8.00 abc	8.00 ab	10.00 a
T_1	1	7.00 abc	8.00 cd	7.00 c	4	10.00 a	4.00 c	5.00 cd
	2	5.00 c	5.00 e	7.00 c	5	7.00 bcd	5.00 bc	5.00 cd
	3	5.00 c	8.00 cd	5.00 c	6	3.00 e	7.00 abc	5.00 cd
T_2	1	9.00 a	7.00 de	7.00 c	4	5.00 de	4.00 c	5.00 cd
	2	5.00 c	5.00 e	5.00 c	5	5.00 de	4.00 c	5.00 cd
	3	6.00 bc	8.00 cd	7.00 c	6	5.00 de	5.00 bc	6.00 cd
T_3	1	6.00 bc	8.00 cd	5.00 c	4	4.00 de	5.00 bc	4.00 d
	2	6.00 bc	7.00 de	5.00 c	5	7.00 bcd	7.00 abc	7.00 bc
	3	8.00 ab	11.00 b	6.00 c	6	6.00 cd	5.00 bc	6.00 cd
LSD		2.19	2.60	2.85	LSD	2.65	2.85	2.31
CV %		19.91	18.09	24.08	CV%	23.76	28.49	22.09

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after three month of fungicide application (Table 22). The highest (7.50%) severity was observed in orchard 1 and the lowest severity ranges of algal rust was (5.25%) observed in orchard 2. The highest (10.00%) severity of anthracnose was observed in orchard 3 and the lowest (6.75%) disease severity was recorded in orchard 2.

In case of die-back, the highest severity (8.25%) was observed in orchard 3 and the lowest severity (5.75%) was observed in orchard 2 (Table 22).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after three month of fungicide application (Table 22). The highest (7.50%) severity was observed in orchard 4 and the lowest severity ranges of algal rust was (5.50%) observed in orchard 6. The highest (6.75%) severity of anthracnose was observed in orchard 5 and the lowest (5.50%) disease severity was recorded in orchard 4. In case of die-back, the highest severity (8.75%) was observed in orchard 6 and lowest severity (6.75%) was observed in orchard 4 (Table 22).

Table 22. Effect of location on disease severity of guava after three month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur			Orchard	Thakurgaon		
	Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
1	7.50 a	8.00 b	7.75 a	4	7.50 a	5.50 a	6.75 b
2	5.25 b	6.75 b	5.75 b	5	6.50 ab	6.75 a	8.00 ab
3	6.00 b	10.00 a	8.25 a	6	5.50 b	6.00 a	8.75 a
LSD	1.38	1.67	1.32	LSD	1.34	1.39	1.42
CV %	26.16	23.97	21.51	CV%	24.40	27.03	21.34

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at P≥ 0.05 level.

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after three month of fungicide application in response of treatments (Table 23). The highest (11.67%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (4.33%) recorded in T_1 and T_3. The highest disease severity of anthracnose disease (16.00%) was observed in T_0. The lowest severity ranges of anthracnose (5.33%) was observed in T_1 and T_2. Similarly, the highest severity (15.67%)

of die-back was observed in T_0 and the lowest severity (4.00%) was observed in T_3 (Table 23).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after three month of fungicide application in response of treatments (Table 23). The highest (12.33%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (4.33%) recorded in T_2 and T_3. The highest disease severity of anthracnose disease (10.67%) was observed in T_0 and the lowest severity ranges of anthracnose (4.00%) was observed in T_3. Similarly, the highest severity (16.67%) of die-back was observed in T_0 and the lowest severity (4.67%) was observed in T_1 and T_3 (Table 23).

Table 23. Effect of treatment on disease severity of guava after three month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur			Thakurgaon		
	Algal rust	Anthracnose	Die-back	Algal rust	Anthracnose	Die-back
T_0	11.67 a	16.00 a	15.67 a	12.33 a	10.67 a	16.67 a
T_1	4.33 b	5.33 b	4.33 b	5.00 b	4.67 b	4.67 b
T_2	4.67 b	5.33 b	5.00 b	4.33 b	5.00 b	4.67 b
T_3	4.33 b	6.33 b	4.00 b	4.33 b	4.00 b	5.33 b
LSD	1.60	1.93	1.53	1.55	1.61	1.63
CV %	26.16	23.97	21.51	24.40	27.03	21.34

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Dinajpur in response of location and treatment effects were recorded after three month of

fungicide application (Table 24). The highest (15.00%) disease severity of algal rust was observed in orchard 1 by T_0 treatment. The lowest (3.00%) algal rust disease severity was recorded in orchard 2 by T_3 treatment. The highest (20.00%) anthracnose disease severity was recorded in orchard 3 by treatment T_0 and the lowest (4.00%) disease severity was observed in orchard 2 by treatment T_1 and orchard 2 by treatment T_2. The highest (20.00%) disease severity of die-back was observed in orchard 3 by T_0 treatment. The lowest (4.00%) die-back disease severity was recorded in orchard 1 and orchard 3 by T_1 treatment and orchard 2 by T_2 treatment and orchard 1, orchard 2 and orchard 3 by treatment T_3 (Table 24).

