MANAGEMENT OF EARLY BLIGHT OF TOMATO THROUGH SELECTED BOTANICALS AND CHEMICAL FUNGICIDES

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CERTIFICATE

This is to certify that the thesis entitled ***"MANAGEMENT OF EARLY BLIGHT OF TOMATO THROUGH SELECTED BOTANICALS AND CHEMICAL 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 **ASHRAFUZZAMAN**, **Registration No. 10-04185** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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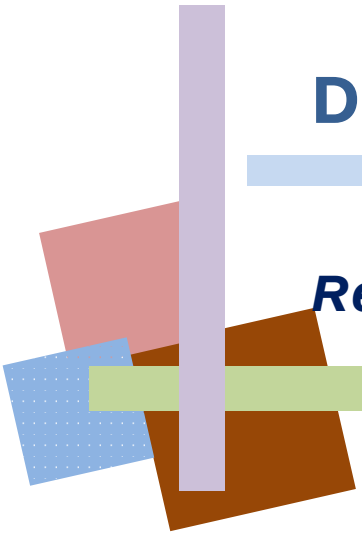

Dedicated To

My Beloved Parents &
Respected Research Supervisor

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MANAGEMENT OF EARLY BLIGHT OF TOMATO THROUGH DIFFERENT BOTANICAL AND CHEMICAL FUNGICIDES

ABSTRACT

A study was carried out at the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh during the period from November 2015 to May 2016 in order to find out the management options of early blight of tomato through selected botanicals and chemical fungicides**.** Eight treatments *viz*. T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter), T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter), T_4 (Foliar spray of Topgun @ 7 g/liter), T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v), T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v), T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) and T_8 (Control) were used for the present study. BARI released variety BARI tomato 2 (Ratan) was used as planting material. Under the present study, among all the fungicides, T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) showed the best promising result in terms of lowest disease incidence (9.63%) with highest % of reduction (86.75%) over control. In terms of growth and yield contributing parameters, The highest plant height (117.80 cm), number of branches plant^{-1} (13.80), Number of fruits plant^{-1} (36.67), Fruit yield plant^{-1} (1.12 kg) and Fruit yield ha^{-1} (65.33 t) were obtained from T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) compared to all the treatments. Botanicals also provided promising results against early blight control of tomato. Among the tested botanicals T_5 (Neem leaf extract @ 1:3 w/v) showed effective control against early blight of tomato followed by marigold extracts.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSIR	=	Bangladesh Council of Scientific and Industrial Research
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the Solanaceae family is one of the most important and popular vegetables in Bangladesh. It is originated in Mexico and gradually disseminated all over the world. Many varieties are now widely grown both in field and greenhouse condition. It ranks third in the world's vegetable production and most consumable vegetable crop next to potato and sweet potato occupying the top of the list of canned vegetable (Chowdhury, 1979). About 170.8 million tons of tomatoes were produced in the world in 2017. The largest producer China (52.6 million tons), accounted for more than one third of the global production followed by India (18.7 million tons) and United states of America (14.5 million tons) (WORLDATLAS, 2017).

Tomato is a good source of vitamin C (31.0 mg per 100g), vitamin A, calcium, iron and minerals. (Matin *et al*., 1996)., It is one of the most popular and nutritious vegetables all over the world including Bangladesh. At present 6.85% area is under tomato cultivation both in winter and summer seasons. The total production of tomato was 251000 tons fresh fruits in the year 2012-2013 (BBS, 2012-2013). The yield of the tomato is very low compared to those of some advanced countries like China, United State and India. (Sharfuddin and Siddique, 1985).

Globally tomato is susceptible to more than 200 diseases. In our country there are some prevailing problems in tomato cultivation. The major constraints in tomato production have been the incidence of wide range of pests and diseases, cold storage facilities resulting in rotting and sprouting and violent price fluctuations. Tomato is highly sensitive to environmental stresses, especially extreme temperature, salinity, drought, excessive moisture and environmental pollution. Tomato yields were also affected by breeding techniques, varieties, growth habit

etc. Some tomato diseases caused serious problems in several countries (Mark *et al*., 2006) such as fungal diseases (Anthracnose, root rot, Early blight, Late blight, Powdery mildew, Pythium damping-off etc.); bacterial diseases (Bacterial canker, Bacterial leaf spot, etc.), viral diseases (Tomato leaf curl, Tomato mosaic etc.) and nemic diseases (Root-knot, Stubby-root, etc.).

Among the fungal diseases, early blight disease caused by *Alternaria solani* is one of the most destructive diseases of tomato in the tropical and subtropical regions. The causal organism is air borne and soil inhabiting and is responsible for leaf spot blight, seedling collar rot and fruit rot of tomato (Datar and Mayee, 1981). This disease causes considerable loss regarding yield and yield contributing characters. The early blight was the most catastrophic diseases incurring loss both at pre and post harvest stages causing 35 to 78 % reduction in yield (Jones *et al*., 1993).

Early blight produces a wide range of symptoms at all stages of plant growth. The disease appears on leaves, stems, petioles, twigs and fruits under favourable conditions resulting in defoliation, drying off of twigs and premature fruit drop (Mathur and Shekhawat, 1986). It causes damping-off, seedling collar rot, stem canker, leaf blight and fruit rot. Tomato fruit, both green and ripe, may also become infected by the fungus. Infection generally begins at the calyx end. Brown leathery areas were formed at infection sites.

The disease affects on all parts of the plant and causes great reduction in qualitative and quantitative fruit yield (Abdel-Sayed, 2006). Infection generally begins at the calyx end and brown leathery areas were formed at infection sites.

Early blight of tomato can be controlled through selective use of chemical fungicides. Primary methods of controlling *Alternaria* leaf blight include preventing long periods of wetness on the host surface, cultural scouting, sanitation, and development of the host resistance (Kirk et al., 2005 and Namanda, 2004). Cultivation of resistant varieties is the ultimate control of this disease.

However, farmers in pursuance of high yield are inclined to cultivate some varieties which may be less resistant to disease. Also unplanned and wide use of fungicides often leads to serious environmental problems and cause health hazards of consumers. So, it is necessary to substitute the use of chemicals with eco friendly approach for controlling disease.

Many plants and plant products have been reported to be antimicrobials against plant pathogenic fungi (Bowers *et al*., 2000; Lawson *et. al., 1998; Grayer and Harbome, 1994, Shetty et. al., 1984).* Plant extracts might be a substantial alternative of chemical pesticides in controlling different plant diseases.

In this context, the present investigations were undertaken with a view to achieving the following objectives:

1. To isolate and identify the causal pathogen (*Alternaria solani*) of early blight of tomato.
2. To evaluate the efficacy of different selected botanicals and chemical fungicides for the management of early blight of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato [*Solanum lycopersicum* Mill.] is the second most important vegetable crop. Early blight disease on tomato caused by *Alternaria solani* is an important and widely distributed disease throughout the world, wherever tomato is grown. The studies with respect to disease development in relation to environmental factors and its management are taken into consideration while reviewing the literature and also to present general picture on this disease, information, which stems mainly from literature on the above species of *Alternaria* spp. causing early blight occurring on different crops are also cited wherever necessary. Accordingly, the literature pertaining to the above aspects is presented here.

