CONTROL OF SCAB (*Elsinoe fawcettii*) AND DIE BACK (*Colletotrichum gloeosporioides*) OF CITRUS THROUGH DIFFERENT FUNGICIDES

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DECEMBER, 2008

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REGISTRATION NO. 03-01100

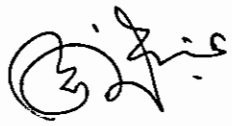
A Thesis

Submitted to **Department of Plant Pathology,**
Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
IN
PLANT PATHOLOGY

JULY-DECEMBER, 2008

Approved
by:



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This is to certify that the thesis entitled "*CONTROL OF SCAB (Elsinoe fawcettii) AND DIE BACK (Colletotrichum gloeosporioides) OF CITRUS THROUGH DIFFERENT FUNGICIDES*" submitted to the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE IN PLANT PATHOLOGY*, embodies the result of a piece of bona fide research work carried out by *Salah Uddin, Registration No. 03-01100,* under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents & style of the thesis have been approved and recommended for submission.

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DEDICATED TO

MY BELOVED PARENTS

ACKNOWLEDGEMENT

All praises and thanks to almighty Allah, the supreme ruler of the universe who enabled the researcher to complete this study.

The author with a deep sense of respect expresses his heartfelt gratitude to his respectable supervisor, ***Dr. Md. Rafiqul Islam*** *Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka for his guidance, valuable suggestions, continuous scholastic supervision and co-operation that have made it possible to complete this piece of research and reviewing the entire manuscript.*

The author deems it a proud privilege to express his heartfelt indebtedness and gratitude to co-supervisor ***Dr. F. M. Aminuzzaman****, Assistant Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka for his cordial inspiration and guidance.*

The author especially grateful to his honorable Teacher ***Mrs. Nasim Akhthar,*** *Chairman, Department of of Plant Pathology, Sher-e-Bangla Agricultural University for her inspiration, guidance and co-operation during the tenure of conducting this experiment.*

The author expresses his gratitude and indebtedness to all the honorable course instructors of Dept. of of Plant Pathology of SAU for their kind help and co-operation in various stages towards completion of this research work.

The author is also grateful to his friends especially ***Nasir, Tahazzat, Mamun, Rubel, Reza, Jakir, Asif, Shahidul, Gazi, Nurul amin, Ferdous, Sumon, Shamim, Sraboni, Jabin, Romana, Sukti*** *and all his friends in Sher-e-Bangla Agricultural University for their help, encouragement and moral support towards the completion of the degree.*

Last but not least, the author expresses his heartfelt gratitude and indebtedness to his beloved father ***Abul Hashem****, mother* ***Misses Samsun Nahar*** *and three sister* ***Surma, Farjana*** *and* ***Amy*** *for their inspiration, encouragement and blessings that enabled him to complete this research work.*

The Author

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ABSTRACT

An investigation was conducted on the citrus plants at the citrus orchard of Sher-e-Bangla Agricultural University, Dhaka, during the period of from April to September 2008 to find the effect of fungicides in controlling the scab and die back of citrus. The citrus plants were sprayed with seven fungicides namely, Cupravit 50WP (0.7%), Bavistin 50 WP (0.1%), Rovral 50WP (0.2%), Ridomil MZ-72 (0.2%), Tilt 250EC (0.05%), Champion 77 WP (0.2%) and Dithane M-45 (0.3%). The performance of the fungicides varied significantly in reducing the disease incidence and severity of citrus scab (*Elsinoe fawcettii*) and die-back (*Colletotrichum gloeosporioides*) compared to control. Incidence of scab (leaf and fruit) was remarkably reduced respectively by Rovral 50WP and Champion 77 WP after the end of sixth spray. Disease incidence of die back after the end of sixth spray was potentially reduced by Dithane M-45 followed by Bavistin 50 WP. The highest reduction of leaf scab severity was performed by Rovral 50WP (86.17%) followed by Champion 77 WP (81.76%) and Dithane M-45 (77.53%). The highest reduction of fruit scab severity was performed by Champion 77 WP (82.35%) followed by Dithane M-45 (76.60%) and Rovral 50WP (70.56%). The highest reduction of die back severity was shown by Dithane M-45 (69.78%) followed by Bavistin 50 WP (64.48%) and Tilt 250 EC (58.96%). Thus Rovral 50 WP and Champion 77 WP can be used for controlling scab of citrus while Dithane M-45 can be used for controlling both scab and die back of citrus.

CHAPTER I

INTRODUCTION

CHAPTER-I
INTRODUCTION

Citrus (*Citrus limon* L.), belongs to the family Rutaceae, is an important fruit crop in Bangladesh as well as many countries of the world. Citrus is a potential source of vitamins and minerals, especially, it is a good source of vitamin-C. Many people of our country are suffering from deficiency of vitamin A and vitamin-C and some mineral like calcium and iron. FAO report showed that, 93% people of our country suffering from deficiency of vitamin –C (FAO,1980). As a potential source of vitamin- C and essential minerals, citrus can play an important role in meeting up these deficiencies.

Citrus has a great demand for its nutritive value, flavor, taste and color in Bangladesh. Slices of lemon are severed as salad in daily meal. Lemon juice is used in tea; flavoring cakes, cookies and other confectionery products. It is also used in pharmaceutical industry for flavor. It is widely used for flavoring candies. Citrus is cultivated in 15008 ha of land and total production is 31750 ton in Bangladesh (BBS, 2005). Eight species of citrus are grown in Bangladesh. Amomg them, Elachi lemon (*Citrus limon* L.), Kagozi lemon (*Citrus aurantifolia* Swing) and Pummelo (*Citrus grandis* L.) are extensively cultivated.

Various diseases and other factors are responsible for lower yield of citrus in Bangladesh. Citrus species suffer from more than 100 diseases around the world. In Bangladesh, citrus species suffer from 12 diseases and among those, scab, die back, sooty mold and canker are major diseases (Alam, 2003).

Scab of citrus caused by *Elsinoe fawcettii* is a serious disease of citrus in Bangladesh (Alam, 2003). It can cause severe deformation of foliage and stunting of certain citrus rootstocks (Singh *et al.*, 2000). Citrus scab (*Elsinoe fawcettii)* attacks leaves of spring shoots of citrus and attack the fruitlets in mid May - late

May. During the autumn, if the temperature and humidity are favorable, it attacks the young shoots and causes dropping of fruitlets up to 65.9 – 71.29% (Huang, 1999). The perfect stage of the causal organism of scab (*Elsinoe fawcettii)* is *Sphaceloma fawcettii* (Janghoong *et al.*, 1998).

Die back caused by *Colletotrichum gloeosporioides* is also a serious disease in citrus which formerly known as decline, wither tip, twig blight, anthracnose etc. The disease occurred widely and has become serious limiting factor of citrus cultivation in many countries (Talukdar, 1974; Ercivan and Karaca, 1979; Ray Chaudhury *et al.*, 1980; Rawal and Saxana, 1997; Alam, 2003 and Timmer *et al.*, 2005). From a survey report, the prevalence of die back on Elachi lemon and Kagzi lime was 89.9% and 100% respectively in Bangladesh (Miah and Fakir, 1987).

Scab and die back of citrus can best be controlled by different fungicides. Siddiquee (2007) observed that Champion 77 WP was the most effective fungicide in controlling scab of citrus that reduced 85.43% leaf scab and 80.12% fruit scab of citrus which was closely followed by Rovral 50WP (83.87%). He found Dithane M-45 most effective against die back. Alam (2006) reported that the highest reduction of scab severity (PDI) was performed by Champion 77 WP and Dithane M-45 was found most effective against die back.

Through considering the above facts, the present research work has been undertaken to achieve the following objectives-

1. To select suitable fungicide in controlling scab of citrus caused by *Elsinoe fawcettii.*
2. To select suitable fungicide in controlling die back of citrus caused by *Colletotrichum gloeosporioides.*

CHAPTER II

RIVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

Scab and die- back of citrus occurred widely in citrus orchards throughout the world. These diseases are serious problem and main limiting factor of citrus production. Many researcher conducted several experiment on the disease symptoms, epidemic nature, causal organism and management of scab and die-back of citrus in different parts of the world. For precise presentation , only the related literatures are cited in this chapter.

2.1.1 Symptoms of scab of citrus

Gopal and Kumar (2003) observed that only young tissues are affected by citrus scab. Leaves are most susceptible to infection just after emergence from the bed. The grown up mature leaves are immune. Fruit remain susceptible for about three months after petal fall. The main symptom is small, grayish-brown corky scabs which develop on the twigs, young leaves and fruit. The fruits are infected when they are very young; the scabs are larger and warty. These lesions are particularly large on fruits. The scabs on fruit which are infected later are slightly raised above the surface of the rind. The numbers of lesions may join together to form large scabby areas. These may develop cracks as the fruit grows up.