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Thakurgaon in response of location and treatment effects were recorded after three month of fungicide application (Table 24). The highest (15.00%) disease severity of algal rust was observed in orchard 4 by T_0 treatment and the lowest (3.00%) algal rust disease severity was recorded in orchard 6 by T_1 treatment. The highest (12.00%) anthracnose disease severity was recorded in orchard 4 by treatment T_0 and the lowest (3.00%) disease severity was observed in orchard 6 by T_3 treatment. The severity of die-back varied significantly according to the location and treatment of the experiment. The highest (20.00%) disease severity of die-back was observed in orchard 6 by T_0 treatment. The lowest (4.00%) die-back disease severity was recorded in orchard 4 by T_1 treatment and orchard 4 by T_2 treatment and orchard 4 by T_3 treatment (Table 24).

Table 24. Interaction effect of location and treatment on disease severity of guava after three month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur			Orchard	Thakurgaon		
		Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
T_0	1	15.00 a	15.00 b	17.00 b	4	15.00 a	10.00 a	15.00 b
	2	10.00 b	13.00 b	10.00 c	5	12.00 b	12.00 a	15.00 b
	3	10.00 b	20.00 a	20.00 a	6	10.00 b	10.00 a	20.00 a
T_1	1	5.00 c	6.00 c	4.00 d	4	7.00 c	4.00 b	4.00 c
	2	4.00 c	4.00 c	5.00 d	5	5.00 cd	5.00 b	5.00 c
	3	4.00 c	6.00 c	4.00 d	6	3.00 d	5.00 b	5.00 c
T_2	1	6.00 c	5.00 c	6.00 d	4	4.00 d	4.00 b	4.00 c
	2	4.00 c	4.00 c	4.00 d	5	4.00 d	5.00 b	5.00 c
	3	4.00 c	7.00 c	5.00 d	6	5.00 cd	6.00 b	5.00 c
T_3	1	4.00 c	6.00 c	4.00 d	4	4.00 d	4.00 b	4.00 c
	2	3.00 c	6.00 c	4.00 d	5	5.00 cd	5.00 b	7.00 c
	3	6.00 c	7.00 c	4.00 d	6	4.00 d	3.00 b	5.00 c
LSD		2.77	3.35	2.64	LSD	2.69	2.79	2.83
CV %		26.16	23.97	21.51	CV%	24.40	27.03	21.34

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after four month of fungicide application (Table 25). The highest (7.75%) severity was observed in orchard 1 and the lowest severity ranges of algal rust was (6.00%) observed in orchard 2. The highest (10.00%) severity of anthracnose was observed in orchard 3 and the lowest (6.75%) disease severity was recorded in orchard 2.

In case of die-back, the highest severity (9.00%) was observed in orchard 1 and lowest severity (6.75%) was observed in orchard 2 (Table 25).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after four month of fungicide application (Table 25). The highest (7.25%) severity was observed in orchard 4 and the lowest severity ranges of algal rust was (6.50%) observed in orchard 5. The highest (6.50%) severity of anthracnose was observed in orchard 5 and orchard 6 and the lowest (6.25%) disease severity was recorded in orchard 4. In case of die-back, the highest severity (9.50%) was observed in orchard 5 and lowest severity (8.75%) was observed in orchard 4 (Table 25).

Table 25. Effect of location on disease severity of guava after four month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur			Orchard	Thakurgaon		
	Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
1	7.75 a	8.75 a	9.00 a	4	7.25 a	6.25 a	8.75 a
2	6.00 b	6.75 b	6.75 b	5	6.50 a	6.50 a	9.50 a
3	6.75 ab	10.00 a	8.75 a	6	6.75 a	6.50 a	9.00 a
LSD	1.46	1.59	1.46	LSD	1.11	1.03	1.49
CV %	25.32	22.13	21.18	CV%	19.23	19.04	19.33

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after four month of fungicide application in response of treatments (Table 26). The highest (16.67%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (3.33%) recorded in T_3. The highest disease severity of anthracnose disease (20.00%) was observed in T_0. The lowest severity ranges of anthracnose (4.67%) was observed in T_1, T_2 and T_3. Similarly, the highest severity

(21.67%) of die-back was observed in T_0 and the lowest severity (3.33%) was observed in T_3 (Table 26).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after four month of fungicide application in response of treatments (Table 26). The highest (15.33%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (3.67%) recorded in T_2 and T_3. The highest disease severity of anthracnose disease (15.00%) was observed in T_0 and the lowest severity ranges of anthracnose (3.33%) was observed in T_2. Similarly, the highest severity (25.00%) of die-back was observed in T_0 and the lowest severity (3.33%) was observed in T_2 (Table 26).