2.1 Fungal diseases of tomato

The pathogen was first isolated from tomato plants in Greece (Saregiannis, 1936). Early blight is one of the important diseases of tomato in many areas of the world, where significant reductions 35 to 78 per cent in yield (Jones *et al*., 1993). Every one per cent increase in intensity can reduce yield by 1.36 per cent and complete crop failure can occur when the disease assumes severity. Yield losses up to 79 per cent had been reported in the U.S., of which 20-40 per cent was due to seedling losses (i.e., collar rot) in the field. Fontern (1993) surveyed 14 nurseries and 67 fields of tomato in Cameroon and*A. solani* was the most destructive among eleven diseases both on leaves and fruits. A survey of tomato diseases and disorders in the main tomato growing regions of South Africa was conducted 1992 to 1995 and *Alternaria* blight was found the most prevalent leaf disease (Uys *et al*., 1996).

Prasad (2002) conducted a field survey in northern districts of Karnataka viz., Raichur, Gulbarga and Dharwad during Kharif 2001 and recorded 28.60 to 65.36

per cent disease index. Abhinandan et al. (2004) conducted a survey in Punjab, India during 2001 and reported that a maximum disease intensity of 49.5 percent was observed at the Tapa District and minimum disease intensity of 8.2 per cent was observed at the Babakala District.

Early blight starts appearing from the seedling stage and persists till the last harvest of fruits. The disease appears on leaves, stem and fruits, causing defoliation, drying of twigs and premature fruit drop depending upon the severity (Waraitch *et al*., 1975). Datar and Mayee (1981) showed that *Alternaria solani* could attack fruits in the green and ripe stages at the stem end growth cause cracks and other wounds.

Mathur and Shekhawat (1986) reported that the disease appears on leaves, stems, petiole, twig and fruits under favourable conditions resulting in defoliation, drying off of twigs and premature fruit drop and thus causing loss from 50 to 86 per cent in fruit yield. Singh (1987) reported that the spots were oval to angular in shape measuring up to 0.3-0.4 cm in diameter and usually with a chlorotic zone around the spot. Shahi and Shyam (1993) reported that the early blight on tomato was characterized by the appearance of brown to dark leathery necrotic spots, first on the leaflets, producing target board effect.

Early blight infection of the plants could result in a complete loss of the crop as yields were reduced by the destruction of foliage and the fruits were damaged directly by the pathogen or by sunblotch on defoliated plants (Rotem, 1994).

2.1.2 Causal organism

Alternaria solani, the mycelium consisted of septate, branched, light brown hyphae, which turned darker with age. The conidiophores were short, 50 to 90 ìm and dark coloured. Conidia were 120-296 × 12-20 ìm in size, beaked, muriform dark coloured and borne singly. It was first recorded in 1882 in New Jersey, USA (Bose and Som, 1986). However in culture they formed short chains. According to

Singh (1987) the conidia contained 5-10 transverse septa and 1-5 longitudinal septa.

Shahi and Shyam (1993) isolated *A. solani* and *A. alternata* f. sp. lycopersici from tomato plants in Himachal Pradesh, India. In laboratory test, *A. alternata* f. sp lycopersici produced symptoms on leaflets, stems and branches following inoculation, while *A. solani* produced only on leaflets. Dhal *et al.* (1997) observed the association of *A. alternata* with blossom end rot of tomatoes for the first time in Orissa, India.

The known asexual (imperfect) stage with conidiophores/conidia develops during shifting warm and damp weather. They germinate in free water and high air humidity. Infection was accompanied by the production of toxins by *A. solani*, including some non-host specific toxins called alternaric acid, zinniol, altersolanol and macrosporin. The toxins caused by disease in the host plant act on the protoplast to disturb physiological processes of plant (Agrios, 2005).

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2.1.3 Pathogenicity

Andrus *et al*. (1945) confirmed the pathogenicity on tomato by using mycelial fragments of *A. solani* as inoculum. Locke (1949) used blended mycelial fragments of *A. solani* for puncture inoculation. Brock (1950), Henning and Alexander (1959) used the suspension of mycelial fragments of *A. solani* to inoculate the leaves of field or green house grown plants.

Barksdale (1968) and Dhiman *et al*. (1980) used suspension containing 2x104 spores/ml for proving pathogenicity of early blight of tomato caused by *A. solani*. Further, they atomized the culture suspension on three leaf stage seedlings at the rate of 30 ml per seedling for successful inoculation.

The effects of inoculum concentration on symptom development and defoliation of tomato plants in these controlled-environment experiments support the observations of Coffey *et al.* (1975), who showed that early blight severity on young tomato plants increased as conidial concentration increased from 5 x 103 to 8 x 104 conidia/ml.

A positive relationship between inoculum concentration and symptom development has also been demonstrated for other Alternaria species (Vloutoglou, 1994). Pathogenicity test was carried out by inoculating with spore suspension and homogenized mycelial bits (2 x 104 spores/ml) of *A. solani* on foliage of 30 days old tomato seedlings (Arunakumara, 2006). Tippeswamy *et al*. (2010) confirmed the pathogenicity of early blight of tomato by spraying 104 conidial suspension of *A. solani* to one month seedlings (30 days), before flowering (60 days) and after flowering (90 days).

2.2 Growth media

Rotem (1996) reported that potato dextrose agar was good medium for growth and sporulation of Alternaria solani. Barksdale (1968) reported that potato dextrose agar and lima bean agar were the best media for growth and sporulation of *A. solani*.

Arunakumara (2006) also reported that among nine different media tested, PDA was found best for mycelial growth and sporulation of *A. solani*.

2.2.4 Effect of growth character on growth of *A. solani*

Rowell (1953) reported that *A. solani* invaded the leaves at all stages, but was mostly confined to older leaves and observed the reduction of hexose content of leaves as they grew older and correlated the disease intensity with the hexose content in leaves. The intensity of attack by *A. solani* was severe on old senescent leaves of tomato or potato than on young ones. Shilpakumari (2008) reported that disease incidence of early blight (*A. porri*) was low when the plants were young but, there was a progressive increase in disease severity with the increase in the age of the host.

Increased susceptibility to infection with increasing host age has been reported in many Alternaria-host systems, such as *A. porri* on onions (Gupta and Pathak, 1986), *A. macrospora* on cotton (Rotem *et al*., 1990), and *A. brassicae* and *A. brassicicola* on brassica crops (Babadoost and Gabrielson, 1979). In some cases a reduction in the thickness of the epicuticular wax layer (Tewari and Skoropad, 1976) or in production of glucosinolates (Porter *et al*., 1991) with increasing plant age may be involved in increased host susceptibility to Alternaria infection. The susceptibility of tomato plants to infection by *A. solani* was determined by the age of the host (Rotem, 1994). The age of plants increased the percentage of leaf area showing symptoms and the percentage of defoliation increased when inoculation of *A. solani* at a constant temperature of 24 ± 20C and 100 per cent relative humidity, the incubation period was 24 hours (Vloutoglou and Kalogerakis, 2000).

2.2.5 Role of weather factors in severity of disease

A. solani was reported to infect tomato and potato plants under both dry and wet conditions (Waggoner and Horsfall, 1969). Bhaskaran and Kandaswamy (1980) noticed increased incidence of *A. helianthi* with increased number of days of low temperature (< 200C). Hiremath *et al.* (1990) reported a positive correlation between disease severity and relative humidity. The high humid conditions

prevailed during rainy season caused Alternaria leaf blight of sunflower disease epidemics in many parts of Karnataka. Borkar and Patil (1995) studied the weather in relation to Alternaria leaf blight disease development in Maharashtra. Temperature of 25.9 ^{o}C to 33.7 ^{o}C with a relative humidity of 89 to 95 per cent favoured disease development. They further reported that development of the disease was influenced by rainfall.