Amador (2002) observed that citrus scab caused by the fungus *Elsinoe fawcettii,* is an important disease in Texas. The disease is more severe on lemons, sometimes troublesome on grapefruit and seldom a problem on sweet orange. Sour orange is highly susceptible, thus, nursery stocks may become infected before young sour orange trees are budded. Because citrus tissue is susceptible to scab only while young, the disease is mainly confined to new growth. The fruit remains susceptible for longer periods, but seldom is mature fruit affected. Small lesions appear as

translucent dots that later become pustules. As the disease progresses, the pustules turn into warts, consisting of a mass of corky tissue pale tan in color. The leaves become twisted and distorted and the entire young branch may be affected.

Hartmond *et al.* (2000) reported that citrus scab caused by the fungus *Elsinoe fawcettii* can occur on all varieties of citrus but it is of economic importance for fruits production of lemons, temples. murcoff, page, minneola, tangelo and in some situations grape fruit. Citrus scab on foliage and shoots causes stunting of plants during seedling root stock production of rough lemon, sour orange and trifoliate orange.

Singh *et al.* (2000) reported that citrus scab caused by *Elsinoe fawcettii* is a serious disease of citrus in India. It can cause severe deformation of foliage and stunting of certain citrus root stocks.

Janghoon *et al.* (1998) reported that citrus scab caused by *Elsinoe fawcettii* cause warty and scabby lesions on the surface of leaves, twigs and fruits of mandarin cv. Satsuma. Warty lesions were mainly developed before July but scabby lesions developed during the summer season in Cheju Island, Korea Republic.

Singh *et al.* (1998) reported that scab is primarily a disease of Sastuma, orange, tangerine, grape fruit, lemon, sour orange and trifoliate orange root stock. It does not affect the sweet orange. Scab affects fruit, leaves and young shoots causing irregular, raised, corky, scabby, wart like outgrowth, severely scabbed leaves and fruits become misshapen and distorted. The rind of scabbed fruit is thick and puffy.

2.1.2 Epidemic nature of scab of citrus (*Elsinoe fawcettii*)

Alam (2003) conducted a survey in the commercially citrus growing areas at Moulavibazer, Sylhet and Chittagong in Bangladesh and listed scab (*Elsinoe fawcettii)* and die back (*Colletotrichum gloeosporioides)* are the major diseases of citrus in Bangladesh.

Huang and Huang (2002) reported that approximately 50% of fruits from Nanfengmiju trees were damaged by citrus scab (*Elsinoe fawcettii*). The main reasons were identified as unfavorable weather conditions (Much rainfall, high humidity and frost damage)

Hartmond *et al.* (2000) in Florida reported that citrus scab caused by *Elsinoe fawcettii* can occur on stems and leaves, especially those of the summer flush, provide the main source of over wintering inoculum. Older scab pustules provide relatively little inoculum compared to those pustules on summer and fall shoot growth. Apparently, scab pustules lose their capacity for spore production as they aged.

Huang (1999) reported that citrus scab (*Elsinoe fawcettii*) attacked the expanded leaves of spring shoots of satsuma mandarin and started to attack the fruitlets in mid-late May in Jiangxi, China. During the autumn, if the temperature and humidity are favourable. The young shoots and fruitlets are attacked and 65.9-72.2% fruit lets are dropped.

Singh *et al.* (1997) conducted a survey at Panjab in India and disease incidence recorded on 3 citrus species viz. rough lemon (*Citrus jambhiri*) 76.5-80.1%, sweet orange (*C. sinensis*) 10.8-20.3% and kinnow (*C. nobilus* X *C. deliciosa*) 46.25-81.07%. The highest disease incidence was recorded in the sub-mountainous zone

on rough lemon (80.1%) and kinnow (80.07%) and the lowest incidence was recorded on sweet orange 10.8% in the arid irrigated zone.

Tripathi and Srivastava (1992) observed that citrus scab caused by *Elsinoe fawcettii* on leaves and fruits appeared during the 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.

2.1.3 Causal organism of scab of citrus

Hyun *et al.* (2001) reported that two scab diseases were recognized currently on citrus: (i) citrus scab caused by *Elsinoe fawcettii*, which has several pathotypes and (ii) Sweet orange scab caused by *E. australis*.

Janghoon *et al.* (1998) reported that the causal organism of scab was morphologically identified as *Sphaceloma fawcettii* (*Elsinoe fawcettii).*

Singh *et al.* (1998) identified the causal organism of citrus scab as *Elsinoe fawcettii* on the basis of spore morphology and pathogenicity test on rough lemon seedling.

Fantin and Kamati (1993) observed *Elsinoe australis* and *Elsinoe fawcettii* were the causal agents of citrus scab.

Tripathi and Srivastava (1992) also reported that citrus scab caused by *Sphaceloma fawcettii* (*Elsinoe fawcettii)* in Srinagar, India.

2.2.1 Symptoms of die-back of citrus

Bobby (2003) reported that wither tip is the major disease of about all citrus species. Symptoms appear initially from top and transmit downward to bottom of infected plant/tree. Diseased twigs start drying at tips and all affected parts become silvery gray and develop black dots. Defoliation and death of the entire plant also caused under severe condition.

Benyahia *et al.* (2003) reported that citrus trees (*Citrus sinensis* L. Osbeck) with symptoms resembling wither tip on twigs and tear stain on fruits were observed in Morocco. Lime (*Citrus aurantifolia)* was not affected. The die-back often progressed to tip wards slowly and caused wilt, turned yellow and dropped. Twigs and branches appeared to have been scorched by fire. When twigs were dry, minute brown to black, slightly raised, clumped pustules were observed. Under humid conditions, a pink slimy material appeared on dead bark and twigs. This symptom has also been observed on seedlings of citrus rootstocks in greenhouses in Morocco. The symptoms were superficial on the unbroken peel and formed dull red to dull radish-green streaks or bands down the fruit. In some cases, these covered a large percentage of fruit surface. On late season, on overripe fruit, the streaks sometimes become brownish in colour, resembling rust mite damage.

Amador (2002) reported that die back affected young branches, start withering from the tip, sometimes producing gum exudation. Wood is discolored underneath the bark. Damage by twig dieback usually is severe.

Rawal and Saxana (1997) reported that anthracnose attacks the young leaves, shoots, blossoms and fruits of small acid limes. Young foliage and blossoms are blighted and distinct lesions formed on leaves and fruits. Affected fruits frequently drop prematurely. Wither tip is characterized by shedding of leaves and die-back of twigs. Leaves show light green spots which turn brown. On dead twigs, black

dot like acervuli appear in concentric rings. The stem end of immature fruits results in fruit drop. In severe cases, branches show die-back and the tree dies in a few years. Symptoms of anthracnose appear on leaves, young shoots and tender fruits. On leaves, the necrotic spots show acervuli arranged in concentric rings. Dead parts of the twigs assume silvery grey appearance. Twigs show a slight gumming and a sharp line of separation between healthy and dead tissues. Affected buds fail to develop and affected fruits drop off. Often, the infected fruits develop reddish brown stain on the rind. The fungus has also been held responsible for russeting and tear staining of rind. This leads to the blight of twig. The infected hyphae produced by appresoria remain latent even after the fruit mature and produce anthracnose in oranges and grape fruit, if the peal is injured or fruits are over matured.

2.2.2 Epidemic nature of die back of citrus (*Colletotrichum gloeosporioides*)

Bobby (2003) reported that high humidity and poor soil conditions favour infection of wither tip causing fungus *Colletotrichum gloeosporioides*, which survives on infected plant parts remain in orchards or present in trees.

2.2.3 Causal organism of die-back of citrus

Peres *et al.* (2003) reported that *Colletotrichum gloeosporioides* causes anthracnose of lime and *C. acutatum* causes post bloom fruit drop of sweet orange. This species produces conidia with at least one end of fusiform conidia.

Amador (2002) reported that twig dieback can be caused by fungi, although non-pathogenic factors probably play a major role. As a result, fungal infection is often secondary, fallowing freeze damage or damage resulting from mechanical or chemical injury. Other factors that can damage twigs are for excessive

fertilization, moisture stress and damage to the root system by cultural practices or heavy nematode infestation.

Timmer *et al.* (1998) reported that *Colletotrichum gloeosporioides* (*Glomerella cingulata*), causes post harvest anthracnose of citrus fruits and a common saprobe in citrus groves, whereas *C. acutum* infects flower petals and causes post bloom fruit drop (PFD).

Rawal and Saxana (1997) reported that anthracnose attacks the young leaves, shoots, blossoms and fruits of small acid limes. The disease is caused by *Gloeosporium limetticolum* Clousen or *G. foliicolum* Nishida. Malta oranges and grape fruits suffer much more damage. *C. gloeosporioides* remains in a dormant condition in the dead twigs and branches.