Table 26. Effect of treatment on disease severity of guava after four month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur			Thakurgaon		
	Algal rust	Anthracnose	Die-back	Algal rust	Anthracnose	Die-back
T_0	16.67 a	20.00 a	21.67 a	15.33 a	15.00 a	25.00 a
T_1	3.67 b	4.67 b	3.67 b	4.67 b	3.67 b	3.33 b
T_2	3.67 b	4.67 b	4.00 b	3.67 b	3.33 b	3.67 b
T_3	3.33 b	4.67 b	3.33 b	3.67 b	3.67 b	4.33 b
LSD	1.69	1.84	1.69	1.29	1.19	1.72
CV %	25.32	22.13	21.18	19.23	19.04	19.33

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Dinajpur in response of location and treatment effects were recorded after four month of

fungicide application (Table 27). The highest (20.00%) disease severity of algal rust was observed in orchard 1 by T_0 treatment. The lowest (3.00%) algal rust disease severity was recorded in orchard 2 by T_1 treatment and orchard 2 by T_2 treatment and orchard 1 and orchard 2 by T_3 treatment. The highest (25.00%) anthracnose disease severity was recorded in orchard 3 by treatment T_0 and the lowest (4.00%) disease severity was observed in orchard 2 by treatment T_1 and orchard 2 by T_2 treatment orchard 2 by treatment T_3. The highest (25.00%) disease severity of die-back was observed in orchard 1 and orchard 3 by T_0 treatment and the lowest (3.00%) die-back disease severity was recorded in orchard 3 by T_1 treatment and orchard 1 and orchard 3 by T_3 treatment (Table 27).

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Thakurgaon in response of location and treatment effects were recorded after four month of fungicide application (Table 27). The highest (16.00%) disease severity of algal rust was observed in orchard 4 by T_0 treatment. The lowest (3.00%) algal rust disease severity was recorded in orchard 5 by T_2 treatment and orchard 4 by T_3 treatment. The highest (15.00%) anthracnose disease severity was recorded in orchard 4, orchard 5 and orchard 6 by treatment T_0. The lowest (3.00%) disease severity was observed in orchard 4 by treatment T_1 and orchard 4 and orchard 5 by treatment T_2 and orchard 6 by T_3 treatment. The highest (25.00%) disease severity of die-back was observed in orchard 4, orchard 5 and orchard 6 by T_0 treatment. The lowest (3.00%) die-back disease severity was recorded in orchard 4 and orchard 6 by T_1 treatment and orchard 4 by T_2 treatment (Table 27).

Table 27. Interaction effect of location and treatment on disease severity of guava after four month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur			Orchard	Thakurgaon		
		Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
T_0	1	20.00 a	20.00 b	25.00 a	4	16.00 a	15.00 a	25.00 a
	2	15.00 b	15.00 c	15.00 b	5	15.00 a	15.00 a	25.00 a
	3	15.00 b	25.00 a	25.00 a	6	15.00 a	15.00 a	25.00 a
T_1	1	4.00 c	5.00 d	4.00 c	4	6.00 b	3.00 b	3.00 b
	2	3.00 c	4.00 d	4.00 c	5	4.00 bc	4.00 b	4.00 b
	3	4.00 c	5.00 d	3.00 c	6	4.00 bc	4.00 b	3.00 b
T_2	1	4.00 c	5.00 d	4.00 c	4	4.00 bc	3.00 b	3.00 b
	2	3.00 c	4.00 d	4.00 c	5	3.00 c	3.00 b	4.00 b
	3	4.00 c	5.00 d	4.00 c	6	4.00 bc	4.00 b	4.00 b
T_3	1	3.00 c	5.00 d	3.00 c	4	3.00 c	4.00 b	4.00 b
	2	3.00 c	4.00 d	4.00 c	5	4.00 bc	4.00 b	5.00 b
	3	4.00 c	5.00 d	3.00 c	6	4.00 bc	3.00 b	4.00 b
LSD		2.93	3.19	2.93	LSD	2.23	2.07	2.97
CV %		25.32	22.13	21.18	CV%	19.23	19.04	19.33

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after five month of fungicide application (Table 28). The highest (8.17%) severity was observed in orchard 1 and the lowest severity ranges of algal rust was (6.92%) observed in orchard 2. The highest (10.50%) severity of anthracnose was observed in orchard 1 and orchard 3. The lowest (8.50%) disease severity was recorded in

orchard 2. In case of die-back, the highest severity (11.25%) was observed in orchard 1 and lowest severity (7.50%) was observed in orchard 2 (Table 28).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after five month of fungicide application (Table 28). The highest (8.75%) severity was observed in orchard 4 and the lowest severity ranges of algal rust was (7.00%) observed in orchard 6. The highest (7.50%) severity of anthracnose was observed in orchard 6 and lowest severity was observed in orchard 4 and orchard 5. In case of die-back, the highest severity (11.33%) was observed in orchard 4 and lowest severity (10.08%) was observed in orchard 6 (Table 28).