Rajivkumar and Singh (1996) studied the influence of weather factors on development of leaf spot of sunflower caused by *A. helianthi* under field conditions during kharif 1990 and 1991. The Most important weather factors favoring disease development were the temperature and relative humidity ranging from 27 ^{o}C to 29 ^{o}C and 78 to 80 per cent respectively, whereas rainfall did not affect the disease development because it was erratic and abnormal distribution during both the years. The disease intensity was highest in last week of August in both the years and there after there was a gradual decline in disease severity.

Murumkar *et al.* (2008) studied the weather in relation to development of Alternaria leaf spot of safflower in Solapur for four years (2004-05, 2005-06, 2006-07 and 2007-08). Rain fall, minimum temperature and relative humidity (minimum and maximum) had a positive correlation with the disease development and rains coupled with high humidity above 80 per cent and temperature in the range of 21 to 33oC favoured the primary infection of *Alternaria carthami*.

Champawat and Sharma (2009) studied the influence of environmental factors such as temperature, relative humidity and rainfall on the development of Alternaria blight of tomato from Rajastan. The multiple regression analysis revealed that weather parameters contribute 77 per cent towards disease incidence. Maximum and minimum temperature has positive while maximum and minimum RH have negative significant correlations with appearance of Alternaria blight of

tomato. The linear regression coefficients for temperature were positively significant while the both RH was negatively significant.

2.3 Management of disease

2.3.1 Evaluation of plant extracts and fungicides

Shenoi *et al*. (1998) evaluated leaf extracts of forty-five plants as antifungal agents against *A. alternata* under in vitro conditions. They obtained best results with *Thevetia peruviana K. Schum., Lawsonia inermis L., Leucas aspera Link. and Pongamia glabra*Vent. against the pathogen. The plant extracts were less effective at lower concentrations but there was a positive correlation between concentration and growth inhibition percentage. The bulb extracts of *A. sativum* and leaf extracts of *Ocimum basilicum* L. at two percent were most effective in suppressing radial growth and biomass production of *A. alternata* (Rashmi and Yadav, 1999).

Patni *et al.* (2005) evaluated methanol extracts of six medicinal plants (*Azadirachta indica*, *Parthenium hysterophorus, Calotropis procera*, *Datura alba*, *Eucalyptus globulus* and *Polyalthia longifolia*) against *Alternaria* blight (*Alternaria brassicae*) of Indian mustard. Eucalyptus, polyalthia and calotropis extracts, in that order, were promising in limiting the growth and sporulation of the pathogen.

Anamika and Sobita Simon (2011) evaluated the efficacy of plant extracts at 5 and 10 per cent concentration on *Alternaria alternata* causing dry rot of aloe vera. Neem leaf extract gave 58.6 percent inhibition of radial growth followed by *Oscimum sanctum* which gave 54.7 percent inhibition.

Kodmelwar *et al.* (1973) reported that copper based fungicides gave the best control of *A. solani* in vitro. Lodha and Prasad (1975) found that Dithane Z-78 very effectively checked the growth of *A. solani* in pot trials and in vitro. In in vitro evaluation of eight fungicides against *A. alternata* causing leaf blight of

turmeric, Propiconazole (tilt) was found superior in inhibiting the growth of the fungus while Ziram a non systemic fungitoxicant found the best in inhibiting the growth of fungus (Mallikarjun, 1996).

Natarajan (1980) conducted fungicidal trials in both in vitro and in vivo using several fungicides to control Alternaria leaf blight of sesame and obtained maximum control with Dithane M- 45 followed by Dithane Z-78, Duter, Captan and Thiram.

Choulwar and Datar (1994) studied the tolerance of *A. solani* to fungicides like Mancozeb, Captofol, Thiophenate methyl and Carbendazim. These were tested at 1000, 1500, 2000, 2500 ppm in vitro. The results indicated that *A. solani* could tolerate 2500 ppm of all the fungicides tested.

Wadiphasme *et al.* (1994) tested six non- systemic and three systemic fungicides in vitro against *A. helianthi* by poison food technique. They found that Dithane M-45 was the most effective followed by Fytalon and Dithane Z-78.

Kamble *et al.* (2000) tested six fungicides against *A. alternata* under in vitro conditions. They reported that Mancozeb was highly effective in inhibiting the mycelial growth followed by Copper Oxychloride and Iprodine at 1000, 2000 and 3000 ppm.

Sharma and Gaur (2009) evaluated nine fungicides against *A. alternata* under in vitro condition. Among the tested fungicides Prochloraz (95.3%) found most effective in inhibiting mycelial growth followed by Propineb (65.8%), Saaf (60.5%) and Mancozeb (57.8%).

Patel and Choudhary (2010) evaluated the efficacy of different systemic and contact fungicides against early blight of tomato. Among systemic fungicides, Difenconazole inhibited maximum growth of *A. solani* and in contact fungicides, Mancozeb gave highest per cent inhibition.

Monaco *et al.* (2001) conducted in vitro studies to investigate a possible integrated use of chemical and biological approaches to control *A. solani*. Six fungal antagonists viz. *Fusarium semitectum* (*F. pallidoroseum*), *Trichoderma polysporum*, *Tolypocladium niveum*, *Chaetomium globosum*, *Rhodotorula* sp., *Cladosporium cladosporioides* and *Nigrospora* sp. and two fungicides (Daconil (chlorothalonil) and Dithane M-45) were used. *Rhodotorula sp* and *Cladosporium cladosporioides* were tolerant to Daconil with high ED 50 values (142.89 and 112.14 ppm, respectively), while *Chaetomium globosum* was tolerant to Dithane M-45 with ED 50 value of 38.72 ppm. The other isolates were sensitive to both fungicides with ED50 values similar or lower than those presented by A. solani. These results suggest that successful integrated control programme can be implemented when *Chaetomium globossum* was used in combination with Dithane M-45 and when *Cladosporium cladosporioides* and *Rhodotorula* sp. were used in combination with daconil.

Arunakumara (2006) observed that among the systemic fungicides evaluated against *A. solani*, propiconazole (84.57%) gave maximum inhibition of the mycelial growth of pathogen. He also reported that among ten plant extracts Clerodendron inerme Gaertn leaf extract (57.22%) was found effective inhibiting mycelia growth followed by Eucalyptus globes Labill (53.69%), *Eupatorium oduratum L*. (42.98%). Least inhibition was observed in *Glyricidia maculata L.* (28.00%). Arunkumar (2008) reported the efficacy of Carbendazim 25% + Iprodione 25% (Quintal) and Carbendazim 12% + Mancozeb 63% (Saaf) in inhibiting mycelia growth of *Alternaria alternata*. Among six botanicals tested NSKE (43.67%) found superior fallowed by neem leaf extract (15.18%). Least inhibition was noticed in case of tulasi (10.09%).

2.3.2 In vivo evaluation of fungicides, plant extracts and bioagents

Choulwar and Datar (1988) reported the least disease intensity both at pre and post harvest stages with increased yield where six early and six late sprays of Mancozeb at 0.2% were given. However, early sprays were most effective than equal number of late sprays. Four fungicides sprayed 4 times at 15 days interval after the first appearance of early blight in tomato and there after at 10 day intervals were evaluated for control of *A. solani*, *Polyram-combi* (Metiram) at 1.5 g/litre or Dithane M-45 (Mancozeb) at 2.5 g/litre gave effective control, where as Bavistin (Carbendazim) at 0.5 g/litre and Captan at 2.5 g/litre were less effective (Mohammad, 1988).

