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

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JUNE, 2016

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A Thesis
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 (MS)
IN
PLANT PATHOLOGY
SEMESTER: JANUARY- JUNE, 2016

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CERTIFICATE

This is to certify that the thesis entitled ***"MANAGEMENT OF LATE 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 **MD. MOSHIUR RAHMAN**, **Registration No. 10-04182** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2016
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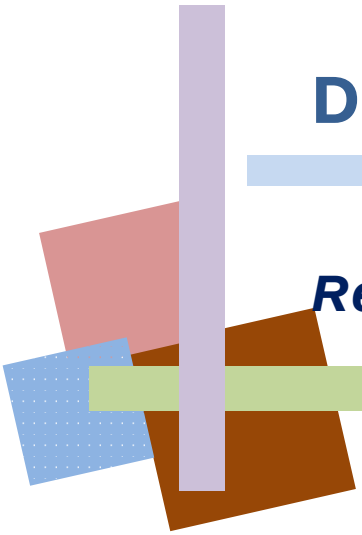

Dedicated To

My Beloved Parents &
Respected Research Supervisor

ACKNOWLEDGEMENTS

The author seems it a much privilege to express his enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work.

The author feels proud to express his deep sense of gratitude, sincere appreciation and immense indebtedness to his supervisor ***Professor Dr. Md. Rafiqul Islam****, Department of* ***Plant Pathology****, Sher-e-Bangla Agricultural University, Dhaka, for his continuous guidance, cooperation, constructive criticism and helpful suggestions, valuable opinion in carrying out the research work and preparation of this thesis, without his intense co-operation this work would not have been possible.*

The author feels proud to express his deepest respect, sincere appreciation and immense indebtedness to his co-supervisor Professor ***Dr. F. M. Aminuzzaman****, Department of* ***Plant Pathology****, SAU, Dhaka, for his scholastic and continuous guidance during the entire period of course, research work and preparation of this thesis.*

The author expresses his sincere respect to ***Dr. Md. Belal Hossain****, Chairman, Department of* ***Plant Pathology****.*

Other respected teachers; Prof. Mrs. Nasim Akhtar, Prof. Dr. M. Salahuddin M. chowdhury, Prof. Nazneen Sultana, Assoc. Prof. khadija Akhter, Assoc. Prof. Abu Noman Faruq Ahmmed, Assoc. Prof. Dr. Fatema Begum, Assoc. Prof. Dr. Nazmoon Nahar Tonu, Assist. Prof. Shukti Rani Chowdhury, Assist. Prof. Md. Ziaur Rahman Bhuiyan, Lecturer Sayed Mohammad Mohsin and Lecturer Hosna Ara Chowdhury Nisha, Department of ***Plant Pathology****, SAU, Dhaka, for their valuable suggestions and cooperation during the study period and also expresses his heartfelt thanks to the teachers of the Department of* ***Plant Pathology,*** *SAU, for their valuable teaching, suggestions and encouragement during the period of the study.*

The author expresses his sincere appreciation to his father and beloved mother and all of his well-wishers.

The Author

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ABSTRACT

An experiment was conducted in the Department of Plant Pathology at Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh; during November 2015 to May 2016 to find out the management options of late blight of tomato through selected botanicals and chemical fungicides**.** The hybrid variety of tomato named Rio grand was used for the present study. The experiment was conducted with 8 treatments *viz*. T_1 (Mahogany seed extract @ 1:6 w/v), T_2 (Neem leaf extract @ 1:3 w/v), T_3 (Papaya leaf extract @ 1:3 w/v), T_4 (Marigold leaf extract @ 1:3 w/v), T_5 (Ridomil Gold @ 0.2%), T_6 (Topgan @ 0.7%), T_7 (Dithane M 45 @ 0.45%), and T_8 (Control). The experiment was carried out at Randomized Complete Block Design (RCBD) with three replications. Ridomil Gold @ 0.2% resulted promising performances in reducing disease incidence (85.98%) and disease severity (82.82%) of late blight of tomato over control. Ridomil Gold showed the highest plant height (127.80 cm), number of branches plant^{-1} (15.72), number of fruits plant^{-1} (34.56), fruit yield plant^{-1} (3.41 kg) and fruit yield ha^{-1} (72.84 t) compared to control. Among the botanicals assayed in the experiment, Neem leaf extract @ 1:3 w/v showed effective control against late blight of tomato. Considering the performances of plant extracts and chemical fungicides evaluated in the experiment, Ridomil Gold (0.2%) as chemical fungicide and Neem leaf extracts as botanical could be suggested for the growers for management of late blight of tomato.

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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 (*Solanum lycopersicum* Mill.) belongs to Solanaceae family is one of the most important and popular vegetables in Bangladesh as well as in the world. The species was originated from Mexico, and spread around the world. Many tomato varieties are now widely grown, even in greenhouses in cooler climates in the world. 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 2016. The largest producer China (52.6 million tons), accounted for about 31% of the global production followed by India (18.7 million tons) and United States (14.5 million tons) (FAO, 2016). Tomato is a good source of vitamin C (31.0 mg per 100g), vitamin A, calcium, iron, minerals etc. (Matin *et al.*, 1996), 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 in Bangladesh. The total production of tomato in Bangladesh was about 4.13 lac tons from 30,000 hectares of land with an average yield of 13.5 t ha^{-1}(BBS, 2015). The yield of the tomato is very low compared to those of some advanced countries (Sharfuddin and Siddique, 1985).

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. Among the constrains of tomato production, diseases are serious problem in several countries in the world (Mark *et al*., 2006).

Among the diseases late blight, early blight, fusarial or bacterial wilt and viral leaf curl and mosaic are major. I.ate blight caused by *Phytophthora infestans* is the most destructive disease of tomato in Bangladesh (Talukdar, 1974). The pathogen

attacks all the aerial parts of the plant including leaves, stems and immature green fruits. The fungus forms a white mildew on the advancing margin of the lesions under surface of the leaves. In humid weather, a white fungal growth may also develop on the affected area. Low temperature (12-15°C), high humidity (90%), drizzle, foggy and cloudy weather are favourable for the development of late blight. It can cause up to 90% loss of tomato in Bangladesh, if the disease is not managed in time (Zahid *et al.*, 1993). But till today, none of the cultivated variety of tomato has been shown meaningful resistance.

Late blight is a highly damaging disease of potatoes and tomatoes and it is a graet threat to food security (Chycoski, 1996). The disease can cause total destruction of plants within a week or two when weather conditions are favourable (Agrios, 1998). Late blight is found in all areas where potatoes and tomatoes are grown but is more severe in humid high rainfall areas (Hartman & Huang, 1995). Farmers try to control the disease through various ways but each of these control measures has considerable limitations. Fungicides are good options to control the disease but that applications of several times (7-8 sprays) are needed (Legard & Fry, 1995), that develops resistance (Lashomb & Casagrande, 1981) and chemical residues in the harvested produce is a problem (Mulandi, 1998).

In this context, botanicals as an ecofriendly approach would be the option in controlling late blight of tomato. Thus the present investigation has been undertaken with the following objectives:

1. To isolate and identify the causal organism of late blight of tomato.
2. To evaluate the efficacy of some selected botanicals and chemical fungicides against late blight of tomato caused by *phytophthora infestans*.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field conditions, which received much attention to the researchers throughout the world. Late blight of tomato cause by *Phytophthora infestans* is a serious disease which can occur sporadically or in epidemic throughout Bangladesh and affecting adversely the quality and yield of the crop. Many investigators in various parts of the world have investigated the response of tomato and its major diseases for its successful cultivation. In Bangladesh, available literature regarding management of late blight of tomato are insufficient and often conflicting. However, some of the literature relevant to this term and also with other crops have been presented in this chapter under the following sub-headings:

2.1 Tomato disease – Late blight

This is a classic disease caused *by Phytophthora infestans.* The disease is of great concern to the plant pathologist throughout the world especially affecting potato and tomato, and taking high toll when weather favours the disease spread. Some review on the symptom on leaves and fruits are cited here.

Agrios (1988) described that symptoms expressed by *Phytophthora infestans* appear at first as circular or irregular water soaked area near the tip of the leaflet which progress rapidly to form brown, blighted area with indefinite borders. A zone of white, downy fungus growth appears at the ventral side of the infected leaves, easily visible in the morning until rising sunlight and air flow evaporate the aggregated moisture.

Watterson (1986) described that the late bight affected leaves have irregular dark lesions around which a fine white moulded ring develops during wet weather.

Brown streaks may occur on stems arid petioles. Affected fruit have firm large irregular brownish-green blotches. The fruit surfaces appear greasy and rough.

Kaloo (1986) observed the symptoms of late blight on fruit as olivaceous, greasy appearing, and water soaked spots. The stem-end portion of the fruit is affected and the water-soaked gray green spots of every side were discernible.