Table 28. Effect of location on disease severity of guava after five month of fungicide application in Dinajpur and Thakurgaon

Orchard	Dinajpur			Orchard	Thakurgaon		
	Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
1	8.17 a	10.50 a	11.25 a	4	8.75 a	7.42 a	11.33 a
2	6.92 a	8.50 a	7.50 b	5	7.25 b	7.42 a	10.50 a
3	7.42 a	10.50 a	10.00 a	6	7.00 b	7.50 a	10.08 a
LSD	1.464	2.100	2.072	LSD	1.110	1.164	1.578
CV %	21.62	25.22	25.54	CV%	17.10	18.47	17.52

Each value is an average of 3 (three) replications. In a column, values having same letter do not differ significantly at $P \geq 0.05$ level.

Algal rust, anthracnose and die-back disease severity of three guava orchards at Dinajpur were recorded after five month of fungicide application in response of treatments (Table 29). The highest (22.33%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (2.33%) recorded in T_2. The highest disease severity of anthracnose disease (28.33%) was observed in T_0. The lowest severity ranges of anthracnose (3.67%) was observed in T_1, T_2 and T_3. Similarly, the highest severity

(28.33%) of die-back was observed in T_0 and the lowest severity (3.00%) was observed in T_3 (Table 29).

Algal rust, anthracnose and die-back disease severity of three guava orchards at Thakurgaon were recorded after five month of fungicide application in response of treatments (Table 29). The highest (21.67%) disease severity of algal rust was recorded in T_0 and the lowest severity of algal rust was (3.00%) recorded in T_1, T_2 and T_3. The highest disease severity of anthracnose disease (20.00%) was observed in T_0. The lowest severity ranges of anthracnose (3.00%) was observed in T_3. Similarly, the highest severity (31.67%) of die-back was observed in T_0 and the lowest severity (3.33%) was observed in T_3 (Table 29).

Table 29. Effect of treatment on disease severity of guava after five month of fungicide application in Dinajpur and Thakurgaon

Treatment	Dinajpur			Thakurgaon		
	Algal rust	Anthracnose	Die-back	Algal rust	Anthracnose	Die-back
T_0	22.33 a	28.33 a	28.33 a	21.67 a	20.00 a	31.67 a
T_1	2.67 b	3.67 b	3.33 b	3.00 b	3.44 b	3.67 b
T_2	2.33 b	3.67 b	3.67 b	3.00 b	3.33 b	3.89 b
T_3	2.67 b	3.67 b	3.00 b	3.00 b	3.00 b	3.33 b
LSD	1.691	2.425	2.393	1.282	1.344	1.822
CV %	21.62	25.22	25.54	17.10	18.47	17.52

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Dinajpur in response of location and treatment effects were recorded after five month of

fungicide application (Table 30). The highest (25.00%) disease severity of algal rust was observed in orchard 1 by T_0 treatment. The lowest (2.00%) algal rust disease severity was recorded in orchard 2 by T_1 treatment and orchard 1 and orchard 2 by treatment T_3. The highest (30.00%) anthracnose disease severity was recorded in orchard 1 and orchard 3 by treatment T_0. The lowest (3.00%) disease severity was observed in orchard 2 by treatment T_1 and orchard 2 by treatment T_2 and orchard 2 by T_3 treatment. The highest (35.00%) disease severity of die-back was by T_0 treatment. The lowest (3.00%) die-back disease severity was recorded in orchard 1 by T_1 treatment and orchard 2 by T_2 treatment and orchard 1 and orchard 2 by treatment T_3 (Table 30).

Severity of algal rust, anthracnose and die-back disease of three guava orchards at Thakurgaon in response of location and treatment effects were recorded after five month of fungicide application (Table 30). The highest (25.00%) disease severity of algal rust was observed in orchard 4 by T_0 treatment and the lowest (2.00%) algal rust disease severity was recorded in orchard 6 by T_1 treatment. The highest (20.00%) anthracnose disease severity was recorded in orchard 4, orchard 5 and orchard 6 by treatment T_0. The lowest (3.00%) disease severity was observed in orchard 4, orchard 5 and orchard 6 by treatment T_3. The highest (35.00%) disease severity of die-back was observed in orchard 4 by T_0 treatment. The lowest (3.00%) die-back disease severity was recorded in orchard 4 and orchard 6 by T_3 treatment (Table 30).

