EFFECT OF SELECTED CHEMICALS AND ENVIRONMENT FRIENDLY COMPONENTS FOR THE MANAGEMENT OF PURPLE BLOTCH OF ONION

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EFFECT OF CHEMICALS AND ENVIRONMENT FRIENDLY COMPONENTS FOR THE MANAGEMENT OF PURPLE BLOTCH OF ONION

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This is to certify that the thesis entitled *"EFFECT OF SELECTED CHEMICALS AND ENVIRONMENT FRIENDLY COMPONENTS FOR THE MANAGEMENT OF PURPLE BLOTCH OF ONION"* submitted to the Faculty of Agriculture, 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 bonafide research work carried out by *Md. Harun Or Rashid, Registration No. 05-01629*, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma elsewhere.

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

Dated: 22 April 2012

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Dedicated To

My Beloved Parents

Effect of Selected Chemicals and Environment Friendly Components for the Management of Purple Blotch of Onion

Abstract

A set of experiment were conducted at the laboratory of the Department of plant Pathology, SAU and Spices Research Centre (SRC), BARI, Shibgoanj, Bogra, Bangladesh, during the month of September-October in 2010. Field experiment was conducted at spices Research Centre, BARI, Shibgonj, Bogra to determine the integrated approach for the management of purple blotch of onion for seed production during October, 2010 to March 2011. The treatment of the expeirment were Rovral wp @ 0.2% (T_1), Rovral wp @ 0.1% + Provax 0.25% (T_2); Trichoderma $5x10^6$ spore/ml @ 100 ml/plant (T_3); Rovral wp @ 0.1% + Bavistin 0.5% (T_4); Neem leaf extract 1:6 (w/v) (T_5); Rovaral wp @ 0.1% +Evaral @ 0.1% (T_6); Rovaral wp @ 0.1% +Ridomil gold MZ-72 @ 0.1% (T_7); Rovaral wp @ 0.1% +Secure @ 0.05% (T_8) and control (T_9). Different treatment has effect on inhibition of mycelial growth of the fungus. The lowest mycelial growth was recorded in case of T_7 followed by T_2 where the highest mycelial growth was recorded in case of control (T_9). In field experiment, the lowest disease incidence (both on leaf infection and stalk infection) were recorded incase of treatment T_7 in comparison to other treatments irrespective of days after transplanted while highest disease incidence was recorded in control treatment (T_9). The disease severity were also recorded the lowest in case of treatment T_7 followed by treatment T_2. The highest PDI was recorded in control treatment. The disease incidence and severity were increased gradually with the age of the plant but the increasing rate was the lowest in treatment T_7 and highest in control (T_9). The highest plant height (81.40cm) and the yield (1.24 ton/ha) were recorded in treatment T_7 where as the lowest plant height (61.20cm) and seed yield (0.82. ton/ha) were recorded in control (T_9).

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The author

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ABBREVIATIONS USED

AEZ	=	Agro-Ecological Zone
@	=	At the rate
ANOVA	=	Analysis of variance
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
B	=	Boron
cm	=	Centimeter
CMI	=	Commonwealth Mycological Institute
Cu	=	Copper
CV	=	Co-efficient of variance
cv.	=	Cultivar variety
DAI	=	Days After Inoculation
DAP	=	Days After Planting
DMRT	=	Duncan's Multiple Range Test
eg.	=	Example
Fe	=	Iron
g	=	Gram
FAO	=	Food and Agricultural Organization
ha	=	Hectare
$HgCl_2$	=	Mercuric chloride
hr	=	Hour
i.e.	=	That is
ISTA	=	International Seed Testing Agency
IDM	=	Integrated Disease Management
K	=	Potash
kg/ha	=	Kilogram per hectare

LAD	=	Leaf Area Diseased
lb	=	Pound
LSD	=	Least Significant Difference
m	=	Meter
mm	=	Millimeter
MP	=	Muriate of ptash
N	=	Nitrogen
NUV	=	Near Ultra Violet
P	=	Phosphorus
PDA	=	Potato Dextrose Agar
PDI	=	Percent Disease Index
ppm	=	Parts per million
q/ha	=	Quintal per hectare
RCBD	=	Randomized Complete Block Design
RH	=	Relative Humidity
S	=	Sulphur
SAD	=	Stalk Area Diseased
SAU	=	Sher-e-Bangla Agricultural University
SRC	=	Spices Research Centre
T	=	Treatment
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
wt	=	Weight
w/v	=	Weight per volume
Zn	=	Zinc
ZnO	=	Zinc Oxide
^0C	=	Degree Centigrate
%	=	Percent

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Onion (*Allium cepa*) is an important spices crop, commercially grown in many countries of the world. It ranks first in production among the spices crop cultivated in Bangladesh. The major onion producing countries like Korea Republic tops the list with 65.25t/ha followed by USA 53.91t/ha, Spain 52.06t/ha, Japan 47.55t/ha (FAO, 2008), where as the productivity of onion in Bangladesh is 8.95t/ha (AIS, 2011) which is very lower than the other onion producing countries. This variation of yield may be due to several constraints that affect onion yield adversely in our country, which may includes the use of low quality seed, imbalanced fertilizers, uneven irrigations; and attack of various insect-pests and diseases. A variety of diseases and disorders affect onion. Most of the diseases are caused by fungi or bacteria where as disorders may be caused by adverse weather, air pollutants, soil conditions, nutritional imbalances and pesticidal affect. Sometimes several diseases and/or disorders may be present at the same time.

In the world, onion is attacked by 66 diseases including 10 bacterial, 38 fungal, 6 nematode, 3 viral, 1 mycoplasmal, 1 parasitic plant and 7 miscellaneous diseases and disorders (Schwartz and Mohan, 2008, Schwartz, 2010). In Bangladesh, several diseases have become widespread and serious enough to limit the production. The common diseases such as purple leaf blotch (*Alternaria porri*), *Stemphylum* blight (*Stemphylium vesicarium)* downy mildew (*Peronospora destructor*) and basal/stem rot (*Fusarium* sp., *Sclerotium* sp., *Rhizoctonia* sp.), damping off etc, are the most destructive diseases that damage the crop and reduce the seed yield up to 100% (Brewster, 2008).

Purple leaf blotch is an important disease caused by *Alternaria porri* and prevalent in all the onion growing areas. The fungus can cause a reduction in yield from 30 to 50 percent (Pascua *et al.,* 1997). Nevertheless 90-100 percent yield loss may be occurred due to this disease. Hot and humid climate with temperature ranging from 21-30^0 C and relative humidity (80-90%) favor the disease development (Brewster, 2008). It is more common in every season and old leaves tend to be more susceptible to the disease. *Alternaria* spores germinate on onion leaves and produce a small, water-soaked spot that turns brown. The elliptical lesion enlarges, becomes zonate (target spot) and purplish. The margin may be reddish to purple and surrounded by a yellow zone. During moist weather, the surface of the lesion may be covered by brown to black masses of fungal spores. Lesions coalease that they kill the entire leaf. Lesions may form on seed stalk and floral parts of seed crop and affect seed development by breaking the stalk. Now a day's *Stemphylium vesicarium*, the causal agent of white blotch of onion are being considered as an organism involved indirectly with the causation of purple blotch of onion. It considered that *Stemphylium vesicarium* initiate the infection, which facilitates subsequent infection of *Alternaria porri* causing purple blotch and hence the disease is designated as purple blotch complex In Bangladesh, the demand of bulb onion as well as the seeds is increasing every year and the price of the true seeds remains fairly high in each season.

The disease is considered as a serious problem for seed production in tropical countries like Bangladesh (Rahman *et al.,* 1988). In primary stage the symptoms appear on leaves or seed stalks as small water-soaked lesion that quickly develops white centre.

Seed production is severely affected by the disease because the disease causes breaking of floral stalks (Munoz *et al.*, 1984). Damage of foliage and breaking of floral stalks due to purple blotch resulting failure of seed production of onion (Munoz *et al.*, 1984; Ashrafuzzaman and Ahmed, 1976). The infected seed stalks break at the point where the blotch lesion is developed (Singh, 1987).

Bulb and seed yields of onions cv. "Nasik Red" were significantly reduced as a result of purple blotch caused by *Alternaria porri* (Gupta and Pathak, 1988). About 20 to 25% losses in seed yield have been recorded in India (Thind and Jhooty, 1982) and 41-44% in Bangladesh (Hossain and Islam, 1993; Fakir, 2002). In Bangladesh the cultivars Faridpuri and Taherpuri are susceptible to the disease (Rahman *et al.*, 1988).

Several workers tried to find out suitable control measures, like cultivation of resistant variety, manipulation of the date of planting, management of fertilizers, bulb size, protective spray of fungicides, etc. (Suheri and Price, 2000; Sherf and Macnab, 1986; Srivastava *et al.*, 1991; Mishra, 1989; and Mondal *et al.*, 1989;). Use of healthy seeds for planting and crop rotation for 2-3 years with cereal crops can check the disease. Schedule and alternate spraying of Mancozeb (0.25%) or Iprodione (0.25%) at first appearance of disease symptoms can reduce the disease. It is reported that, spraying of Rovral (0.2%) + Antracol + Dithane M-45 combinedly can reduce the purple blotch disease severity (Anon., 2010; and Rahman *et al.*, 2010) and that Secure + Rovral showed the best performance in reducing the purple blotch disease of summer onion. Use of plant extracts is however a recent approach to plant diseases management and it has drawn special attention of the plant pathologist all over the world. Many researchers reported plant extracts having antifungal properties and thus having potential to be used against plant diseases (Ayub and Sultana, 2004; and Hossain, 2008; Peters, 1990).

Keeping these facts in mind, the present study was undertaken with the following objectives:

1. Isolation and identification of the causal pathogen.

2. To findout the effective management components for purple blotch of onion for seed production.

3. To integrate the selected components for management of the disease.

Chapter 2

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Onion is one of the most important spice crops, which received much attention of the researchers throughout the world. Purple blotch of onion caused by *Alternaria porri*, is a common and most important disease throughout the world. It causes serious yield reduction of the crop. Numerous investigators in various parts of the world have investigated the integrated approach for the management of the disease by using chemical fungicides, host resistance, cultural practices, botanicals and biological control measures. In Bangladesh very less works have been done in this respect. The available information in this connection over the world have been tried to review in this chapter.

2.1. Growth of *Alternaria porri in-vitro* and *in-vivo*

A study on the sporulation of *Alternaria porri* was conducted by Khare and Nema (1981). They observed maximum sporulation at 8-00 a.m. under field condition. A seasonal periodicity was also noted, indicating maximum sporulation immediately after rains. Under laboratory conditions maximum sporulation was at 22^0C at 90% RH followed by 30^0C. Khare and Nema (1982) also reported that temperature, humidity and nutrients seemed to play an important role for ensuring infection of *A. porri* on onion. Cent percent spore germination occurred *in vitro* within 4 hrs at 22^0C, while maximum germination was recorded within 6 hrs at 25^0C on the host surface. According to them, temperatures between 22 to 25^0C are the best for the leaf blotch disease development.

Raju and Mehta (1982) demonstrated an experiment on certain nutritional aspects of *Alternaria porri* (Ellis) Ciferri on onion *in vitro* and summarized that potato dextrose agar having p^H 6 was best to culture the fungus. Temperature ranging 22-25^{0}C was optimum for mycelial growth and sporulation of *Alternaria porri.*

Sixty-days-old onion plants (cv. Nasik Red) were most susceptible to the purple blotch pathogen (*Alternaria porri*) (Gupta and Pathak, 1986). Plants inoculated at high RH (100%) for 120 hours resulted in maximum disease severity and shortest incubation period.

Ariosa-Terry and Herrera-Isla (1986) measured the damage of onion due to purple blotch caused by *A. porri.* The first symptoms appeared 50 days after sowing and disease intensity was the highest at 110 days. White onions were more affected than red onions.

Evert and Lacy (1990, examined formation of conidia by *Alternaria porri* under variable dew duration and controlled relative humidity (RH). Viable conidia produced on lesions after 9 hrs of dew to 38 hrs and conidia formed during 16 hrs of dew duration caused typical lesions. Conidia were formed at all RHs tested (75-100%); numbers were very low at 75-85% RH but increased with increasing RH. Conidia formed on lesions on senescent leaves when incubated in dew chamber at 25^{0}C and conidia formed repeatedly (up to eight cycles) on lesions to alternating low RH (35-50%) and high (100%) RH.

The intensity and dynamics of *Alternaria porri* conidial germination were studied by Rodriguez *et al.* (1994) in different temperatures (5-40^{0}C) and RH (76-100%). Conidia developed at 5-37.5^{0}C, with an optimum temperature of 30^{0}C. Germination started within 1 hr of incubation at 20-35^{0}C and 50% of the conidia germinated at 4 hrs of incubation.

Srivastava *et al.* (1994) reported the high incidence (2.5 - 87.8%) of purple blotch (*Alternaria porri*) in both the kharif and robi onions, when high humidity prevailed, during the 5 years of the survey (1988-93).

Everts and Lacy (1996) studied the factors influencing infection of onion leaves by *Alternaria porri* and subsequent lesion expansion. Conidia deposited on onion leaves formed single to several germ tubes and appressoria and often penetrated at more than one locus under favorable conditions. After 3 hrs in the dew chamber at 24^0 C following inoculation of onion leaves, 73% of conidia germinated and 5% formed appressoria. Infection hyphae were not observed until 6 h following inoculation, at which time 2% of conidia formed infection hyphae and 0.5% of conidia caused visible lesions. Length of dew period was significantly and positively correlated with lesion numbers

2.2. Varietal resistance and symptomology

Thirumalachar *et al.* (1953) reported about the existence of some varietal resistance and they stated that the fungus *Alternaria porri* (purple blotch) caused severe scorching of some onion varieties at the College of Agriculture Sabour; but the indigenous red variety had remained uninfected.

Shandhu *et al.* (1982) reported that none of 102 genotypes they screened was resistant to *Alternaria porri.* However, they could locate 12 genotypes which showed moderate resistance reaction. The genotypes that had flat erect leaves showed moderate resistant reaction. Whereas all those with curved, drooping leaves were susceptible.

Nuchnart Jonglaekha *et al.* (1982) observed that symptoms of purple blotch disease appearing on onion, shallat, multiplur onion, leek and garlic were similar except that the levels of susceptibility were different. They also observed that most of the conidia produce germ tubes and penetrate through wounds on leaves within 8 hrs. of inoculation. The conidia observed were club-shaped with transverse and longitudinal septa. This fungus produces spores when the temperature lies between18-26^{0} C.

but not with lesion

2.3. Relevant information regarding the pathogen, epidemiology and its management

Fanceli and Kimati (1991) conducted an experiment in Brazil to determine the influence of culture media and light on the sporulation of *Alternaria dauci.* They noted that Czapek's and host leaf extract medium yielded better sporulation of the fungus compared to other tested media.

Bhode *et al.* (2001) observed the effect of varying irrigation frequencies and N fertilizer levels on onion cv. Agrifound Dark Red seed production during rabi

1998/99 and 1999/2000 at Nasik, Maharashtra, India. The irrigation frequencies tested were: (I_1) irrigation at 15- day's intervals up to day 60, 12-days intervals from day 60 to 100 and 8-days intervals from day 100 until maturity; (I_2) irrigation at 12-days intervals up to 60 and 8-days intervals thereafter; and (I_3) irrigation at 10-days intervals throughout the cropping period. The N fertilizer treatments included: (N_1) 80 kg/ha applied in 2 splits, 50% at planting and 50% at 45 days after planting (DAP); (N_2) 100 kg/ha applied in 2 splits, 50% at planting and 50% at 45 DAP; and (N_3) 120 kg/ha applied in 3 splits, 33% at planting, 33% at 45 DAP and 33% at 60 DAP. Based on these traits and on the resistance to purple blotch (*Alternaria porri*) and thrips, no significant differences in any of these traits were observed as a result of varying Nitrogen level, while the interaction effects were only significant for seed germination

Khare and Nema (1982) also reported that the temperature ranged between 22^0 C to25^0 C was not only suitable for growth and sporulation of *Alternaria porri* but also optimum for spore germination as well as for infection in onion. They also argued that spore germination on leaves decreased with the increase of nitrogen doses to the host. They also reported that temperature, humidity and nutrients seemed to play important roles for ensuing infection of *Alternaria porri* in onion. Cent percent (100%) spore germination occurred in vitro within 4 hrs at 22^0 C, while maximum germination was recorded within 6 hrs at 25^0 C on the host surface.

