CONTROL OF PURPLE BLOTCH COMPLEX OF ONION THROUGH FERTILIZER AND FUNGICIDE APPLICATION

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CERTIFICATE

This is to certify that the thesis entitled *"CONTROL OF PURPLE BLOTCH COMPLEX OF ONION THROUGH FERTILIZER AND FUNGICIDES APPLICATION"* 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 bona fide research work carried out by ***Md. Hasan Ali, Registration No. 03-01190***, 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.

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ABBREVIATIONS USED

AEZ	=	Agro-Ecological Zone
@	=	At the rate
ANOVA	=	Analysis of variance
Anon.	=	Anonymous
B	=	Boron
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CMI	=	Commonwealth Mycological Institute
Cu	=	Copper
CV	=	Co-efficient of variance
cv.	=	Cultivar
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	=	Potassium
kg/ha	=	Kilogram per hectare
LAD	=	Leaf Area Diseased
lb	=	Pound

LSD	=	Least Significant Difference
m	=	Meter
mm	=	Millimeter
Mn	=	Manganese
MP	=	Muriate of potash
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
T	=	Treatment
t / ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
wt.	=	Weight
w/v	=	weight per volume
Zn	=	Zinc
$ZnSO_4$	=	Zinc Sulfate
^0C	=	Degree Centigrade
%	=	Percent

CONTROL OF PURPLE BLOTCH COMPLEX OF ONION THROUGH FERTILIZER AND FUNGICIDE APPLICATION

BY

MD. HASAN ALI

ABSTRACT

An investigation was carried out in the seed health laboratory of the Department of Plant Pathology and in the farm of Sher-e-Bangla Agricultural University to evaluate the effect of selected fungicides and micronutrients against *Alternaria porri and Stemphylium vesicarium* causing purple blotch complex of onion. Four chemical fungicides, viz. Rovral 50 WP, Dithane M-45, Ridomil gold and Cupravit and micronutrients ($ZnSO_4$ + Borax) were assayed alone and in combination in the investigation. In *in vitro* test Rovral 50 WP (0.2%) showed the promising result against mycelial growth of *Alternaria porri and Stemphylium vesicarium* that reduced the mycelial growth by 69.00% and 76.56% respectively followed by Dithane M-45. In the field experiment, the fungicides were tested alone and in combination with micronutrients ($ZnSO_4$ + Borax), comprised with ten treatments. Among those treatments, the application of chemical fungicide in combination with micronutrients always performed better than the application of chemical fungicide alone in controlling purple blotch complex of onion. Rovral 50 WP (0.2%) + Micronutrients reduced the disease incidence (% Leaf infection) and disease severity (% Leaf area diseased) by 20.92% and 44.88%, respectively followed by Rovral 50 WP (0.2%) alone, Dithane M-45 (0.45%) + Micronutrients and Dithane M-45 (0.45%) alone. The bulb yield and yield contributing characters viz. plant height, plant dry matter, root length and weight were found significantly higher in case of application of Rovral 50 WP (0.2%) + Micronutrients where yield was increased by 36.88% over control.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important and familiar spices crop throughout the world. It is used as important and popular vegetables in Australia, Belgium, India, Japan, United Kingdom, USA and many other countries. Spices are important constituents of food items in Bangladesh. A good number of spices crops are grown in Bangladesh. The major ones are Onion, Garlic, Zinger, Turmeric, Coriander, Chili, etc. The onion suffers from different diseases and incurs substantial losses every year in Bangladesh.

In Bangladesh onion is mainly grown in winter season as a spice crop. Out of 15 important vegetables and spice crops listed by the FAO, onion stands second in terms of annual world production (Anon. 1997). The world average yield of onion is 17.5t/ha. In Bangladesh, it is grown in 51820 hectares of land with an annual production of 272000 metric tons. The average yield of onion in Bangladesh is 5.2 t/ha, which is too low compared to the world average (Anon. 2004). In Bangladesh, the present production of onion is nearly 7,69,000 metric tons from 115742 ha of land (BBS, 2006). The annual yield of onion in the country is only 6.644 tons/ ha (BBS, 2006), which is quite low compared to other onion growing countries of the world. Our annual requirement of onion is around 14,00,000 tons (BBS, 2006). In Bangladesh, onion bulbs are grown almost in all districts and its cultivation in commercial scale is found in the greater Faridpur, Pabna, Jessore, Rajshahi, Dhaka, Mymensingh, Comilla and Rangpur (Anon. 2003).