Maheswari *et al.* (1991) conducted field trials using six fungitoxicants and found out the most effective control of *A. solani* by Copper oxychlorode (64.7%) followed by Mancozeb (61.7%). Bharadwaja (1991) reported that sequential application of Captofol, Mancozeb and Copper oxychloride (all at 0.25%) at 40, 55, 70 days after transplanting, increased the yield by 50.5 per cent with reduced incidence of *A. solani*.

Sinha and Prasad (1991) reported that the best control of early blight of tomato caused by *Alternaria solani* was by Dithane M-45 (Mancozeb) at 0.2 per cent among seven fungicides tested in the field over three seasons. The treatment was also cost effective and gave the highest yield.

Sattar and Kaseem (1991) studied the effectiveness of Rovral (Iprodione), Dithane M- 45, Zineb, Topsin M-7 and Ridomil 5G against Alternaria disease in tomato at 5 per cent and found that among these Iprodione gave the best control with maximum yield.

Sawant and Desai (2001) studied the efficacy of Dodine 65 WP and Mancozeb 75 WP with Alachlor 50 EC and Acephate 75 SP against early blight (*Alternaria solani*) on tomato. Disease incidence was maximum during Kharif (44%) and

during winter (22.17%) at 65 days after transplanting. The most effective treatment against early blight was spraying of Alachlor before transplanting + 2 applications of Dodine + 2 applications of Acephate. Alachlor and Acephate applied in plots treated with Mancozeb and Dodine had no adverse effect on the efficacy of the fungicides.

The efficacy of fungicides, namely Carbendazim (0.05%) and Mancozeb (0.25%), botanicals i.e. Neem seed and leaf extract (each at 5%) and Tobacco decoction (2%) was evaluated in a field experiment for the management of early blight of tomato. The lowest per cent disease incidence (PDI) was observed in Carbendazim (13.93) and Mancozeb (15.46) treatments. Similarly the highest yield of tomato fruits was recorded with Carbendazim (200.86 q/ha) followed by Mancozeb (179.10 q/ha). The plant products, namely Neem seed extract (19.75 PDI), Neem leaf extract (20.36 PDI) and Tobacco decoction (23.87 PDI) were also effective in reducing disease incidence and increasing fruit yield by 168.56, 156.43 and 147.66q/ha, respectively (Patil et al., 2003).

Tofoli *et al.* (2003) evaluated the effectiveness of various groups of fungicides for controlling early blight (*Alternaria solani*) as well as their effect on tomato fruit yield, following early blight severity in leaflets and stems. Percentage of leaf drop, incidence of healthy, infected and sun-damaged fruits; yield and the percentages of large, medium and small sized fruits were evaluated. The highest levels of disease control, quality and increase in fruit yields were obtained with Pyraclostrobin + Metiram.

Bernat (2004) reported the efficacy of a new fungicide Pyton consento 450 SC in controlling late blight (*Phytophthora infestans*) and early blight (*Alternaria solaniand A. alternata*). The fungicide effectively reduced the development of late blight (77-99%) and early blight (40-61%), compared with the untreated control, when applied in a dose of 2 lt/ha.

Abhinandan *et al*. (2004) tested the efficacy of commercial fungicides Dithane M-45 (mancozeb) at 0.25 per cent, Kavach (Chlorothalonil) at 0.25 per cent, Rovral (Iprodione) at 0.20 per cent, Blitox (copper oxychloride) at 0.25 per cent, Syllit (dodine) at 0.3 per cent, Antracol (propineb) at 0.15 per cent, Tilt (propiconazole) at 0.05 per cent and Topaz (penconazole) at 0.05 per cent in controlling the disease. Dithane M-45 followed by Kavach were found very effective in controlling the disease with more than 50 per cent disease control compared to the control treatment.

Anon. (2006) reported a combi product Iprodione + Carbendazim @ 0.2% as effective fungicide for the management of Alternaria blight of sunflower. Ilhe et al. (2008) tested the efficacy of Mancozeb 75 WP (0.25%) and Tebuconazole 25 EW (0.05%) in controlling the early blight and powdery mildew of tomato. Alternate sprays of both the chemicals found effective in controlling the disease with 71.08 per cent disease control and also given better yield.

Sali *et al.* (2010) reported that two sprays of Mancozeb (0.3%) or Propiconazole (0.05%) at an interval of 15 days were found effective for reducing disease intensity from 54.32 per cent (control) to 35.27 and 35.32 per cent respectively. Patel and Choudhary (2010) reported the efficacy of foliar spray of contact fungicide mancozeb 75WP (0.2%) against *A. solani* gave maximum fruit yield (245.30q/ha). Among systemic fungicides Difenconazole (0.1%) was effective in controlling the disease.

Seed treatment of pigeonpea with talc based formulation of fluorescent Pseudomonas @ 4 g per kg of seed followed by soil application at the rate of 2.5 kg/ha at 0, 30 and 60 days after sowing controlled pigeonpea wilt incidence under field conditions. The additional soil application of talc based formulation improved disease control and increased yield compared to seed treatment alone (Vidhyasekaran *et al.*, 1997).

Delivering of Pseudomonas fluorescens as seed treatment followed by three foliar applications suppressed rice blast under filed conditions (Krishnamurthy and Gnanamanickam, 1998). Treatment of tomato seeds with powder formulation of PGPR (Bacillus. subtilis and B. pumilus) reduced symptom severity of tomato mottle virus and increased the fruit yield (Murphy *et al*., 2000).

Combined application of talc based formulation of fluorescent Pseudomonas comprising of Pf1 and FP7 through seed treatment, seedling dip, soil application and foliar spray, suppressed rice sheath blight and increased plant growth betterthan application of the same strain mixture either through seed, seedling dip or soil (Nandakumar *et al*., 2001).

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Plant Pathology Laboratory and Central Farm Field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh, during the period from November 2015 to May 2016 to find out the management option of early blight of tomato through selected botanicals and chemical fungicides. The materials and methods for the experiment were presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted in the Plant Pathology Laboratory and Central Farm field of Sher-e-Bangla Agricultural University (SAU), Sher-e- Bangla Nagar, Dhaka-1207. The experimental site is shown in Appendix I.

3.2 Experimental period

The experiments were conducted in the winter season started from November 2015 to May 2016.

3.3 Laboratory experiment

3.3.1 Collection of diseased specimens

Diseased samples of tomato (*Solanum lycopersicum*) were collected from the Farm field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka- 1207 (Plate 1). Collected samples were put in polyethylene bags immediate after collection to protect from drying.

3.3.2 Sterilization of materials and equipments

For surface sterilization, 0.1 %sodium hypochlorite (NaOCl) was used for plant materials such as leaf,stem etc., and rectified spirit was used for sterilization otherequipment's like inoculation-needles, inoculation chamber, forceps, hands etc.