Miller (1983) reported that measurements of infected leaves were taken weekly from bulb initiation to bulb maturity. They observed that the leaf damage levels were significantly lowered on younger than older leaves. Leaves emerging 9, 8, 7, 6 and 5 week before bulbing maturity required $5^1/_2$, 5, $4^1/_2$, $3^1/_2$ and $2^1/_2$ weeks respectively to reach 50% damage.

Khare and Nema (1984) conducted an experiment to determine the effect of temperature and humidity of the development of symptoms of purple blotch of onion incited by *Alternaria porri* and noted that temperature between 22^0 to 25^0 C and relative humidity 90% are the best for the development of leaf blotch symptom.

Gupta and Pathak (1988) reported that bulb and seed yields and 1000 seed weight of Nashik Red onion were significantly reduced by *Alternaria porri* infection. Disease severity was computed in terms of the co-efficient of disease index (Codex). A linear relationship was found between yield and Codex.

Srivastava *et al.* (1996) conducted *in vitro* studies to determine the role of infected plant debris and soil in the perpetuation of disease and air borne spore of purple blotch (*Alternaria porri*) and Stemphylium blight (*S. vesicarium*) on onions in Haryana, India, in order to establish a forecasting system for effective control measures. The pathogens remained viable for 4 months on diseased plant debris, 3 months at soil in depths of 2.5, 5.0 and 7.5 cm and for 2 months at soil in depths of 10.0 and 15.0 cm. It was suggested that the inoculum load of *Alternaria porri* and *Stemphylium vesicarium* during ploughing of infected soil was higher during the winter.

Larka (1999) conducted an experiment at the Choudhury Charan Singh Haryana Agricultural University, Hisar, India, found that numerous purple spots / blotches were observed on older leaves and scapes when fortnightly dew fall was >1.0 mm, mean maximum relative humidity > 75% and mean maximum temperature 20-30^0 C with > 18 hr favorable temperature (10-30) duration. Exposure of leaf and/or scape to wetness for 8 hr was a pre-requisite for conidial germination with increasing disease intensity, every field component was adversely affected.

2.4. Chemical control

Bekhit *et al.* (1963) in a field experiment observed that Zineb and Captan were superior to Bordeaux mixture in controlling purple blotch of onion *(Alternaria porri,* where infection was reduced by 50%).

Ashrafuzzaman and Ahmed (1976) reported that among 5 fungicides Benlate (Benomyl) at 500 ppm or Dithane M-45 (Mancozeb) at 500 ppm gave the best control of *Alternaria porri* on onions and significantly increased the yield. Lower concentrations (125 or 250 ppm) were less effective.

Patil *et al.* (1976) evaluated different fungicides against leaf blotch of onion. In culture media the fungus was inhibited by Kitazin, Cuman, Difolatan, Vitavax, Captan, Hinosan, Dutex, Miltox and Aureofungin. As a prophylactic spray, Kitazin was proved to be superior to all the other fungicides applied.

Padule and Utikar (1977) found the best control and the highest yield of onion by using Dithane M-45 followed by Zineb, Miltox, (Zineb+Ca) and Fytolan (Cu-oxychloride) in a field trial against *Alternaria porri.*

Joi and Sonone (1978) evaluated nine fungicides for the control of leaf blight of onion (*Alternaria porri*) in three experiments over three years and found that Dithane M-45 reduced the disease by 23.6% and increased the yield by 35%, whereas Miltox reduced the disease by 22.6% and increased the yield by 26%.

Bedi and Gill (1978) studied on purple blotch of onion and its control in the Punjab. *Alternaria porri* causing purple blotch of onion was significantly reduced by Bordeaux mixture or Dithane M-45 (Mancozeb) + Thiodan (Endosulfan).

Nuchnart Joglackha *et al.* (1982) worked on the effectiveness of ten selected fungicides against the fungus cultured on PDA, artificially inoculated plants and naturally infected plants in the field. It was revealed that Mangate-D was the most effective one while Dithane M-45 and Antracol becomes the second to control purple blotch of onion. Azinmag and Delsene MX also showed satisfactory results *in-vitro* tests.

Quadri *et al.* (1982) reported that out of eight fungicides, Difolatan (Captafol), Thiram, Dithane M-45 (Mancozeb) and Bavistin (Carbendazim) gave the best control against *Alternaria porri* under culture condition. Millar (1983) observed that the severity of leaf blotch is directly correlated with the age of leaves of onion.

Georgy *et al.* (1983) found disease severity of purple blotch reached 100% on plants in non sprayed plots while they screened several fungicides to combat the disease. Fungicides differed in their effectiveness and differences between treatments in most cases, were significant. The Ridomil group especially Ridomil MZ (Metalaxyl + Mancozeb) proved most effective in reducing disease severity and increasing bulb and seed yield.

Comparative effectiveness of 10 fungicides to control Alternaria infection (*Alternaria* spp.) of mustard was evaluated in India by Sharma (1984). He reported that among the tested fungicides, Dithane M-45 gave the best control against the disease followed by Daconil, Dithane Z-78. The fungicides reduced the infection rate by 16.6 - 30.1%.

Miura (1985) found that *Alternaria porri*, *A. alternata* and *Fusarium spp.* predominated among the fungi isolated from onion seeds. Fungicides based on Iprodione gave the best results obtaining 97.4% control of the fungi with 81.4% germination against 54.8% germination of untreated seeds.

Ramos *et al.*, (1985) reported that in field trials under natural infection, Metalaxyl gave the best results against *Alternaria porri*.

Gupta *et al.* (1986) tested 10 fungicides for 3 growing seasons and found Dithane M-45 (Mancozeb) effective against *Alternaria porri* with a maximum return / net profit. Spraying 5 times at 15-days interval with Dithane M-45 + the sticker triton was recommended for control of purple blotch of onion seed crops.

Sharma (1986) reported that the best control of *A. porri* under field condition was obtained by spraying Dithane M-45 (Mancozeb) 6 times from the on set of infection. However, he added that, 3 sprays were optimum for maximizing bulb yields of onion.

Gupta *et al.* (1987) observed in the field tests over 3 years that Dithane M-45 (Mancozeb) sprays at 0.25% reduced incidence and severity of infection by *Alternaria porri* and thereby increased bulb yield of onion.

Ahmed and Goyal (1988) carried out an experiment by taking onion seedling with 85% natural infection by *Alternaria porri* and dipped in suspension of Aureofungin (Parnino Ocetophenonne). Bavistin (Carbendazim), Brassicol (Quintozene), Cman (Ziram), Difolatan (Captafol), Dithane M-45 (Mancozeb), Dithane Z-78 (Zineb) and Topsin-M (Thio-phanate methyl) and then transplanted. Half the plots were later sprayed 3 times with the same fungicide at 20 days intervals. All treatments significantly reduced disease incidence and resulted increased bulb yield.

Gupta *et al.* (1996) stated that Stemphylium blight (*Stemphylium vesicarium*) and purple blotch (*Alternaria porri*) is important diseases causing considerable damage to onion crops in India. The diseases were severe during the rainy seasons especially when thrips were also associated with the crops. Studies were undertaken in Karnal, Haryana, India, during kharif, 1994 and 1995 to control the diseases. Treatment comprised of either 5,4 0r 3 sprays of Mancozeb, Chlorothalonil and Fosetyl as (aliette) starting at 40 DAP at intervals of 10 days starting at 50 DAP reduced infection caused by *Stemphylium vesicarium* and *Alternaria porri.* Three spray of 0.25% kavatch at 10 days intervals starting 60 DAP was also effective.

The efficacy of six fungicides was evaluated by Rahman *et al.* (1988) for controlling leaf blotch of onion (*Alternaria porri*). Rovral and Dithane M-45 were found to be the best both in laboratory and field conditions. Under field conditions, all the test fungicides gave significant reduction of disease severity but significant increase of onion yield was achieved with Rovral, Dithane M-45 and Bordeaux mixture that gave 61, 35 and 29% yield increases, respectively.

Barnoczki-stoilova *et al.* (1989) conducted trials with onion cv. Makoi Brons to determine the efficacy of several treatments (2 insecticides and 4 fungicides) for pest and disease control during flowering. At the initiation of flowering (10-15% open flowers), spraying had a beneficial effect on seed yield and plant health. Spraying at full bloom (50-60% open flowers) should be avoided for harmful effect. At the end of flowering (5-10% open flower), spraying improved seed health. Ridomil plus 50 WP (Methyl + Copper oxychloride) and Rovral 25 FW were the most effective fungicides.

Mishra *et al.* (1989) evaluated 7 fungicides against purple blotch of onion (*Alternaria porri*) and found Dithane M-45 as effective at 0.2% followed by Jkstein that reduced disease intensity and increased bulb yield by 25.73 and 17%, respectively over untreated control.

Rahman *et al.* (1989) evaluated six fungicides viz. Antracol (Propineb) 65 WP, Bordeaux mixture (Copper sulphate and lime), Cupravit (copper oxychloride), Dithane M-45 (Mancozeb), Rovral (Iprodione) and Trimiltox forte (Cu-salts and Mancozeb) for their efficacy against leaf blotch (*Alternaria porri*) of onion in laboratory and field condition. All the fungicides gave significant reduction of mycelial growth and disease severity. Increase of onion yield was achieved with Rovral, Dithane M-45 and Bordeaux mixture. Maximum yield increase was achieved with Rovral (61%) followed by Dithane M-45 (36%) and Bordeaux mixture (29%).

Tahir *et al.* (1991) tested 7 fungicides against *Alternaria porri* in a field trial and found Daconil (Chlorothalonil) as the most effective one followed by Cupravit, Ridomil MZ-72 and Pencozeb (Mancozeb). Fungicidal treatments increased bulb yield by 8.4-19.9% over control.

Srivastava *et al.* (1991) evaluated 4 fungicides viz. Copper oxychloride, Mancozeb, Carbendazin and Thiram against *Alternaria porri* and all the fungicides significantly reduced the disease incidence.

Gupta *et al.* (1991) evaluated on the economical spray schedule of Mancozeb for the control of purple blotch disease of kharif onion. In field trials conducted at the Regional Research Station, Karnal, Haryana, India, during 1987-89. Three sprays of Mancozeb at 0.25% applied at 7- days intervals after the appearance of disease symptoms provided good control of *Alternaria porri* which resulted maximum yield (280 q/ha).

Perez- Moreno *et al.* (1992) observed that Iprodione gave the best control of purple spot and downy mildew followed by Fosetil. Fosetil gave the best control of the disease in the fresh market cultivars whereas; Iprodione gave the most effective disease control in the hybrids (USA origin). Iprodione gave the highest yield followed by Fosetil.

Gupta *et al.* (1992) observed that *Alternaria porri* and *Stemphylium vesicarium* cause the most important disease of onion crop, which is grown throughout India. Both were successfully controlled by 4 sprays of Dithane M-45 (Mancozeb) at 0.25% applied at weekly intervals.

Filajdic and Suttan (1992) evaluated four fungicides alone or in combination to control *Alternaria* blotch of apples (*Alternaria mali)* but no satisfactory control was achieved except Iprodione (Rovral). About 75.1% disease reduction was obtained using higher (0.30g/liter) rate. After artificial inoculation, disease reduction ranged from 53.7 to 68.9% at the higher and lower rates of Iprodione.

Sugha *et al.* (1993) reported that 5 spray of Metalaxyl+ Mancozeb (0.3%), at 15 days interval from the appearance of disease gave the most effective control of purple blotch of onion. Sprays of Metalaxyl+ Mancozeb (0.3%) were superior to those of Copper oxychloride (0.25%), Captafol (.0.2%) and Mancozeb (0.25%).

Perez Moreno and Chavez (1993) conducted an experiment with three fungicides (Iprodione, Fosetyl-aluminium and Maneb) to control *Alternaria porri* on three commercial cultivar of onion in Mexico. They opined that Iprodione performed excellent in reducing disease intensity and gave highest yield.

Srivastava and Gupta (1993) reported that three fungicides (0.25% Mancozeb, 0.3% Copper oxychloride and 0.25% Captan) in combination with 2 insecticides (0.05% Monocrotophos and 0.05% Demetonmethyl) were assessed against *Alternaria porri, thrips tabaci* on onions in Maharastra, India, in 1988-91, Mancozeb at 0.25% + Monocrotophos at 0.5% reduced infection and infestation and increased seed yield and improved the cost benefit ratio.

Sugha *et al.* (1993) conducted experiments during the winter seasons of 1989-90 and 1990-91 to study the effect of heat treatment of bulbs alone and in combination with a spray of Metalaxyl + Mancozeb (as Ridomil MZ) for the control of *Alternaria porri* in the onion cv. Patna red. Heat treatment to onion bulbs at 35^0C for 8 hr before sowing followed by a single prophylactic spray of Metalaxyl + Mancozeb (0.25%) at the bolting stage or no heat treatment and 3 sprays of Metalaxyl + Mancozeb (0.3%) at 15 days intervals from the appearance of disease gave the most effective control. Heat treatment of bulbs at 40 and 45^0C reduced crop growth. Sprays of Metalaxyl + Mancozeb (0.3%) were superior to those of Copper oxychloride 0.25%, Captafol 0.27 and Mancozeb 0.25%.

During surveys in the Cape Province of South Africa, Aaveling *et al.* (1993) found *Alternaria porri* and *Stemphylium vesicarium* to be very destructive seed-borne pathogens of onion. Six fungicides (Anilazine, Benomyl, Carbendazim/ flusilazole mixture, Procymidone, Tebuconazole and Thiram) were tested for their efficacy to control *Alternaria porri* on the seed and in culture. None of the treatments eradicated *Alternaria porri* and *Stemphylium vesicarium* from onion seeds.

During 1992-93 and 1993-94 in Haryana, India, total failure of onion seed crop occurred due to Stemphylium blight (*Stemphylium vesicarium*) and purple blotch (*Alternaria porri*). To overcome this alarming situation Srivastava *et al.* (1995) conducted trials with Iprobenfos (Kitazin), Iprodione (Rovral), Fosetyl (Aliette), Kavatch, Thiophanate-methyl (Topsin M), Benomyl, Metalaxyl (Ridomil) and Mancozeb. They recommended that seed growers in North India should apply fortnightly sprays of 0.25% Mancozeb or 0.25% Iprodione to control onion seed diseases caused by *Stemphylium vesicarium* and *Alternaria porri*.

Kolte *et al.* (1993) reported association of *Alternaria porri* in 142 diseased samples of onion out of 200. They observed that foliar spray with Dithane M-45 at 40 DAT, 61 DAT and 82 DAT (days after transplanting) were the most economic and effective compared with Thiram, Copper oxychloride, Bavistin (Carbendazim), Calixin (tridemorph), Aliette (fosetyl), Topsin (thiophanate methyl) and Rovral (Iprodione).

Yazawa (1993) reported that application of Captan, Dithane and Benlate at 10 days interval gave excellent control of *Alternaria porri* for healthy onion seed production.

Rochecouste (1984) recommended use of Ridomil (Metalaxyl + Mancozeb) against *Puccinia alli*, *Alternaria porri* and *Peronospora destructor* of garlic and onion.

Rovral had also been reported to be effective against bulb rot of onion (Presly and Maude, 1980; Kritzman, 1983; Rod and Janyska, 1984).

A field trial was conducted by Upadhaya and Tripathi (1995) to determine the effect of Bavistin (Carbendazin), Blitox (copper oxychloride), Calixin (Tridemorph), Captafol, Dithane M-45 (Mancozeb), Dithane Z-78 (Zineb), Jkstein (Methyl), Karathane EC (Dinocap) and Topsin M-70 (thiophanate-methyl) on control of *Alternaria porri* on onions (*Allium cepa*). All treatments significantly reduced disease intensity and gave increased yields over the control. The best results, however, were obtained with Captafol.