The 23 districts of onion growing areas of the country are Faridpur, Comilla, Manikganj, Dinajpur, Jessore, Pabna, Rajshshi, Mymensingh, Jamalpur, Patuakhali, Kishorganj, Tangail, Borishal, Bandarban, Khagrachari, Sylhet, Bogra, Rangamati, Kustia, Dhaka, Chittagong and Rangpur. The highest yield 2,08,935 metric ton was in Faridpur in 78,695 acre of land. (BBS, 2007).

Pre-eminant produce in volume grown and traded is the common onion bulb. Recently, Bunching onion (*Allium fistulatum*) is coming up as a popular vegetable too. It does not form bulbs but grows in clusters with long white stems (Benoit and Ceusterman's, 1987). Onion has manifold uses; such as spice, vegetables, salad dressing etc. It is also used as condiments for flavoring a number of foods and medicines (Vohora *et al*., 1974).

The local varieties namely Faridpuri and Taherpuri are commonly grown in Bangladesh. In Bangladesh, the demand of bulb onion as well as the onion seeds is increasing every year and the price of the true seed remains fairly high in each season.

Onions are attacked by ten diseases caused by various pathogens (Ahmed and Hossain, 1985; Bose and Som, 1986). Most of the disease caused by the fungi and among the fungal diseases, the most important and damaging ones are seed borne. Seven diseases were reported as seed borne viz. purple blotch, seed rot, germination reduction, black mould, germination failure and white rot. Proper disease control measures can improve the quality of onion bulbs and significantly increase the yield.

Purple blotch of onion is noted as a major disease throughout the world including Bangladesh (Ahmed and Hossain, 1985; Meah and Khan, 1987; Bose and Som, 1986 and Castellanos-Linares *et al*., 1988). In India purple blotch of onion is a major devastating and widespread disease and causes serious yield reduction (Ahmed and Goyal, 1988). The disease is also a threat for seed production of onion (Gupta *et al*., 1986; Rahman *et al*. 1988 and Yazawa, 1993).

The disease is characterized with small water-soaked lesions initially produce on leaves and seed stalk that quickly develop white centers. As lesions enlarge, they become zonate, brown to purple, surrounded by a yellow zone and extend upward and downward for some distance. Under humid condition, the surface of the lesion may be covered with brown to dark gray structure of fungus. A few large lesions have been formed in a leaf or seed stalk which may coalesce and girdle the leaf or seed stalks and tissues , distal to the lesions die. Usually the affected leaves or seed stalks fall down and die within 4 weeks if the environment favours the disease (Gupta *et al.,* 1991).

Now a days *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 is 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.

Damage of foliage and breaking of floral stalks due to purple blotch resulting failure of seed production of onion are common (Ashrafuzzaman and Ahmed, 1976). Hossain *et al,* (1997) reported that the disease causes 41-44% yield loss in Bangladesh. Sharma (1986) reported that under favourable environmental conditions, complete failure of the crop takes place and there will be no seed setting. In India, the disease causes 20 to 25 % loss in seed yield (Thind and Jhooty, 1982).

Temperature and humidity are the most predominant factors for the development of purple blotch disease. The disease is favoured by moderate temperature (24-30^{0}C) and high relative humidity (Gupta and Pathak, 1986 ; Evert and Locy,1990 and Rodriguez *et al*., 1994).

Literature from home and abroad indicate that many researchers explored to find out suitable control measures of the disease, viz. resistant variety, date of planting, use of fertilizers and chemical control with fungicides (Shandhu *et al.,* 1983; Vishwakarma, 1986; Gupta and Pathak ,1987 ; Martinez – Reyes , 1987 ; Mishra *et al*., 1989; Sugha *et al.,* 1993 and Srivastava *et al*., 1995). The recent realization that presence of naturally occurring substances in plant species plays a significant role in plant disease resistance. Available literature indicating quite a large number of plant species have been reported to have the antipathogenic activity (Ahmed and Sultana, 1984; Singh *et al*., 1991; Bhowmick and Vardhan, 1991 and Sharvamangala and Datta,1993).