3.3.3 Identificationof *Alternaria solani* observing undermicroscope

Diseased leaf samples of tomato were brought to the laboratory (Plate 2). Sample surface was sterilized by dipping in 0.1 % Hg_2Cl_2 solution for 30 second and rinsed in sterile water. Leaf samples were placed on moist blotter paper on petridish, incubated at 20 ± 2^0 C for 2 days in 12 hours with alternate light and darkness. For sporulation, the inocula was placed on potato slices and incubated for 20 days at 20 ± 2^0 C in the normal lab condition. After incubation when the whitish growth of fungus was observed on the tomato slices. Temporary slides were prepared for identification under compound microscope. The incubated potato slices were also observed under stereoscopic microscope (Plate 3). The *Alternaria solani* was identified following the key out lined by Alexopoulos (1961) and Ingram and Williams (1971).

Plate 1. Symptom of early blight of tomato leaf caused by *Alternaria solani*

Plate 2. Collection of diseased leaves caused by *Alternaria solani*

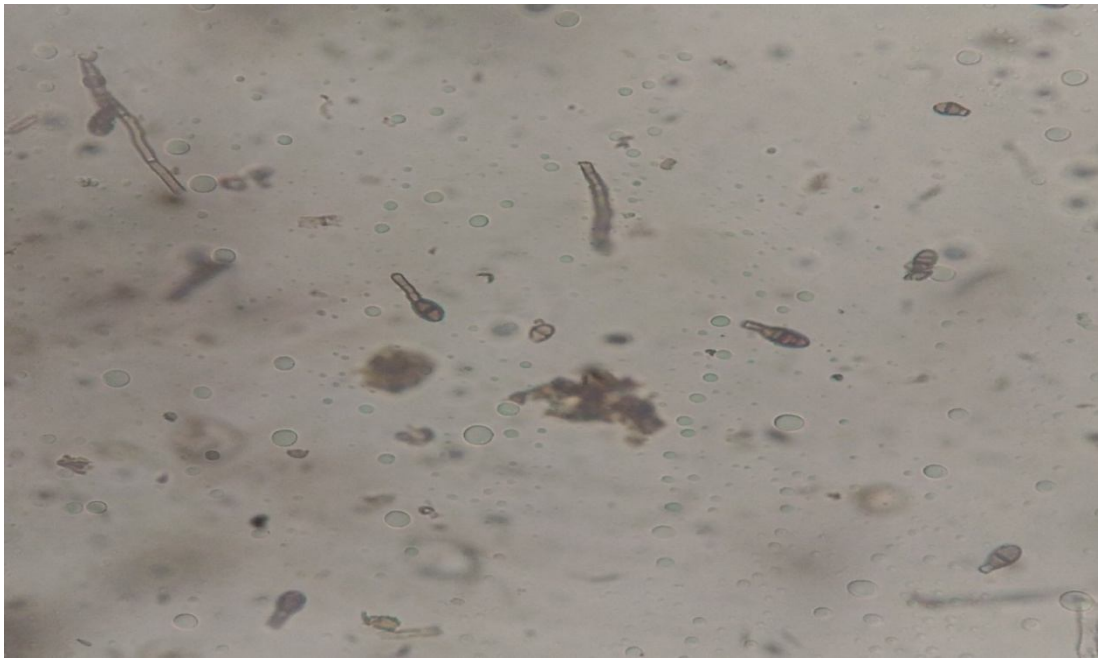

Plate 3. Conidia of *Alternaria solani* under compound microscope

3.4 Field experiment

3.4.1 Climate

The experimental area was under the sub-tropical climate which characterized by the comparatively low rainfall, low humidity, low temperature, relatively short day during November to Mayand high rainfall, high humidity, high temperature and long day period during April to September are presented in Appendix II.

3.4.2 Soil type

The soil of the experimental site belongs to the Agro-Ecological Region of "Madhupur Tract" (AEZ No. 28). It was Deep Red Brown Terrace soil and belongs to "Nodda" cultivated series. The top soil is slightly clay loam in texture.Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63.The information about AEZ 28 is given below:

3.4.3 Fertility status of the field soil:

The soil of experimental site was analyzed in Soil Resource Development Institute (SRDI), Dhaka and found as loamy soil which contains total Nitrogen 0.061(%),Phosphorus 35022 microgram per gram of soil, Sulphur 22.60 microgram per gram of soil, Potassium 0.030 miliequivalent per 100 gram soil and Calcium 2.67 miliequivalent per 100 gram soil. The initial status of soil is given in Appendix III.

3.4.4 Variety

BARI released variety BARI tomato 2 (Ratan) was used for this experiment.

3.4. 5 Design of the experiment

The experimental plots were arranged in Randomized Complete Block Design (RCBD) with three (3) replications. Layout of the experiment field was given in Appendix-IV.

3.4.6 Land preparation

A piece of medium high land with well drainage system was selected. The experimental field was first ploughed on 20 November 2015. The land was ploughed thoroughly with a power tiller and then laddering was done to obtain a desirable tilt. The clods of the land were hammered to make the soil into small pieces. Weeds, stubbles and crop residues were cleaned from the land. The final plugging and land preparation was done on 30 November, 2015.

3.4.7 Layout

The field layout was done as per experimental design on 1 December, 2015. The field was divided into three blocks each of which representing a

replication. The unit plot size was 1m × 4 m and plot to plot distance was 0.4 m and block to block distance was 0.75 meter.

3.4.8 Plantation of tomato seedlings

Selected healthy and disease free tomato seedlings were planted in the experimental field. Planting was done with the help of khurpi (a hand operated implement). For planting, a hole was made with khurpi, so that the seedlings of tomato was dipped in soil. Watering was done in the conducted field after transplanting of tomato seedlings.

3.4.9 Treatments

There were eight (8) treatments in the study with 3 replications; Following treatments were used for spraying of tomato seedlings:

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter

T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter

T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter

T_4 = Foliar spray of Topgun @ 7 g/liter

T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)

T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)

T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)

T_8 = control

3.4.10 Intercultural Operation

Different intercultural operations were done as follows.

3.4.10.1 Plant protection

The crop was kept protected from the attack of insect-pest by spraying insecticide Ektara. The insecticide spraying was done as required according to the recommended doses.

3.4.10. 2 Gap filling

Gap filling was done within 7 days of transplanting.

3.4.10. 3 Irrigation

Frequent irrigation was done at 5-7 days interval as per necessity.

Fig 1: Irrigation by watering cane

3.4.10. 4 Weeding

Weeding was done fourth time in the experimental period starting from 20 days after planting, 40 days after planting, 55 days after planting and 70 days afterplanting.

3.4.11 Collection of fungicides and plant extracts

Four fungicides namely Bavistin 50 WP, Topgan, Rovral 50 WP and Dithane M 45 were collected from local market. Leaves of neem, papaya and marigold were collected from Sher -e- Bangla Agricultural University campus. Poultry manure was collected from the Agargoan nursery, Sher -e- Bangla Nagar, Dhaka-1207.

3.4.12 Preparation of fungicidal suspension

Recommended doses of fungicidal solution were prepared by mixing thoroughly with requisite quantity of fungicide and normal water. It was required 7 g/liter of Topgun, 4.5 g/liter of Dithane M 45, 2 g/liter of Rovral 50 WP and 1 g/liter Bavistin 50 WP for preparation of solution for recommended concentration

3.4.13 Preparation of plant extracts

The plant extracts were prepared by using the method exercised by Ashrafuzzaman and Hossain (1992). For the preparation of extracts, weighted plant parts were crushed in a mortar and pastel and then blended in a blender mixing distill water.