2.1 Pathogen(s) and pathogenesis

Ahmed (1999) studied isolation of *P. infestans.* He collected diseased leaf, stem and fruit samples which were surface sterilized by dipping in 10% Sodium hypo-chloride solution for three minutes and then rinsed in sterile water. The leaves were then placed on moist blotter paper in petridish with sterile forceps and incubated at 20 ± 2^{0} C to allow the pathogen to grow. After incubation period the fungus was identified under stereoscopic and compound microscopes. The pathogen produced breached sporangiophores. Lemon shaped papillate sporangia were produced at the tips of the branches of the sporangiophores. Sporangia were pointed at the end.

Van Derzaag (1996) reported that *Phytophthora infestans* can survive under adverse conditions and over winter in the form of oospores. The pathogen however, invades and infects tomato plants in the field via zoosporangia or zoospores which disperse via soil water, rain splash and wind.

Islam *et al*. (2000) reported that at 7 days of incubation white mycelial growth of the fungus on PDA in petridish was observed and then its colour gradually turned into grayish white. Sporangiophores and sporangia were observed under compound microscope and the fungus was identified as *P. infestans*. The pathogen produced branched sporangiophores. Lemon shaped papillate sporangia were produced at the tips of the branches of the sporangiophores. Sporangia were pointed at ends. At the places where sporangia were produced the sporangiophores formed swelling, characteristics of *P. infestans.* Zoospores of *P. infestans* were

liberated during the incubation period at 12 ± 1^0 C for 24 hours. Zoospores were basically ellipsoid ovoid in shape and possessed a groove that ran longitudinally along the zoospore. After competition of swimming period the zoospores incest. Single sporangium also germinated by sending out germ tube.

Rich (1983) reported that the zoosporangia of *P. infestans* may directly germinate on potato organs or produce zoospores in sporangium, which are motile and disperse, following encystment, rain or sprinkler irrigation. Infection occurs when leaves are moist for at least 5 hours at $15\text{-}20^0$ C. Spore germination results in colonization and infection causing symptoms on leaves, stem or tubers and production of new spores within 4-5 days.

Hooker (1981) and Fry *et al*. (1993) reported that tomato plants (*Solanum lycopersicum* Mill.) may totally destroy by *P. infestans* within two weeks in wet conditions.

Erwin and Ribeiro (1996) reported that epidemics of late blight happen with high intensity , practically in all the areas where potato and tomato are grown, especially during the wet season and rainy weather. *P. infestans* usually requires low temperatures for development, the optimum temperature and relative humidity being $18–22^0$ C and 100%, respectively.

2.2 Disease symptoms

Watterson (1986) observed that late blight affected leaves have irregular dark lesions around which a fine white moulded ring develops during wet weather. Brown streaks may occur on stems and petioles. Affected fruit have firm large irregular brownish-green blotches. The fruit surfaces appear rough.

Agrios (1988) described the symptoms caused by *Phytophthora infestans* that appear at first as circular or irregular spots, usually the tips or edges of the lower leaves. Then spots enlarge rapidly and form brown, blighed area with indefinite

borders. A zone of white, downly fungus growth appears at the border of the lesions on the undersides of the leaves resulting the entire leaflet infected which soon die and become limp.

2.5 Management through fungicides

Thind *et al*. (1989) tested 6 fungicides under laboratory pot house and field conditions. They observed that only Ridomil (Metalaxyl) controlled (*P. infestans*) when applied after infection.

Sharma (1993) conducted an experiment for two years at CPRS, Jalandahor, Panjab, India to evolve effective fungicidal spray schedule against *P. infestans*. He claimed that one spray of Ridomil MZ-72 WP @ 0.25% alternated with two sprays of Dithane M-45 reduced foliage blight from 99.75% to 11.65%. The spray schedule was as much effective in checking disease as application of two sprays of Ridomil MZ-72 WP and was superior to Dithane M-45 (41.53%) .

Vanitha and Ramacandran (1999) observed that the application of @ 0.2% Ridomil (Metalaxyl) or chlorothalonil @ 0.1% or thiram @ 0.3% at the first sing of *P. parasitica* (*P. nicotiana var. parasitica*) infection and 15 days later another application of Ridomil @ 0.2%, or chlorothalonil @ 0.1%, plus notch leaf extract gave the lowest disease incidence.

2.7 Effect on diseased and yield components

Ahmed (1999) observed that the use of single effect of sanitation, fungicide and garlic extract reduced late blight incidence and severity and increased 36.55%, 22.12% and 36.17% fruits yields over control respectively. The combined applications of sanitation, fungicide and garlic extract increased only 23.76% fruit yield over control.

Fontem *et al*. (2005) reported that temperatures remain generally low in tropical areas. Yield losses caused by late blight can be very high when control measures

are not appropriately adopted. Losses have been estimated to be as high as 71% in potato and 100% in tomato.

Use of botanical extract

Chowdhury, S. D. (2005) stated that the wheat seed sample contained 25-percentage seeds infection with *Bipolaris sorokiniana*, 13 percent seeds with *Fusarium oxysporum* and 7 percent contamination *Curvularia lunata*, respectively. In the untreated seeds having 75 percent germination. Treatment with 1:5 dilutions of nascent garlic, datura, and turmeric extracts raised the germination of wheat seeds up to 85- 90 percent while reducing all the seed-borne pathogens within acceptable seed health standard.

Islam (2005) tested 11 botanicals to control Phomopsis blight and fruit rot of egg plant. Out of 11 botanicals , garlic (*Allium sativum*) bulb and allamanda *(Allamanda cathertica* L.) leaf extracts were found promising arresting mycelial growth and inhibiting spore germination of *Phomopsis vexans* in vitro and controlled Phomopsis blight and fruit rot of egg plant in the field significantly . He also found that combinations of apparently healthy seeds, seeds treated with garlic bulb extracts and soil treated with *Trichoderma harzianum* completely controlled damping off , tip over and seedling blight in the nursery bed in the net house and eventually increased germination by 48.83 % over control.

Anonymous (2004) reported that garlic tablet is a botanical fungicide. It has a great medicinal value against both plant and human diseases. The tablet has been proved effective in plant disease control, especially for seed borne diseases.

Meah *et al.* (2004) reported that among 30 combinations of 1PM components, apparently healthy seeds treated with garlic extract (1:l) allamanda extract (1:1) sown in soil treated with formulated *Trichoderma harzianum* gave the effective results against *Phomopsis vexans* in controlling damping off, tip over and seedling blight in the nursery.

Jebunnaher (2004) separated successfully 5 single compounds from Allamanda leaf extract through column chromatography. The compounds were tested against *P. vexans* individually. Among the separated compounds, one compound completely inhibited the growth of *P. vexans* while the other compounds had little inhibitory effect.

Hossain (2003) observed that neem oil as seed treatment had better, response on plant growth in reducing galls and nematode development. Seed treatment with neem fruit extract gave better response followed by neem bark extract in promoting plant growth and suppressing development of the nematode. Neem leaf extract as seed treatment was found to be less effective due to lower plant growth characters with higher number of galls and juvenile populations.

Hawlader (2003) reported that seed treatment with garlic bulb extract (1:1) effectively increased germination of eggplant seeds and completely eliminated damping off and seedling blight. The findings are in agreement with reports of Kuprashvile (1996) who reported seed disinfection and yield increase of eggplant for seed treatment with extracts. Garlic bulb extracts as seed treating agent has been reported very promising in curbing seed borne infection in jute (Fakir and Khan, 1992), in Acacia (Dubey and Dwivedi, 1991).

Shah *et al.* (2003) stated that the population of root knot nematodes *was* significantly reduced in soil treated with Neem oil followed by Furadan + Ammonia, Furadan, Ammonia and NPK fertilizers also suppressed the nematode population compared to untreated plants (control).

Zhao and Kang (2002) studied the role of plant volatiles in host plant location of the leaf minor *(Liriomyza sativae)* and found that in behaviour both males and females were attracted by the odour of the bean *(Phaseolns vulgaris).* They had distinct EAG responses to bean odour. They found no significant sexual difference in behaviour and EAG responses. They recorded electroantennograms from female

L. sativa to 14 plant volatile compounds. The most distinct EAG responses were obtained for (1) the general green leaf volatiles 1-hexanol (E)-2-hexen 1-01, (E)-3-hexanyl acetate and the aldehyde hexanal: and (2) limonene, a compound associated with tomato.

Singh *et al.* (2001) reported that a resurgence of interest in garlic due to recent revelations of its beneficial effects in the treatment of various human and plant diseases, and also due to validation of claims made in traditional systems of medicine has resulted to a plethora of publications on different aspects of garlic in recent years.

Ahmed and Islam (2000) used neem, garlic, onion and bishkatali (*Polygonum hydropiper)* extracts, among them neem and garlic extracts were effective against *Bipolaris oryzae* at 1:1 dilution.