In Bangladesh, limitted attempts have been made to find out the suitable control measures of this disease for bulb and seed production (Ashrafuzzaman and Ahmed, 1976 and Rahman *et al*., 1988 and Rahman, 1990) also found Rovral and Dithane M-45 effective against the disease. A good number of fungicides, cultural practices are yet remained untested against this disease. Considering the present situation of the disease in the country, further selection of fungicides against leaf blotch of onion is urgently necessary. Fertilizer management like use of ash, cowdung, mustard oil cake and NPK, Zn, S and B could be the options for the management of purple blotch complex of onion.

People globally are conscious about environmental hazards due to use of costly and toxic chemicals. So, to save the nature and escape pollution of environment, a judicial use of fungicide is to be employed. Therefore, the present study was undertaken with the following objectives

1. To determine the efficacy of selected fungicides in controlling growth of *Alternaria porri* and *Stemphylium vesicarium in-vitro*.

2. To determine the effect of selected fungicides and micronutrients on purple blotch complex of onion *in-vivo*/in the field.

CHAPTER 2
REVIEW OF LITERATURE

Purple blotch of onion caused by *Alternaria porri*, is a common and most important disease throughout the country. It causes serious yield reduction of the crop. Management of the disease by using chemical fungicides, host resistance, cultural practices and biological control measures are being explored in many countries of the world. Literature in relation to management of purple blotch complex of onion with fungicide and fertilizer is reviewed and presented in this chapter.

2.1. 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.

Sandhu *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 moderately resistance 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 between 18 – 26^{0} C.

2.2. 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^{0}C at 90% RH followed by 30^{0}C. 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^{0}C, while maximum germination was recorded within 6 hrs at 25^{0}C on the host surface. According to them, temperatures between 22 to 25^{0}C 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 had 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 conditions favorable. After 3 hrs in the dew chamber at 24^{0} C following inoculation of onion leaves, 73% of conidia had germinated and 5% had formed appressoria. Infection hyphae were not observed until 6 h following inoculation, at which time 2% of conidia had formed infection hyphae and 0.5% of conidia had caused visible lesions. Length of dew period was significantly and positively correlated with lesion numbers but not with lesion size.

2.3. 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, Miltoz, (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 Ditanne 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 infected plants in the field. It was revealed that Mangate-D was the most effective one while Dithane M-45 and Antracol become 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 were 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*. are predominated among the fungi isolated from onion seeds. In vitro products based on iprodione gave the best results resulting 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 of 5 times at 15-days interval with Dithane M-45 + the sticker triton is recommended for control of purple blotch of onion seed crops.

Sharma (1986) reported that the best control of *A. porri* under field condition was given by Dithane M-45 (mancozeb) applied at 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 (Carbendazin), 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) stand that stemphylium blight (*Stemphylium vesicarium*) and purple blotch (*Alternaria porri*) are important diseases causing considerable damage to onion crops in India. The diseases are severe during the rainy seasons especially when thrips are also associated with the crops. Studies were undertaken in Karnal, Haryana, India, during kharif, 1994 and 1995 to control the diseases. Tretment comprised of either 5,4 0r 3 sprays of Mancozeb, Chlorrathalonil and Fosetyl as (aliette) starting at 40 DAP at intervals of 10 days intervals 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 were 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

flowers), 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/litre) rate. After artificial inoculation, disease reduction ranged from 53.7 to 68.9% at the higher and lower rates of Iprodione.

From India, 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. Observation on disease intensity/PDI were recorded at fortnightly intervals, just before each spray,and a total of 5 sprays were applied. 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) and leaf spot (Hall and Kavanagh, 1981).

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 the lowest and crop yield was the highest in the 3.5 litres 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.

2.4. Effect of fertilizer

Awad *et al.* (1978) found that applications of nitrogen fertilizer at twice the normal dose increased the percentage and severity of infection, while a double dose of calcium super phosphate reduced infection.

Sandhu *et al.* (1982) reported that in field trials against *Alternaria porri* the disease intensity was decreased at lower N levels.

Rashid (1983) recommended 10 tons cowdung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh. Soto (1988) carried out an experiment with critical level for P, K and S and response to N rates were 100 kg/ha each of N, P_2O_5 and K_2O and 50 kg/ha, N was applied at 0, 50, 100 and 150 kg/ha. He mentioned that 50 kg/ha gave the best yield response.