Sugha (1995) conducted a field trial on the management of purple blotch of garlic caused by *Alternaria porri* during winter season of 1989-90, 1990-91 and 1991-92 and reported that three foliar sprays of Iprodione @ 0.1% alone or in combination with Copper oxychloride 0.1% and Mancozeb 0.1% at 15- days intervals resulted in 53.5 to 62% protection to the crop. Clove dip in Iprodione 0.25% for 1 hr before sowing followed by 2 sprays of Metalaxyl + Mancozeb (Ridomil MZ @ 0.25%) or Iprodione @ 0.2% proved highly effective, giving 79.6-84.9% control of the disease. Iprodione and Metalaxyl + Mancozeb were superior to Chlorothalonil, Copper oxychloride, Mancozeb and Zineb improving protection to garlic crop from purple blotch.

The efficacy of 10 fungicides in controlling downy mildew caused by *Perenospora destructor* and purple blotch caused by *Alternaria porri* on onion was tested by El-Shehaby *et al.* (1995) in experimental plots. Fungicide sprays at the rate of 250g/100 liters were started 45 days after planting and repeated 5 times, every 15 days until harvesting. Metalaxyl 8% + Mancozeb 64% (Ridomil-MZ 72%) and Metalaxyl 10% + Mancozeb 48% (Ridomil MZ 58) were the most effective, reducing disease on seed and bulb onions by 86% and increasing seed and bulb yield by 194 and 199%, respectively, compared to control.

Borkar and Patil (1995) tested different fungicides for control of *Alternaria porri* on onions during a severe disease outbreak. Mancozeb reduced disease intensity by 6%, increased yield by 10.99% and also had a higher cost: benefit ratio than other fungicides.

Islam (1995) evaluated seven fungicides against *Alternaria porri* causing purple blotch of onion. Score (Difenconazole) was found as the most effective fungicide followed by Rovral (Iprodione), Tilt 250 EC (Propiconazole) and Folicur (Tebuconazole). Percentage of reduction in disease index varied from 48.34 to 65.44 in score, 45.48 to 64.02 in Rovral, 34.90 to 47.24 in Tilt 250 EC and 32.93 to 46.34 in Folicur. Fungicidal treatments increased bulb yield by 10.53% to 95.53% over unsprayed control.

Datar (1996) tested eight fungicides, viz. Carbendazim, Copper oxychloride, Zineb, Mancozeb, Iprodione, Thiophanate methyl, Dithianon and Ziram at 100, 250 and 500 ppm which significantly reduced the conidial germination of *Alternaria porri* on onion cv. N-53-1 over control.

Srivastava *et al.* (1999) conducted an experiment at Nashik, India, during the robi seasons from 1994 to 1998, using onions cv. Agrifound Light Red. The treatments were Pendimenthalin (0 or 3.5 liters/ha), nitrogen (0, 50 or 100 kg/ha) and Mancozeb (0.25%), Copper oxychloride 0.3%, or no fungicides application against purple blotch disease. *Alternaria porri* incidence was significantly lower and crop yield was the highest in the 3.5 liters Pendimenthalin/ha treatment. The lowest purple blotch incidence was recorded with Mancozeb.

Islam *et al.* (1999) evaluated seven fungicides against *Alternaria porri* causing purple blotch of onion. Score (Difenconazole) was found as the most effective fungicide followed by Rovral (Iprodione). Tilt 250 EC (Propiconazole) and Folicur (Tebuconazole). Percentage of reduction in disease index varied from 48.34 to 65.44 in score. 45.48 to 64.02 in Rovral, 34.90 to 47.24 in Tilt 250 EC and 32.93 to 46.34 in Folicur. Fungicidal treatments increased bulb yield by 10.53% to 65.53% over unsprayed control.

Islam *et al.* (2003) reported the relative efficiencies of ten fungicides against *Alternaria porri* causing purple blotch of onion. Rovral and Ridomil reduced all disease parameters and incurring higher seed yield.

Rahman (2004) observed the effect of three fungicides viz., Ridomil, Rovral and Tilt 250 EC (0.2%) comprising 13 treatments in field experiment. Eight sprays of

Rovral or Ridomil at 7 days interval minimized disease incidence and increased yield. Rovral 0.2% spray at 7 days interval treatment was the best, which gave the highest reduction in disease incidence and severity of leaf blotch and eventually increased the yield of onion.

Prodhan (2005) evaluated thirteen fungicides to control purple blotch of onion. All the tested fungicides reduced the severity of the disease. The performance of Rovral, Controll, Contaf and Pharzeb was the best in reducing mean severity of the disease and increased bulb yield compared to control.

Uddin (2005) conducted an experiment at the research farm of Sher-e-Bangla Agricultural University, Dhaka during the rabi season of January-April, 2004 to study the management of purple blotch complex of onion (*Alternaria porri* and *Stemphylium botryosum*) with selected fungicides. Six treatments Dithane M-45 @0.45%, Rovral 50WP @0.2%, Bavistin 50WP @0.1%, Tilt 250EC @0.2%, Ridomill MZ-72 @0.2% and untreated Control (bulb treatment and foliar spraying with normal water) were evaluated in the experiment. Bulb treatment followed by six foliar spraying at 10 days interval starting from 20 days after bulb sowing with Dithane M-45 (0.45%) or Rovral (0.2%) minimized disease incidence and severity and increased seed yield. The least seed infection by *Alternaria porri* and the highest seed germination was recorded in the seed sample picked up from Dithane M-45 and Rovral 50WP treated plot in a post harvest seed health test.

Ali (2008) conducted an experiment both in Seed Health Laboratory, Department of Plant Pathology and in the research farm of Sher-e-Bangla Agricultural

University, Dhaka during the winter cropping season of 2007-2008 to study the control of Purple Blotch complex of onion through fertilizer and fungicide application. The *in vitro* test with ten treatments comprising Dithane M-45, Rovral 50WP, Cupravit 50WP, Ridomill Gold MZ-72 in combination with micronutrients and Control were explored in the experiment. Among the fungicides, Rovral 50WP @ 0.2% reduced the highest mycelia growth of *Alternaria porri* and *Stemphylium vesicarium* followed by Ridomill Gold MZ-72 @ 0.2% and Dithane M-45 @ 0.45% compared to control. In the field experiment, the treatments showed significant effect in respect of disease incidence, disease severity, seed yield and seed yield contributing characters. The lowest disease incidence and disease severity were observed in Rovral 50WP @ 0.2% + micronutrients followed by Rovral 50WP @ 0.2% alone, Dithane M-45 @ 0.45% +micronutrients and Dithane M-45 @ 0.45% alone. The highest disease incidence and disease severity were recorded in control treatment.

2.5. Control through use of Botanical

Reports are available about the successful use of plant extracts in reducing the sporulation, growth and infection of fungal pathogen; some of them are cited below;

Lakshmanan *et al.* (1990) reported that Aqueous extracts of Neem (*Azadiracta indica*) and Baganbilash (*Bougainvilla spectabilis*) inhibited mycelial growth and sclerotial germination of *Thanatephorus cucummeris*.

Mia *et. al* (1990) tested extracts of 16 plants species against five fungal pathogens of rice; where 4 showed more than 50 % inhibition of mycelial growth.

Bhowmick and Vardhan (1991) reported the relative efficacy of leaf extracts of some plants on growth, sporulation and spore germination of *Curvularia lunata* manifesting different types of leaf spot disease. Among the extracts, *Cinnamonum camphora* and *Catharanthus rosen* completely cheeked the radial growth and spore germination of the test fungus followed by *Azadirachta indica, Clerodendrum viscosum* and *Vitex megundo*. Leaf extracts of *Myctanthes arbor-tristis*, *Acalypha indica* and *Kalanchoe pinnate* were ineffective. Mycelial dry weight of the test pathogen was reduced in varying proportions after treatment with all the above mentioned leaf extracts. Scanty sporulation was induced by the application of leaf extracts of *V. megundo, A. indica, C. viscosum* and *Phyllanthes arbortristis* and excellent sporulation by *Acalypha indica, Kalanchoe pinnata* and in control (no leaf extract, only plain water) treatments.

Dubey and Dwivedi (1991) investigated the fungitoxic properties of *Acacia arabica* (*Fruit and berk*), *Allium cepa* and *A. Sativum* (*leaf and bulb*) against vegetative growth and sclerotial viability of *Macrophomina phoseolina* and found that bulb extract of *A. sativum* was more effective than its leaf extract. Even 0.1% concentration extracts cheeked the growth of *M. phaseolina* by 54.2%. Similarly, berk extract of *A. arabica* exhibited two -fold greater inhibitory effect on fungal growth than the fruit extracts. Bulb extract of *A. Sativum* revealed greater fungal effect than *A. cepa* where sclerotia germination was reduced significantly by 27% as compared to control.

Antifungal activity of leaf extracts of *Azadirachta indica, Calotropis gigantea, Catharanthus roseus, Eucalyptus sp., Parthenium hystrophorus* and *Pongamia pinnata* were tested by Sarvamangala and Datta (1993) against *Cerotelium fici* and *Cercospora morciola* in vitro causing leaf rust and leaf spot diseases of mulberry, respectively, *Azadirachta indica* was more effective, inhibiting spore germination by 91.2% whereas extracts of *Eucalyptus sp.* and *C. gigantean* proved highly toxic to *C. moricota* inhibiting condial germination by 91.5 and 91.3% respectively.

Islam (2003) reported the relative efficiencies of seven plant extracts (Dhatura, Dholkalmi, Garlic, Ginger, Marigold, Neem, Nymbicidine) which was tested in the field condition. Nymbicidine showed the best performance in reducing the disease incidence and giving higher yield.

Prasad and Barnwal (2004) reported the effects of leaf extracts of leaf extracts of *Azadirachta indica, Pongamia pinnata, Datura metel, Ocimum sanctum (Ocimum tenuflorum), Eucalyptus citriodora and Mentha arvensis* on Stemphylium blight and Purple blotch of onion (cv, N-53). In *in vivo* evaluation, disease intensity was the lowest with 20% leaf extracts of *A. indica* (recording 38.1 and 38.2% intensity during 1998-99 and 1999-2000 crop seasons, respectively), followed by 20% leaf extract of *Datura metel*(with disease intensities of 41.4 and 43.2%, respectively). Bulb yields were the highest in plots sprayed with 20% leaf extracts of *Datura* *metel* (177.8 and 173.3 q/ha), followed by sprays of 20% A. indica leaf extract (172.2 and 168.9 q/ha), during 1998-99 and 1999-2000 crop seasons, respectively.

Akter (2007) conducted a field experiment at the research farm of Sher-e-Bangla Agricultural University, Dhaka during the rabi season of 2006-2007 to study the management of purple blotch of onion through chemicals and plant extracts. Eleven treatments comprising Dithane M-45, Rovral 50WP, Bavistin 50WP, Cupravit 50WP, Proud 250EC, Champion, Tilt 250EC, Ridomill Gold, Neem leaf extract, Allamanda leaf extract and Control were explored in the experiment. The highest bulb yield (8.767 t/ha) and bulb diameter (3.787 cm) were obtained with Rovral 50WP treated plot. The percent plant infection, percent leaf infection, percent Leaf Area Diseased (% LAD) and Percent Disease Index (PDI) were the lowest in foliar spray with Rovral 50WP and the highest in control treatment. Between the two plant extracts Neem extract performed better than Allamanda extract.

Hossain (2008) conducted an experiment both in Seed Health Laboratory, Department of Plant Pathology and in the research farm of Sher-e-Bangla Agricultural University, Dhaka during the winter cropping season of 2007-2008 to study the management of purple blotch of onion for seed production.

The *in vitro* test with nine treatments comprising Dithane M-45, Rovral 50WP, Bavistin 50WP, Cupravit 50WP, Ridomill Gold MZ-72, Neem leaf extract, Allamanda leaf extract in combination with micronutrients and Control were explored in the experiment.Among the fungicides, Rovral 50WP @ 0.2% reduced the highst mycelial growth of *Alternaria porri* followed by Ridomill Gold MZ-72 @ 0.2% and Dithane M-45 @ 0.45% compared to control. Between two botanical treatments, Neem leaf extract (1:6 w/v) gave the better result than with Allamanda leaf extract (1:6 w/v). In the field experiment, the treatments showed significant effect in respect of disease incidence, disease severity, seed yield and seed yield contributing characters. The lowest disease incidence and disease severity were observed in Rovral 50WP @ 0.2% + micronutrients followed by Ridomill Gold MZ-72 @ 0.2% + micronutrients and Dithane M-45 @ 0.45% +micronutrients. The highest infection observed in control treatment. Between the two botanical treatments Neem leaf extract (1:6 w/v) + micronutrients performed better than Allamanda leaf extract (1:6 w/v) + micronutrients.

Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The materials used and methodologies adopted for the research works are elaborately described in this chapter. It included a description of both *in-vitro* screening of fungicide and *in-vivo* efficacy of the fungicides and botanical extracts under field conditions. These comprised isolation of causal pathogens from infected onion plant and bioassay of fungicides, plant extract & bioagent against the test pathogen (*Alternaria porri*) under laboratory condition.

3.1. Laboratory experiment

The experiment was conducted at the Laboratory of the Department of Plant Pathology, Spices Research Centre, Bangladesh Agricultural Research Institute, Shibgonj, Bogra, Bangladesh during the month of September-October in 2010.

3.1.1. Collection of fungicides

The fungicides Rovral 50 WP, Provax, Evaral, Bavistin, Secure, Ridomil Gold (MZ-72) were collected from Toha Enterprise, Mohasthan, Shibgonj, Bogra Bangladesh and Neem leaf extract and Trichoderma collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

Plate-1: Neem (*Azadirachta indica*)

Particulars of the chemicals (fungicides) used in this study

Fungicides	**Active ingredient**
Rovral 50 WP	Iprodione 50%
Provax	Carboxin+Thiram (37.5+37.5)%
Ridomil Gold (MZ-72)	Metalaxyl 67% + Mancozeb 6%
Evaral	Iprodione50%
Bavistin	Carbendazim 50%
Secure	Fenamidone+Mancozeb(10%+50%)

3.1.2. Preparation of fungicidal suspension

Recommended doses of fungicidal solution were prepared by mixing thoroughly with requisite quantity of chemical and normal water. It was required 1 gm/liter of Provax, 2 gm/liter of Rovral 50 WP, 2 gm/liter of Evaral, 2 gm/liter of Ridomil Gold (MZ-72), 1 gm/liter of Secure, 1gm/liter of Bavestin for preparation of solution for recommended concentration.

3.1.3. Isolation of *Alternaria porri* and *Stemphylium vesicarium*

The diseased leaves were cut into pieces (4 mm diameter) and surface sterilized with $HgCl_2$ (1:1000) for 30 seconds. Then the cut pieces were washed in water thrice and were placed on to acidified PDA in Petri dish. The plates containing leaf pieces were placed at room temperature for seven days. When the fungus grew well and sporulated, then slides were prepared and was observed under microscope and identified with the help of relevant literature (CMI Description Vol. No. 338).

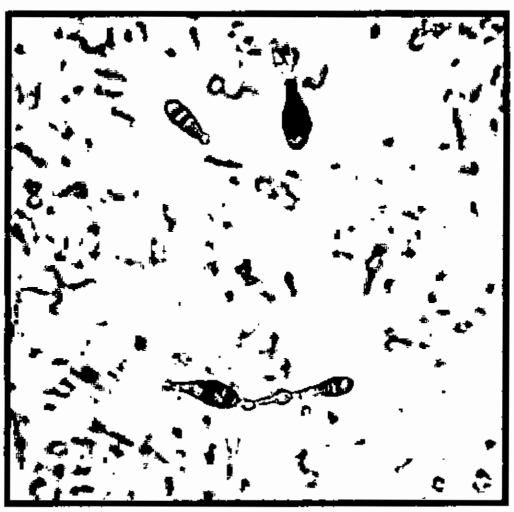


Plate-2: Conidia of *Alternaria porri* (X 40)

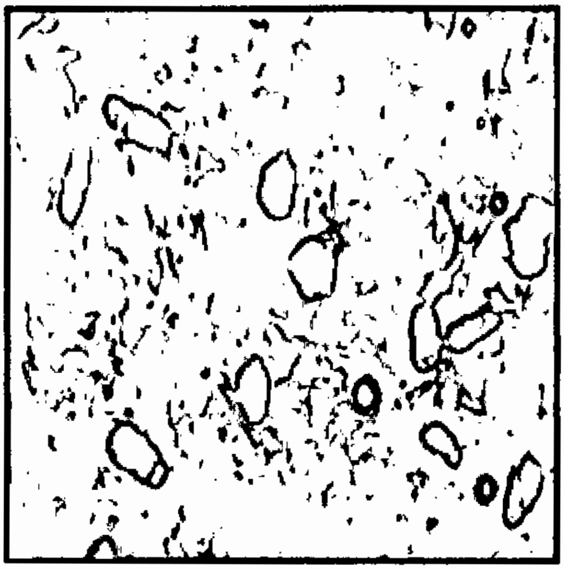


Plate-3: Conidia of *Stemphylium vesicarium* (X 40)

3.1.4. Bioassay of fungicides against *Alternaria porri*

3.1.4.1. Cup / Groove method

From a PDA plate three 5 mm discs of the medium were scooped from three places maintaining an equal distance from the centre by a sterilized disc cutter. One milliliter fungicides solution was put into each hole and the plates were stored overnight in refrigerator for diffusion of the input in the medium around the hole before resumption of fungal growth. The next day, one 5 mm culture block of *Alternaria porri* was cut and placed at the centre of the treated PDA plate. Each treatment was replicated thrice. For control treatment, only sterile water was used instead of fungicides. The plates were then placed at 25±1°C for 10 days. The linear growth (cm) of mycelium of *Alternaria porri* was recorded at 3 days interval until the control plates were filled in (Islam *et al.*, 2001).