Ploetz *et al.* (1996) reported that the most commonly isolated fungi from citrus decline (dieback) were *Alternaria alternata*, *Cladosporium* sp., *Colletotrichum gloeosporioides* (*Glomerella cingulata*), *Dothiorella dominicana*, *Fusarium* spp., *Botryodiplodia theobromae*, *Penicillium* sp., *Pestaliopsis* sp. and *Phomopsis* spp.

Mourichon (1994) observed that a serious dieback caused by *Ceratocystis fimbriata* in Colombia over the last 3-4 years, which threatens overall citrus production.

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

Ray Chaudhuri *et al.* (1980) reported that numerous agents including greening virus were involved in the causal complex of the devastating citrus die-back disease occurring in India..

Talukdar (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 twigs of die-back affected citrus plants. In the pathogenicity test, they found the fungus most pathogenic to Kagzi lime among several citrus species including lemon.

2.3.1 Management of scab of citrus through fungicides

Siddiquee (2007) conducted a research work using plant extracts and fungicides for controlling scab and die-back of citrus. He observed that Champion 77 WP was the most effective fungicide in controlling scab of citrus that reduced 85.43% leaf scab and 80.12% fruit scab of citrus which was closely followed by Rovral 50WP (83.87%).

Alam (2006) conducted a research work on standing citrus plant using bio-agent, plant extracts and fungicides for controlling scab and die-back of citrus. The highest reduction of scab severity (PDI) was performed by Champion 77 WP (72.72% leaf scab and 83.98% fruit scab) followed by Bishkatali extract (67.54%, 79.99%), Bordeaux mixture (66.26%, 72.01%) and *Trichoderma harzianum* T_{22} (62.36%, 63.34%), respectively.

Timmer *et al.* (2005) reported that three applications of fungicides are needed to control the diseases, one at about ¼ expansion of the spring flush, a second at petal fall, and a third about three weeks later. If there is little carryover of disease from the previous season, the first spray can be omitted. Ferbam, Abound, Zem or Headline is good choices for the first application because they are all able to kill the fungus in old lesions and then reduce inoculum as well as protecting foliage. Copper fungicides, Abound, Gem or Headline are good choices for the third spray

since they will protect fruit from scab, but copper products are less effective for scab and should not be selected where scab pressure is high.

Yesmin (2004) conducted an experiment of citrus scab. She used Capravit- 50 WP (0.4), Dithane M-45 (0.3%) and Rovral 50 WP (0.2%). All the fungicide showed significant effect in controlling scab of citrus. The highest reduction of scab incidence was recorded in case of applying Rovral 50 WP on *Citrus limon.*

Fang *et al.* (2004) conducted an experiment in South China in a Satsuma mandarin orchard. Among the materials used, 75% Menghashen (Mancozeb) and 77% Dodine found promizing that reduced the scab disease by 87.1% and 75.5%, respectively over control.

Xu *et al.* (2004) conducted an experiment in China with 15 years old satsuma trees. Fungicides used included 50% Xinling (Carbendazim + Mancozeb), 80% Bideli (Copper hydroxide) and 20% Qingdaoful (of unstated composition). Best control of citrus scab (*Elsinoe fawcettii*) was done by 600 times solution of 80% Bideli.

Agostini *et al.* (2003) conducted an experiment in Argentina in a Greenhouse rough lemon orchard. Oxycom, Nutriphite, Messenger, Goemar H11, Serenade, Rezist, Prophyt, Aliette, Actigard and Keyplex were evaluated and compared with benomyl or strobilurin fungicides as standards. Among the fungicides the most effective products were Rezist and Actigard that contain phosphorous acid.

Huang and Huang (2002) reported that control of die-back was possible by spraying spring buds with Bordeaux mixture followed by 2 spraying of Bordeaux mixture between August and October.

Zhou *et al.* (2001) conducted an experiment to control citrus scab by chemical. They observed that the most effective chemical control for preventing attack of young leaves by scab was spraying of a copper and ammonium mixed solution (500 g Copper sulphate + 2.25 kg ammonium bicarbonate) in mid-late March.

Ran *et al.* (2001) sprayed Mancozeb M-45, Carbendazim, Pyridaben and Topsin (Thiophanatemethyl) in a citrus orchard at different concentrations to control citrus diseases and citrus rust mite. Spraying was applied at different stages. The results showed that the best control of citrus scab was achieved by spraying a 600 times solution of 80% Mancozeb M-45 when the shoots were 2 cm long, then twice more spraying at 10 days intervals (total of 3times). Spraying a 600 times solution of 80% Mancozeb M-45 after fall and again at intervals of 15 days (total of 4 times) gave good control of citrus black spot.

Singh *et al.* (2000) conducted an experiment for management of citrus scab. They used Blitox-50 (Copper oxychloride), Bordeaux mixture, Derosal (Carbendazim), Chlorothalonil and Indofil M-45 (Mancozeb) at 1000 ppm each 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-50 at 0.3%, Bordeaux mixture at 1%, Derosal at 0.2%, Chlorothalonil 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%, respectively over control.

Bushong and Timmer (2000) reported that Benomyl was effective if applied 72 hour after inoculation and fenbuconazole and azoxystrobin were effective if applied within 16 to 48 hours after inoculation. They showed that use of post infection sprays under field conditions appears to be promising for scab control.

Huang (1999) investigated the effects of fungicide against citrus scab caused by *Elsinoe fawcettii*. They used Bordeaux mixture or thiophanate methyl (as Topisn-

M) for control of citrus scab on mandarin. Thiophanate methyl controlled citrus scab by 75% over control. Spraying of Bordeaux mixture at the bud break stage gave effective disease control.

Li *et al.* (1997) conducted an experiment on four years old trees of Satsuma cv. Winzhou and Mandarin cv. Ponggan in China. They applied Pujunk (Copper hydroxide) and Bordeaux mixture as a spray 500 times in the Spring, or 700 times in the summer and found that Pujunk controlled citrus scab (*Elsinoe fawcettii*) more effective than Bordeaux mixture.

Gottwald (1995) observed that Catafol significantly affected the spatiotemporal dynamics of citrus scab epidemics by reducing both inoculum production and poroviding protection to susceptible new leaves.

Whiteside (1990) conducted 3 years trial with 4 fungicides namely Dithane, Catafol, and 2 sterol inhibiting fungicides, Diniconazole and Difeconazole to evaluate them against citrus scab caused by *Elsinoe fawcettii* in Florida, USA. They observed that Dithane performed better than copper fungicide treatments. However, Difeconazole usually gave better control of scab than Dithane. Where spray treatments were delayed until after some fruit had become infected, Difeconazole reduced scab severity even more than catafol.

Rawal (1990) reported that spraying of Difolatan 0.2% and Ferbam 75 WP gave effective control against scab of citrus caused by *Elsinoe fawcettii.* Ferbam has been found to be superior over Bordeaux mixture.

2.3.2 Management of citrus die-back through fungicides

Siddiquee (2007) conducted an experiment in Bangladesh using plant extracts and fungicides for controlling scab and die-back of citrus. Among the treatments

evaluated against die back (*Colletotrichum goleosporioides),* Dithane M-45 was found most effective in controlling die back of citrus which reduced die-back severity by 58.01% over control. Bavistin 50WP, Allamanda leaf extract, Tilt 250EC and Champion 77WP also showed promising effect in reducing disease severity of die back that reduced PDI (twig) by 56.49%, 54.72% and 50.53%, respectively.

Alam (2006) conducted a research work on the standing citrus plant raised at citrus orchard in Bangladesh. The highest reduction of die-back severity (PDI) over control was resulted by Dithane M-45 (73.46%) followed by Neem extract (67.34%), Bordeaux mixture (59.19%) and *Trichoderma harzianum* T22 (57.67%).

Peres *et al.* (2003) reported that post bloom fruit drop (PFD) of citrus, caused by *Colletotrichum gloeosporioides* was controlled effectively by spraying of Benomyl (Benlate 50 WP) in reasearch field and as well as in the commercial orchards.

Das *et al.* (1998) conducted an experiment to evaluate eight fungicides in controlling *Colletotrichum gloeosporioides (Glomerella cingulata) in vitro.* The fungicides tested were Carbendazim (as Bavistin), Propiconazole (as Tilt), Expoxiconazole (as Opus), Tridemorph (as Calixin), Metalaxyl + mancozeb (as Ridomil M-72), Mancozeb (as Dithane M-45), Copper oxychloride (as Biltox- 50) and Thiram at different concentrations. Epoxiconazole completely inhibited the linear mycelial growth at 50 mg/L and higher concentrations. Carbendazin and Ridomil M-72 inhibited linear mycelial growth at 250 mg/L. Tridemorph effectively checked the total growth at 500 mg/L. Mancozeb, Copper oxychloride and Thiram were moderately effective even at 500 mg/L.