For getting 1:3 (w/v) ratio 300 ml of distilled water was added with 100g plant parts. The blended mass was filtered before spraying.

3.4.14 Application of fertilizers and manures

The following dose of fertilizers and manures were applied for the tomato cultivation.

Fertilizers / Manures	**Dose /ha**
Urea	300 kg
TSP	200 kg
MOP	220 kg
Gypsum	40 kg
Cow dung	10 tons

The 1/3rdurea and whole amount of other fertilizers were applied as basal dose and rest 2/3rd urea was applied at 30 DAP and 50 DAP followed by an irrigation.

3.4.15 Application of fungicides

At recommended doses, the suspension/solution of fungicides were prepared by mixing thoroughly with requisite quantity of normal plain water. Spraying was started from one month after transplanting. Altogether 7 sprayings were done with 7 days intervals with a hand sprayer. To avoid the drifting of the fungicides during application, spraying was done very carefully, specially observing air motion. A control treatment was maintained in each block where spraying was done with plain water only.

Fig 2: Field view of experiment plot

3.4.17 Application of fungicides and plant extracts

The fungicides and plant extracts were applied to the foliar part of plants of potato plants by hand sprayer with 7 days interval. Precautions were taken to avoid drifting of spray materials from plant to neighboring plants.

3.4.18 Data collection

The data were recorded on the following parameters

1. Disease Incidence (% plant infection & % leaf infection)
2. Disease Severity (% leaf area diseased)
3. Growth and yield parameters
   a) Plant height
   b) Number of branches plant^{-1}
   c) Number of fruits plant^{-1}
   d) Average fruit weight
   e) Yield plant^{-1}
   f) Yield ha^{-1}

Calculation of disease incidence and severity

Percent disease incidence and severity were calculated using the following formula:

$$\text{Percent disease Incidence} = \frac{\text{Number of diseased plant /leaves}}{\text{Number of total plants/leaves observed}} \times 100$$

$$\text{Percent disease severity} = \frac{\text{Amount of tissue infected}}{\text{Total area inspected}} \times 100$$

3.5 Statistical analysis

Randomized Completely Block Design (RCBD) was followed for field experiments. The data were statistically analyzed by using computer package program MSTAT-C.

CHAPTER IV

RESULTS AND DISCUSSIN

This chapter comprises the explanation and presentation of the results obtained from the experiment on management of early blight of tomato through different botanical and chemical fungicides. The data have been presented and discussed and possible interpretations are made under the following sub-headings:

4.1 Symptoms of early blight of tomato

Symptoms of early blight occur on fruit, stem and foliage of tomatoes. Initial symptoms on leaves appear as small 1-2 mm black or brown lesions and under conducive environmental conditions the lesions will enlarge and are often surrounded by a yellow halo. Lesions greater than 10 mm in diameter often have dark pigmented concentric rings. Symptoms first appear on the lower, older leaves as small brown spots with concentric rings that form a “bull's eye” pattern. As lesions expand and new lesions develop entire leaves may turn chlorotic and dehisce, leading to significant defoliation. Lesions occurring on stems are often sunken and lens-shaped with a light center, and have the typical concentric rings. On young tomato seedlings lesions may completely girdle the stem, a phase of the disease known as “collar rot,” which may lead to reduced plant vigor or death.

4.2 Identification of the causal organism

The organism was grown on moist blotter paper from the diseased leaf samples and observed under compound microscope by preparing semi permanent slide and permanent slide. The pathogen was identified as *Alternaria solani.* (Illustrated fungi).

The tomato leaf sample affected by *Alternaria solani* took 6-7 days to sporulate in moist blotter paper but on potato slices the sporulation of *Alternaria solani*

delayed upto 20 days. The pathogen produced hyaline lemon shaped sporangia arose straightly from the surface of the substrate. (Plate 3.)

4.3 Effects of the selected treatments on percent disease incidence

Significant influence was observed among the treatments regarding percent disease incidence (Table 1).The treatments showed promising performance in reducing the disease incidence (%).The performances of all the treatments revealed significant difference in controlling the disease incidence. Results showed that the lowest disease incidence (9.63%) was scored by T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) (18.63%) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) (24.17%). The highest disease incidence was recorded in control (72.68%).

In terms of percent (%) reduction of disease incidence over control, the best performance was observed in T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) (86.75%) followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) (74.37%) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) (66.74%) where the lowest percent (%) reduction of disease incidence over control was found in T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) (37.16%).

Table 1. Effect of different selected treatments on the disease incidence of early blight of tomato under field conditions

Treatments	Diseases incidence (%)	% reduction of disease incidence over control
T_1	18.63 g	74.37
T_2	24.17 f	66.74
T_3	09.63 h	86.75
T_4	35.17 e	51.61
T_5	38.67 d	46.79
T_6	42.40 c	41.66
T_7	45.67 b	37.16
T_8	72.68 a	--
$LSD_{0.05}$	2.367	--
CV(%)	9.416	--

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter
T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter
T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter
T_4 = Foliar spray of Topgun @ 7 g/liter
T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)
T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)
T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)
T_8 = control

4.4 Effects of different treatments on percent disease severity

Significant variation was observed among the treatments regarding percent disease severity (Table 2). The treatments showed promising performance in reducing the disease incidence (%). The recital of the treatments revealed that the lowest disease severity (14.50 %) was scored by T_3 (Foliar spray ofRovral 50 WP @ 2 g/liter followed by T_1 (Foliar spray ofBavistin 50 WP @ 1 g/liter (18.63%) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) (22.67 %). The highest disease severity was recorded in control (32.60 %) followed by T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) (55.28%).

In terms of percent (%) reduction of disease severity over control, the best performance was observed in T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) (82.82%) followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter (73.14%) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) (61.37%) where the lowest percent (%) reduction of disease incidence over control was found in T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) (34.50%).

Table 2. Effect of different selected treatments on disease severity of early blight of tomato under field conditions

Treatments	Diseases severity (%)	% reduction of disease severity over control
T_1	22.67 g	73.14
T_2	32.60 f	61.37
T_3	14.50 h	82.82
T_4	40.48 e	52.04
T_5	45.57 d	46.01
T_6	48.79 c	42.19
T_7	55.28 b	34.50
T_8	84.40 a	--
$LSD_{0.05}$	3.247	--
CV(%)	8.344	--

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter
T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter
T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter
T_4 = Foliar spray of Topgun @ 7 g/liter
T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)
T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)
T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)
T_8 = control

4.5Effect of different treatments on growth and yield of tomato

4.5.1 Plant height

The effect of different treatments regarding plant height against early blight of tomato caused by *Alternaria solani*is presented in (Table 3). The treatments showed significant different plant height.The effect of chemical fungicides showed significantly better performance than the botanical fungicides.Among the chemical fungicides the highest plant height(32.53, 68.72 and 117.80 cm at 30, 60 and 90 DAS) was recorded in case of T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), while the lowest plant height (24.68, 44.31 and 83.58 cm) was recorded in control followed by T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) and T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v).