3.1.5. Bioassay of plant extract against *Aalternaria porri.*

3.1.5.1 Preparation of plant extract

For extraction of juice, required amount of respective parts of each plant was taken, washed in tap water, crushed in a mortar and pestle. The crushed materials were blended in an electric blender adding six times of sterile water for getting 1:6 solution. The blend was filtered through sterile cheesecloth.

3.1.5.2 Cup/Groove method

From a PDA plate three 5 mm discs of the medium were scooped from three places maintaining an equal distance from the centre by a sterilized disc cutter. One milliliter plant extract solution was put into each hole and the plates were stored overnight in refrigerator for diffusion of the input in the medium around the hole before resumption of fungal growth. The next day, one 5 mm culture block of *Alternaria porri* was cut and placed at the centre of the treated PDA plate. Each treatment was replicated thrice. For control treatment, only sterile water was used instead of plant extract. The plates were then placed at 25±1°C for 10 days. The linear growth (cm) of mycelium of *Alternaria porri* was recorded at 3 days interval until the control plates were filled in (Islam *et al.,* 2001).

3.2. Field experiment

A field experiment with different fungicides alone and combination of fungicides with botanicals (Neem extract, *Trichoderma*) and botanicals alone was assayed in the Rabi season (October, 2010 to March, 2011) to control the purple blotch of onion for seed production.

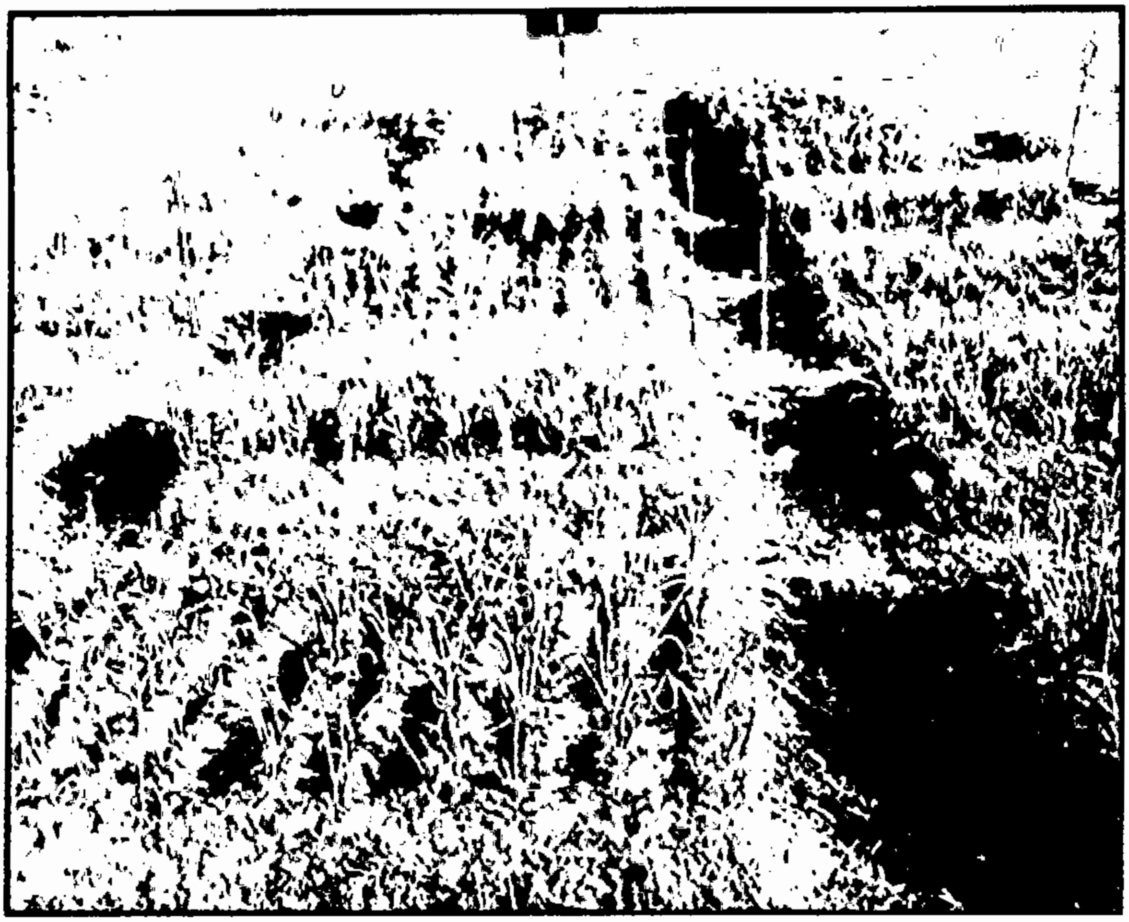


Plate-4: Showing experimental plot of onion

3.2.1. Experimental site

The research was conducted at the experimental field of Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Shibgonj, Bogra, during the period from 11 November, 2010 to 30 April, 2011. The experimental field is located at $89^0 20'$ E longitude and $24^0 587'$ N latitude at a height of 20 meter above the sea level. (Fig.1).The land was medium high and well drained.

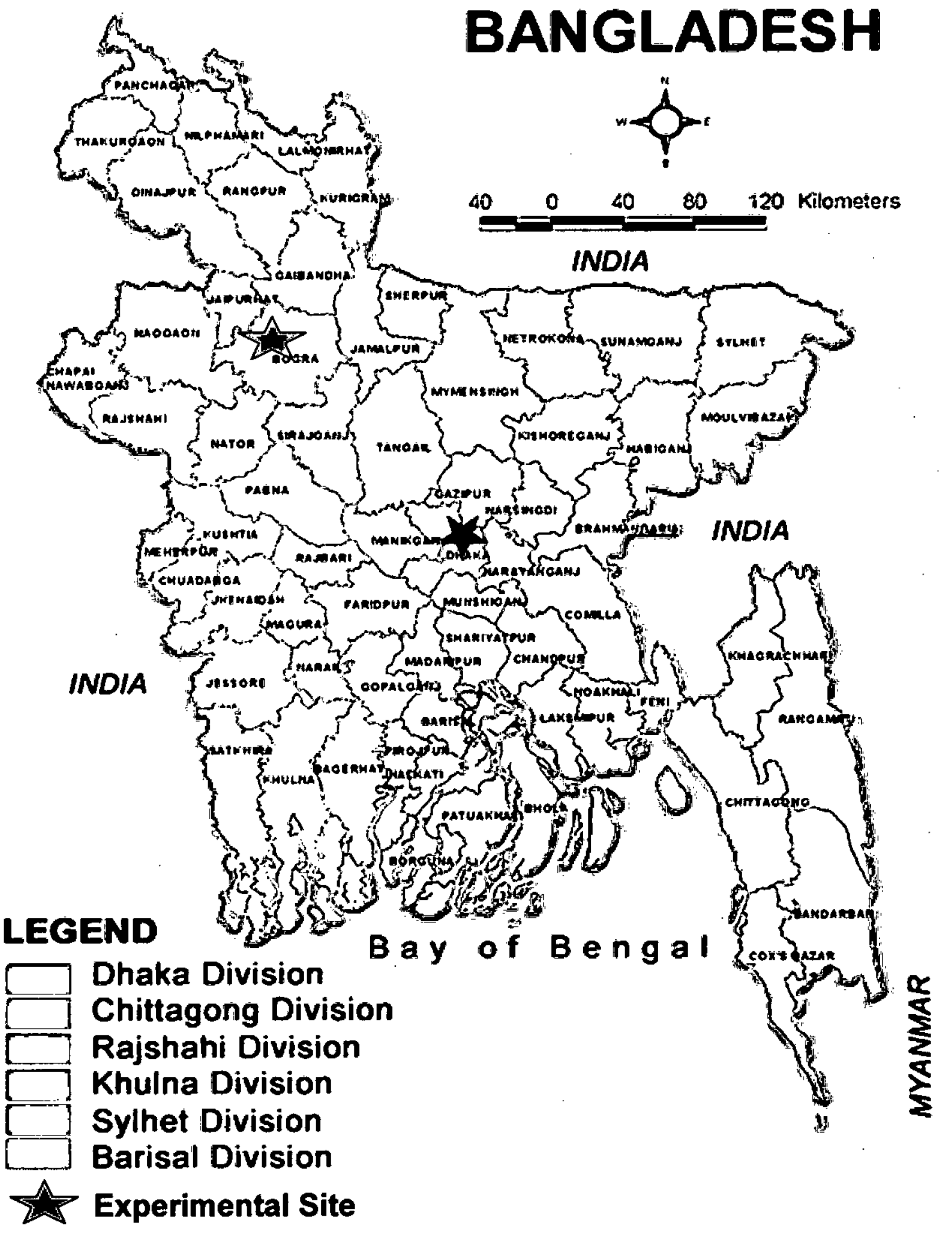


Fig.1. Map showing the experimental site under study

3.2.2. 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 October to March, and high rainfall, high humidity, high temperature and long day period during April to September.

The annual precipitation and potential evapotranspiration of the site were 2152 mm and 1297 mm, respectively. The average maximum and minimum temperature was 30.34^0C and 21.21^0C, respectively with mean temperature of 25.17^0C. (Appendix- II)

Temperature during the cropping period ranged between 12.2^0C to 31.2^0C. The humidity varied from 73.52% to 81.2%. The day length ranged between 10.5-11.0 hours only and there was no rainfall during the experimentation.

3.2.3. Soil type

The soil of the experimental site belongs to the Agro-Ecological Region of "Level Barind Tract" (AEZ No. 25). It was Red Brown Terrace soil and belongs to "Acdala" cultivated series. The top soil is slightly clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.0-5.7. The information about AEZ 25 is given below:

Characteristics of AEZ-25

Land type	Medium high land
General soil type	Shallow grey and deep grey terrace soil.
Soil series	Acdala
Topography	Upland
Elevation	20
Location	SRC farm, Bogra
Field Level	Above flood level
Drainage	Fairly good
Firmness (consistency)	Compact to friable when dry

3.2.4. Land preparation

The experimental field was ploughed with power tiller drawn rotovator. After ploughing the field it was left to nature for 10 days for sun and nature to work upon. Subsequent cross ploughing was done followed by laddering to make the land level. Then the soil clods were broken by a wooden hammer and all weeds, stubbles and residues were removed from the field. Later, Cowdung @ 10 ton/ha and chemical fertilizer like Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) was mixed with soil during final land preparation.

3.2.5. Fertilizer application

The experimental field was fertilized with Nitrogen (in the form of Urea), Phosphorus (in the form of Triple Super Phosphate -TSP), Potassium (in the form of Muriate of Potash -MP), Gypsum, ZnO and Boric powder. As per the treatment whole quantity of TSP, MP, Gypsum, ZnO, Boric powder and one fourth of Urea were applied at final plot preparation. But micronutrients (Gypsum, ZnO, Boric powder) were not applied in control plot. The rest third fourth Urea was applied later in three installments on (40, 60 and 80 days after planting). Fertilizer was applied as recommended doses. Applied doses were as follows:

Doses of chemical fertilizers

Name of the nutrient element	Name of the Fertilizer	Fertilizer dose (kg/ha)	Fertilizer applied during final land preparation (kg/183.75 m^2 land)	Rest installments (Urea)(kg/183.75m^2 land)		
				1st	2nd	3rd
N	Urea	320	1.47	1.47	1.47	1.47
P	TSP	415	7.62	-	-	-
K	MP	168	3.08	-	-	-
S	Gypsum	100	1.83	-	-	-
Zn	ZnO	5	0.09	-	-	-
B	Boric powder	5	0.09		-	-

3.2.6. Experimental design

The experimental plots were arranged in Randomized Complete Block Design (RCBD) with three (3) replications (Appendix-I). The experiment details were given bellow:

- Total plot area : 202.5 m^2
- Number of plot : 27
- Plot size :7.5 m^2
- Block to block distance : 1.0 m
- Plot to boundary distance : 1 m
- Plot to plot distance: 0.5 m
- Plant to plant spacing : 15 cm
- Row to row spacing : 25 cm

3.2.7. Treatments of experiment

Altogether there were 09 different treatments as stated bellow. The treatments were applied into the assigned plots as per design of the experiment.

Treatments

T_1 = Rovral 0.2% (Recommended)

T_2 =Rovral + Provax (0.1% + 0.25%)

T_3 = Trichoderma ($5x10^6$ spore/ml)

T_4 =Rovra l+ Bavistin (0.1% + 0.5%)

T_5 = Neem leaf extract (1:6 w/v)

T_6 =Rovral + Evaral (0.1% + 0.1%)

T_7 =Rovral + Ridomil (0.1% + 0.1%)

T_8 =Rovral + Secure (0.1% + 0.05%)

T_9 = Control

3.2.8. Fertility status of the field soil:

The soil of experimental site was analyzed in Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur for physical and chemical characteristics and texturally found as Sandy Loam 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 100gram soil and Calcium-2.67 miliequivalent per 100 gram soil.

Physical and chemical properties of the experimental soil

Soil properties	Value
Soil texture	Sandy loam
Soil pH	5.8
Organic matter (%)	1.35
Total N (%)	0.08
C : N ratio	10 : 1
Available P (ppm)	35
Exchangeable K (me/100g soil)	0.18
Available S (ppm)	40

3.2.9. Test crop:

The crop used in the experiment was a high yielding variety of onion (BARI Piaz-1) released by Spices Research Centre, Shibgonj, Bogra under Bangladesh Agricultural Research Institute.

3.2.10. Growing of onion

3.2.10.1. Time of planting:

Uniform seed (mother) bulbs were planted in the experimental plot in 11November 2010.

3.2.10.2. Planting procedure:

The healthy bulbs were selected for planting in experimental plots. The bulbs were planted maintaining row to row distance 25 cm and plant to plant distance 15 cm. Before plantation, the neck of bulbs were cut with a sharp knife, the prepared bulb was planted, as per design and spacing

3.2.11. Intercultural operation:

3.2.11.1 Irrigation

Irrigation was normally done after each weeding. Subsequent irrigation was done as per requirements.

3.2.11.2. Weeding and mulching

Weeding and mulching were done when required to keep the crop free from weeds, for better soil aeration and conserve soil moisture. The common weeds were *Cynodon dactylon* L. (Durba grass), *Cyperus rotundus* L. (Mutha) etc. Weeding was done carefully keeping the delicate plants undisturbed. The first weeding was done on 12.01.2008 and second weeding was done on 31 January'08.

3.2.12. Field spray of fungicides

Fungicides and plant extracts spraying were started from 34 days after bulb planting. Totally 5 spraying were done at 10 days intervals with a hand sprayer. One liter of suspension of each plant extract and fungicide were used to spray the plants under each treatment. To avoid the drifting of the fungicides during application, temporary fencing was made with polyethylene sheet surrounding the unit plot. A control treatment was maintained in each block where spraying was done with plain water only.

3.2.12.1. Preparation of spray solution:

At recommended doses suspension/solution of fungicides were prepared by mixing thoroughly with requisite quantity of normal clean water. Spray was given at seven days interval in the assigned plots.