Table 30. Interaction effect of location and treatment on disease severity of guava after five month of fungicide application in Dinajpur and Thakurgaon

Treatment	Orchard	Dinajpur			Orchard	Thakurgaon		
		Algal rust	Anthracnose	Die-back		Algal rust	Anthracnose	Die-back
T_0	1	25.00 a	30.00 a	35.00 a	4	25.00 a	20.00 a	35.00 a
	2	22.00 b	25.00 b	20.00 c	5	20.00 b	20.00 a	30.00 b
	3	20.00 b	30.00 a	30.00 b	6	20.00 b	20.00 a	30.00 b
T_1	1	3.00 c	4.00 c	3.00 d	4	4.00 c	3.33 b	4.00 c
	2	2.00 c	3.00 c	4.00 d	5	3.00 c	3.33 b	3.33 c
	3	3.00 c	4.00 c	3.00 d	6	2.00 c	3.67 b	3.67 c
T_2	1	2.67 c	4.00 c	4.00 d	4	3.00 c	3.33 b	3.33 c
	2	1.67 c	3.00 c	3.00 d	5	3.00 c	3.33 b	4.67 c
	3	2.67 c	4.00 c	4.00 d	6	3.00 c	3.33 b	3.67 c
T_3	1	2.00 c	4.00 c	3.00 d	4	3.00 c	3.00 b	3.00 c
	2	2.00 c	3.00 c	3.00 d	5	3.00 c	3.00 b	4.00 c
	3	4.00 c	4.00 c	3.00 d	6	3.00 c	3.00 b	3.00 c
LSD		2.929	4.200	4.145	LSD	2.221	2.329	3.157
CV %		21.62	25.22	25.54	CV%	17.10	18.47	17.52

Each value is an average of 3 (three) 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 Iprodione

T_2 = Spraying of Copper oxychloride

T_3 = Spraying of Mancozeb

CHAPTER 5

DISCUSSION

CHAPTER 5

DISCUSSION

An investigation was undertaken to find out the status of major diseases of citrus and guava with their effective management practices in some orchards of Thakurgaon and Dinajpur under the supervision of Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during July, 2017 to May, 2018. The occurrence, severity and management of diseases were assessed at different locations with control measures in different orchards of citrus and guava plants. Disease status was investigated under natural epiphytotic conditions throughout the experimental period. The diseases were assessed based on symptoms expressed on leaves at every one month interval continuing up to five months with altogether five spray of fungicide application.

In case of citrus plants, one bacterial disease, canker and three fungal diseases, viz, scab, anthracnose and die-back were identified as major diseases throughout the experimental period. Severity of all the diseases were significantly ($P \geq 0.05$) varied according to different orchards based on treatments. All the treatments used in the experiment showed their superiority by reducing the disease severity compared to control treatment in the orchards of Thakurgaon and Dinajpur districts. The findings of this study is strongly supported by Ravikumar *et al.* (2001), Ran *et al.* (2001), Singh *et al.* (2000), Ebenezar *et al*. (1996), Thakore *et al.* (1994), Hossain (1993) and Pandey (1988). The variation of disease severity may be occurred due to different cultural operations such as fertilizer application, irrigation, weeding, pruning etc. done by orchard owner (farmers) or maybe due to soil texture, soil structure, planting density and canopy density that may affect the internal micro-climate of orchard. Spraying with Iprodione @ 2 g/L (T_1), Copper oxychloride @ 3 g/L (T_2) and Mancozeb @ 3 g/ L (T_3) showed best performance for the

management of these diseases compared to control (T_0) treatment in the experimental orchards.

In citrus plants, in case of canker symptoms, canker have characteristic lesions on leaves, stems, and fruit with raised, brown, water-soaked margins, usually with a yellow halo or ring effect around the lesion. Older lesions have a corky appearance, still in many cases retaining the halo effect. Canker significantly affects the vitality of citrus trees, causing leaves and fruit to drop prematurely. Findings of this experiments is highly correlated with the findings of Sarao *et al.* (2011) and Ye *et al.* (2001). They also stated that environmental parameter like rain and flooding can help to develop distinctly raised appearance of the lesion may be the diagnostic tool for disease identification.

The highest (8.00%) canker severity was found in orchard 5 after 5^{th} month and the minimum (5.00%) severity was observed in orchard 1 after 1^{st} month of fungicide application. Likely, the highest (19.00%) severity of canker was found in T_0 treatment after 5^{th} spray of fungicide but the lowest (2.33%) severity was found after 5^{th} spray of T_1 treatment in Dinajpur. This result is supported by Ravikumar *et al.* (2001) and Kale *et al.* (1994). They observed that, canker can be suppressed with the spraying of Copper oxychloride either alone or in combination even at 7 days interval as evident with lower number of pathogenic population/ colony development within the lesions developed on the affected tissues suppressing the pathogenic dissemination but enhancing the growth of the host plant.