Mondal *et al.* (1989) found that a higher doses of N (150 or 200 kg urea/ha) in combination with higher doses of P (Triple super phosphate) and with 80 kg muriate of potash/ha increased the number of leaves and seed stems/plant and reduced the number of diseased (*Alternaria porri*) inflorescence stalks and infected umbels. The practice increased yields up to 234% over controls.

Nasiruddin *et al*. (1993) conducted experiment on the effect of potassium and sulphur on growth and yield of onion at Mymensingh, Bangladesh. They reported that application of both potassium and sulphur either individually or combinedly increased the plant height, leaf production ability of the plants, bulb diameter, bulb weight as well as bulb yield. They recommended 100 kg potash and 30 kg sulphur per hectare for cultivation of onion on BAU farm soil.

2.5. 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 include: (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

A study on the sporulation of *Alternaria porri* was conducted by Khare and Nema (1981). They observed maximum sporulation at 8.00 am under field condition. A seasonal periodicity was also noted, indicating maximum sporulation at 22^0 C at 90% RH.

Khare and Nema (1982) also reported that the temperature ranged between 22^0 C to 25^0 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.

Nuchart Joglaekha *et al*. (1982) observed that most of the conidia produced germ tubes and penetrated wounds on leaves within 8 hrs. after inoculation. The conidia were club shaped with cross and longitudinal septa. This fungus produces spores when the temperature lies between 18 - 26^0C.

Raju and Metha (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 the best to culture the fungus. Temperature ranging 22-25^0C was optimum for mycelial growth and sporulation of *Alternaria porri*.

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.

Lakra (1999) conducted an experiment at the Choudhury Charan Singh Haryana Agricultural University, Hisar, India, found that numerous purple spots / blotchs 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 favourable 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 tield component was adversely affected; the most severe infection reduced the number of scapes/plant, the height of scape, the number of umblets/umbel, the number of seeds/umblet, 1000-grain weight, number of seeds/plant and the seed yield/plant by 28.7, 74.5, 89.9, 41.7, 35.7, 95.7 and 97.3% respectively compared with healthy plants.

Hassan and Hussein (2004) reported that onion plants (*Allium cepa* cv. ‘Giza 6’) in several commercial fields in utter Egypt, exhibited symptoms of blight on the leaves and seed-stalk. Initial symptoms on leaves consisted of tip necrosis followed by small white and/or large purple spots. A fungus was consistently isolated from diseased tissue and identified as *Stemphylium vesicarium*.

CHAPTER 3
MATERIALS AND METHODS

This chapter described the materials and methods that were used in carrying out the experiment. It included a description of both in-vitro screening of fungicide and in-vivo efficacy of the fungicides under field conditions. These comprised isolation of *Alternaria porri* from infected onion plant and bioassay of fungicides against the test pathogen (*Alternaria porri*) under laboratory condition.

3.1. Laboratory experiment

The experiment was conducted at the Seed Health Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the month of March- April, in 2008.

3.1.1. Collection of fungicides

The fungicides Cupravit 50 WP, Rovral 50 WP, Dithane M-45, Ridomil Gold (MZ-72) were collected from Krishibid Nursery, Farmgate and Kustia seed store, Mirpur-11, Dhaka, Bangladesh.

Particulars of the chemicals (fungicides) used in this study

Fungicides	**Active ingredient**
Rovral 50 WP	Iprodione 50%
Dithane M-45	Mancozeb 80% + manganese ethylene
Ridomil Gold (MZ-72)	Metalaxyl 67% + Mancozeb 6%
Cupravit 50 WP	Copper oxychloride (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 6 gm/liter of Cupravit 50 WP, 2 gm/liter of Rovral 50 WP, 4.5 gm/liter of Dithane M-45, 2gm/liter of Ridomil Gold (MZ-72) 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 from pathogenic structures and was observed under microscope and identified with the help of relevant literature (CMI Description Vol. No. 338).