The spray solution of fungicides used in the experiment were presented below with their doses.

Fungicides	Doses rate
1. Rovral 50 wp	0.2% (Recommended)
2. Rovral+Provax	(0.1% + 0.25%)
3. Ridomil gold MZ-72+Rovral	(0.1% + 0.1%)
4. Rovral+Bavistin	(0.1% + 0.5%)
5. Rovral+Evaral	(0.1% + 0.1%)
6. Rovral+Secure	(0.1% + 0.05%)

3.2.12.2. Application of fungicide

At recommended doses suspension/solution of fungicides were prepared by mixing thoroughly with requisite quantity of normal clean water. Spraying was started from one month after transplanting. In total 7 spraying were done at 7 days interval 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 normal water only.

3.2.12.3. Application of plant extracts

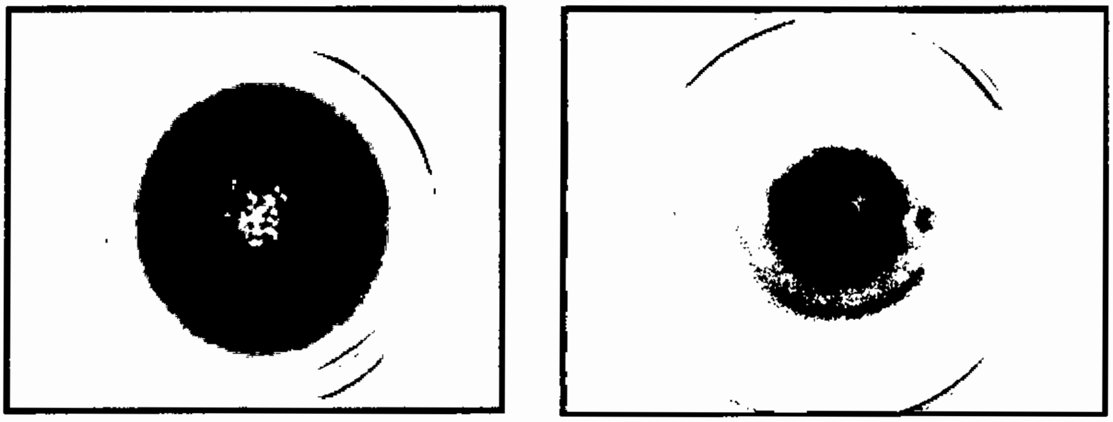
The neem leaf extracts were prepared as described above in the experiment (page-33). The extracts were sprayed at flower formation on mitigation stage as pre-inoculation spray (before 34 hours of inoculation) and pest inoculation spray (after 24 hours of inoculation). The spraying was done with the help of a hand sprayer to cover whole surface of plant leaf, and flower stalk. An amount at 50 ml solution (page-33) was sprayed in one plant. Precautions were taken to avoid drifting of spray materials to neighbouring plants with polythene barrier.

3.2.12.4. Application of bioagents as spore suspensions

Spraying of onion with spore suspension ($5x10^6$ spore/ml) of *Trichoderma harzianum* was done by using haemocytometer at flower stalk initiation stages of the crop through spraying conidial suspension onto all leaves and stalks of a plant @ 100 ml/plant.

3.3. Isolation and identification of pathogens from leaf tissue

The diseased leaves were cut into pieces (4 mm diameter) and surface sterilized with $HgCl_2$ (1:1000) for 30 seconds. Then the cut pieces were washed in sterile water thrice and were dried keeping in untreated blotting paper then placed on to acidified PDA in petridish. The plates containing leaf pieces were placed at room temperature for seven days. When the fungus grew well, and sporulated, then the pathogen slide was prepared and was identified under microscope with the help of relevant literature. After incubation the mycelial growth of the fungus from each concentration of the fungicide was recorded.



a b

Plate-5: Pure culture of (a) *Alternaria porri* (b) *Stemphylium vesicarium*

3.4. Data collection

Ten plants were selected randomly for each unit plot and tagged for data collection. Data collection was started after the onset of the disease symptoms and continued up to maturity with 7 days intervals.

3.4.1. Total no. of Plants/plot

Number of total plants was counted at different vegetative growth stages.

3.4.2. Healthy plants/plot

Number of healthy plants was counted at different vegetative growth stages.

3.4.3. No. of symptoms bearing plants/plot

Number of infected plants under each treatment was counted at different observation dates as scheduled.

3.4.4. No. of leaf/plant

Number of leaves per plants was counted from randomly selected 10 plants from the each plot at different dated as scheduled.

3.4.5. No. of infected leaf/plant of different treatment

Number of leaf infected per plant were recorded and used for calculation of disease incidence. The leaf with characteristic purple colored spot or blighted tip was denoted as diseased leaf.

Calculation of disease incidence of different treatment

The percent disease incidence was calculated using the following formula.

$$\%\text{ Plant infection} = \frac{\text{Number of infected plants}}{\text{Total number of plant observed in unit plot}} \times 100$$

$$\%\text{ Leaf infection} = \frac{\text{Number of infected leaf}}{\text{Total number of inspected leaf}} \times 100$$

3.4.6. Leaf Area Diseased (LAD)/plant in different treatment

Leaf area diseased of the ten selected plants in each plot against each treatment were measured and recorded by conversion to percentage. Mean percentage of leaf area diseased was calculated by dividing number of total observation and used for PDI (percent disease index) estimation.

3.4.7 Number of infected seed stalk/plot

Number of infected seed stalk/plot was recorded at different days after planting and used for calculation of disease incidence (Wheleer, 1969).

$$\% \text{ Stalk infection} = \frac{\text{Number of infected stalk}}{\text{Total number of inspected stalk}} \times 100$$

3.4.8 Seed stalk area diseased (SAD)

Seed stalk area diseased of the ten selected plants in every unit plot under each treatment were measured and recorded by conversion to percentage.

3.4.9. Estimation of PDI

The following diseased scoring scale 0-5 scale was used to estimate the disease severity (PDI) of purple blotch of onion for each unit plot under each treatment.

0= No disease symptoms

1= a few spots towards the tip, covering less than 10% leaf area.

2= several dark purplish brown patches covering 10%to less than 20% leaf area

3= several patches with paler outer zone, covering 20% to 40% leaf area

4= long streaks covering 40% to 75% leaf area or breaking of leaves/stems from the center

5= complete drying of the leaves / stems or breaking of the leaves/stems from the base.

The percent disease index (PDI) was calculated using the following formula (Islam, 2003):

$$\text{PDI (Leaf/Stalk)} = \frac{\text{Total sum of numerical ratings}}{\text{No. of observation X Maximum disease rating in the scale}} \times 100$$

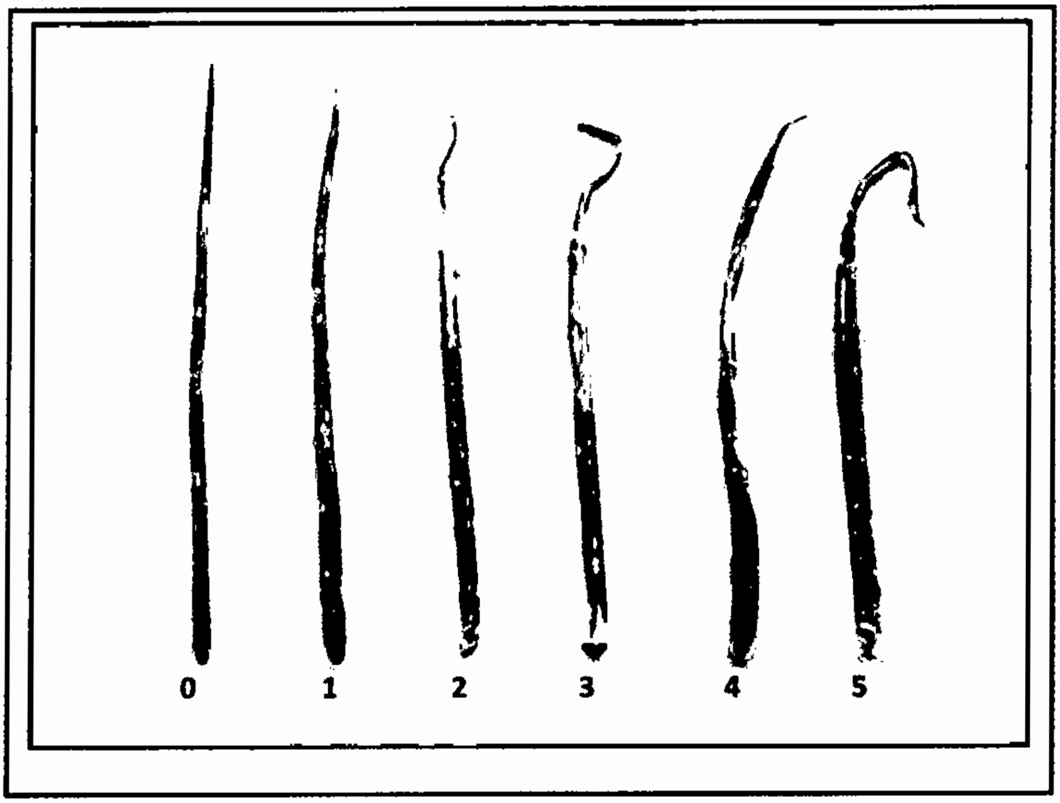


Plate-6: Purple blotch severity of onion leaf showing '0 – 5' rating scale

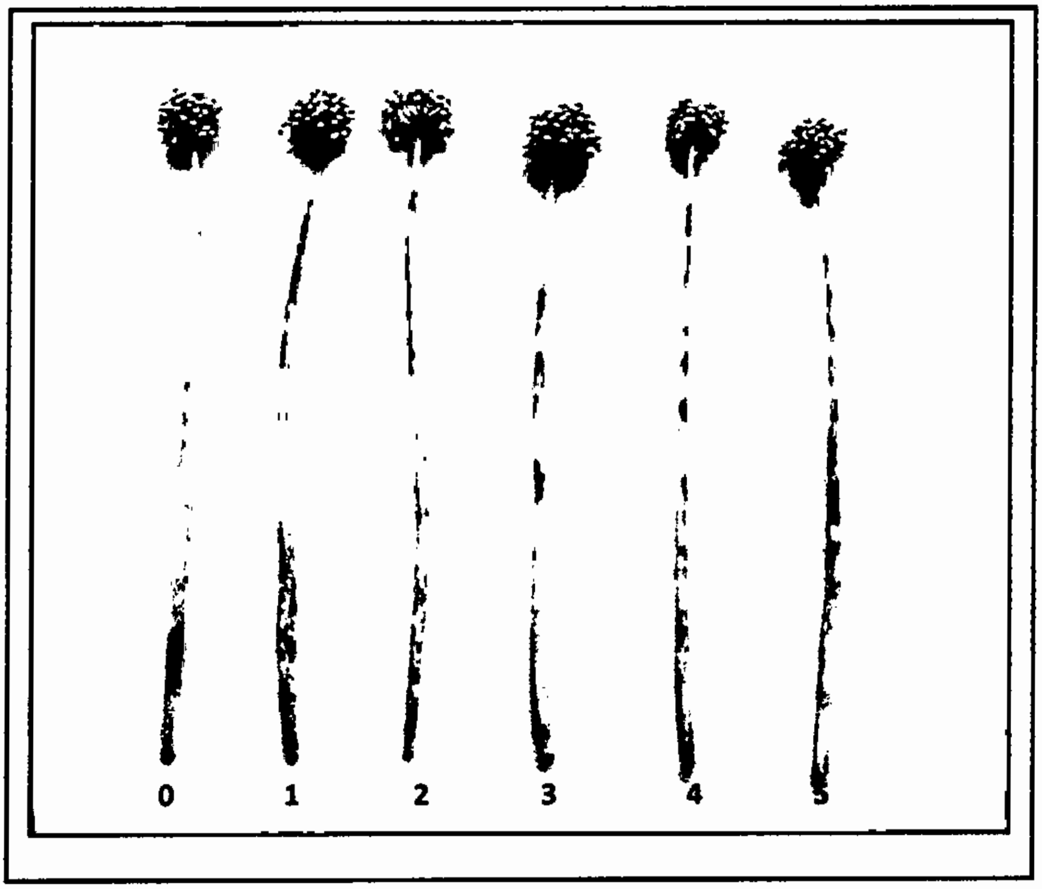


Plate-7: Purple blotch severity of onion seed stalk showing '0-5' rating scale.

3.4.10. Harvesting

Onion matured umbels were harvested on 20 March 2011 to 30 April 2011, at which the umbels have been showing the sign of drying. Onion umbels were carefully cut with the help of knife. After harvesting the umbels were dried in open sunny place and later seed weight was taken.

3.4.11 Number of umbel per plot

Numbers of umbels per plot were recorded.

3.4.12. Weight of seed per plot

Weight of onion seeds per plot were recorded individually for each treatment.

3.4.13 Weight of 1000 seed per plot of different treatments

Weight of 1000 seeds per plot was recorded individually by digital balance (2.00 g) for each treatment.

3.4.14. Yield of onion seed per hectare

Yield of onion seed was calculated as ton per hectare.

3.4.15. Storing of the seeds:

After harvesting and sun drying, the onion seeds were stored at store house of Spices Research Centre, Shibgonj, Bogra.

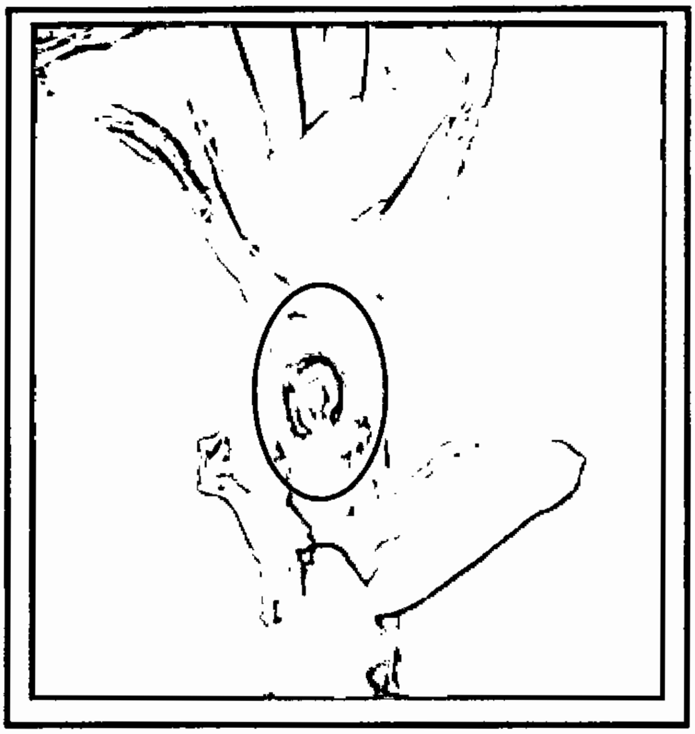


Plate-8: Photograph showing typical symptom of purple blotch on onion plant.

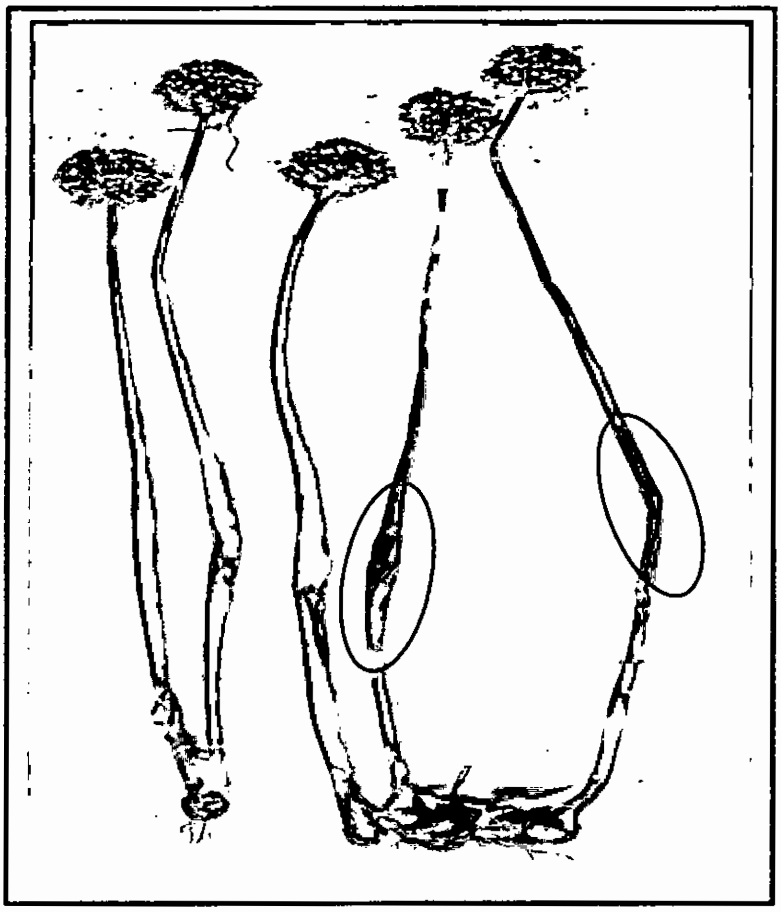


Plate-9: Photograph showing typical symptom of purple blotch on onion stock.