Mohammad and Akhtar (2000) reported that the symptoms of root-gall caused by *M. incognita* were significantly reduced by the bare-root-dip treatment of tomato seedling, in a neem based commercial product and in an aqueous extract of neem seeds. Treatments with all concentrations at various periods of dipping; time reduced root-knot development. It was also investigated that improvement in plant weight and height were correlated to reduction in nematode infestation.

Amin *et al.* (2000) conducted four laboratory experiments with the leaves of three plant species viz. Akonda (*Asclepias calotropis)*, Bishkatali (*Polygonum hydropiper)* and neem (*Azadirachta indica)* for studying their relative efficacy against the lesser grain borer. They found that 2, 3 und 4% water extract of all the three plant species had repellency as well as direct toxicity; while the 3% showed strong feeding deterrency effect.

Khan (1999) found that the incidence and severity of the disease varied from one plant extract to another when aqueous leaf extract of Neem, Allamanda and Bael were applied at flowering, fruiting and peak fruiting stages in 3 different doses (S,

S/0 and S/100). Allamanda (S) was most effective to reduce percent leaf and fruit infection and lesion size followed by Bael (S). Differential effectiveness of plant extracts against *Phomopsis vexans* was reported by Mohanty *et. al.* (1995) and Kuprashvile (1996). Mohanty *et al.* (1995) evaluated 5 aqueous plant extracts against *Phomopsis vexans* and found that fungal growth was inhibited to a maximum by leaf extracts of Allamanda followed by Bael.

Khan (1999) studied the effect of plant extracts (Allamanda, Bael and Neem) for the management of Phomopsis blight/fruit rot of eggplant in field condition by spraying and observed among the 3 plant extracts, Allamanda was more effective than Bael and Neem extracts.

Jayashree *et al.* (1999) stated that among the ten plant extracts tested for their efficacy in controlling pumpkin yellow vein mosaic virus. *Bougainvillea spectabilis* showed maximum inhibition of the virus transmission followed by *Boerhaavia diffusa.* In the plant derivatives, Neem oil and Thusa 30 inhibited the virus effectively. The only animal product tested was buttermilk, which was also found to reduce virus transmission Acetyl salicylic acid recorded the best virus transmission among the virus inhibitory chemicals tested followed by Barium Chloride.

Srivastava and Lae *et al.* (1997) assessed that an *in vitro* test indicated fungicidal properties in aqueous leaf extracts of *Calotropis procera. Azadirachta indica*, *Lantana camara* and *Ocimum basilicum* against *Curvularia tuberculata* and *Alternaria alternata* isolate obtained from fruits of pear and *Alternaria alternata* isolate B' from diseased fruit of pomegranate. An *in vitro* study revealed 64 to 85 percent control of rot.

Kurucheve *et al.* (1997) assayed five selected plant products for fungi toxicity against *Pythium aphanidermatum* (Edson) Fitz, the causal organism of damping off of chillies. Among them extract from *Allium sativum* (garlic) bulb (10%)

recorded the minimum mycelial growth (176.00 mg) followed by *Lawsonia inermis* leaf extract. Maximum percentage of seed germination, growth and vigour of chilli seedlings were also observed with garlic bulbs.

Kurucheve and Padmavathi (1997) prepared extracts of plant products at 10% concentration. The collected K-l chillies were mixed with the extracts and fungicide separately and dipped for five hours. Thiram (0.2%) served as a standard seeds treatments fungicide. Untreated seeds served as the control. By following roll towel method (ISTA), the seed germination growth and vigour of chilli seedling were observed.

Panda *et al.* (1996) tested efficacy of leaf extracts of Debdaru. Thuza, Allamanda, Bael and Kathgolap and observed excellent potential from leaf extracts of Allamanda against Phomopsis blight.

Khaleduzzaman (1996) reported that out of four plant extracts tested, garlic was found best in reducing seed-borne pathogens and increasing germiantion percentage of seed followed by Ginger, Neem and Bishkatali extract. The medicinal plant extract reduced seed-borne prevalence of all the fungi. The reduction of different fungi differ significantly from the control. However, among the 6 extracts neem bark extract performed better in reducing seed-borne prevalence of all the major fungi and increasing germination followed by Garlic, Bishkatali and Gagra extract. Crude-extract and dilution extracts (1:1 v/v) of the selected plant species were used for treating the seeds. Neem bark, Garlic clove and and bishkatali gave better results. Further investigation in controlling seed-borne fungi in wheat seed using alcoholic extracts of neem bark and garlic clove gave best results. Again using diluted alcohol extracts of Gagra and garlic clove gave best results.

Louis and Balakrishan (1996) observed that the five medicinal plant extracts tested showed more virus inhibitory activity when applied before virus inoculation than

applied after inoculation. Pre-inoculation application of the medicinal plant extracts at different time intervals raveled that virus inhibitory effect of *Base I la alba* and *Glycyrrhyiza glabra* decreased gradually. Whereas that of *Phyllanthus fraternus* and *Thespesia populnea* reached maximum after some time gap.

Srivastava and Verma (1995) worked with the aqueous extract of fresh leaves of *Chenopodium murale.* The extract showed antiviral activity and induced systemic resistance in the plants reacting hypersensitivity to tobacco mosaic virus and sunhemp rosette virus. The inhibitor in the leaf extract was active even when heated to 98°C for 10 mins. Diluted up to 1:20 and stored up to 8 days at 4°C. The inhibitor was non-dialyzahle and precipitated by 60% ammonium sulphate.

Hossain *et at.* (1993) also reported that the extracts of *Lawsonia alba, Ipomea fistulosa, Allium sativum,* and *Leucas aspera* when screened for their antifungal property against *Bipolaris sorokiniana,* only *A. sativum* completely inhibit the mycelial growth at dilution ratio of 1:4 (wt/v).

Ashrafuzzaman and Khan (1992) evaluated Thankuni *(Hydrocotyl asiatica),* Mehedi *(Lawsonia alba)* and Duranta *(Duranta plumeri)* against *Rhizoctonia solani* and found all the treatments inhibited mycelial growth and sclerotial formation effectively.

Ashrafuzzaman and Hossain (1992) and Ashrafuzzaman and Khan (1992) evaluated the extract of Biskatali *(Polygonum hydropiper) in vitro* against *Rhizoctonia solani* in two separate experiments and obtained that the extract inhibited the mycelial growth and spore germination effectively.

Ashrafuzzaman and Hossain (1992) reported the Pudina (*Mentha viridis)* extracts was evaluated against *Bipolaris sorokiniana* and observed that the extract inhibited mycelial growth and spore germination. In the same work they have found that extract of castor (*Ricinus communis)* and Dantha Kalash *(Leucas*

aspera) were also found inhibitory against mycelial growth and spore germination of *Bipolaris sorokiniana.*

Anandaraj and Leela (1990) studied the effect of plant extracts on growth of *P. capsici*, sporulation, sporangial germination and zoospore germination and found that mycelial growth, sporangia production, zoospore production and release, and zoospore germination were completely inhibited by *Chromalaena odorata* extracts at 2.0% concentration. *Azadirachta indica* extracts also acted similarly but mycelial growth was inhibited only by 75.5%. *Piper coluhrium* extracts inhibited mycelial growth and sporangial at 2.0% concentration. *Strychnos nuxvomica* and *Lantana camara* also effective equally at 0.25% and 2.0% respectively.

Tariq and Magee (1990) carried out on the effect of volatiles from garlic bulb extracts on *Fusarium oxysporum* f. sp. *lycopersici.* Volatiles components of crude aqueous extracts of garlic bulbs inhibuited germination of microconidia and hyphal extension in *Fusarium oxysporum* f. sp. *lycopersici* in axenic culture. The inhibitory effects were reversible except when microconidia were exposed to volatile from extracts containing a high cone, of garlic (500 mg/ml) while those from extracts containing only 10 mg garlic/ml promoted formation of the latter spore type while the level of micro-conidia formation was unaffected.

Chalfo and Carvalho (1987) studied the inhibition of mycelial growth of *Gibberella zeae (Firsarium growth)* by means of treatments, with garlic extract compared to chemical fungicide Captafol. All treatments inhibited mycelial growth of *G. zeae.* The most effective concentration being 8000 and 10000 ppm for garlic extract and 10000 ppm for Captafol.

Kashem and Vijai (1987) tested the effect of ten medicinal plants on growth of fungi and potential in plant disease control. Ten medicinal plants: Lemon grass, Nux-vomica tree, Dcrris, Urging croton, Staranise, Clove trees, Garlic and Cara way against *Photophthora spp., Phythium aphanidermatum, Rhizopus*

microsporus. Alternaria alternate, Fusarium solani, Staranise, at the concentration of 20000 ppm. completely inhibited growth of all tested fungi followed by Caraway, Lemongrass, Clove tree and Garlic respectively.