Plate 1. Conidia of *Alternaria porri* (x 40)

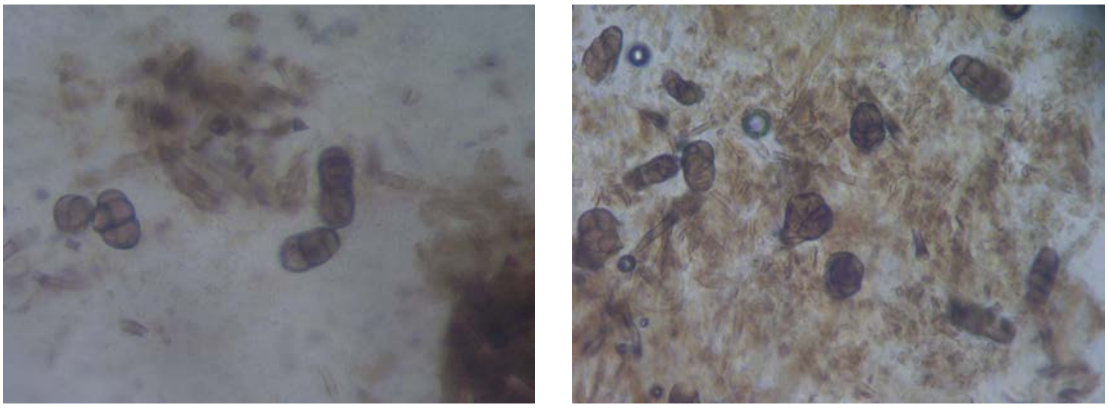


Plate 2. Conidia of *Stemphylium vesicarium* (x 40)

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 15 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; Nene and Thaplial, 1993; McKeen *et al*. 1986).

3.2. Field experiment

A field experiment with different fungicides alone and combination of fungicides with micronutrients (Gypsum, Zinc oxides and Boric acids) was assayed in the Rabi season (November, 2007 to March, 2008) to control the purple blotch complex of onion for bulb production.

3.2.1. Experimental site

The research was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, during the period from 1st November, 2007 to 31st March, 2008. The experimental field is located at

$90^{0}33'$ E longitude and $23^{0}77'$ N latitude at a height of 9 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^{0}C and 21.21^{0}C, respectively with mean temperature of 25.17^{0}C. (Appendix- II)

Temperature during the cropping period ranged between 12.2^{0}C to 31.2^{0}C. 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 “Madhupur Tract” (AEZ No. 28). It was Deep Red Brown Terrace soil and belongs to “Nodda” cultivated series. The top soil is slightly clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63. The information about AEZ 28 is given below:

Characteristics of AEZ-28

Land type	Medium high land
General soil type	Non-Calcareous Dark gray floodplain soil
Soil series	Tejgaon
Topography	Upland
Elevation	8.45
Location	SAU Farm, Dhaka
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 (BARC, 1997). Applied doses were as follows:

Doses of chemical fertilizers

Name of the Fertilizer	Fertilizer dose (kg/ha)	Fertilizer applied during final land preparation (kg/183.75 m^2 land)	Rest installments (Urea) (kg/183.75 m^2 land)		
			1st	2nd	3rd
Urea	320	1.47	1.47	1.47	1.47
TSP	415	7.62	-	-	-
MP	168	3.08	-	-	-
Gypsum	100	1.83	-	-	-
ZnO	5	0.09	-	-	-
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 area : 183.75 m^2
- No. of plot : 30
- Plot size : (2×1.5) m^2
- Block to block distance : 1.0 m
- Plot to boundary distance : 1 m
- Plot to plot distance (Length wise) : 0.5 m
- Plot to plot distance (Breath wise) : .0.5 m
- Plant to plant spacing : 15 cm
- Row to row spacing : 20 cm

3.2.7. Treatments of experiment

Altogether there were 10 different treatments as stated bellow. The treatments were applied into the assigned plots as per design of the experiment.

Treatments

T_0 = Control

T_1 = Micronutrients ($ZnSO_4$ + Borax)

T_2 = Rovral 50 WP + Micronutrients

T_3 = Dithane M-45 + Micronutrients

T_4 = Ridomil Gold + Micronutrients

T_5 = Cupravit + Micronutrients

T_6 = Rovral 50 WP

T_7 = Dithane M-45

T_8 = Ridomil Gold

T_9 = Cupravit 50 WP

3.2.8. Fertility status of the field soil:

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

Physical and chemical properties of the experimental soil

Soil properties	**Value**
Soil texture	clay 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. Variety used:

BARI Peyaz-1 variety collected from "Spices Research Center", Bangladesh Agricultural Research Institute, Shibganj, Bogra was used in this experiment.