3.5. Analysis of Data/Statistical Analysis

Data were analyzed statistically using MSTAT Computer Program. Data were transformed, whenever necessary, following Arcsine transformation. Means of treatment were separated using Duncan's Multiple Range Test (DMRT), (Gomez and Gomez, 1984).

3.6. Weather report

The monthly average data on temperature, rainfall and humidity during experimental period were collected from the Metrological station, Spices Research Centre, Shibgonj, Bogra which are presented in Appendix (II).

Chapter 4

Results

CHAPTER IV

RESULTS

The present experiments were conducted to find out the effect of chemicals and environmental friendly components for the management of purple blotch of onion. Data were recorded on radial mycelial growth of *Alternaria porri* in laboratory condition, % infected leaf, disease severity (leaf), % infected stalk, disease severity (stalk), yield contributing characters and yield of onion seed in field condition. The analyses of variance (ANOVA) of the data on different parameters are given in Appendix III-IX. The results have been presented and discussed, with probable interpretations in the chapter.

4.1 Laboratory experiment

Efficacy of the chemicals and environmental friendly components in controlling purple blotch of onion caused by *Alternaria porri* was assessed based on the growth rate in diameter.

4.1.1 Bioasay of fungicides and their combinations against *Alternaria porri*

The effectiveness of different chemicals and environment friendly components against the mycelial growth of *Alternaria porri*, the causal fungus of purple blotch of onion showed significant differences (Table 1). Different treatment has effect on inhibition of mycelial growth of the fungus. At 3 DAI (days after incubation), the lowest mycelial growth (0.62 cm) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical

(0.86 cm) with T_2 (Rovral WP @ 0.1% + Provax 0.25%) and closely followed by T_8 (Rovral WP @ 0.1% + Secure @ 0.05%) and T_1 (Rovral WP @ 0.2%) and subsequently by T_6 (Rovral WP @ 0.1% + Evaral @ 0.1%) and T_4 (Rovral WP @ 0.1% + Bavistin 0.5%). On the other hand, the highest mycelial growth was recorded in T_9 (control) succeeded by T_3 (Trichoderma 5×10^6 spore/ml @ 100 ml/plant) and T_5 (Neem leaf extract 1:6 (w/v), at different 3 DAI. At 6 DAI, the lowest mycelial growth was recorded in T_7 and T_2 (1.02 cm) which was statistically similar with T_8 (1.54 cm) and T_1 (1.62 cm) and closely followed by T_6 (1.95 cm) and T_4 (2.03 cm), while the highest mycelial growth was also recorded in T_9 (4.10 cm) which was closely followed by T_3 (2.86 cm) and T_5 (2.68 cm). At 9 DAI, the lowest mycelial growth was recorded in T_7 (1.56 cm) which was statistically similar with and T_2 (1.64 cm), T_1 (1.80 cm) and T_8 (1.82 cm) followed by T_6 (2.22 cm), whereas the highest mycelial growth was recorded in T_9 (5.94 cm) which was closely preceded by T_3 (3.40 cm) and T_5 (2.92 cm). At 12 DAI, the lowest mycelial growth was recorded in T_7 (1.88 cm) which was statistically similar with T_2 (1.90 cm) and T_8 (2.15 cm) followed by T_1 (2.64 cm), T_6 (2.82 cm) and T_4 (2.90 cm), and the highest mycelial growth was recorded in T_9 (6.22 cm) which followed by T_3 (3.64 cm) and subsequently by T_5 (3.22 cm). At 15 DAI, the lowest mycelial growth was also recorded in T_7 (2.05 cm) which was statistically similar with T_2 (2.10 cm) and T_8 (2.40 cm) followed by T_1 (2.88 cm), whereas the highest mycelial growth was recorded in T_9 (7.46 cm) which was preceded by T_3 (4.05 cm).

Table 1. Effect of chemicals and environment friendly components on mycelial growth of *A. porri* at different days after incubation (DAI)

Treatment	Radial mycelia growth (cm) at				
	3 DAI	6 DAI	9 DAI	12 DAI	15 DAI
T_1	0.96 d	1.62 cd	1.80 ef	2.64 d	2.88 cd
T_2	0.68 e	1.02 d	1.64 f	1.90 e	2.10 e
T_3	1.74 b	2.86 b	3.40 b	3.64 b	4.05 b
T_4	1.30 c	2.03 c	2.48 d	2.90 cd	3.16 c
T_5	1.65 b	2.68 b	2.92 c	3.22 c	3.69 b
T_6	1.22 c	1.95 c	2.22 de	2.82 d	3.02 c
T_7	0.62 e	1.02 d	1.56 f	1.88 e	2.05 e
T_8	0.95 d	1.54 cd	1.82 ef	2.15 e	2.40 de
T_9	3.18 a	4.10 a	5.94 a	6.22 a	7.46 a
$LSD_{(0.05)}$	0.212	0.590	0.413	0.342	0.525
CV(%)	8.84	6.29	9.04	6.48	8.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

4.2 Field experiment

Efficacy of the chemicals and environmental friendly components were assessed against *Alternaria porri* in controlling purple blotch of onion. The efficacy of the treatments were measured in respect of % infected leaf, percent disease index (leaf), % infected stalk, percent disease index (stalk), growth parameters, yield contributing characters and yield.

4.2.1. Percentage of infected leaf

Percent of infected leaf of purple blotch of onion caused by *Alternaria porri* showed significant differences regarding the effectiveness of different chemicals and environmental friendly components of the disease (Table 2). Different treatments have profound effect on % infected leaf at 45, 55, 65, 75 and 85 DAP (days after planting). At 45 DAP, the lowest infected leaf (17.45%) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical with T_2 (Rovral WP @ 0.1% + Provax 0.25%), T_8 (Rovral WP @ 0.1% + Secure @ 0.05%) and T_1 (Rovral WP @ 0.2%) and followed by T_6 (Rovral WP @ 0.1% + Evaral @ 0.1%). On the other hand, the highest infected leaf (37.37%) was recorded in T_9 (control) preceded by T_3 (Trichoderma 5×10^6

Table 2. Effect of chemicals and environment friendly components on % infected leaf of purple blotch of onion caused by *A. porri* at different days after planting (DAP)

Treatment	% Infected leaf				
	45 DAP	55 DAP	65 DAP	75 DAP	85 DAP
T_1	20.80 de	25.77 de	32.45 de	37.80 cd	43.73 def
T_2	18.20 e	23.00 e	29.73 e	35.13 d	41.67 ef
T_3	29.27 b	35.13 b	41.60 b	46.20 b	51.70 b
T_4	26.80 bc	29.77 cd	35.60 cd	43.00 bc	48.30 bcd
T_5	27.50 bc	34.60 bc	39.00 bc	45.30 b	49.23 bc
T_6	24.10 cd	27.15 de	34.27 de	41.00 bcd	46.42 cde
T_7	17.45 e	22.60 e	29.57 e	34.80 d	41.10 f
T_8	20.70 de	25.40 de	31.70 de	37.60 cd	43.43 def
T_9	37.37 a	43.50 a	49.40 a	55.70 a	62.33 a
$LSD_{(0.05)}$	3.382	4.941	4.477	5.972	4.742
CV(%)	7.91	9.62	7.20	8.25	5.76

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

spore/ml @ 100 ml/plant), T_5 (Neem leaf extract 1:6 (w/v) and T_4 (Rovral WP @ 0.1% + Bavistin 0.5%). At 55 DAP, the lowest infected leaf was recorded in the treatment T_7 (22.60%) which was statistically identical with T_2 (23.00%), T_8 (25.40%), T_1 (25.77%) and T_6 (27.15%), while the highest infected leaf (43.50%) was recorded in T_9 preceded by T_3 (35.13%) and T_5 (34.60%). At 65 DAP, the lowest infected leaf was recorded in the treatment T_7 (29.57%) which was statistically identical with T_2 (29.73%), T_8 (31.70%), T_1 (32.45%) and T_6 (34.27%), while the highest infected leaf (49.40%) was recorded in T_9 preceded by T_3 (41.60%) and T_5 (39.90%). At 75 DAP, the lowest infected leaf was recorded in the treatment T_7 (34.80%) which was statistically identical with T_2 (35.13%), T_8 (37.60%), T_1 (37.80%) and T_6 (41.00%), while the highest infected leaf (55.70%) was recorded in T_9 preceded by T_3 (46.20%) and T_5 (45.30%). At 85 DAP, the lowest infected leaf was recorded in the treatment T_7 (41.10%) which was statistically identical with T_2 (41.67%), T_8 (43.43%) and T1 (43.73%), while the highest infected leaf (62.33%) was recorded in T_9 preceded by T_3 (51.70%) and T_5 (49.23%).

4.2.2 Percent disease index (PDI) of leaf

Statistically significant variation was recorded for the effectiveness of different chemicals and environmental friendly components against percent disease index of onion purple blotch caused by *Alternaria porri* (Table 3). Different treatment has profound effect on percent disease index at 45, 55, 65, 75 and 85 DAP. At 45 DAP (days after planting), the lowest disease index (18.30%) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical (19.20%, 20.40%, 21.10% and 22.55%) with T_2 (Rovral WP @ 0.1% + Provax 0.25%), T_8 (Rovral WP @ 0.1% + Secure @ 0.05%), T_1 (Rovral WP @ 0.2%) and T_5 (Neem leaf extract 1:6 (w/v) and closely followed (22.75%) by T_6 (Rovral WP @ 0.1% + Evaral @ 0.1%). On the other hand, the highest disease index (33.60%) was recorded in T_9 (control) which was followed (25.87% and 23.90%) by T_3 (Trichoderma 5×10^6 spore/ml @ 100 ml/plant) and T_4 (Rovral WP @ 0.1% + Bavistin 0.5%). At 55 DAP, the lowest disease index was recorded in the treatment T_7 (21.20%) which was statistically identical with T_2 (21.80%), T_8 (22.65%), T_1 (23.30%) and T_6 (24.85%), and the highest disease index was recorded in T_9 (39.70%) which was followed by T_3 (28.90%) and T_5 (26.95%). At 65 DAP, the lowest disease index was recorded in the treatment T_7 (25.80%) which was statistically identical with T_2 (26.15%), T_8 (27.60%), T_1 (28.50%) and T_6 (29.40%), and the highest disease index was recorded in T_9 (43.80%) which was followed by T_3 (35.50%) and T_5 (32.25%). At 75 DAP, the lowest disease index was recorded in the treatment T_7 (29.50%) which was statistically identical with T_2 (29.90%), T_8 (31.00%), T_1 (31.70%) and T_6 (33.00%), and the highest disease index was recorded in T_9 (47.40%) which was followed by T_3 (36.90%), T_5 (35.10%) and T_4 (34.60%). At 85 DAP, the lowest disease index was recorded in the treatment T_7 (33.20%) which was statistically identical with T_2 (34.00%), T_8 (35.60%), T_1 (36.45%) and T_6 (37.90%), and the highest disease index was recorded in T_9 (58.70%) which was followed by T_3 (42.30%), T_5 (40.30%) and T_4 (39.13%).

Table 3. Effect of chemicals and environment friendly components on percent disease index (PDI-Leaf) of purple blotch of onion caused by *A. porri* at different days after planting (DAP)

Treatment	Percent diseases index (PDI-leaf) of onion at				
	45 DAP	55 DAP	65 DAP	75 DAP	85 DAP
T_1	21.10 cde	23.30 cde	28.50 cde	31.70 cd	36.45 c-f
T_2	19.20 de	21.80 de	26.15 e	29.90 d	34.00 ef
T_3	25.87 b	28.90 b	35.50 b	36.90 b	42.30 b
T_4	23.90 bc	25.53 bcd	31.20 cd	34.60 bc	39.13 bcd
T_5	22.55 b-e	26.95 bc	32.25 bc	35.10 bc	40.30 bc
T_6	22.75 bcd	24.85 cde	29.40 cde	33.00 bcd	37.90 b-e
T_7	18.30 e	21.20 e	25.80 e	29.50 d	33.20 f
T_8	20.40 cde	22.65 de	27.60 de	31.00 cd	35.60 def
T_9	33.60 a	39.70 a	43.80 a	47.40 a	58.70 a
$LSD_{(0.05)}$	3.915	3.560	3.978	4.074	4.263
CV(%)	9.80	7.88	7.38	6.85	6.20

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

4.2.3 Percentage of infected stalk

Statistically significant variation was recorded in terms of percent of infected stalk of onion purple blotch caused by *Alternaria porri* for the effectiveness of different chemicals,botanicals and Trichoderma as fungal antagonist against the disease (Table 4). Different treatment has profound effect on % infected stalk at 75, 90, 105, 120 and 135 DAP. At 75 DAP, the lowest infected stalk (4.30%) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical (4.70%) with T_2 (Provax 0.25% + Rovral WP @ 0.1%) and followed by (5.20%, by T_8 (Rovral WP @ 0.1% + Secure @ 0.05%). On the other hand, the highest infected stalk (9.70%) was recorded in T_9 (control) preceded by T_3 (Trichoderma 5×10^6 spore/ml @ 100 ml/plant) and T_5 (Neem stalk extract 1:6 (w/v). At 90 DAP, the lowest infected stalk was recorded in the treatment T_7 (8.60%) which was statistically identical with T_2 (8.90%) and T_8 (9.40%), while the highest infected stalk (14.20%) was recorded in T_9 preceded by T_3 (11.50%), T_5 (10.90%) and T_4 (10.65%). At 105 DAP, the lowest infected stalk was recorded in the treatment T_7 (11.20%) which was statistically identical with T_2 (12.10%) and closely followed by T_8 (12.95%) and T_1.The highest infected stalk (19.55%) was recorded in T_9 preceded by T_3 (15.80%), T_5 (15.10%) and T_4 (14.70%). At 120 DAP, the lowest infected stalk was recorded in the treatment T_7 (14.40%) which was statistically identical with T_2 (14.85%), T_8 (15.50%), T_1 (15.95%), and the highest infected stalk (23.60%) was recorded in T_9 preceded by T_3 (18.60%) and T_5 (17.50%). At 135 DAP, the lowest infected stalk was recorded in the treatment T_7 (19.30%) which was statistically identical with T_2 (20.10%), T_8 (20.85%), T_1 (21.60%), and the highest infected stalk (29.60%) was recorded in T_9 preceded by T_3 (24.75%) and T_5 (23.90%).