Ansar *et al.* (1997) conducted an experiment in Pakistan and found *C. gloeosporioides*, the main causal agent of guava decline could be effectively controlled by combined use of Topsin-M (Thiophanate methyl) and Cupravit.

Ebenezar and Shubramanian (1996) observed the 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 Aureofungin for testing their efficacy. All the fungicides reduced die-back of acid lime. Among the treatment, Carbendazim (0.1%) and Bordeaux mixture (0.8%) showed better control.

Shayesta (1995) tested Cupravit (copper oxychloride) against leaf spot and twig blight disease of *Euchalyptus camaldutensis* caused by *Colletotrichum gloeosporioides, as foliar sprays.* He found that the disease was controlled and minimized by Cupravit sprayed at 1g/L concentration with ten days intervals.

Thakore *et al.* (1994) tested some fungicides against die-back of citrus in Rajasthan. They treated die-back affected plant with Biltox-50 (copper oxychloride), Dithane M-45 (Mancozeb) and Macuprex (Cupraneb + Boradeaux). They found all the fungicides were effective against the disease at 2000 ppm concentration.

CHAPTER III

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted in the citrus orchard of Sher-e-Bangla Agricultural University, Dhaka.

3.2 Experimental period

The experiment was carried out during April, 2008 – September, 2008 (in Kharif season)

3.3 Soil type

The description of the Agro-ecological zone (UNDP and FAO, 1988) of the experimental site is as follows:

Agro-ecological region	:	Madhupur tract (AEZ-28)
Land type	:	Medium High Land
General Soil type	:	Non-Calcarious dark-gray flood plain Soil
Soil series	:	Tejgaon
Topography	:	Up land
Elevation	:	8.45
Location	:	SAU campus, Dhaka.
Field Level	:	Above flood level
Drainage	:	Fairly good
Firmness (consistency)	:	Compact of friable when dry.

3.4 Plant selection

Twenty four plants were selected from the citrus orchard of Sher-e-Bangla Agricultural University (SAU) campus, Dhaka. All plants were equal aged (7 years old) and these plants were used as the experimental unit of this study.

3.5 Treatments

Table 1. Treatments used in the experiment

Treatment	Fungicide	Chemical name	Active ingredient	Dose used
T_1	Cupravit 50 WP	Copper Oxychloride	Copper Oxychloride 50%	0.7 %
T_2	Bavistin 50 WP	Methyl-2-Benzimidazole carbamate	Carbendazime 50%	0.1%
T_3	Rovral 50 WP	1-Isopropyl carbammoyl-3-dichlorophynyl hydration	Iprodione 50%	0.2%
T_4	Ridomil MZ-75	N-(2,6 dimethyl phenyl N-methoxy acetyl)- alanine methyl ester (C12H2N4)	Metalaxyl (72%)	0.2%
T_5	Tilt 250 EC	Propiconazole	Propiconazole 25%	0.05%
T_6	Champion 77 WP	Copper hydroxide $Cu(OH)_2$	Copper hydroxide 77 %	0.2 %
T_7	Dithane M-45	Manganous ethylene bisdithio – carbamate	Dithiocarbamate 80%	0.3 %

Treatment 8 is designed as control

3.6 Design of experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) comprising three replications for each treatment. Thus there were altogether 8 treatments for 24 plants used for the study. Different treatments were assigned randomly to the unit plant.

3.7 Weeding

Weeding was performed three times during the experimental period with 30 days intervals starting from 1st April 2008.

3.8 Irrigation

The plants were irrigated six times. The first irrigation was done at 2nd April, 2008 and the fallowing irrigations were done with 15 days intervals.

3.9 Application of fertilizers and manure

Fertilizers and manure were applied to the experimental unit plant as per recommendation of Krishi Projukti Hat Boi published by BARI (Bangladesh Agricultural Research Institute). The following doses of fertilizers were applied to the unit plant-

Fertilizer /Manure	Dose/plant
Urea	500 gm
TSP	400gm
MP	400gm
Cow-dung	20 kg

Half of the urea, TSP and MP and all amount of cow dung were used at the time of 1st weeding. The rest half of the urea, TSP and MP were applied at 1st July, 2008.

3.10 Application of insecticide

Insecticide Aktara was applied three times @ 0.5 gm/liter water at 15 days interval from 3rd April, 2008 to protect the plants from insects.

3.11 Tagging and data collection

Five twigs were selected randomly from each plant. These twigs were tagged for determination of scab and die back infection. Mean infection values were calculated to get ratting score (Rahman and Hossain, 1988). But for fruit infection the whole plant was considered. Data were recorded on different parameters on individual plant basis just after onset of the disease symptom in experimental plot. As many as seven observations were taken starting from 15 May, 2008 with 15 days intervals.

3.12 Preparation of spray solution

The fungicidal solutions were prepared by mixing prescribed amount of fungicides with tap water to get 0.7% solution for Cupravit 50 WP, 0.1% solution for Bavistin 50 WP, 0.2% solution for Rovral 50 WP, 0.2% solution of Ridomil MZ-72, 0.05% solution for Tilt 250 EC, 0.2% solution for Champion 77WP and 0.3% solution for Dithane M-45.

3.13 Application of spray solution

All fungicides were sprayed with compressed hand sprayer. Three plants were sprayed with each fungicide and for each treatment. First spray was done in 15

May, 2008. The plants were sprayed 6 times at an interval with 15 days. Required amount of spray-solution was applied per plant covering branches, twigs, leaves and fruits properly. Control plants were sprayed with plain water only. Precautions were taken to avoid drifting of spray materials to neighboring plants with polythene barrier.

3.14 Disease symptoms observed in the orchard

The plants were routinely observed from the time of spraying. Onset of new infection was recorded and symptoms of the scab and die- back were observed, recorded and photographed.

3.15 Data collection

Data were collected on the following parameters:

3.15.1 Total number of leaves per twig

Number of total leaves/twig was counted from randomly selected five twigs from each plant at different dates as per schedule.

3.15.2 Total number of scab infected leaves per twig

Number of scab infected leaves/twig under each treatment was counted at different observation dates as per schedule.

3.15.3 Calculation of disease incidence of leaf scab of different treatments

The percent disease incidence of leaf was calculated using the following formula (Islam *et al*, 2001)

$$\text{Disease incidence} = \frac{\text{Number of infected leaves}}{\text{Total number of observation (leaves)}} \times 100$$

3.15.4 Total number of fruits per plant

Numbers of total fruits were recorded at different observation dates as per schedule.

3.15.5 Total number of scab infected fruits per plant

Number of scab infected fruits/plant under each treatment was counted at different observation dates as per schedule.

3.15.6 Calculation of disease incidence of fruit scab of different treatments

The percent disease incidence of fruit was calculated using the following formula (Islam *et al*, 2001)

$$\text{Disease incidence} = \frac{\text{Number of infected fruits}}{\text{Total number of inspected fruits}} \times 100$$

3.15.7 Total number twigs per branch

Number of total twigs/branch was counted from randomly selected five branches from each plant at different dates as per schedule.

3.15.8 Total number of die back infected twigs per branch

Number of die back infected twigs/branch under each treatment was counted at different observation dates as per schedule.

3.15.9 Calculation of disease incidence of die back of different treatments

The percent disease incidence was calculated using the following formula (Islam *et al*, 2001)

$$\text{Disease incidence} = \frac{\text{Number of infected twigs}}{\text{Total number of observation (twigs)}} \text{ X } 100$$

3.15.10 Evaluation of leaf and fruit scab severity

Percent leaf area diseased (LAD) and fruit area diseased (FAD) were measured. Area of single leaf or fruit was considered as 100%. Deducting the healthy area, the diseased area was estimated. Then average of % LAD and % FAD was calculated dividing the total diseased areas by total number of investigated leaves and fruits (Islam *et al.*, 2001). The leaf and fruit scab severity was recorded following 0-5 scale with slight modification as designed by Gonzalez *et al.* (1993). The gradation is given below.

Grade		**% area infected**
0	=	No infection
1	=	Up to 5% area infected
2	=	5-10% areas infected
3	=	11-20% areas infected
4	=	21-30% area infected and
5	=	above 30% area infected.

The percent disease index (PDI) was calculated using the following formula (Gonzalez *et al.* 1993)

$$\text{PDI} = \frac{\text{Total sum of numerical rattings}}{\text{Number of observation} \times \text{Maximum grade in the diseases ratting scale}} \times 100$$

3.15.11 Evaluation of die back severity

The die back severity was recorded following 0-5 scale with slight modification as designed by Rahman and Hossain (1988). The gradation is given below:

Grade		% twig infected
0	=	No infection
1	=	Up to 10% twig area infection
2	=	11 - 20% twig area infected
3	=	21- 30% twig area infected
4	=	31 - 50% twig area infected and
5	=	above 50 % twig area infected

The percent disease index (PDI) was calculated using the formula (Rahman and Hossain 1988)

$$PDI = \frac{\text{Total sum of numerical rattings}}{\text{Number of observation} \times \text{Maximum grade in the diseases ratting scale}} \times 100$$

3.16Analysis of data

The data on various parameters were analyzed using analysis of variance to find out the variation obtained from different treatments. Compilation of the experimental data and analysis were done by the MSTAT-C computer program following the statistical procedures of Gomez and Gomez (1983). Treatment means were compared by DMRT (Duncan's Multiple Range Tests).