In case of scab, the characteristics symptoms of the disease was observed as raised, irregular corky spots on leaves and fruits. The disease is first noticed as small, somewhat raised spots and then became irregular corky on leaves and fruits. The spots ranged from a few millimeters to one centimeter in diameter. Badly infected leaves became crinkled and

stunted. Several spots coalesced together to form large patches of corky out growth as supported by Timmer *et al.* (1992). The highest (8.50%) scab disease severity was found in orchard 2 after 5th month and the minimum (5.75%) disease severity was observed in orchard 6 after 1st month and orchard 4 after 3rd month of fungicide application. The highest (10.00%) severity of scab was found in T_0 treatment after 3rd spray of fungicide but the lowest (2.33%) severity was found after 5th spray of T_1 treatment as in agreement with the results of Ran *et al.* (2001) and Singh *et al.* (2000) either in *vivo* or in *vitro* even at two days interval of fungicide application. In case of anthracnose disease, Leaves display more or less circular spots of light tan color with a prominent purple margin. The center of these spots gradually turn grayish and, in the later phases of the infection, it may show tiny dispersed black flecks. The spore masses growing on the lesions are usually brown to black, but under humid conditions, they can turn pink to salmon. Several spots coalesced together to form large patches. In case of severe infection, the twig will be distorted. The highest (10.75%) anthracnose disease severity was found in orchard 3 after 5th month but the minimum (5.50%) severity was observed in orchard 5 after 1st month of fungicide application. The highest (28.33%) severity of anthracnose was found in T_0 treatment after 5th spray of fungicide and the lowest (3.00%) severity was found after 5th spray of T_2 treatment in Thakurgaon. In case of die-back, the plant begins to die backwards form the top of a branch. Young shoots, leaves and fruits are readily attacked, while they are still tender. The disease develops from the infected twigs and then petiole and young leaves which may drop down or fall leaving the dried twigs without leaves, extending towards the fruit bottom penetrating a few inches to more causing dying up of the fruit is observed by Knorr *et al.* (1957), Klotz and Stewart (1948) and Bates (1936).The highest (11.25%) severity of die-back was found in orchard 1 after 5th month of fungicide and the lowest (6.25%) severity was found in orchard 4 after 1st month of

fungicide application. The highest (29.33%) severity of die-back was found in T_0 treatment after 5th spray of fungicide; while the lowest (3.00%) severity was found after 5th spray of T_3 treatment in Thakurgaon. The results of Ebenezar *et al.* (1996) strongly supports our experimental results clearly indicating that tested fungicides showed their best performance in managing the diseases in orchards of Thakurgaon and Dinajpur as evident with reduced disease severity may be happened due to the inactivation of the virulence of the pathogen somewhat by their less number of inocula and spreading attitude owing to retention of fungicides on the leaf surfaces and the affected tissues.

In guava plants, one rust disease; algal rust and two fungal diseases; anthracnose and die-back were identified as major disease throughout the experimental period. Severity of all the diseases were significantly ($P \geq 0.05$) varied according to different orchards as well as treatment. The treatments used in the experiment enhancing their superiority on the occurrence of disease by suppressing the disease severity compared to control treatment in the orchards of Thakurgaon and Dinajpur districts.

The variation of diseases may be occurred due to different cultural operations such as fertilizer application, irrigation, weeding, pruning 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 micro-climate of orchard. Working with Iprodione @ 2 g/L (T_1), Copper oxychloride @ 3 g/L (T_2) and Mancozeb @ 3 g/ L (T_3) gave best performance for the management of these diseases compared to control (T_0) treatment in the experimental orchard.

In case of guava plants, regarding algal rust symptoms, algal infects immature guava leaves during early spring flush. Minute, shallow brown velvety lesions appear on leaves specially on leaf tips, margins or areas near the mid vein and as the disease progresses, the

lesions enlarge to 2-3 mm in diameter. They are darkish green to brown or black to color. This symptom was observed by Pathak (1989). He also added that, pathogen is extended between cuticle and epidermis followed by penetration into the epidermal cell. The highest disease severity (8.75%) of algal rust was found in orchard 4 after 5th month and the minimum (5.25%) disease severity was observed in orchard 2 after 3rd month of fungicide application. The highest (22.33%) severity of algal rust was found in T_0 treatment after 5th spray but the lowest (2.33%) severity was found after 5thspray of T_2 treatment. In case of anthracnose disease, Leaves display more or less circular spots of light tan color with a prominent purple margin. The center of these spots gradually turn grayish and, in the later phases of the infection, it may show tiny dispersed black flecks. They are usually brown to black, but under humid conditions, they can turn pink to salmon. Several spots coalesced together to form large patches. In case of severe infection, the twig will be distorted. Symptoms of the disease is observed by Tandon & Singh (1969). The highest (10.50%) anthracnose disease severity was found in orchard 3 after 2nd month and orchard 1 and 3 after 5th month but the minimum (5.00%) severity was observed in orchard 2 after 1st month of fungicide application. The highest (28.33%) severity of anthracnose was found in T_0 treatment after 5th spray of fungicide application and the lowest (3.00%) severity was found after 5th spray of T_3 treatment. The results of this experiment are in corroboration with the results of Hossain (1993), Pandey (1988) and Rahman & Hossain (1988). They reported that tested fungicides are acted as inhibitor for the growth of the mycelium reducing the rate of spore germination followed by the length of the germ tube development specially suppressing the fungal colonization into leaf tissues and the affected areas of the host tissues. In case of die-back, the plant begins to die backwards form the top of a branch. Young shoots, leaves and fruits are readily attacked, while they are still tender. The disease develops from the infected twigs and then petiole