Table 4. Effect of chemicals and environment friendly components on % infected stalk of purple blotch of onion caused by *A. porri* at different days after planting (DAP)

Treatment	% Infected stalk at				
	75 DAP	90 DAP	105 DAP	120 DAP	135 DAP
T_1	5.95 d	9.70 de	13.60 cde	15.95 cd	21.60 b-e
T_2	4.70 f	8.90 ef	12.10 ef	14.85 d	20.10 de
T_3	7.40 b	11.50 b	15.80 b	18.60 b	24.75 b
T_4	6.80 c	10.65 bc	14.70 bc	16.80 bcd	23.10 bcd
T_5	7.10 bc	10.90 bc	15.10 bc	17.50 bc	23.90 bc
T_6	6.30 d	10.30 cd	13.90 cd	16.40 bcd	22.30 b-e
T_7	4.30 f	8.60 f	11.20 f	14.40 d	19.30 e
T_8	5.20 e	9.40 ef	12.95 de	15.50 cd	20.85 cde
T_9	9.70 a	14.20 a	19.55 a	23.60 a	29.60 a
$LSD_{(0.05)}$	0.438	0.848	1.460	2.209	3.120
CV(%)	12.96	4.68	5.89	7.48	7.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

4.2.4 Percent of disease index (PDI) of stalk

Statistically significant variation was recorded for the effectiveness of different chemicals and environmental friendly components regarding percent disease index of onion stalk for purple blotch of onion caused by *Alternaria porri* (Table 5). Different treatment has profound effect on percent of disease index for 75, 90, 105, 120 and 135 DAP. At 75 DAP, the lowest disease index in onion stalk (4.50%) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical with T_2 (Rovral WP @ 0.1% + Provax 0.25%), T_8 (Rovral WP @ 0.1% + Secure @ 0.05%) and T_1 (Rovral WP @ 0.2%). On the other hand, the highest disease index (9.65%) was recorded in T_9 (control) preceded (6.10% and 5.75%) by T_3 (Trichoderma 5×10^6 spore/ml @ 100 ml/plant) and T_4 (Rovral WP @ 0.1% + Bavistin 0.5%). At 90 DAP, the lowest disease index in onion stalk was recorded in the treatment T_7 (7.20%) which was statistically identical with T_2 (8.10%), T_8 (8.40%) and closely followed by T_1 (8.90%), whereas the highest disease index was recorded in T_9 (16.00%) preceded by T_3 (11.30%), T_5 (10.65%) and T_4 (10.10). At 105 DAP, the lowest disease index was recorded in the treatment T_7 (10.10%) which was statistically identical with T_2 (11.00%), T_8 (12.95%) and T_1 (13.60%), while the highest disease index was recorded in T_9 (21.70%) preceded by T_3 (13.90%), T_5 (13.70%) and T_4 (12.90%). At 120 DAP, the lowest disease index was recorded in the treatment T_7 (14.80%) which was statistically identical with T_2 (14.90%), T_8 (15.30%),

Table 5. Effect of chemicals and environment friendly components on percent disease index (PDI-Stalk) of purple blotch of onion caused by *A. porri* at different days after planting (DAP)

Treatment	Percent diseases index (PDI-stalk) of onion at				
	75 DAP	90 DAP	105 DAP	120 DAP	135 DAP
T_1	5.00 cd	8.90 de	11.35 de	15.80 cde	20.10 bcd
T_2	4.60 d	8.10 ef	11.00 e	14.90 de	18.50 d
T_3	6.10 b	11.30 b	13.90 b	17.80 b	23.40 b
T_4	5.25 c	10.10 bcd	12.90 bc	16.60 bcd	21.05 bcd
T_5	5.75 b	10.65 bc	13.70 bc	16.80 bc	22.70 bc
T_6	5.15 c	9.55 cde	12.50 cd	15.90 cde	20.55 bcd
T_7	4.50 d	7.20 f	10.10 e	14.80 e	17.90 d
T_8	4.75 cd	8.40 ef	11.30 de	15.30 cde	19.40 cd
T_9	9.65 a	16.00 a	21.70 a	25.35 a	30.65 a
$LSD_{(0.05)}$	0.490	1.346	1.289	1.606	3.254
CV(%)	5.01	7.76	5.66	5.45	8.71

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

T_1 (15.80%) and T_6 (15.90%), while the highest disease index was recorded in T_9 (25.35%) preceded by T_3 (17.80%) and T_5 (16.80%). At 135 DAP, the lowest disease index was recorded in the treatment T_7 (17.90%) which was statistically identical with T_2 (18.50%), T_8 (19.40%), T_1 (20.10%) and T_6 (20.55%), and the highest disease index was recorded in T_9 (30.65%) preceded by T_3 (23.40%), T_5 (22.70%) and T_4 (21.05%).

4.2.5 Growth, yield contributing characters and yield of onion seeds

4.2.5.1 Plant height

Statistically significant variation was recorded in terms of plant height for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion (Table 6). The maximum plant height (81.40 cm) was recorded in the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) which was statistically identical (81.00 cm and 78.50 cm) with T_2 (Rovral WP @ 0.1% + Provax 0.25%) and T_8 (Rovral WP @ 0.1% + Secure @ 0.05%). On the other hand, the minimum plant (61.20 cm) was recorded in T_9 (control) which was followed (67.40 cm) by T_3 (Trichoderma 5×10^6 spore/ml @ 100 ml/plant).

Table 6. Effect of chemicals and environment friendly components on growth parameters of onion

Treatment	Plant height (cm)	Number of leaves per plant	Number of flower stalk per hill	Height of onion seed stalk (cm)	Umbel diameter (cm)
T_1	77.80 ab	18.10 ab	4.90 bc	60.60 ab	6.03 abc
T_2	81.00 a	19.50 a	5.10 ab	61.90 a	6.26 ab
T_3	67.40 d	16.13 bc	3.40 e	54.30 cd	5.46 d
T_4	71.90 cd	17.00 ab	4.10 d	56.90 abc	5.72 cd
T_5	70.10 cd	16.70 abc	3.80 d	55.50 bcd	5.61 cd
T_6	74.50 bc	17.60 ab	4.60 c	58.70 abc	5.84 bcd
T_7	81.40 a	19.50 a	5.30 a	62.20 a	6.32 a
T_8	78.50 ab	18.30 ab	5.00 ab	60.50 ab	6.02 abc
T_9	61.20 e	14.20 c	2.50 f	51.20 d	5.02 e
$LSD_{(0.05)}$	5.038	2.492	0.367	5.194	0.424
CV(%)	10.95	8.25	4.93	5.18	8.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

4.2.5.2 Number of leaves per plant

Number of leaves per plant for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion showed statistically significant variation (Table 6). The maximum number of leaves per plant was recorded in the treatment T_7 and T_2 (19.50) which was statistically identical with T_8 (18.30), T_1 (18.10), T_6 (17.60), T_4 (17.00) and T_5 (16.70),and the minimum number (14.20) was recorded in T_9 preceded by T_3 (16.13).

4.2.5.3 Number of flower stalk per hill

Statistically significant variation was recorded in terms of number of flower stalk per hill for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion under the present trial (Table 6). The maximum number of flower stalk per hill was recorded in the treatment T_7 (5.30) which was statistically identical with T_2 (5.10) and T_8 (5.00), and the minimum number (2.50) was recorded in T_9 preceded by T_3 (3.40).

4.2.5.4 Height of onion seed stalk

Different chemicals and environmental friendly components against purple blotch of onion varied significantly in terms of height of onion seed stalk for the effectiveness of (Table 6). The longest seed stalk was recorded in the treatment T_7 (62.20 cm) which was statistically identical with T_2 (61.90 cm), T_8 (60.50 cm), T_1 (60.60 cm), T_6 (58.70 cm) and T_4 (56.90 cm).The shortest seed stalk (51.20 cm) was recorded in T_9 preceded by T_3 (54.30 cm) and T_5 (55.50 cm).

4.2.5.5 Umbel diameter

Statistically significant variation was recorded in terms of umbel diameter for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion (Table 6). The highest diameter of umbel was recorded in the treatment T_7 (6.32 cm) which was statisticaliy identical with T_2 (6.26 cm), T_8 (6.02 cm), T_1 (6.03 cm), while the lowest diameter (5.02 cm) was recorded in T_9 preceded by T_3 (5.46 cm) and T_5 (5.61 cm).

4.2.5.6 Number of florets per umbel

Significant difference was recorded in terms of number of florets per umbel for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion (Table 7). The maximum number of florets per umbel was recorded in the treatment T_7 (310) which was statistically identical which was followith T_2 (308) and T_8 (301), and the minimum number (224) was recorded in T_9 preceded by T_3 (263).

4.2.5.7 Number of effective florets per umbel

Number of effective florets per umbel for the effectiveness of different chemicals and environmental friendly components against purple blotch of onion showed statistically significant differences (Table 7). The maximum number of effective florets per umbel was recorded in the treatment T_7 (286) which was statistically identical with T_2 (284) and T_8 (271), and the minimum number (193) was recorded in T_9 preceded by T_3 (223).

Table 7. Effect of chemicals and environment friendly components on yield and yield contributing characters

Treatment	Number of florets per umbel	Number of effective florets per umbel	Number of seeds per umbel	Weight of 1000 seeds (g)	Seed yield (t/ha)
T_1	294 abc	262 abc	936 ab	3.43 ab	1.17 abc
T_2	308 a	284 a	953 a	3.55 a	1.21 ab
T_3	263 c	223 d	872 c	3.11 c	1.05 c
T_4	279 abc	245 bcd	902 bc	3.32 abc	1.11 bc
T_5	271 bc	234 cd	886 c	3.24 bc	1.09 bc
T_6	288 abc	258 abc	912 bc	3.38 abc	1.14 abc
T_7	310 a	286 a	954 a	3.56 a	1.24 a
T_8	301 ab	271 ab	943 ab	3.51 ab	1.18 ab
T_9	224 d	193 e	754.00 d	2.76 d	0.82 d
$LSD_{(0.05)}$	28.66	28.01	38.12	0.257	0.110
CV(%)	5.87	6.46	5.44	7.52	5.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Rovral WP @ 0.2%

T_2 = Rovral WP @ 0.1% + Provax 0.25%

T_3 = Trichoderma 5×10^6 spore/ml @ 100 ml/plant

T_4 = Rovral WP @ 0.1% + Bavistin 0.5%

T_5 = Neem leaf extract 1:6 (w/v)

T_6 = Rovral WP @ 0.1% + Evaral @ 0.1%

T_7 = Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%

T_8 = Rovral WP @ 0.1% + Secure @ 0.05%

T_9 = Control

4.2.5.8 Number of seeds per umbel

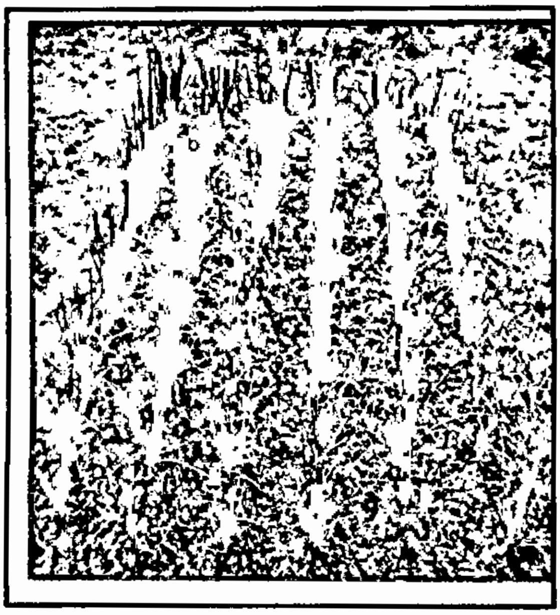
Statistically significant difference was recorded in terms of number of seeds per umbel for the effectiveness of different chemicals and environmental friendly components against onion purple blotch (Table 7). The maximum number of seeds per umbel was recorded in the treatment T_7 (954) which was statistically identical with T_2 (953) and T_8 (943), and the minimum number (754) was recorded in T_9 preceded by T_3 (872) and T_5 (886).

4.2.5.9 Weight of 1000 seeds

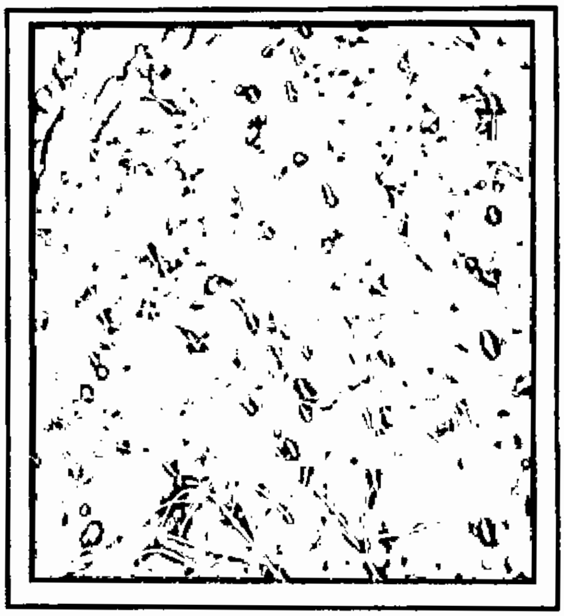
Different chemicals and environmental friendly components against onion purple blotch showed statistically significant variation in terms of weight of 1000 seeds for the effectiveness of (Table 7). The highest weight of 1000 seeds was recorded in the treatment T_7 (3.56 g) which was statistically identical with T_2 (3.55 g), and the lowest weight (2.76 g) in T_9 preceded by T_3 (3.11 g).

4.2.5.10 Seed yield

Statistically significant variation was recorded for weight of seed yield in the effectiveness of different chemicals and environmental friendly components against onion purple blotch (Table 7). The highest seed yield was recorded in the treatment T_7 (1.24 t/ha) which was statistically identical with T_2 (1.21 t/ha), T_8 (1.18 t/ha), T_1 (1.17 t/ha) and T_6 (1.14 t/ha), and the lowest seed yield (0.82 t/ha) was recorded in T_9 preceded by T_3 (1.05 t/ha), T_5 (1.09 t/ha) and T_4 (1.11 t/ha).



(A) Plot treated with Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1% at pre-flowering stage.



(B) Untreated control plot

(C) Plot treated with Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1% at post-flowering stage.

(D) Untreated control plot

Plate 10. Photograph showing the Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1% treated plot compared to untreated control plotf

Chapter 5

Discussion

CHAPTER V

DISCUSSION

5.1 Laboratory experiment

The present experiment was conducted to find out the effect of chemicals and environmental friendly components for the management of purple blotch of onion. Efficacy of the chemicals and environmental friendly components in controlling purple blotch of onion caused by *Alternaria porri* was assessed based on the mycelial growth against the test materials. Different treatments have effect on inhibition of mycelial growth of the fungus. The lowest mycelial growth was recorded in the treatment T_7 where Rovral 50 WP (0.1%) is used combinedly with Ridomil Gold (0.1%) followed by T_2 (Rovral 50 WP 0.1%+ Provax 0.25%), T_8 (Rovral 50WP 0.1% + Secure @ 0.05%) and T_1 (Rovral WP @ 0.2%). The highest mycelial growth was recorded in T_9 (control). Treatment T_3 (Trichoderma 5×10^6 spore/ml) and T_5 (Neem leaf extract 1:6 (w/v),showed significantly better performance than the control but less effective than the chemical alone or combined. The findings of the experiment revealed that Rovral 50 WP @ 0.2% or combination of Rovral with other fungicides was more effective for the inhibition of mycelial growth of the fungus. Rahman *et al.* (1989) evaluated six fungicides against *A. porri* in the laboratory and found Rovral as a promising fungicide in reducing the mycelial growth of the fungus. Islam *et al.* (2001) also found that Rovral 50 WP as the most effective fungicides in inhibition of mycelial growth of the fungus. Similar results also reported by BARI (2004-2005) and Datar (1996) from their earlier research.

5.2 Field experiment

Efficacy of the chemicals and environmental friendly components were assessed against *Alternaria porri* in controlling purple blotch of onion.The fungicide Rovral 50 wp alone in recommended dose (0.2%) or in combination with other fungicides @ half of the recommended dose and two eco-friendly components were applied as foliar spray. The effect of Rovral 50 WP was more promising singly or in combination with other fungicides in terms of % infected leaf, percent disease index (leaf), % infected stalk, percent disease index (stalk), growth parameters, yield contributing characters and yield against the disease. The treatment T_7 (Rovral 50 WP @ 0.1% +Ridomil gold MZ-72 @ 0.1%) showed the highest performance followed by T_2 (Rovral @ 0.1%+Provax @ 0.25%), T_8 (Rovral 50 WP @ 0.1%+Secure @ 0.05%) and T_1 (Rovral WP @ 0.2%) and T_6 (Rovral 50 WP @ 0.1%+Evaral @ 0.1%). The lowest performances were recorded in T_9 (control) which was preceded by T_3 (Trichoderma 5×10^6 spore/ml), T_5 (Neem leaf extract 1:6 (w/v) and T_4 (Rovral 50 WP @ 0.1% + Bavistin @ 0.5%). The present findings were supported by the reports of Ahmed *et al.*, 1999; Filajdic and Sutton (1992) Sugha, 1995; Rahman, 2004; Srivastava *et al.*, 1996 and Islam *et al.*, 2001.