3.17 Weather

The monthly mean of daily maximum, minimum and average temperature, relative humidity and monthly total rainfall at the experiment site during the period of the study have been collected from the surface synoptic data card, Bangladesh Meteorological Department, Dhaka (Appendix 1).

CHAPTER IV

RESULTS

CHAPTER IV

RESULTS

4.1. Scab symptoms observed in the orchard

The citrus plants were much infected when the experiment was started. But different stages of disease development and symptom pattern were seen in the citrus orchard. The initial stage of disease was manifested as the irregular corky spot on the leaves and fruits (Photograph 1, 2 and 3) .The spots ranged from a few mm up to 1cm in diameter. In later stage of disease development, spots became warty and erupted with cracks and scabby on the leaves. The spots were found more often on the lower surface than on the upper. On the fruits, the warty growth was surrounded by yellowish or chlorotic halo. In many cases several spots coalesced to form large patches of corky outgrowth. The lesions also appeared on shoots. Heavily infected fruits drop shortly after being attacked.

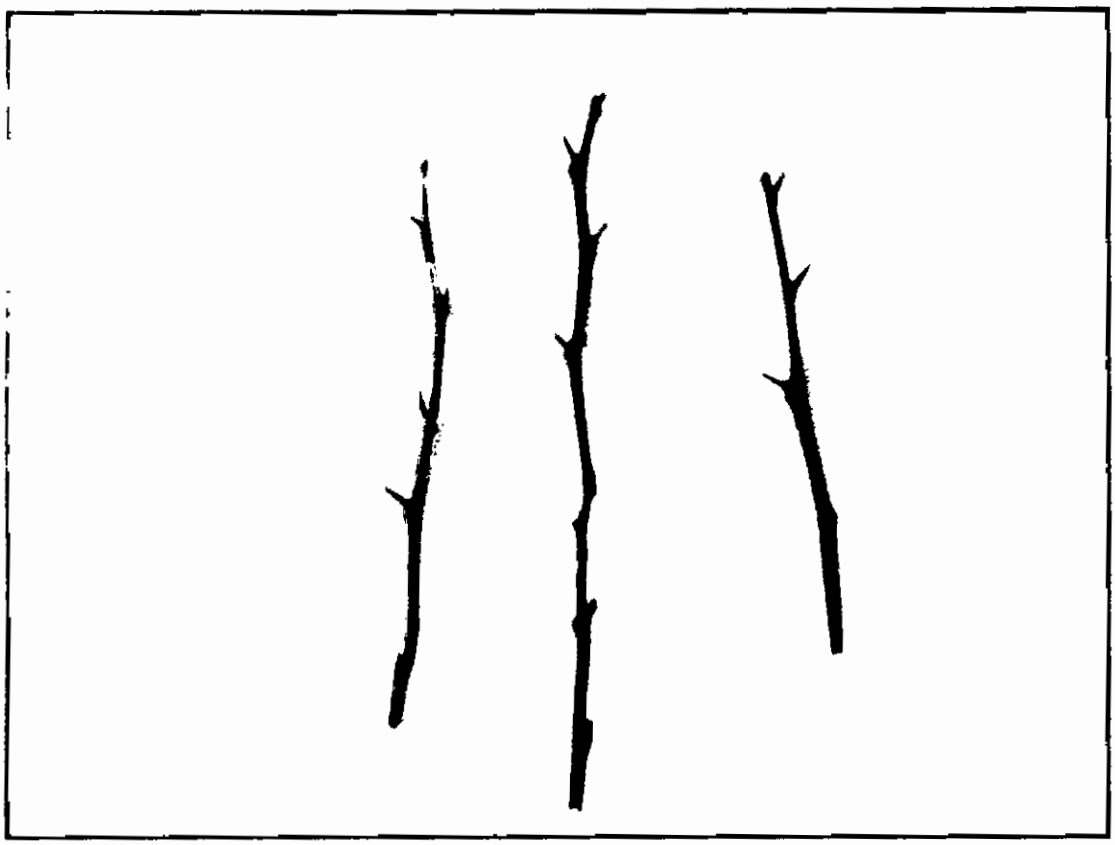
Photograph 1. Scab infected twig of citrus

4.2. Die back symptoms observed in the orchard

The characteristic symptom of the disease was drying of the shoots downwards to the stem that resulted in the death of twigs or top of the branches. The first visible symptom of the disease was characterized by shading of the green color of the tip of twigs and the leaves. The die back progressed slowly and caused wilting of leaves, turned yellow and drop off. The twigs gradually started drying from the top to downwards(Photograph 4 and 5).

After the symptom noticed, the drying of the twig was usually rapid which extended 5 to 12 cm downwards ending in a sharp line. Afterwards, the disease progressed slowly or rapidly in the similar way towards the stem affecting more twigs and branches. In some cases, the tip of the die back affected young branches, produced gum exudation.

Twigs and branches appeared to have been scorched by fire. When twigs were dried, minute brown to black, slightly raised, clumped pustules were observed. Later on in some cases, black dot like structures (acervuli) were found to develop on the light or grayish brown to whitish ashy membranous dead twigs or branches. In severe cases, branches showed die back and tree dies gradually.



Photograph 2. Die back infected twig of citrus

Photograph 3. Severely die back infected plant

4.3 Incidence and severity of scab of citrus (leaf) before commencement of spray schedule

The disease incidence and severity of scab of citrus plants (leaf) before commencement of the spray schedule was statistically similar for the citrus plants selected for each and every treatment (Table 2). The disease incidence (leaf) ranged from 26.16% to 28.92% and the disease severity (PDI-leaf) ranged from 22.56% to 24.50%.

4.4 Effect of fungicides in controlling leaf scab of citrus after one month of starting spray

The effect of fungicides in controlling leaf scab of citrus after one month of starting of spray was assessed and presented in Table 2. The disease incidence under different treatments differed significantly from one another. The lowest incidence of leaf scab (18.68%) was found in T_3 (Rovral 50WP) and the highest incidence (28.87%) in T_8 (Control). The second lowest incidence of leaf scab (19.46%) of citrus was found in T_6 (Champion 77 WP) which is statistically similar with T_2 (Bavistin 50 WP). The effect of treatment T_1 (Cupravit 50 WP), T_4 (Ridomil MZ-72) and T_7 (Dithane M 45) did not differ significantly in case of disease incidence.

The disease severity (PDI-leaf) under different treatments also differed significantly. The lowest disease severity (14.53 %) was found in T_3 (Rovral 50 WP) and the highest disease severity (27.18 %) was in T_8 (Control). The second lowest disease severity (15.30 %) was found with T_6 (Champion 77 WP) followed by T_7 (Dithane M 45).

The highest PDI decreased over control (46.54%) was found in T_3 (Rovral 50 WP) followed by T_6 (Champion 77 WP), T_7 (Dithane M 45), and T_2 (Bavistin 50 WP). The lowest decrease of PDI-leaf was noted in T_4 (Ridomil MZ-72) proceeded by T_4 (Cupravit 50 WP) and T_5 (Tilt 250 EC) (Table 2).

Table 2. Effect of fungicides on the incidence and severity of leaf scab of citrus after one month of starting spray

Treatments	Before spraying		After one month of starting of spray		
	Disease incidence (leaf)	Percent Disease index (PDI-leaf)	Disease Incidence (leaf)	Percent Disease index (PDI-leaf)	PDI-leaf decreased over control (%)
T_1= Cupravit 50 WP	26.70 a	22.75 ab	22.56 b	17.76 bc	34.66
T_2= Bavistin 50 WP	26.16 a	23.22 ab	19.74 cd	16.48 cde	39.37
T_3= Rovral 50 WP	28.37 a	23.15 ab	18.68 d	14.53 f	46.54
T_4= Ridomil MZ-72	27.19 a	23.80 ab	23.77 b	18.55 b	31.75
T_5=Tilt 250 EC	28.12 a	22.56 b	21.58 bc	17.32 bcd	36.28
T_6= Champion 77 WP	26.93 a	24.42 a	19.46 cd	15.30 ef	43.71
T_7= Dithane M -45	28.92 a	23.63 ab	22.25 b	15.95 def	41.32
T_8= Control	28.61 a	24.50 a	28.87 a	27.18 a	
CV%	7.51	3.88	5.96	4.89	

The means having same latter(s) does not significant at 5% level

4.5 Effect of fungicides in controlling leaf scab of citrus after two months of starting spray

The effect of fungicides in controlling leaf scab of citrus after two month of starting of spray was recorded and are presented in Table 3.