Singh and Dwivedi (1987) observed that hyphal dry weight and sclerotia production of *Sclerotium rolfsii* Sacc. were significantly reduced by bark extracts of *Acacia arabica.* They also tried bulb and leaf extracts of garlic and onion, leaf extracts of *Rauvolfia serpentina, Lowgonia alba, Daturam stramonium, Solanum xanthocarpum, Calotropics procera. Eucalyptus globus* and *Azadirachta indica* fruit and leaf extract of *Embelica offrcinalis* and rhizome extracts were more or less effective in inhibiting the fungus. Some researchers compared the anti-fungal properties of plant extracts with fungicides.

El-Shami, *et al.* (1986) compared anti-fungal property of garlic clove juice with recommended dose of fungicidal treatments against *Fusarium* wilt of watermelon. In the *in vitro* experiment, the garlic extract inhibited spore germination and mycelial growth of *Fusarium oxysporum f.* sp. *niveum* in extent similarly to five different fungicides. In the *in vitro* experiment, soaking watermelon in the extract gave better control of seedling than that of seed treatment with Benlate, Vitavex, Carboxin (Captan+Carboxin) or Thirum.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out in the Plant Pathology Laboratory and Central Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh, from November 2015 to May 2016 to find out the management options of late blight disease 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 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. Collected samples were put in polyethylene bags immediately after collection to protect from drying and loss of moisture.

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 other equipment's like inoculation-needles, inoculation chamber, forceps, hands etc.

3.3.3 Identification of *Phytophthora infestans* observing under microscope

Diseased leaf samples were brought to the laboratory. 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 potato slices. Temporary slides were prepared for identification under compound microscope. The incubated potato slices were also observed under stereoscopic microscope. The *Phytophthora infestans* was identified following the key out lined by Alexopoulos (1961) and Ingram and Williams (1971).

Plate 1. Symptom of late blight of tomato leaf caused by *Phytophthora infestans*

Plate 2. Collection of diseased leaves caused by *Phytophthora infestans*

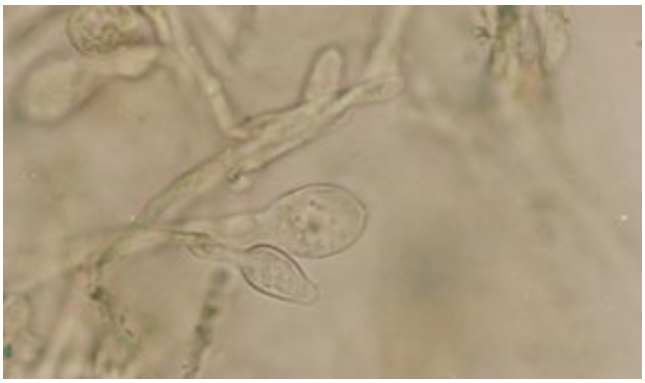

Plate 3. Sporangium of *Phytophthora infestans* under compound microscope

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 May and 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

The hybrid variety of tomato named Rio grand was used for the present experiment.

3.4. 5 Design of the experiment

The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications.

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 tilth. The clods of the land were hammered to make the clods into small pieces. Weeds, stubbles and crop residues were

cleaned from the land. The final ploughing 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 1 m × 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. After transplanting of tomato seedlings, it was watered by watering cane.

3.4.9 Treatments

T_1 = Mahogany leaf extract @ 1:6 (w/v)
T_2 = Neem leaf extract @ 1:3 (w/v)
T_3 = Papaya leaf extract @ 1:3 (w/v)
T_4 = Marigold leaf extract @ 1:3 (w/v)
T_5 = Ridomil Gold @ 0.2 %
T_6 = Topgan @ 0.7 %
T_7 = Dithane M 45 @ 0.45 %
T_8 = Control

3.4.10 Intercultural Operation

3.4.10.1 Plant protection

The crop was 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.

3.4.10. 4 Weeding

Weeding was done four time in the experimental period starting at 20 days after planting, 40 days after planting, 55 days after planting and 70 days after planting.

3.4.11 Collection of fungicides and plant extracts

Three fungicides namely Ridomil gold, Topgan and Dithane M 45 were collected from local market. Seeds of mahogany, leaf of neem, leaf of 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 gm/liter of Topgun, 4.5 gm/liter of Dithane M 45, 2 gm/liter of Ridomil Gold 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 preparation of extracts, collected leaves were weighted in an electric balance and then washed in the water. After washing the big leaves were cut into small pieces. For getting extract, weighted plant parts were blended in a mortar & pastel and then distilled water was added into the mortar. The pulverized mass was squeezed through 3 folds of fine cotton cloth. For getting 1:3 (w/v) ratio 300 ml of distilled water was added with 100g plant parts.

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 1/3rd urea 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 Experimental design

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.

3.4.16 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. Totally 7 spraying 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.

Plate 4: Field view of experiment plot

Plate 5: A bunch of tomato fruits

3.4.17 Application of fungicides and plant extracts

The fungicides and plant extracts were applied to the foliar part of tomato 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 at an interval of 30 days.

1. Disease Incidence (% plant infection & % leaf infection)
2. Disease Severity (% leaf area diseased)
3. Yield (ton/ha)

Calculation of disease incidence and disease severity

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

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

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

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

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

4.1 Symptoms of late blight of tomato

Symptom of the disease firstly appeared as water soaked small patches on leaves. The patches gradually spread, turned brown and covered larger areas. Symptoms also found to develop on petiols and stems. The whole leaf appeared as burnt in extreme case. In dry weather condition the spots were restricted and wither off. On humid weather blackish water soaked lesions occured on the leaves and whitish sporulation of the pathogen was seen around the margin of the lesions, particularly on the ventral side of the leaf.

Plate 6: Showing symptoms of late blight of tomato

4.2 Identification of the causal organism

The organism grown on moist blotter paper and tomato slices isolated from the diseased leaf samples were observed directly under sterio microscope and under compound microscope by preparing semi permanent slide and identified as *Phytophthora infestans* following the key outline stated by Alexopoulos (1961) and Ingram and William (1971) in Plate-3.

The tomato leaf sample affected by *Phytophthora infestans* took 6-7 days to sporulate in moist blotter paper (Plate-8) but on tomato slices the sporulation of *Phytophthora infestans* delayed upto 20 days. The pathogen produced hyaline lemon shaped sporangia arose straightly from the surface of the substrate.

4.3 Effects of different 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 the treatments revealed significant difference in controlling the disease incidence. Results showed that the lowest disease incidence (10.61%) was scored by T_5 (Ridomil Gold @ 0.2%) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%). 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_5 (Ridomil Gold @ 0.2%) (85.98%) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%) where the lowest percent (%) reduction of disease incidence over control was found in T_4 (Marigold leaf extract @ 1:3 w/v).

Table 1. Effect of treatments on the occurrence of late blight infection showing disease incidence under field conditions

Treatments	Diseases incidence (%)	% reduction of disease incidence over control
T_1	38.67 d	48.92
T_2	35.17 e	53.54
T_3	42.40 c	43.99
T_4	45.67 b	39.67
T_5	10.61 h	85.98
T_6	20.63 g	72.75
T_7	26.17 f	65.43
T_8	75.70 a	--
$LSD_{0.05}$	2.367	--
CV(%)	9.416	--

T_1 = Mahogony leaf extract @ 1:6 (w/v)

T_2 = Neem leaf extract @ 1:3 (w/v)

T_3 = Papaya leaf extract @ 1:3 (w/v)

T_4 = Marigold leaf extract @ 1:3 (w/v)

T_5 = Ridomil Gold @ 0.2%

T_6 = Topgan @ 0.7%

T_7 = Dithane M45 @ 0.45%

T_8 = Control

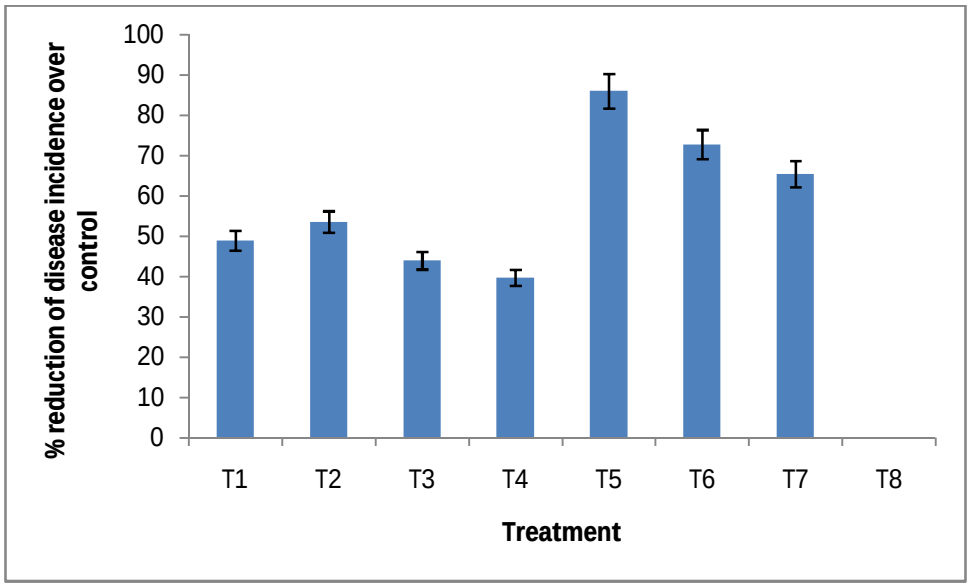

Figure 1. Effect of treatments on the occurrence of late blight infection showing percent reduction of disease incidence over control

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 performance of the treatments revealed that the lowest disease severity (14.50%) was scored by T_5 (Ridomil Gold @ 0.2%) followed by T_6 (Topgan @ 0.7%). The highest disease severity was recorded in control (32.60%) followed by T_4 (Marigold 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_5 (Ridomil Gold @ 0.2%) (82.82%) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%) where the lowest percent (%) reduction of disease incidence over control was found in T_4 (Marigold leaf extract @ 1:3 w/v) (34.50%).