Ahmed *et al.* (1999) reported that the fungicides Rovral 50 WP @ 0.2% found to be effective in reducing disease incidence and severity of purple blotch of onion. Filajdic and Suttan (1992) evaluated four fungicides alone or in combination to control *Alternaria* blotch of apples (*Alternaria mali)* but no satisfactory control was achieved except Iprodione (Rovral). About 75.1% disease reduction was obtained using higher dose (0.30g/liter). After artificial inoculation, disease reduction ranged from 53.7 to 68.9% at the higher and lower rates of Iprodione. Islam (1995) reported that percentage of reduction in disease index(PDI) varied from 48.34 % to 65.44 % in score,and 45.48 to 64.02 % in Rovral. Rahman (2004) observed that Rovral 0.2% spraying at 7 days interval showed the best performance, which gave the highest reduction in disease incidence and severity of leaf blotch of onion and eventually increased the yield . Ali (2008) reported that Rovral 50WP @ 0.2% reduced the highest mycelia growth of *Alternaria porri* and *Stemphylium vesicarium* followed by Ridomil Gold MZ-72 @ 0.2% and Dithane M-45 @ 0.45% compared to control. In the field experiment, the treatments showed significant effect in respect of disease incidence, disease severity, seed yield and seed yield contributing characters. The lowest disease incidence and disease severity were observed in Rovral 50WP @ 0.2% + micronutrients followed by Rovral 50WP @ 0.2% alone, Dithane M-45 @ 0.45% +micronutrients and Dithane M-45 @ 0.45% alone. The highest disease incidence and disease severity were recorded in control treatment. Barnoczki-stoilova *et al.* (1989) reported that Rovral 50 WP (Iprodione) and Ridomil plus 50 WP (Methyl + Copper oxychloride) proved less harmful and effective in controlling purple blotch complex of onion disease in seed production.

Islam *et al.* (2003) reported the relative efficiencies of ten fungicides against *Alternaria porri* causing purple blotch of onion.The fungicides Rovral and Ridomil reduced all the disease parameters incurring higher seed yield. Prodhan (2005) observed that performance of Rovral was the best in reducing mean severity of the disease and increased bulb yield compared to control. Rahman *et al.* (1989) reported that increase of onion yield was achieved with Rovral, Dithane M-45 and Bordeaux mixture. Maximum yield increase (61%) was achieved with Rovral followed by Dithane M-45 (36%). Rahman (2004) reported that among 6 fungicides, Rovral 50 WP significantly reduced the disease severity of purple blotch of onion. Srivastava *et al.* (1996) observed that seedling dipped in Carbendazim and thiophanate methyl followed by 4 sprays of Rovral 50 WP was effective against purple blotch of onion. Islam, *et al.* (2001) reported that Rovral 50 WP gave promising effect in reducing the disease severity of purple blotch of onion. Hoque (2008) reported that the bulb treatment with Rovral 50 WP (0.2%) followed by foliar spraying with Rovral 50 WP at 7 days interval starting from onset of the disease minimized disease incidence and severity of purple blotch of onion.

No report is available about the combined use of different fungicides against purple blotch of onion. In the present experiment the combined use of Rovral with other fungicide @ half of the recommended doses of each showed better performance than the use of Rovral 50WP (@ recommended dose) alone for the management of purple blotch of onion for seed production.

The performance of ecofriendly components Trichoiderma and Neem leaf extract against the disease were signicantly better than control but not up to the mark compaired to the fungicide alone or in combination.

Chapter 6
Summary and Conclusion

CHAPTER VI

SUMMARY AND CONCLUSION

Onion is considered as one of the most important spices crop in Bangladesh as well as in all over the world. Usually onion production is affected by different diseases worldwide and among them purple blotch, caused by *Alternaria porri* incurred tremendous yield loss. The fungus reduces the bulb yield, seed production and quality of onion seeds. The present research program was conducted to determine the effect of chemical and environmental friendly components on controlling purple blotch of onion caused by *Alternaria porri.*

The experiment was conducted at the Laboratory of the Department of Plant Pathology, Spices Research Centre, BARI, Shibgonj, Bogra, during the month of September-October in 2010. Field experiment with different fungicides alone and in combination of Neem extract (a botanical) and *Trichoderma* (a bioagent) was conducted in October, 2010 to March, 2011 to control the purple blotch of onion for seed production. The treatments were T_1 (Rovral WP @ 0.2%); T_2 (Rovral WP @ 0.1% + Provax @ 0.25%); T_3 (Trichoderma 5×10^6 spore/ml); T_4 (Rovral WP @ 0.1% + Bavistin @ 0.5%); T_5 (Neem leaf extract 1:6 (w/v); T_6 (Rovral WP @ 0.1%+ Evaral @ 0.1%); T_7 (Rovral WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%); T_8 (Rovral WP @ 0.1% + Secure @ 0.05%) and T_9 (Control). Data were recorded on radial mycelial growth of *Alternaria porri* in laboratory condition. Data on percent infected leaf, disease severity (leaf), % infected stalk, disease severity (stalk), yield contributing characters and yield of onion were collected for field experiment.

Different treatments have remarkable effect on inhibition of mycelial growth of *Alternaria porri*. The lowest mycelial growth was recorded in case of the treatment T_7 (Rovral 50 WP @ 0.1% + Ridomil gold MZ-72 @ 0.1%) and the highest mycelial growth was recorded in T_9 (control) irrespective of different DAI (Days after inoculation).

In field experiment different treatment showed promising effect in reducing % infected leaf, % infected stalk, % disease index (leaf), % disease index (stalk) and increasing yield and yield contributing characters. The lowest infected leaf (17.45%, 22.60%, 29.57%, 34.80% and 41.10%) were recorded in the treatment T_7, while the highest infected leaf (37.37%, 43.50%, 49.40%, 55.70% and 62.33%) were recorded in T_9 (control) at 45, 55, 65, 75 and 85 Days After Planting (DAP) respectively. The lowest disease index in onion leaf (18.30%, 21.20%, 25.80%, 29.50% and 33.20%) were recorded in the treatment T_7 and the highest disease index in onion leaf (33.60%, 39.70%, 43.80%, 47.40% and 58.70%) were recorded in T_9 (control) at 45, 55, 65, 75 and 85 Days After Planting (DAP) respectively.

The lowest infected stalk (4.30%, 8.60%, 11.20%, 14.40% and 19.30%) were recorded in the treatment T_7 and the highest infected stalk (9.70%, 14.20%, 19.55%, 23.60% and 29.60) were recorded in T_9 (control) at 45, 55, 65, 75 and 85 Days After Planting (DAP) respectively. The lowest disease index in onion stalk

(4.50%, 7.20%, 10.10%, 14.80% and 17.90%) were recorded in the treatment T_7 and the highest disease index (9.65%, 16.00%, 21.70%, 25.35% and 30.65%) was recorded in T_9 (control) at 45, 55, 65, 75 and 85 Days After Planting (DAP) respectively. The longest plant (81.40 cm), maximum number of leaves per plant (19.50), maximum number of flower stalk per hill (5.30), longest seed stalk (62.20 cm), highest diameter of umbel (6.32 cm), maximum number of florets per umbel (310), maximum number of effective florets per umbel (286), maximum number of seeds per umbel (954), highest weight of 1000 seeds (3.56 g) and highest seed yield (1.24 t/ha) was recorded in the treatment T_7, whereas the shortest plant (61.20 cm), the minimum number of leaves per plant (14.20), minimum number of flower stalk per hill (2.50), the shortest seed stalk (51.20 cm), the lowest umbel diameter (5.02 cm), minimum number of florets per umbel (224), minimum number of effective florets per umbel (193), minimum number of seeds per umbel (754), the lowest weight of 1000 seeds (2.76 g) and lowest seed yield (0.82 t/ha) were recorded in T_9 (control). The performance of ecofriendly components Trichoiderma and Neem leaf extract against the disease were signicantly better than control but not up to the mark compaired to the fungicide alone or in combination.

From the findings it may be concluded that the onion growers may be suggested to apply Rovral 50WP @ recommended dose (0.2%) or Rovral 50 WP (0.1%) with combination of Ridomil Gold MZ-72 (0.1%), Provax-200 (0.25%), Secure (0.05%) @ half of the recommended dose of each in controlling purple blotch of onion for seed production.

Chapter 7
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CHAPTER VII

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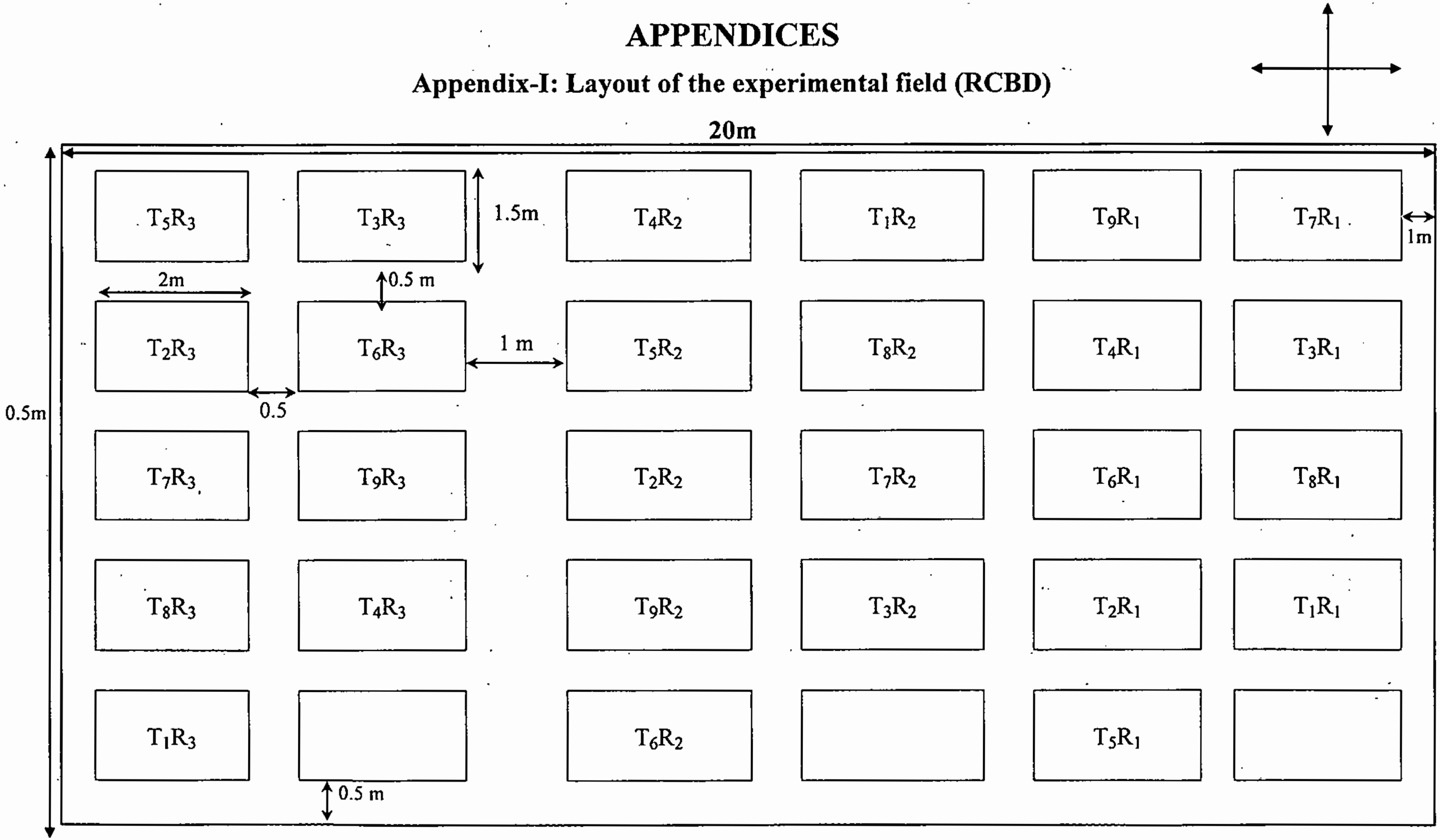
Appendices

APPENDICES

Appendix-I: Layout of the experimental field (RCBD)



Total area = 20 x 10.13 = 202.6 m2

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November, 2010 to April, 2011

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
November, 2010	29.0	19.8	24.40	73.90	3.0
December, 2010	27.0	15.7	21.35	62.79	0.0
January, 2011	24.9	13.2	19.05	67.5	3.0
February, 2011	28.1	17.8	22.95	61.5	4.0
March, 2011	32.5	22.6	27.55	66.6	155.0
April, 2011	39.5	25.7	32.6	75.2	199.5

Source: Metrological Station ,Spices Research Centre, Shibgonj, Bogra

Appendix-III. Analysis of variance of the data on mycelial growth of *A. porri* at different days after incubation (DAI) as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		Radial mycelia growth (cm) at				
		3 DAI	6 DAI	9 DAI	12 DAI	15 DAI
Replication	2	0.005	0.086	0.054	0.029	0.040
Treatment	8	1.838**	2.932**	5.735**	5.314**	8.239**
Error	16	0.015	0.116	0.057	0.039	0.092

**: Significant at 5% level of significance

Appendix-IV. Analysis of variance of the data on % infected leaf of *A. porri* at different days after incubation (DAI) as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		% Infected leaf				
		45 DAP	55 DAP	65 DAP	75 DAP	85 DAP
Replication	2	1.247	0.341	0.007	7.563	0.316
Treatment	8	119.974**	142.396**	125.544**	132.740**	130.567**
Error	16	3.818	8.148	6.691	11.903	7.506

**: Significant at 5% level of significance

Appendix-V. Analysis of variance of the data on percent disease index (PDI-leaf) of *A. porri* at different days after incubation (DAI) as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		Percent diseases index (PDI-leaf) of onion at				
		45 DAP	55 DAP	65 DAP	75 DAP	85 DAP
Replication	2	1.183	0.080	0.250	1.248	0.538
Treatment	8	63.189**	96.618**	96.174**	90.308**	177.669**
Error	16	5.117	4.230	5.281	5.540	6.065

**: Significant at 5% level of significance

Appendix-VI. Analysis of variance of the data on % infected stalk of *A. porri* at different days after incubation (DAI) as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		% Infected stalk				
		75 DAP	90 DAP	105 DAP	120 DAP	135 DAP
Replication	2	0.003	0.250	0.321	0.134	0.100
Treatment	8	8.059**	8.595**	17.824**	23.049**	28.637**
Error	16	0.064	0.240	0.711	1.629	3.250

**: Significant at 5% level of significance

Appendix-VII. Analysis of variance of the data on percent disease index (PDI-stalk) of *A. porri* at different days after incubation (DAI) as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		Percent diseases index (PDI-stalk) of onion at				
		75 DAP	90 DAP	105 DAP	120 DAP	135 DAP
Replication	2	0.174	0.490	0.234	0.517	1.102
Treatment	8	7.605**	20.078**	35.640**	32.005**	44.304**
Error	16	0.080	0.605	0.555	0.861	3.534

**: Significant at 5% level of significance

Appendix-VIII. Analysis of variance of the data on growth parameters of onion as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm)	Number of leaves per plant	Number of flower stalk per hill	Height of onion seed stalk (cm)	Umbel diameter (cm)
Replication	2	0.001	0.123	0.040	5.138	0.031
Treatment	8	136.943**	8.488**	2.595**	42.651**	0.506**
Error	16	8.471	2.073	0.045	9.005	0.060

**: Significant at 5% level of significance

Appendix-IX. Analysis of variance of the data on yield and yield contributing characters of onion as influenced by chemicals and environmental friendly approach

Source of variation	Degrees of freedom	Mean square				
		Number of florets per umbel	Number of effective florets per umbel	Number of seeds per umbel	Weight of 1000 seeds (g)	Seed yield (t/ha)
Replication	2	44.444	11.111	87.259	0.009	0.007
Treatment	8	2196.000**	2758.500**	11749.704**	0.197**	0.047**
Error	16	274.194	261.861	485.009	0.022	0.004

**: Significant at 5% level of significance