The disease incidence under different treatments differed significantly. The lowest incidence of leaf scab (12.35%) was found in T_3 (Rovral 50 WP) which was statistically similar with T_6 (Champion 77 WP) (13.48) and the highest incidence (29.35%) in T_8 (Control). The second lowest incidence of leaf scab (14.62%) of citrus was found in T_2 (Bavistin 50 WP).

The disease severity (PDI-leaf) under different treatments also differed significantly. The lowest disease severity (8.42%) was found with T_3 (Rovral 50 WP) and the highest disease severity (30.82%) in T_8 (Control). The second lowest disease severity (9.51%) was found with T_6 (Champion 77 WP).

The highest PDI decreased over control (72.68%) was found with T_3 (Rovral 50 WP) followed by T_6 (Champion 77 WP) (69.14%) and T_7 (Dithane M-45) (65.15%). The lowest decrease of PDI was noted (53.34%) in T_4 (Ridomil MZ-72) preceded by T_1 (Cupravit 50 WP) (56.98 %) and T_5 (Tilt 250 EC) (58.79%) (Table 3).

Table 3. Effect of fungicides on the incidence and severity of leaf scab of citrus after two month of starting of spray

Treatments	Before spraying		After two month of starting of spray		
	Disease incidence (leaf)	Percent Disease index (PDI-leaf)	Disease incidence (leaf)	Percent Disease index (PDI-leaf)	PDI-leaf decreased over control (%)
T_1= Cupravit 50 WP	26.70 a	22.75 ab	18.74 b	13.26 bc	56.98
T_2= Bavistin 50 WP	26.16 a	23.22 ab	14.62 de	11.65 de	62.2
T_3= Rovral 50 WP	28.37 a	23.15 ab	12.35 e	8.42 g	72.68
T_4= Ridomil MZ-72	27.19 a	23.80 ab	19.56 b	14.38 b	53.34
T_5=Tilt 250 EC	28.12 a	22.56 b	16.33 cd	12.70 cd	58.79
T_6= Champion 77 WP	26.93 a	24.42 a	13.48 e	9.51 fg	69.14
T_7= Dithane M- 45	28.92 a	23.63 ab	17.88 bc	10.74 ef	65.15
T_8= Control	28.61 a	24.50 a	29.35 a	30.82 a	
CV%	7.51	3.88	7.05	5.18	

Means bearing same letter within the same column do not differ significantly at 5% level.

4.6 Effect of fungicides in controlling leaf scab of citrus after three months of starting spray

The effect of fungicides in controlling leaf scab of citrus after three months of starting of spraying was determined and are presented in Table 4.

The disease incidence under different treatments differed significantly. The lowest incidence of leaf scab (7.76 %) was found in T_3 (Rovral 50 WP) which was statistically identical (8.90 %) with T_6 (Champion 77 WP) and the highest incidence (29.87 %) was recorded in T_9 (Control). The second lowest incidence of leaf scab of citrus (11.13%) was found T_2 (Bavistin 50 WP) which was statistically similar with T_5 (Tilt 250 EC).

The disease severity (PDI-leaf) under different treatments also differed significantly. The lowest disease severity (4.64%) was found with T_3 (Rovral 50 WP). The second lowest disease severity was recorded in T_6 (Champion 77 WP) (6.12 %). The highest disease severity was recorded (33.56 %) in Control (T_8) preceded by T_1 (Cupravit 50 WP) (7.25%) and T_4 (Ridomil MZ-72) (11.26%).

The highest PDI decreased over control (86.17%) was found with T_3 (Rovral 50 WP) followed by T_6 (Champion 77 WP) (81.76 %) and T_7 (Dithane M-45) (77.53 %). The lowest decrease of PDI was noted (26.45%) in T_4 (Ridomil MZ-72) (62.57 %) preceded by Cupravit 50 WP (11.73 %) and T_5 (Tilt 250 EC) (10.44 %) (Table 4).

Table 4. Effect of fungicides on the incidence and severity of leaf Scab of citrus after three months of starting spray

Treatments	Before spraying		After three month of starting of spray		
	Disease incidence (leaf)	Percent Disease index (PDI-leaf)	Disease incidence (leaf)	Percent Disease index (PDI-leaf)	PDI-leaf decreased over control (%)
T_1= Cupravit 50 WP	26.70 a	22.75 ab	16.27 bc	11.73 b	65.05
T_2= Bavistin 50 WP	26.16 a	23.22 ab	11.13 d	9.27 d	72.38
T_3= Rovral 50 WP	28.37 a	23.15 ab	7.76 e	4.64 g	86.17
T_4= Ridomil MZ-72	27.19 a	23.80 ab	17.86 b	12.56 b	62.57
T_5=Tilt 250 EC	28.12 a	22.56 b	12.65 d	10.44 c	68.89
T_6= Champion 77 WP	26.93 a	24.42 a	8.90 e	6.12 f	81.76
T_7= Dithane M 45	28.92 a	23.63 ab	14.72 c	7.54 e	77.53
T_8= Control	28.61 a	24.50 a	29.87 a	33.56 a	
CV%	7.51	3.88	7.90	5.19	

Means bearing same letter within the same column do not differ significantly at 5% level

4.7 Incidence and severity of fruit scab of citrus before commencement of spray schedule

The disease incidence and severity of scab of citrus fruits before application of spray was recorded and are presented in Table 5. The disease incidence in fruit ranged from 28.25 % to 35.45 % and the disease severity (PDI- fruit) ranged from 25.36 % to 27.85 %.

4.8 Effect of fungicides in controlling fruit scab of citrus after one month of starting of spray

The effect of fungicides and plant extract in controlling scab of citrus fruits after one month of starting of spray was summarized and are presented in Table 5.

The treatment effects were differed significantly in respect of disease incidence and severity. In case of disease incidence (fruit), the lowest incidence (17.58 %) was recorded in T_6 (Champion 77 WP). The second lowest disease incidence (Fruit) was found in T_7 (Dithane M- 45) (19.73). The highest disease incidence (38.78 %) was recorded in case of T_8 (control).

In case of disease severity (PDI- fruit), the lowest disease severity was recorded in T_6 (Champion 77 WP) (17.51%), which was statistically similar with that of Dithane M-45 (18.22%). T_3 (Rovral 50 WP) (18.83 %) scored second highest severity in the experiment which is statistically similar with T_2 (Bavistin 50 WP) (19.46 %) and T_5 (Tilt 250 EC) (20.13 %). The highest disease severity was observed in control (27.54 %).

The highest reduction of PDI over control was observed in case of T_6 (Champion 77 WP) (36.42 %) followed by T_7 (Dithane M-45) (33.84 %) and T_3 (Rovral 50 WP) (31.62 %). The lowest reduction of PDI was noticed in case of T_4 (Ridomil MZ-72) (21.39 %) preceded by T_1 (Cupravit 50 WP) (24.11 %) and T_5 (Tilt 250 EC) (26.91 %) over control (Table 5).

Table 5. Effect of fungicides on the incidence and severity of fruit scab of citrus after one month of starting spray

Treatments	Before spraying		After one month of starting of spray		
	Disease incidence (fruit)	Percent Disease index (PDI-fruit)	Disease incidence (fruit)	Percent Disease index (PDI- fruit)	PDI-fruit decreased over control (%)
T_1= Cupravit 50 WP	30.76 bc	26.28 ab	21.22 bcd	20.90 bc	24.11
T_2= Bavistin 50 WP	29.85 cd	27.54 a	21.46 bc	19.46 cde	29.34
T_3= Rovral 50 WP	30.57 c	26.62 ab	20.10 cd	18.83 def	31.62
T_4= Ridomil MZ-72	28.25 d	26.75 ab	22.61 b	21.65 b	21.39
T_5=Tilt 250 EC	29.52 cd	27.21 a	20.82 cd	20.13 bcd	26.91
T_6= Champion 77 WP	32.43 b	27.85 a	17.58 e	17.51 f	36.42
T_7= Dithane M	30.68 bc	27.41 a	19.73 d	18.22 ef	33.84
T_8= Control	35.45 a	25.36 b	38.78 a	27.54 a	
CV%	3.14	3.11	3.65	4.18	

Means bearing same letters within the same column do not differ significantly at 5% level.

4.9 Effect of fungicides in controlling fruit scab of citrus after two months of starting of spray

The effect of treatments in controlling scab of citrus fruits after two months of starting of spray was determined and presented in Table 6.