and young leaves which may drop down or fall leaving the dried twigs without leaves. Symptom is observed by Dwivedi *et al.* (1994) & Tandon and Agarwala (1954). They noticed that main trunk of the host is badly damaged and cracking of the bark by the attack of the pathogen immediately after infection. The highest (11.33%) severity of die-back was found in orchard 4 after 5th month and the lowest (5.50%) severity was found in orchard 3 after 1st month of fungicide application. The highest (31.67%) severity of die-back was found in T_0 treatment after 5th spray of fungicide while the lowest (3.00%) severity was found after 5th spray of T_3 treatment in Dinajpur. The result is strongly supported by Thakore *et al.* (1994). He also reported that, all the tested fungicides, Mancozeb and Copper oxychloride were effective against the disease.

In case of canker disease of citrus, treatment T_1 exhibited the lowest (2.33%) disease severity; while the minimum (2.33%) severity of scab was found with T_1 compared to other treatments. Regarding anthracnose disease of citrus, treatment, T_2 exhibited the lowest (3.00%) severity compared to other treatments. In case of die-back disease of citrus treatment, T_3 exhibited the lowest (3.00%) severity compared to other treatments. On the basis of location, effects of the treatment at several intervals (after one to five months) are significantly varied in decreasing the disease severity in different orchard working with different treatments on several locations, the highest response of the fungicides (Iprodione) in the treatment T_1 on canker and scab disease severity of citrus. In case of anthracnose, Copper oxychloride in the treatment T_2 was very effective to control the disease and in die-back Mancozeb in the treatment T_3 give the highest response compare to other treatments. In guava plants, in case of algal rust disease, T_2 exhibited the lowest severity (2.33%) compared to other treatments, i.e. Copper oxychloride was very effective to control algal rust disease in guava Dinajpur. Similarly, in case of anthracnose disease, T_3 exhibited the lowest severity (3.00%) compared to other treatments, i.e. Mancozeb was

very effective to control anthracnose in Thakurgaon. T_3 exhibited the lowest (3.00%) die-back disease severity compared to other treatments i.e. Mancozeb was highly effective to control die-back disease of guava in Dinajpur. All the chemicals (Iprodione, Copper oxychloride and Mancozeb) as treatments T_1, T_2 and T_3 used in the experiment give the highest response compared to control treatment as the indication of maximum response combating pathogenic population of the pathogen (*Xanthomonas axonopodis pv. citri*) & (*Sphaceloma fawcettii var. scabiosa*), (*Glomerella cingulata)*, (*Colletotrichum gloeosporioides)*, (*Fusarium solani*), (*Botryodiplodia theobromae*) causing canker, scab, anthracnose and die-back, respectively on citrus and (*Cephaleuros virescens*), (*Colletotrichum gloeosporioides*) and (*Gloeosporium psidii*) causing algal rust, anthracnose and die-back, respectively on guava through the attenuation of their fructification as well as dissemination or dispersal from foliage to foliage, bud, stem, twig and later on plant to plant may be the hindrance of spreading of the disease reaching moderate to higher magnitude as the cause for spraying of the plants with the chemical or fungicide specially foliage at regular intervals (one to five months) limiting the disease progress similarly followed by the treatments like T_1 (Iprodione), T_2 (Copper oxychloride) and T_3 (Mancozeb) with the same pattern delineating the disease progress causing reduction of disease severity. So that, colonization and further spread of the pathogenic propagules within the host tissue may be interrupted due to the application of used chemicals viz. T_1 (Iprodione), T_2 (Copper oxychloride) and T_3 (Mancozeb) compared to control with the happening of the same phenomenon applicable here as stated clearly above. Side by side in some orchards, treatment T_2 was found promising resulting its best performance against the diseases lessening the disease progress through the inhibition of spreading of the pathogens into the host tissues (leaf or foliage) treated by the chemicals (Iprodione, Copper oxychloride and Mancozeb) at regular intervals (one to five months).