Table 2. Effect of treatments on the occurrence of late blight showing disease severity under field conditions

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

T_1 = Mahogony leaf extract @ 1:6 (w/v)

T_2 = Neem leaf extract @ 1:3 (w/v)

T_3 = Papaya leaf extract @ 1:3 (w/v)

T_4 = Marigold leaf extract @ 1:3 (w/v)

T_5 = Ridomil Gold @ 0.2%

T_6 = Topgan @ 0.7%

T_7 = Dithane M45 @ 0.45%

T_8 = Control

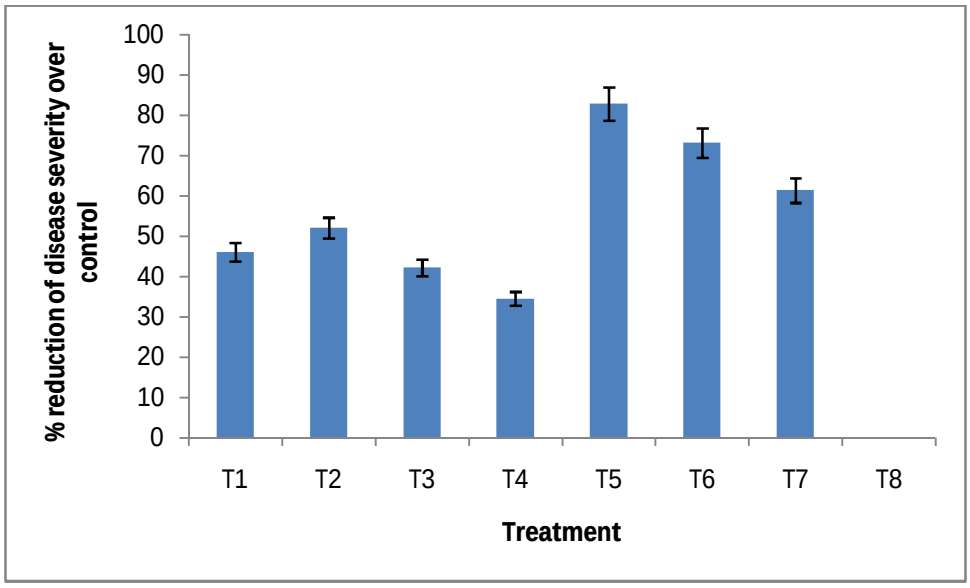

Figure 2. Effect of treatments on the occurrence of late blight showing percent reduction of disease severity over control

4.5 Effect of different treatments on growth and yield of tomato

4.5.1 Plant height

The effect of different treatments regarding plant height against late blight of tomato caused by *Phytophthora infestans* is presented in Table 3. The treatments showed significantly 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, 78.72 and 127.80 cm at 30, 60 and 90 DAS respectively) was recorded in T_5 (Ridomil Gold @ 0.2%) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%), while the lowest plant height (24.68, 54.3183.58 cm at 30, 60 and 90 DAS respectively) was recorded in control followed by T_3 (Papaya leaf extract @ 1:3 w/v) and T_4 (Marigold leaf extract @ 1:3 w/v).

Table 3. Effect of botanicals and chemical fungicides on plant height of tomato and its affect on management of late blight of tomato

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	27.64 d	70.46 d	109.06 e
T_2	29.95 c	72.88 c	113.30 d
T_3	26.48 e	67.39 e	104.83 f
T_4	26.20 e	65.18 f	94.64 g
T_5	32.53 a	78.72 a	127.80 a
T_6	31.88 b	75.38 b	121.72 b
T_7	30.02 c	74.60 b	117.50 c
T_8	24.68 f	54.31 g	83.58 h
$LSD_{0.05}$	0.644	1.024	2.853
CV(%)	8.529	7366	9.428

T_1 = Mahogony leaf extract @ 1:6 (w/v)

T_2 = Neem leaf extract @ 1:3 (w/v)

T_3 = Papaya leaf extract @ 1:3 (w/v)

T_4 = Marigold leaf extract @ 1:3 (w/v)

T_5 = Ridomil Gold @ 0.2%

T_6 = Topgan @ 0.7%

T_7 = Dithane M45 @ 0.45%

T_8 = Control

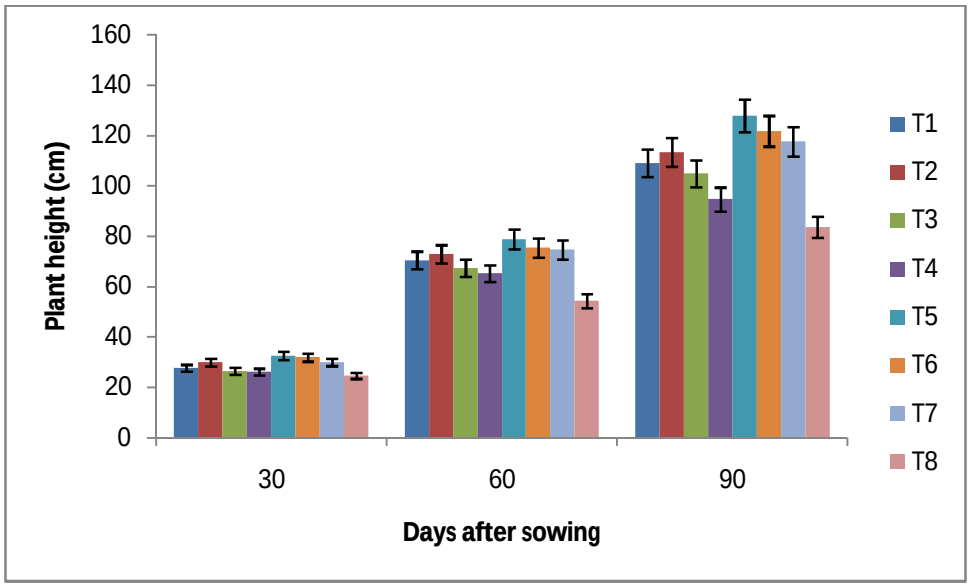

Figure 3. Effect of botanicals and chemical fungicides on plant height of tomato and its affect on management of late blight of tomato

4.5.2 Number of branches plant^{-1}

The effect of different treatments regarding number of branches plant^{-1} against late blight of tomato caused by *Phytophthora infestans* 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 botanicals. Among the chemical fungicides the highest number of branches plant^{-1} (3.37, 14.58 and 15.72 at 30, 60 and 90 DAS respectively) was recorded in T_5 (Ridomil Gold @ 0.2%) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%) while the lowest number of branches plant^{-1} (2.20, 5.77 and 5.82 at 30, 60 and 90 DAS respectively) was recorded in T_8 (Control). Among the botanical treatments, T_2 (Neem leaf extract @ 1:3 w/v) gave the highest number of branches plant^{-1} followed by T_1 (Mahogony seed extract @ 1:6 w/v) and T_3 (Papaya leaf extract @ 1:3 w/v).