3.2.10. Growing of onion

3.2.10.1. Age of the seedling:

Forty five days old healthy seedlings of onion having more or less uniform vigour were collected from Spices Research Centre, BARI, Shibganj, Bogra and transplanted in the experimental plot.

3.2.10.2. Transplanting of seedling:

The healthy seedlings were selected for transplanting in experimental plots. The seedlings were transplanted maintaining row to row distance 20 cm and plant to plant distance 15 cm. The seedlings were transplanted on 15th December, 2007.

3.2.10.3. Transplantation procedure:

Before transplantation, the top of seedling's leaves, at length of 10 to 12 cm from the base was cut with a sharp knife, the roots were also cut at a 2 cm from the base (a usual practice followed by farmers which may help decreased transpiration and faster root development). The prepared seedling was transplanted, as per design and spacing in the evening and watered on the next following days up to establishment of seedlings. A good number of seedlings were transplanted at the border for later use as gap fillers.

3.2.11. Intercultural operation:

3.2.11.1 Irrigation

Irrigation was normally done after each weeding. The young plants were irrigated by a watering can on 16.12.2007 (the day after transplantation). Subsequence irrigation was done as per requirements.

3.2.11.2. Gap filling

The dead or sick seedlings were replaced by healthy seedlings within a week after plantation. The damaged plants were also replaced by border plants through gap filling.

3.2.11.3. 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 young 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

3.2.12.1. Preparation of suspension/solution/chemicals:

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 suspensions of fungicides used in the experiment were presented below with their doses.

Fungicides	Doses rate
1. Rovral 50 wp	0.2%
2. Dithane M-45	0.45%
3. Ridomil gold MZ-72	0.2%
4. Cupravit 50 wp	0.6%

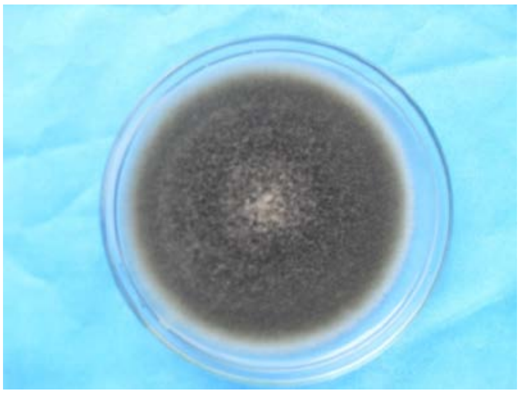
3.2.12.2. Application of fungicide

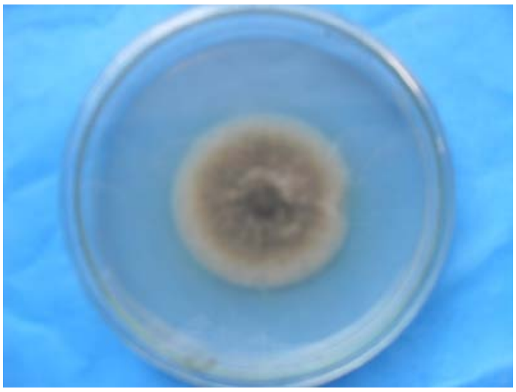
At recommended doses suspension/solution of fungicides were prepared by mixing thoroughly with requisite quantity of normal clean water. Spraying was started from one month after transplanting. Totally 7 spraying were done at 7 days intervals with a hand sprayer. To avoid the drifting of the fungicides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

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 in keeping 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 3. 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.

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

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. 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 bricking 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)**:**

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

0 1 2 3 4 5

Plate 4. Purple blotch severity of onion leaf showing '0 – 5' rating scale

3.4.8. Harvesting

Onion bulbs were harvested on 27th March 2008, at which the plants have been showing the sign of drying out of most leaves. Onion bulbs were carefully lifted with the help of khurpy. To avoid injury, care was taken during harvesting the bulbs by khurpy. Then the stalks were cut 2 cm above bulbs and dried in the sun and later weight was taken**.**

3.4.8.1. Weight of bulb per plot

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

3.4.8.2. Yield of onion per hectare

Yield of onion was calculated as ton per hectare.