The treatment effects differed significantly in respect of disease incidence and severity. In case of disease incidence on fruits, the lowest incidence (10.45 %) was recorded in T_6 (Champion 77 WP) which was statistically identical with T_7 (Dithane M-45). The second lowest incidence was recorded in T_3 (Rovral 50 WP) (12.55 %). The highest disease incidence (41.20%) was recorded in control (T_8).

In case of disease severity (PDI- fruit), the lowest severity was recorded in T_6 (Champion 77 WP) (10.34 %). Second lowest disease severity was found in T_3 (Rovral 50 WP). The highest disease severity (30.68%) was observed in control.

The highest reduction of PDI over control was observed in case of T_6 (Champion 77 WP) (66.30 %) followed by T_3 (Rovral 50 WP) (56.81 %) and T_2 (Bavistin 50 WP). The lowest reduction of PDI was noticed in case of T_4 (Ridomil MZ-72) (42.70 %) proceeded by T_1 (Cupravit 50 WP) (45.50 %) and T_5 (Tilt 250 EC) (49.05%) over control (Table 6).

Table 6. Effect of fungicides on the incidence and severity of fruit scab of citrus after two months of starting spray

Treatments	Before spraying		After two month of starting of spray		
	Disease incidence (fruit)	Percent Disease index (PDI-fruit)	Disease incidence (fruit)	Percent Disease index (PDI- fruit)	PDI-fruit decreased over control (%)
T_1= Cupravit 50 WP	30.76 bc	26.28 ab	16.15 c	16.72 bc	45.50
T_2= Bavistin 50 WP	29.85 cd	27.54 a	13.73 de	14.47 dc	52.84
T_3= Rovral 50 WP	30.57 c	26.62 ab	12.55 ef	13.25 e	56.81
T_4= Ridomil MZ-72	28.25 d	26.75 ab	18.44 b	17.58 b	42.70
T_5=Tilt 250 EC	29.52 cd	27.21 a	14.83 cd	15.63 cd	49.05
T_6= Champion 77 WP	32.43 b	27.85 a	10.45 g	10.34 f	66.30
T_7= Dithane M	30.68 bc	27.41 a	11.86f g	16.62 bc	45.83
T_8= Control	35.45 a	25.36 b	41.20 a	30.68 a	
CV%	3.14	3.11	5.72	5.67	

Means bearing same letter within the same column do not differ significantly at 5% level

4.10 Effect of fungicides and in controlling fruit scab of citrus after three months of starting spray

The effect of fungicides in controlling scab of citrus (fruit) after three months of starting of spraying (six sprays applied) was determined and presented in Table 7.

The treatment effects were differed significantly in respect of disease incidence and severity. In case of disease incidence (fruit), the lowest incidence (6.80 %) was recorded in T_6 (Champion 77WP) .Second and third lowest incidence was found in case of T_7 (Dithane M-45) (8.35%) and T_3 (Rovral 50 WP)(9.65). The highest disease incidence (43.95%) was recorded in control (T_8).

In case of disease severity (PDI- fruit), the lowest disease severity was recorded in T_6 (Champion 77WP) (5.67%) followed by T_7 (Dithane M-45) (7.52%) and T_3 (Rovral 50 WP) (9.46%). The highest disease severity was observed in control (32.13%) proceeded by T_4 (Ridomil MZ-72) and T_1 (Cupravit 50 WP).

The highest reduction of PDI over control was observed in T_6 (Champion 50 WP) (82.35 %) followed by T_7 (Dithane M-45) (76.60 %) and T_3 (Rovral 50 WP) (70.56). The lowest reduction of PDI was noticed in case of T_4 (Ridomil MZ-72) (45.38 %) proceeded by T_1 (Cupravit 50 WP) (52.60 %) and T_5 (Tilt 250 EC) (57.24 %) over control (Table 7).

Table 7. Effect of fungicides on the incidence and severity of fruit scab of citrus after three months of starting spray

Treatments	Before spraying		After three month of starting of spray		
	Disease incidence (fruit)	Percent Disease index (PDI-fruit)	Disease incidence (fruit)	Percent Disease index (PDI- fruit)	PDI-fruit decreased over control (%)
T_1= Cupravit 50 WP	30.76 bc	26.28 ab	13.24 bc	15.23 c	52.60
T_2= Bavistin 50 WP	29.85cd	27.54 a	11.28 d	11.35 e	64.67
T_3= Rovral 50 WP	30.57 c	26.62 ab	9.65 e	9.46 f	70.56
T_4= Ridomil MZ-72	28.25 d	26.75 ab	14.37 b	17.55 b	45.38
T_5=Tilt 250 EC	29.52 cd	27.21 a	12.72 c	13.74 d	57.24
T_6= Champion 77 WP	32.43 b	27.85 a	6.80 g	5.67 h	82.35
T_7= Dithane M	30.68 bc	27.41 a	8.35 f	7.52 g	76.60
T_8= Control	35.45 a	25.36 b	43.95 a	32.13 a	
CV%	3.14	3.11	4.39	5.38	

Means bearing same letter within the same column do not differ significantly at 5% level.

4.11 Incidence and severity of die back of citrus of before commencement of spray schedule

The disease incidence and severity of die-back of citrus plants before spraying was statistically more or less similar among the treatment. (Table 8). The disease incidence was ranged from 40.64% to 46.65 % and the disease severity (PDI-twig) ranged from 31.50 % to 35.26 %.

4.12 Effect of fungicides in controlling die back of citrus after one month of starting of spray

The effect of treatments in controlling die-back of citrus after one month of starting of spraying was summarized and presented in Table 8.

The treatment effects were differed significantly in controlling die back of citrus in terms of disease incidence and severity. The lowest disease incidence was recorded in case of Dithane M- 45 (35.64 %) followed by Bavistin 50 WP (36.75%). The highest disease incidence was observed in case of control (47.46%).

In case of disease severity, the lowest disease severity (PDI-twig) was recorded in case of Dithane M-45 (20.27%) followed by Bavistin 50 WP (21.36%). The highest PDI-twig was observed in case of control (33.73%).

The reduction of PDI-twig over control was recorded highest (39.90%) with T_7 (Dithane M-45) followed by Bavistin 50 WP (36.67 %) and T_5 (Tilt 250 EC) (33.23 %). The lowest reduction of PDI-twig over control was recorded in case of T_4 (Ridomil MZ-72) (20.69 %) proceeded by T_3 (Rovral 50 WP) (23.98 %) and T_1 (Cupravit 50 WP) (27.57 %) (Table 8).

Table 8. Effect of fungicides on the incidence and severity of die-back of citrus after one month of starting spray

Treatments	Before spraying		After one month of starting of spray		
	Disease incidence (twig)	Percent Disease index (PDI-twig)	Disease incidence (twig)	Percent Disease index (PDI- twig)	PDI- twig decreased over control (%)
T_1= Cupravit 50 WP	42.53 cde	32.72 cd	39.86 cd	24.43 cd	27.57
T_2= Bavistin 50 WP	40.64 e	32.35 cd	36.75 fg	21.36 fg	36.67
T_3= Rovral 50 WP	43.32 bcd	34.64 ab	41.25 bc	25.64 bc	23.98
T_4= Ridomil MZ-72	44.78 ab	35.26 a	42.36 b	26.75 b	20.69
T_5=Tilt 250 EC	41.47 de	31.50 d	37.43 ef	22.52 ef	33.23
T_6= Champion 77 WP	46.65 a	34.88 ab	38.52 de	23.25 de	31.07
T_7= Dithane M -45	45.22 ab	33.55 bc	35.64 g	20.27 g	39.90
T_8= Control	44.37 bc	32.64 cd	47.46 a	33.73 a	
CV%	2.59	2.33	2.17	4.15	

Means bearing same letter within the same column do not differ significantly at 5% level

4.13 Effect of fungicides in controlling die-back of citrus two months after starting spray

The effect of fungicides and plant extract in controlling die-back of citrus recorded after two months of starting of spraying (four sprays applied) was summarized and presented in Table 9. The treatment effects were differed significantly in controlling die back of citrus in terms of disease incidence and severity.

The lowest disease incidence was recorded in case of Bavistin 50WP (30.60%) which was statistically similar with Dithane M-45 (32.06%) followed by Tilt 250 EC (32.56%). The highest disease incidence was observed in case of control (51.52 %).

In case of disease severity, the lowest disease severity (PDI-twig) was recorded in case of Dithane M- 45 (13.45%) followed by Bavistin 50 WP (15.12%)which was statistically similar with the effect of Tilt 250 EC (16.66%). The highest PDI-twig was observed in case of control (33.95%).

The highest reduction of PDI-twig over control was recorded (60.38 %) when sprayed with T_7 (Dithane M-45) followed by T_2 (Bavistin 50 WP) (55.46 %) and T_5 (Tilt 250 EC) (50.93 %). The lowest reduction of PDI-twig over control was recorded in case of T_4 (Ridomil MZ-72) (33.02 %) proceeded by T_3 (Rovral 50 WP) (37.17 %) and T_1 (Cupravit 50 WP) (41.62 %) (Table 9).