This might be happened with residual effect of the fungicide residing on leaf surfaces for the period being spraying effectively develop harmonious relationship with the chemicals against disease as suppressing their rate of infection, development of infection foci, frequency of life cycle as well as possibility of further invasion and rapid dispersal of inoculum inhibiting phyto-aggressiveness of the pathogen producing in a lesser manner as envisaged with the development of the lowest disease severity.

Out of the used chemical as treatments on different orchards in Thakurgaon and Dinajpur to control canker, scab, anthracnose and die-back of citrus and algal rust, anthracnose and die-back of guava treatments like T_1 (Iprodione), T_2 (Copper oxychloride) and T_3 (Mancozeb) exhibited their superior performance developing the lowest disease severity as well as the lowest disease progress with their maximum response. Iprodione, Copper oxychloride and Mancozeb may be found promising in arena of disease control as mentioned above. These chemicals (Iprodione, Copper oxychloride and Mancozeb) can explore magnifying a new horizon of chemical control of diseases of citrus and guava in Thakurgaon and Dinajpur districts. Therefore, T_3 (Mancozeb) followed by T_2 (Copper oxychloride) and T_1 (Iprodione) may be recommended for the management of the diseases of citrus and guava in different orchards of Dinajpur and Thakurgaon districts, respectively.

CHAPTER 6

SUMMARY AND CONCLUSION

CHAPTER 6

SUMMARY AND CONCLUSION

The present study has been conducted to survey the citrus and guava diseases in different orchards of Dinajpur and Thakurgaon districts with their effective management practices under the supervision of Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during July, 2017 to May, 2018. Among the diseases, (canker, scab anthracnose and die-back) of citrus and guava diseases (algal rust, anthracnose and die-back) were recorded in orchards of Dinajpur and Thakurgaon. To find out the effective management practices for controlling disease of citrus and guava leaves, altogether three fungicides were selected including control as four treatments viz. Iprodione, Copper oxychloride and Mancozeb. In case of tested fungicides, Iprodione was found in superior action on the suppression of disease severity inversely resulting the highest performance to control the canker (2.33%) and scab (2.33%) diseases of citrus in orchards of Dinajpur district. Disease severity of anthracnose (3.00%) and die-back (3.00%) were more suppressed by spraying of Copper oxycholoride followed by Mancozeb respectively in orchard of Thakurgaon district. Mancozeb was effective to control die-back of citrus in orchard of Thakurgaon district. It is obvious that disease severity was higher in orchard of Dinajpur than that of Thakurgaon in citrus regarding anthracnose and die-back but inversely for canker and scab. Canker and scab of citrus was more suppressed than other diseases being treated with the fungicides like Iprodione followed by other treatments in the orchard of Dinajpur than that of Thakurgaon. In guava plants (algal rust, anthracnose and die-back diseases), in case of algal rust disease (2.33%) Copper oxychloride was very effective than other treatments in the orchard of Dinajpur. Disease severity of anthracnose (3.00%) and die-back (3.00%)were more suppressed by

spraying of Mancozeb in the orchard of Thakurgaon and Dinajpur districts respectively. It is obvious that disease severity was higher in algal rust, anthracnose in orchard of Dinajpur and in die-back in orchard of Thakurgaon district respectively. Algal rust of guava was more suppressed than other diseases being treated with the fungicides like Copper oxychloride followed by other treatments in the orchard of Dinajpur. Among the tested fungicides, Mancozeb followed by Copper oxychloride and Iprodione may be recommended to control the diseases of citrus and guava in orchards of Dinajpur and Thakurgaon districts, respectively.

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APPENDICES

APPENDICES

Appendix 1

Weather data

Table 1. Month-wise air temperature, relative humidity and rainfall from June, 2017 to November, 2017, Dinajpur district

Month	Air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
June, 2017	34.16	26.03	30.10	82.93	5.29
July, 2017	32.8	23.75	28.28	78.87	5.51
August, 2017	31.07	21.48	26.28	77.6	6.41
September, 2017	28.57	16.75	22.67	75.77	3.31
October, 2017	27.77	13.38	20.58	72.39	0.0
November, 2017	24.80	10.89	17.85	79.81	4.4

Source: Rajbari Weather Station, Dinajpur Sadar, Dinajpur

Appendix 2

Weather data

Table 2. Month-wise air temperature, relative humidity and rainfall from June, 2017 to November, 2017, Thakurgaon district

Month	Air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum	Average		
June, 2017	32.92	26.03	29.48	80.30	10.22
July, 2017	31.50	25.85	28.68	78.23	3.96
August, 2017	30.10	23.12	26.61	73.73	0.93
September, 2017	26.81	19.91	23.36	70.32	1.48
October, 2017	25.61	14.14	19.88	72.39	0.0
November, 2017	22.90	13.10	18	83.5	0.0

Source: BADC Weather Station, Hajee Para, Thakurgaon