Table 3. Effect of different botanicals and chemical fungicides on the growth of tomato

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	31.88 b	65.38 b	111.72 b
T_2	30.02 c	64.60 b	107.50 c
T_3	32.53 a	68.72 a	117.80 a
T_4	29.95 c	62.88 c	103.30 d
T_5	27.64 d	60.46 d	99.06 e
T_6	26.48 e	57.39 e	94.83 f
T_7	26.20 e	55.18 f	90.64 g
T_8	24.68 f	44.31 g	83.58 h
$LSD_{0.05}$	0.644	1.024	58.53
CV(%)	8.529	7.366	9.428

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter
T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter
T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter
T_4 = Foliar spray of Topgun @ 7 g/liter
T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)
T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)
T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)
T_8 = Control

4.5.2 Number of branches plant^{-1}

The effect of different treatments regarding number of branches plant^{-1} against early blight of tomato caused by *Alternaria solani* is presented in Table 4. The treatments showed significant different on number of branches plant^{-1}. Chemical fungicides treatments showed significantly better performance than the botanical fungicides. Among the chemical fungicides the highest number of branches plant^{-1} (2.32, 11.84 and 12.26 at 30, 60 and 90 DAS) was recorded in case of T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), while the lowest number of branches plant^{-1}(1.20, 4.77 and 4.80 at 30, 60 and 90 DAS) was recorded in T_8 (Control). Among the botanical treatments, T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v) gave the highest number of branches plant^{-1} followed by T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v).

Table 4. Effect of different selected botanicals and chemical fungicides on the no. of branches / plant against early blight of tomato

Treatment	Number of branches plant^{-1}		
	30 DAS	60 DAS	90 DAS
T_1	2.29 a	13.48 a	13.72 a
T_2	2.32 a	11.84 b	12.26 b
T_3	2.37 a	13.58 a	13.80 a
T_4	2.04 ab	9.82 c	10.16 c
T_5	1.86 c	9.36 d	9.52 d
T_6	1.80 c	8.40 e	8.56 e
T_7	1.71 d	8.28 e	8.48 e
T_8	1.20 e	4.77 f	4.80 f
$LSD_{0.05}$	0.021	0.544	0.689
CV(%)	7.122	8.314	7.283

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter
T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter
T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter
T_4 = Foliar spray of Topgun @ 7 g/liter
T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)
T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)
T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)
T_8 = Control

4.5.3 Number of fruits plant^{-1}

Number of fruits plant^{-1} against early blight of tomato caused by *Alternaria solani* showing significant variation are presented in Table 5. Regarding number of fruits plant^{-1} chemical fungicides treatments showed significantly better performance than the botanicals. The highest number of fruits plant^{-1} (36.67) was recorded in T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) treatment followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), while the lowest number of fruits plant^{-1} (16.40) was recorded in T_8 (Control). Among the botanical treatments, T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v) gave the highest number of fruits plant^{-1} (28.33) followed by T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v).

4.5.4 Average fruit weight

Average fruits weight was significantly influenced by different treatments against early blight of tomato caused by *Alternaria solani* are presented in Table 5. In case of average fruits weight, botanicals showed significantly better performance than the chemical fungicides. The highest average fruits weight (36.14 g) was recorded in T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) treatment followed by T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v) and T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v), while the lowest average fruits weight (25.61 g) was recorded in T_8 (Control). Among the chemical treatments, T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) gave the highest average fruit weight (28.33) followed by T_1 (Foliar spray ofBavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter).

4.5.6 Fruit yield plant^{-1}

Fruit yield plant^{-1}against early blight of tomato caused by *Alternaria solani* showed significant variation (Table 5). Results revealed that the highest fruit yield plant^{-1} (1.12 kg) was recorded in T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter)

treatment followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), while the lowest fruit yield plant^{-1} (0.42 kg) was recorded in T_8 (Control). Among the botanical treatments, T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v) gave the highest fruit yield plant^{-1}(54.25).

4.5.7 Fruit yield ha^{-1}

Fruit yield ha^{-1} against early blight of tomato caused by *Alternaria solani* showed significant variation (Table 5). Results revealed that the highest fruit yield ha^{-1} (65.33 t) was recorded in T_3 (Foliar spray of Rovral 50 WP @ 0.5 g/liter) treatment followed by T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) and T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), while the lowest fruit yield ha^{-1} (24.50 t) was recorded in T_8 (Control). Among the botanical treatments, T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v) gave the highest fruit yield ha^{-1} (54.25 t).

Table 5. Effect of some yield contributing parameters against early blight tomato by using selected botanicals and chemical fungicides

Treatment	Number of fruits plant^{-1}	Average fruit weight (g)	Fruit yield plant^{-1} (kg)	Fruit yield ha^{-1} (t)
T_1	35.83 b	29.58 e	1.06 b	61.83 b
T_2	34.78 c	29.33 e	1.02 c	59.50 c
T_3	36.67 a	30.54 d	1.12 a	65.33 a
T_4	31.66 d	30.32 d	0.96 d	56.00 d
T_5	28.33 e	32.83 c	0.93 e	54.25 e
T_6	24.67 f	35.67 b	0.88 f	51.33 f
T_7	23.52 f	36.14 a	0.85 g	49.58 g
T_8	16.40 g	25.61 f	0.42 h	24.50 h
$LSD_{0.05}$	0.564	0.267	0.011	1.142
CV(%)	8.571	7.389	5.276	8.351

T_1 = Foliar spray of Bavistin 50 WP @ 1 g/liter
T_2 = Foliar spray of Dithane M-45 @ 4.5 g/liter
T_3 = Foliar spray of Rovral 50 WP @ 2 g/liter
T_4 = Foliar spray of Topgun @ 7 g/liter
T_5 = Foliar spray of Neem leaf extract @ 1:3 w/v)
T_6 = Foliar spray of Marigold leaf extract @ 1:6 w/v)
T_7 = Foliar spray of Papaya leaf extract @ 1:3 w/v)
T_8 = Control

As per the overall performance of the plant extracts (as Botanicals) and the chemical fungicides, Rovral 50 WP showed the promising performance in management of early blight of tomato. Rovral 50 WP reduced disease incidence by (86.75%) and disease severity by (82.82 %) and followed by Bavistin 50 WP reduced disease incidence by (74.37 %) and disease severity by (73.14 %).

The performances of botanicals were not so promising as chemical fungicides but as an ecofriendly approach, neem leaf extract showed comparatively better performances than other plant extract compared to control.

Since the disease incidence and severity of early blight of tomato were significantly controlled by Rovral 50 WP and Neem leaf extract, their influences were observed in yield and yield contributing characters of tomato against the disease. The highest plant height (117.80 cm), number of branches plant^{-1} (13.80), number of fruits plant^{-1} (36.67), fruit yield plant^{-1} (1.12 kg) and fruit yield ha^{-1}(65.33 t) were observed by the fungicide Rovral 50 WP followed by Bavistin 50WP.

Among the botanicals, Neem leaf extract also showed comparatively promising performances regarding those yield contributing characters and fruit yield.

Similar result were also found by the previous researchers while they arranged different treatments against early blight of tomato. (Anamika *et.al.*, Patni *et.al.*, Rashmi and Yadav., Sattar and Kashem., Anon., (2006) Sinha and Prasad., (1991)).

Anamika and Sobita Simon (2011) reported that Neem leaf extract provided 58.6 % inhibition against *Alternaria* spp.

Patni *et.al.*, also showed the efficacy of Neem leaf extract in lessening the growth and sporulation of *Alternaria spp*.

Rashmi and Yadav *(1999)* evaluated the performance of bulb extracts as botanical fungicides against *Alternaria alternata.*

In terms of chemical fungicides, Sattar and Kashem (1991) conducted an experiment to evaluate the efficacy of chemical fungicides and showed that Rovral 50 WP (Iprodione) gave the best performances with maximum yield.