Table 9. Effect of fungicides on the incidence and severity of die-back of citrus after two month of starting of spray

Treatments	Before spraying		After two month of starting of spray		
	Disease incidence (twig)	Percent Disease index (PDI-twig)	Disease incidence (twig)	Percent Disease index (PDI- twig)	PDI- twig decreased over control (%)
T_1= Cupravit 50 WP	42.53 cde	32.72 cd	36.84 bcd	19.82 c	41.62
T_2= Bavistin 50 WP	40.64 e	32.35 cd	30.60 e	15.12 e	55.46
T_3= Rovral 50 WP	43.32 bcd	34.64 ab	37.88 bc	21.33 bc	37.17
T_4= Ridomil MZ-72	44.78 ab	35.26 a	40.78 b	22.74 b	33.02
T_5=Tilt 250 EC	41.47 de	31.50 d	32.56 de	16.66 e	50.93
T_6= Champion 77 WP	46.65 a	34.88 ab	34.39 cde	18.27 d	46.19
T_7= Dithane M	45.22 ab	33.55 bc	32.06 e	13.45 f	60.38
T_8= Control	44.37 bc	32.64 cd	51.52 a	33.95 a	
CV%	2.59	2.33	6.49	4.40	

Means bearing same letter within the same column do not differ significantly at 5% level

4.14 Effect of fungicides in controlling die-back of citrus after three months of starting of spray

The effect of fungicides in controlling die-back of citrus recorded after three months of starting of spray (six sprays applied) was summarized and presented in Table 10. The treatment effects differed significantly in controlling die back of citrus in respect of disease incidence and severity.

The lowest disease incidence was recorded in case of Dithane M-45 (25.47%) followed by Bavistin 50 WP (28.57%) and Tilt 250 EC (31.64). The highest disease incidence was observed in case of control (55.63%).

In case of disease severity, the lowest disease severity (PDI-twig) was recorded in case of Dithane M-45 (10.66%) followed by Bavistin 50 WP (12.53%) and Tilt 250 EC (14.48%). The highest PDI-twig was observed in case of control (35.28%)

The reduction of PDI-twig over control was recorded the highest (69.78 %) sprayed with T_7 (Dithane M-45) (69.78%) followed by T_2 (Bavistin 50 WP) (64.48 %) and T_5 (Tilt 250 EC) (58.96 %). The lowest reduction of PDI-twig over control was recorded in case of T_4 (Ridomil MZ-72) (36.34 %) preceeded by T_3 (Rovral 50 WP) (42.04 %) and T_1 (Cupravit 50 WP) (46.88 %) (Table 10).

Table 10. Effect of fungicides on the incidence and severity of die-back of citrus after three months of starting spray

Treatments	Before spraying		After three months of starting of spray		
	Disease incidence	Percent Disease index (PDI-twig)	Disease incidence	Percent Disease index (PDI–twig)	PDI – twig decreased over control (%)
T_1= Cupravit 50 WP	42.53 cde	32.72 cd	36.15 d	18.74 bc	46.88
T_2= Bavistin 50 WP	40.64 e	32.35 cd	28.57g	12.53 ef	64.48
T_3= Rovral 50 WP	43.32 bcd	34.64 ab	37.95 c	20.45 b	42.04
T_4= Ridomil MZ-72	44.78 ab	35.26 a	39.53 b	22.46 b	36.34
T_5=Tilt 250 EC	41.47 de	31.50 d	31.64 f	14.48 dc	58.96
T_6= Champion 77 WP	46.65 a	34.88 ab	34.32 e	16.35 cd	53.66
T_7= Dithane M	45.22 ab	33.55 bc	25.47 h	10.66 f	69.78
T_8= Control	44.37 bc	32.64 cd	55.63 a	35.28 a	
CV%	2.59	2.33	2.30	10.45	

Means bearing same letter within the same column do not differ significantly at 5% level

CHAPTER V

DISCUSSION

CHAPTER V
DISCUSSION

Foliar spray of chemical fungicides significantly reduced the disease incidence and severity compared to control (T_8). Among the chemical fungicides, Rovral 50 WP was the most effective fungicide in controlling leaf scab of citrus that reduced 86.17% leaf scab at the end of the sixth spray. Fruit scab was most effectively controlled by champion 77 WP that reduces 82.35 % of fruit scab severity. Dithane M-45 also showed promising performance against leaf scab (77.53%) and fruit scab (76.60%). In controlling die-back of citrus, Dithane M-45 was found to be the most effective fungicide that reduced 69.78 % die-back severity after the sixth spray. Bavistin 50WP also gave good result that reduced 64.48% die- back severity. It was observed that the incidence and severity of scab and die back of citrus gradually decreased with the increase of spray frequency and reached to the lowest after sixth spray. But in case of control the incidence and severity gradually increased with time. The findings of the present investigation agreed with the findings of Singh *et al.* (2000), Li *et al.* (1997), Ebenezar and Subramanian. (1996), Thakore (1994), Hossain (1993), Harsh *et al.* (1992) and Rahman and Hossain (1988). Singh *et al.* (2000) who reported that copper fungicides Blitox-50 controlled citrus scab by 81.1% applied as foliar spray. Li *et al.* (1997) found that Pujunk (Copper hydroxide) controlled citrus scab (*Elsinoe fawcettii*) more effectively than others. Whiteside (1990) reported that Dithane M-45 was not so effective against scab of citrus. Thakore (1994) reported that the best control of die back of citrus was achieved by spraying Dithane M-45 at 2000 ppm.

Siddiquee (2007) observed that Champion 77 WP was the most effective fungicide against scab of citrus that followed by Rovral 50WP. He reported Dithane M-45 as most effective against die back. Alam (2006) reported that the highest reduction of scab severity (PDI) was performed by Champion 77 WP and Dithane M-45 was found most effective against die back.

From the findings of this present experiment, it has revealed that, Rovral 50 WP and Champion 77 WP were found to be very effective fungicide in controlling scab of citrus followed by Dithane M-45. In controlling die back of citrus Dithane M-45 was the most effective fungicide followed by Bavistin 50WP.

CHAPTER VI

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

An experiment was conducted on the citrus plants at the citrus orchard of Sher-e-Bangla Agricultural University, Dhaka, during the period of kharif season in months of April to September 2008 to find the efficacy of fungicides in controlling the scab (leaf and fruit) and die back of citrus. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications.

Isolation and identification of the fungi was done in the seed pathology laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka. The effect of fungicides in controlling scab and die back of citrus was determined by recording data in different dates before and after spraying of fungicide.

Citrus plants were sprayed with fungicides for 6 times; starting from 15 May, 2008 with 15 days intervals. Data were collected seven times and disease symptoms of the infected plants were determined compared with the control plants. The citrus plants were sprayed with Cupravit 50WP (0.7%), Bavistin 50 WP (0.1%), Rovral 50WP (0.2%), Ridomil MZ-72 (0.2%), Tilt 250EC (0.05%), Champion 77 WP (0.2%), Dithane M-45 (0.3%).

The highest leaf infection and the highest fruit infection were observed in control. Among the treatments, Rovral 50 WP was the most effective fungicide in controlling leaf scab of citrus that reduced 86.17% leaf scab after the end of the sixth spray. Fruit scab was most effectively controlled by champion 77 WP that reduces 82.35 % of fruit scab severity. The performance was closely followed by dithane M-45.

In controlling die-back of citrus, Dithane M-45 found as the most effective fungicide that reduced 69.78 % die-back severity after the end of the sixth spray

which was closely followed by Bavistin 50WP that reduces 64.48% die- back severity.

From the findings of the present experiment, it can be concluded that Rovral 50 WP (0.2%) and Champion 77 WP (0.2%) was the most effective fungicide in controlling leaf scab and fruit scab respectively followed by Dithane M-45 (0.3%). In controlling die back of citrus, Dithane M-45 (0.3%) was the most effective fungicide followed by Bavistin 50WP (0.1%).

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APPENDICES

APPENDICES

Appendix 1. Monthly mean daily maximum, minimum and average temperature, relative humidity and total rainfall during April, 2008 to September, 2008

Month	Temperature (⁰C)**			Relative Humidity**	Rainfall (mm)*
	Max.	Min.	Ave.		
April	34.15	24.45	33.5	86.65	140
May	35.2	25.75	34.25	77.4	143
June	34.65	27.3	31.30	70	158
July	35.3	24.65	30.5	91.35	289
August	37.80	24.15	30.55	91.5	321
September	36.45	26	30.85	90.2	368

Source: Station Name: BPO, Dhaka, Station No. 41923, Surface synoptic data card, Bangladesh. Meteorological Department, Sher-e-Bangla Nagar, Dhaka-1207

* = Monthly total

** = Monthly average