Table 4. Effect of botanicals and chemical fungicides on number of branches plant^{-1} as affected in management of late blight of tomato

Treatment	Number of branches plant^{-1}		
	30 DAS	60 DAS	90 DAS
T_1	2.82 d	10.36 d	10.56 e
T_2	3.04 c	10.82 c	11.15 d
T_3	2.84 d	9.40 e	9.56 f
T_4	2.71 e	9.28 d	9.48 f
T_5	3.37 a	14.58 a	15.72 a
T_6	3.29 a	14.48 a	15.30 b
T_7	3.35 b	12.84 b	13.26 c
T_8	2.20 f	5.77 f	5.82 g
$LSD_{0.05}$	0.015	0.144	0.389
CV(%)	5.337	8.314	7.283

T_1 = Mahogony leaf extract @ 1:6 (w/v)

T_2 = Neem leaf extract @ 1:3 (w/v)

T_3 = Papaya leaf extract @ 1:3 (w/v)

T_4 = Marigold leaf extract @ 1:3 (w/v)

T_5 = Ridomil Gold @ 0.2%

T_6 = Topgan @ 0.7%

T_7 = Dithane M45 @ 0.45%

T_8 = Control

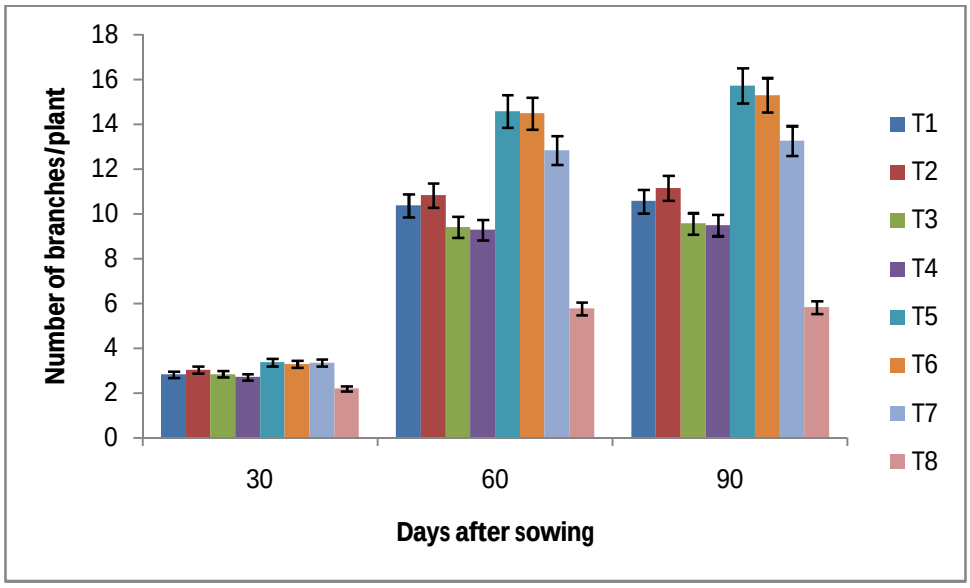

Figure 4. Effect of botanicals and chemical fungicides on number of branches plant^{-1} as affected in management of late blight of tomato

4.5.3 Number of fruits plant^{-1}

Number of fruits plant^{-1} against late blight of tomato caused by *Phytophthora infestans* showed significant variation 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} (34.56) was recorded in T_5 (Ridomil Gold @ 0.2%) treatment followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%), while the lowest number of fruits plant^{-1} (15.42) was recorded in T_8 (Control). Among the botanical treatments, T_2 (Neem leaf extract @ 1:3 w/v) gave the highest number of fruits plant^{-1} (28.33) followed by T_1 (Mahogony leaf extract @ 1:6 w/v).

4.5.4 Average fruit weight

Average fruits weight was significantly influenced by different treatments against late blight of tomato caused by *Phytophthora infestans* presented in Table 5.

Regarding average fruits weight, botanical fungicides treatments showed significantly better performance than the chemical fungicides. The highest average fruits weight (116.38 g) was recorded in T_4 (Marigold leaf extract @ 1:3 w/v) treatment followed by T_3 (Papaya leaf extract @ 1:3 w/v) and T_1 (Mahogony seed extract @ 1:6 w/v), while the lowest average fruits weight (88.80 g) was recorded in T_8 (Control). Among the chemical treatments, T_5 (Ridomil Gold @ 0.2%) gave the highest average fruit weight (107.06 g) followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%).

4.5.5 Fruit yield plant^{-1}

Fruit yield plant^{-1} against late blight of tomato caused by *Phytophthora infestans* showed significant variation (Table 5). Results revealed that the highest fruit yield plant^{-1} (3.41kg) was recorded in T_5 (Ridomil Gold @ 0.2%) treatment followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%), while the lowest fruit yield plant^{-1} (1.65 kg) was recorded in T_8 (Control). Among the botanical treatments, T_2 (Neem leaf extract @ 1:3 w/v) gave the highest fruit yield plant^{-1} (3.07 kg) followed by T_1 (Mahogony seed extract @ 1:6 w/v) and T_3 (Papaya leaf extract @ 1:3 w/v).

4.5.6 Fruit yield ha^{-1}

Fruit yield ha^{-1} against late blight of tomato caused by *Phytophthora infestans* showed significant variation (Table 5). Results revealed that the highest fruit yield ha^{-1} (72.84 t) was recorded in T_5 (Ridomil Gold @ 0.2%) treatment followed by T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%), while the lowest fruit yield ha^{-1} (35.22 t) was recorded in T_8 (Control). Among the botanical treatments, T_2 (Neem leaf extract @ 1:3 w/v) gave the highest fruit yield ha^{-1} (54.25 t) followed by T_1 (Mahogony seed extract @ 1:6 w/v) and T_2 (Neem leaf extract @ 1:3 w/v).

Table 5. Effect of botanicals and chemical fungicides on yield parameters as affected in management of late blight of tomato

Treatment	Number of fruits plant^{-1}	Average fruit weight (g)	Fruit yield plant^{-1} (kg)	Fruit yield ha^{1} (t)
T_1	27.84 e	107.19 c	2.98 e	63.66 e
T_2	29.21 d	105.06 d	3.07 d	65.47 d
T_3	25.66 f	114.58 b	2.94 e	62.72 f
T_4	24.15 g	116.38 a	2.81 f	59.96 g
T_5	34.56 a	107.06 c	3.41 a	72.84 a
T_6	32.32 b	102.16 e	3.30 b	70.44 b
T_7	31.48 c	103.52 e	3.26 c	69.52 c
T_8	15.42 h	88.80	1.65 g	35.22 h
$LSD_{0.05}$	1.364	1.114	0.106	1.042
CV(%)	8.571	7.389	5.276	8.351

T_1 = Mahogony leaf extract @ 1:6 (w/v)

T_2 = Neem leaf extract @ 1:3 (w/v)

T_3 = Papaya leaf extract @ 1:3 (w/v)

T_4 = Marigold leaf extract @ 1:3 (w/v)

T_5 = Ridomil Gold @ 0.2%

T_6 = Topgan @ 0.7%

T_7 = Dithane M45 @ 0.45%

T_8 = Control

As per the overall performance, the plant extracts and fungicides, the Ridomil Gold showed the promising performance in management of late blight of tomato. Ridomil Gold reduced disease incidence by 85.98% and disease severity by 82.82% followed by Topgan which reduced disease incidence by 72.75% and disease severity by 73.14%.

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

As the disease incidence and severity of late blight of tomato were significantly control by Ridomil Gold and Neem leaf extract. Their influences were observed in yield and yield contributing characters of tomato against the disease. The highest plant height (127.80 cm), number of branches plant^{-1} (15.72), number of fruits plant^{-1} (34.56), fruit yield plant^{-1} (3.41 kg) and fruit yield ha^{-1} (72.84 t) were observed by the fungicide Ridomil Gold followed by Topgan.

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

Similar results were found by the previous researchers while they assayed different treatment against late blight of tomato.

Thind *et al.* (1989) evaluated different fungicides in laboratory and field conditions and reported that Ridomil Gold effectively controlled late blight of tomato and resulted promising yield.

Sharma *et al.* (1993) conducted an experiment for two years at Punjab, India to evolve effective fungicidal spray schedule against *P. infestans* and claimed that Ridomil Gold and followed by Dithane M 45 reduced late blight of tomato from 99.75% to 11.65%.

Vanitha and Ramachandran (1999) observed that the application of Ridomil Gold reduced the infection of *P. infestans* effectively.

Ahmed and Islam (2000) used neem, garlic, onion and bishkatali extracts, among them neem and garlic extracts were effective against *P. infestans.*

Khaleduzzaman (1996) evaluated different plant extracts and reported that neem extract reduced seed-borne pathogens prevalence of all the fungi.

Thus, the tomato growers may be suggested to apply Ridomil Gold as protective fungicide and Neem extract as eco-friendly options for the management of late blight of tomato.

CHAPTER V

SUMMARY AND CONCLUSION

A field and Laboratory study was conducted in the Department of Plant Pathology at Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh, from November 2015 to May 2016 to find out the management of late blight of tomato disease through different botanicals and chemical fungicides**.**

The hybrid variety of tomato named Rio grand was used for the present study. There were 8 treatments *viz* T_1 (Mahogany seed extract @ 1:6 w/v), T_2 (Neem leaf extract @ 1:3 w/v), T_3 (Papaya leaf extract @ 1:3 w/v), T_4 (Marigold leaf extract @ 1:3 w/v), T_5 (Ridomil Gold @ 0.2%), T_6 (Topgan @ 0.7%), T_7 (Dithane M 45 @ 0.45%) and T_8 (Control). The experiment was carried out at Randomized Complete Block Design (RCBD) with three replications. 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.