Anon. (2006) showed that a combi product of Iprodione + carbendazim @ 0.2 % is effective for the management of Alternaria spp. Causing diseases.

Sinha and Prasad (1991) also reported that early blight of tomato can be controlled effectively by the use of Dithane M 45.

With the circumstances stated above, the tomato growers may be suggested to apply Rovral as protective fungicide and Neem leaf extract as eco friendly options for the management of early blight of tomato.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh during the period from November 2015 to May 2016 in order to find out the management of late blight of tomato disease through different botanical and chemical fungicide**.**

Eight treatments *viz*. T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter), T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter), T_3 (Foliar spray of Rovral 50 WP @ 0.5 g/liter), T_4 (Foliar spray of Topgun @ 7 g/liter), T_5 (Foliar spray of Neem leaf extract @ 1:3 w/v), T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v), T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) and T_8 (Control) were used for the present study. BARI released variety BARI tomato 2 (Ratan) was used as planting material.

Under the present study, chemical fungicide, T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) gave the best promising resultin terms of lowest disease incidence (9.63%) with highest % reduction over control (86.75%). Lowest disease severity (14.50%) with highest % reduction over control (86.75%) was also achieved by T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter).

In terms of growth and yield contributing parameters, under the present study, T_3 (Foliar spray of Rovral 50 WP @ 0.5 g/liter) gave the best performance. The highest plant height (117.80 cm), number of branches plant^{-1} (13.80), Number of fruits plant^{-1} (36.67), Fruit yield plant^{-1} (1.12 kg) and Fruit yield ha^{-1} (65.33 t) were obtained from T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) compared to control treatment. But T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) gave the highest average fruit weight (36.14 g).

T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter), T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) and T_4 (Foliar spray of Topgun @ 7 g/liter) also gave promising effect against late early blight of tomato.

Botanical fungicides also provided promising results considering early blight control of tomato. Among the tested botanical fungicides T_2 (Neem leaf extract @ 1:3 w/v) also showed effective control against early blight of tomato. Treatment, T_6 (Foliar spray of Marigold leaf extract @ 1:6 w/v) and T_7 (Foliar spray of Papaya leaf extract @ 1:3 w/v) were also effective against early blight of tomato.

Performances of chemical fungicides and plant extracts were evaluated in the experiment, it is suggested that either T_3 (Foliar spray of Rovral 50 WP @ 2 g/liter) or T_1 (Foliar spray of Bavistin 50 WP @ 1 g/liter) or T_2 (Foliar spray of Dithane M-45 @ 4.5 g/liter) could be used against early blight of tomato. As eco-friendly components Neem leaf extracts and Marigold could also be used against the disease. However, the investigation need to be continued for several consecutive years including more eco-friendly option for the management of disease.

CHAPTER VI

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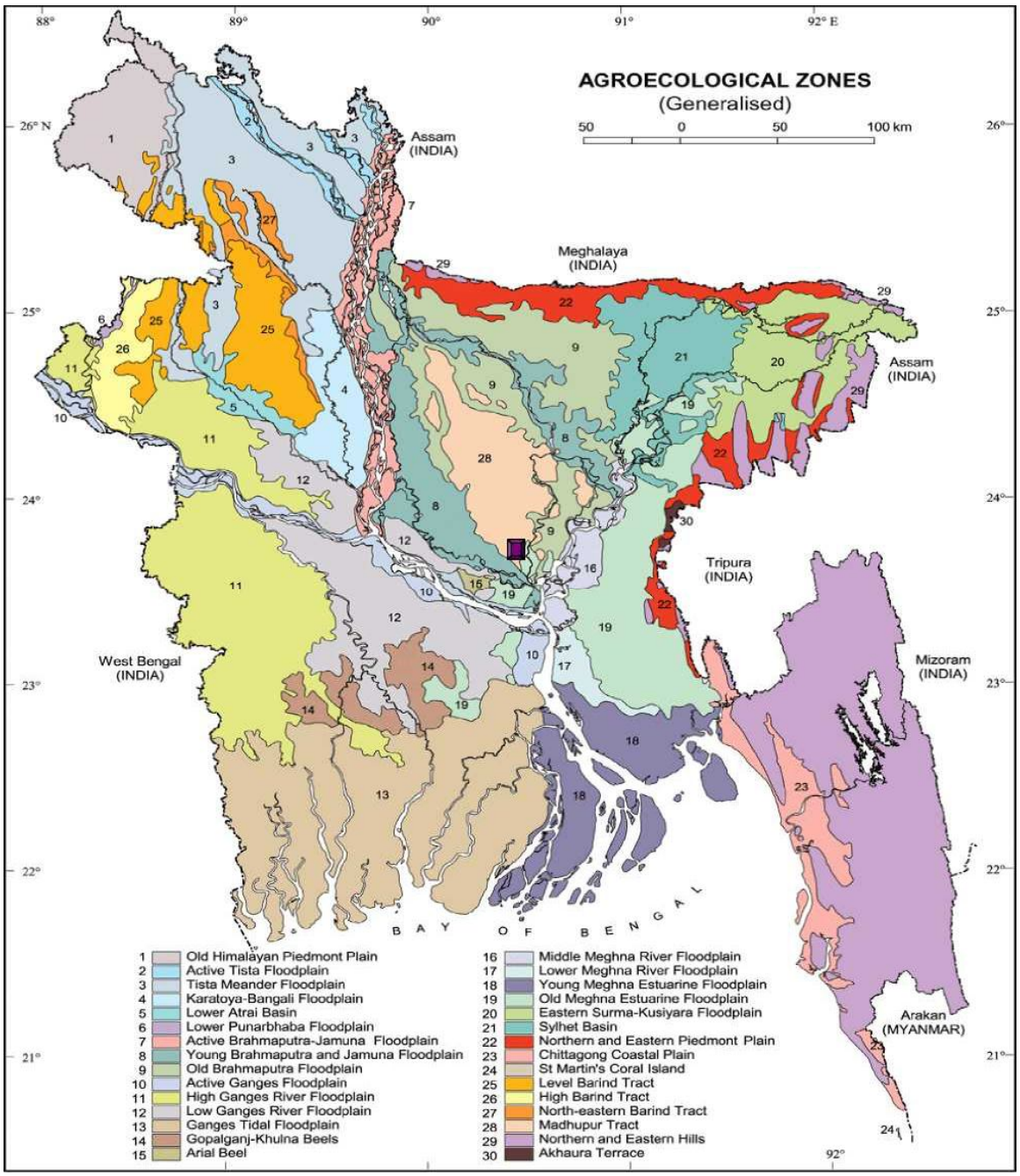
CHAPTER VII

APPENDICES

Appendix l: Experimental site showing in the map under the present study



Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from November 2015 to February 2016

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)	Sunshine (Hours)
2015	October	33.1	18.0	25.6	77	130	5.4
2015	November	32.0	15.0	23.5	67	14	7.8
2015	December	28.2	13.5	20.9	79	8	3.8
2016	January	24.5	11.5	18.0	72	6	5.7
2016	February	33.1	12.9	23.0	55	10	8.1
2016	March	33.6	15.3	24.5	63	43	7.5
2016	April	36.0	21.20	28.6	65	86	9.5

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (µ gm/gm)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix IV. Layout of the experiment field