The present finding indicated that at every case, chemical fungicides showed better performance than botanical fungicides except average fruit weight. Under the present study, chemical fungicide, T_5 (Ridomil Gold @ 0.2%) devoted promising performances in reducing disease incidence (85.98%) and disease severity (82.82%) over control.

In terms of growth and yield parameters in the study, T_5 (Ridomil Gold @ 0.2%) treated plot gave the best performance. The highest plant height (127.80 cm), number of branches plant^{-1} (15.72), Number of fruits plant^{-1} (34.56), Fruit yield plant^{-1} (3.41 kg) and Fruit yield ha^{-1} (72.84 t) were obtained from T_5 (Ridomil Gold @ 0.2%) compared to control treatment. T_6 (Topgan @ 0.7%) and T_7 (Dithane M45 @ 0.45%) also gave promising effect against late blight of tomato. Botanical fungicides also gave promising results considering late blight

management of tomato. Among the entire botanicals, T_2 (Neem leaf extract @ 1:3 w/v) also showed effective control against late blight of tomato. Treatment, T_1 (Mahogony seed extract @ 1:6 w/v), T_3 (Papaya leaf extract @ 1:3 w/v) and T_4 (Marigold leaf extract @ 1:3 w/v) also effective against late blight of tomato.

Considering the performances of plant extracts and chemical fungicides evaluated in the experiment, it is suggested that either Ridomil Gold (0.2%) or Dithane M 45 (0.45%) or Topgan (0.7 %) could be used against late blight of tomato.

As eco-friendly component, Neem leaf extracts and Mahogony seed extracts also could be used against the disease. However, the investigation need to be continued for several consecutive years including more eco-friendly options for the management of late blight of tomato disease.

REFERENCES

Agrios , G. N. (1998). Plant pathology. Academic Press. New York.

Agrios, G. N. (1988). Plant pathology. 3rd Edn, Academic Press, London. 803 p.

Ahmed, K. U. (1976). Phul Phal O Shak Shabji (In Bangla). 3rd Edn. Alhaj Kamisuddin Ahmed. Banglow No.2. Farmgate, Dhaka-15, Bangladesh. 470p.

Amin, M. L., Asad-ud- doullah. M. Pramanik, B.K. and Ashrafuzzaman, M. 2000. Management of leaf curl disease of tomato. *Pakistan Journal of Biological Sciences*, **4(12):** 1512-1514.

Anandaraj, M. and Leela, N. K. (1996). Toxic effect of some plant extract on *Phytophthora capsici*, the foot rot pathogen of black pepper. *Indian Phytopathology*, **49(2):** 181-184.

Anonymous, (2004). Annual Report, Bangladesh Agricultural Research Institute, Joydevpur.

BBS (Bangladesh Bureau of Statistics). (2011). Statistical Pocket Book of Bangladesh. Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka. p.215.

Cao, K. Q. and Forrer, H. C. (1997). Inhibitory efficacy of several plant extracts and plant products on *Phytophthora infestans*. *Journal of Agricultural University of Hebei*, **24(2)**: 90–96.

Chowdhury, B. (1979). Vegetables. 6th Edition, The Director, National Book Trust, New Delhi, India. p.46.

Chycoski, C. I. and Z. K. Punja. (1996). Characteristics of populations of *Phytophthora infestans* from potato in British Columbia and other regions of Canada during 1993-1995. *Plant Disease,* **80**: 579-589.

El-Shami, M. A., Tawfik, A. R. Sirry and M. M. El-Zayat. (1986), Antifungal property of garlic clove juice compared with fungicidal treatments against Fusarium wilt of water melon. *Egyptian J. Phytopath*. **17(1):** 55-62.

Erwin, M. K. and Ribeiro, G. M. (1996). Managing Botrytis in greenhouse grown flower crops. *Plant Disease* . **80(11)**: 1212-1219.

Fontem, D. A. and Aighewi, B. (1993). Effect of fungicides on late blight control and yield loss of potato in the western highlands of Cameroon. *International J, Pest Management*. **39(2)**: 152-155.

Fry, W. E., Goodwin, S. B., Dyer,A. T., Mutuszak, J. M., Drenth, A., Tooley, P. W., Sujkowski, L. S., Koh, Y. J., Cohen, B. A., Spielman, L. J., Deahl, K. L., Inglis, D. A. and Sandlan, K. P. (1993). Historical and recent migration of *Phytophthora infestans* chronology, pathway and implications. *Plant Disease*, **77**: 653-661.

Hossain, I. and Shamsuzzaman. (2003). Developing *Trichoderma* based bio-fungicide using agro-wastes. Bangladesh Agricultural University. Res. Prog. 14: 49.

Hossain. L, H. Ashrafuzzaman and M. H. H. Khan. (1993). Bio-control of *Rhizoctonia solani*. BAU Res. Prog. 7: 264-269.

Islam, M. S. (2005). Management of late blight ot tomato. M.S. Thesis. Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh. p. 89.

Jayashree, K. Pun, K. B. and Doraiswamy, S. (1999). Effect of plant exracts and derivatives, butter milks and virus inhibitory chemical on pumkin yellow vein mosaic virus transmission. *Indian Phytopathology*, **52(4)**: 357-361.

Jebunnaher, A. L. 2004. Paper bags for pest control and pesticide use reduction on tomato fruits. *Scientia Agricola,* **59(2)**: 281-289.

Kasem, Soytong and Vijai, Rakridhyasastra. (1987). Effect of some medicinal plants *Crotontigilum. Eugenia caryphyllus. Allium sativum. Cymbopogn citratus, Dautra metel, Stemona strychnosnus-vomica. Derris elliptica. Illicium verum* on growth of fungi and potential in plant disease control. Third annual conference on methodological Techniques in Biological Sciences, p. 12-13. November, 1985. Nakhaon pathon (Thiland). 55-56.

Khaleduzzaman, S. (1996). Effect of micvrobial antagonists in the control of soil-bome root infecting fungi in tomato and okra. *Pakistan J. Bot*. **26(1):** 179-182.

Lashomb, H. J. and R. Casagrande. (1981). Advances in Potato Pest Management. Hutchinson Ross Publishing Company, Stroudsburg; Pennsylvania.

Mark, L. Gleason and Brooke, A. Edmunds, (2006), Tomato diseases and disorders. *Physiological disorder*, 12pp.

Matin, M. A., Haq, M. A., Karim, M. R. and Baksha, E. (1996). Farm Level Yield Analysis of Tomato Cultivation in Selected Areas of Bangladesh: An Economic Profile. *Bangladesh J. Agril. Res*. **21(1)**: 50-57.

Mulandi, M. A. S. (1998). Horticulture: development and marketing. 12th biennal Ambassadors/High Commissioners Conference “Democracy and Development Towards the Next Millenium”, 26th July - 5th August, 1998, Mombasa, Kenya.

Panda, S., Benddine, F., Moumen, A. and Kheddam, M. (1996). Status of tomato viruses and control strategies in Algeria. Proceedings of the EPPO workshop on tomato yellow leaf curl begomoviruses (TYLCV), Faro. Portugal. 21-23 May, 2001. Bulletin OEPP. **32(1)**: 21-24.

Rich, A. E. 1983. Potato Diseases Academic Press Inc., New York. 227p.

Shah. G. S., Pathan. M. A., Lodhi, A. M. and Rajput. M. A. (2003). Effect of different management practices on *Meloidogyne incognita*. *Pakistan Journal of Nematology* **21(1)**: 25-30.

Sharfudin, A. F. M. and Siddique, M. A. (1985). Sabji Bigyan. 1st Edition, Bangladesh Agricultural University, Mymensingh. p. 4.

Sharma, K. K., Shekhawat, G. S., Khurana, S. M. P., Pandey, S. K. and chandla, V.K. (1993). Fungicidal Spray schedule and its economics for potato late blight management in North Western Plains. Potato: present and future. Proceedings of the National symposium held at Modipuram during 1-3, March 1993. 197-199.

Singh, R. K. and R. S. Dwivcdi. (1987). Fungitoxicity of different plant against *Sclerotium rolfsiii sacc. Nat. Aca. Set. Lett. H)* **(3):** 89-91.

Srivastava, A. K. and Lae, B. (1997). Studies on biofungicidal properties of leaf extract of some plants. *Indian Phytopathology*. **50(3):** 408-411.

Srivastava, N and Verma, H. N. (1995). *Chenopodhm murale* leaf extract, a potent virus inhibitor. *Indian Phytopathology*. **48(2):** 177-179.

Talukder, M. J. (1974). Plant Disease in Bangladesh. *Bangladesh J. agril. Res*. **1(1):**71.

Tariq, V. N. and A. Q. C. Magee. (1990). Effects of volatiles from garlic bulb extracts on Fusarium f sp. lycopersici. *Mycological Res.* **94(50):** 617-620.

Thind, T. S., Chander, M., Bedi, J. S., Grewal, R. K. and Sokhi, S. S. (1989). Role of application time of fungicides in the control of late blight of potato. *Plant Disease Res.*, **4(2)**:113-117.

Van Derzaag, D. E. (1996). Potato Diseases, Disease, Pest and Defects. NIVAA. The Netherlands.

Vanitha, V. G. and Endo, R. M. (1985). Over wintering hosts. Compatibility types and races of *Phytophthora infestans* on tomato in Southern California. *Plant Disease*: **69(6)**:516-519.

Watterson, J. C. (1986). Diseases. The tomato crops. Edited by Atherton and Rudich. Chapman and Hall Ltd. NY.pp. 461-462.

Zahid, M. I., K. D. lapan and B. C. Chowdhury. (1993). Major diseases of potato, tomato, brinjal, laddi's fingerand country bean and their control (In Bengali). *Bangla Press*, BARC. Dhaka. 20:5.

Zhao. Y.X. and Kang, L. (2002). Role of plant volatiles in host plant location of the leaf minor. Liriomyza sativae (Diptera: Agromyzidae). *Physiological Entomology* **27(3):** 103-111.

APPENDICES

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

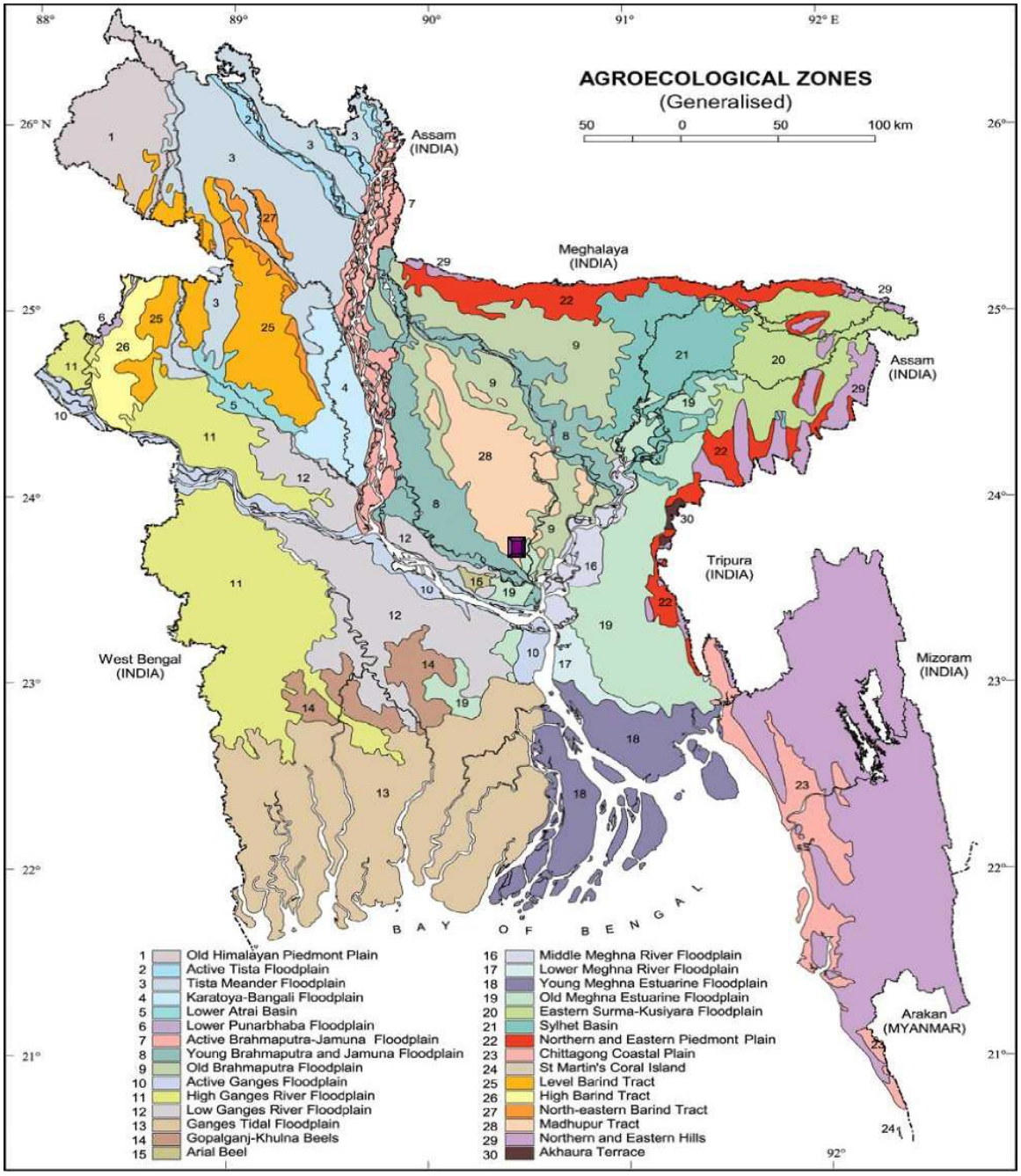

Figure. 1. Map of Bangladesh remarked with study area.

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

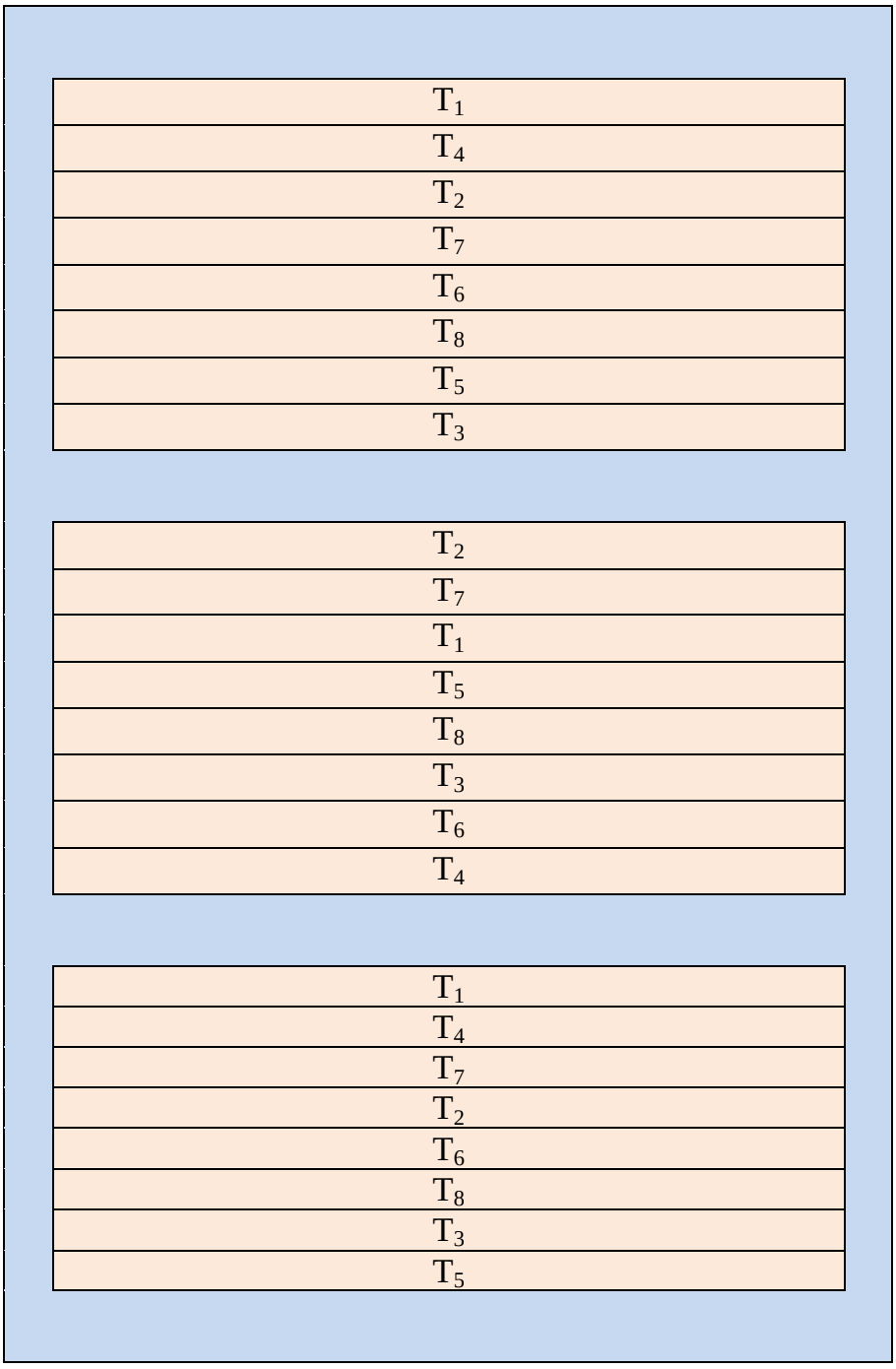

Figure 2. Layout of the experiment field.