3.4.8.3. Storing of the bulbs:

After harvesting, curing and sun drying, the onion bulbs were stored at room temperature for the months of May to August, on the floor of a pakka room keeping good ventilation.

Plate 5. Photograph showing typical symptom of white leaf blotch of onion.

Plate 6. Photograph showing typical symptom of purple leaf blotch of onion.

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 authority of Bangladesh Metrological Department, Agargoan, Dhaka which are presented in Appendix (II).

CHAPTER 4
RESULTS

4.1. Laboratory Experiment

Efficacy of the treatments in controlling purple blotch complex of onion caused by *Alternaria porri* and *Stemphylium vesicarium* was assessed based on the growth rate in diameter.

4.1.1. Bioassay of fungicides against *Alternaria porri* using poison food technique (cup method).

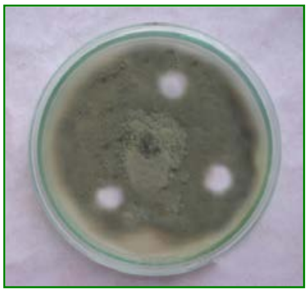
The effectiveness of fungicides against the mycelial growth of *Alternaria porri*, the causal fungus of purple blotch complex of onion was presented in Table-1. The fungicide Rovral 50 WP and Dithane M-45 appeared better in controlling the mycelial growth of *Alternaria porri* at different days after incubation (DAI). At 15 DAI, the lowest mycelial growth was recorded in case of Rovral 50 WP (1.86 cm) followed by Dithane M-45 (2.10 cm), Cupravit (2.70 cm) and Ridomil Gold (2.80 cm). The mycelial growth of the fungus was reduced by 69% in case of Rovral 50WP followed by Dithane M-45 (65%). The maximum mycelial growth of the fungus was recorded in control (6.00 cm) plate, where only sterile water was used instead of fungicides.

a

b

c

d



e

Plate 7. Inhibition of mycelial growth of *Alternaria porri* by poison food technique (cup method).

a. **Inhibition of mycelial growth by Rovral 50 WP (0.2%) at 15 DAI (Days after inoculation).**

b. **Inhibition of mycelial growth by Dithane M-45 (0.45%) at 15 DAI.**

c. **Inhibition of mycelial growth by Ridomil gold (0.2%) at 15 DAI.**

d. **Inhibition of mycelial growth by Cupravit (0.2%) at 15 DAI.**

e. **Mycelial growth in control at 15 DAI.**

Table 1. Effect of different fungicides on mycelial growth of *A. porri* at different days after incubation (DAI).

Fungicides	**Radial mycelial growth (cm)**				**%Reduction in mycelial growth at 15 DAI**
	6 DAI	9 DAI	12 DAI	15 DAI	
Rovral 50 WP	1.06 d	1.24 e	1.48 e	1.86 e	69.00
Dithane M-45	1.40 c	1.60 d	1.90 d	2.10 d	65.00
Ridomil gold	1.80 b	2.00 c	2.40 c	2.80 b	53.34
cupravit.	2.20 a	2.50 b	2.60 b	2.70 c	55.00
Control	2.50 a	4.00 a	5.50 a	6.00 a	-
CV (%)	2.88	1.37	2.23	1.50	
LSD (P=0.05)	0.3151	0.05753	0.08136	0.1151	

4.1.2. Bioassay of fungicides against *Stemphylium vesicarium* using

poison food technique (cup method).

The effectiveness of fungicides against the mycelial growth of *Stemphylium vesicarium*, the causal fungus of purple blotch complex of onion is presented in Table-2. The fungicide Rovral 50 WP and Dithane M-45 appeared to be promising in controlling the mycelial growth of *Stemphylium vesicarium* at different days after incubation (DAI). At 15 DAI, the lowest mycelial growth was recorded in case of Rovral 50 WP (1.50 cm) followed by Dithane M-45 (1.80 cm), Ridomil Gold (2.25 cm) and Cupravit (3.50 cm). The mycelial growth of the fungus was reduced by 76.56% in case of Rovral 50WP followed by Dithane M-45 (71.87%). The maximum mycelial growth of the fungus was recorded in control (6.40 cm) plate, where only sterile water was used instead of fungicide.

Table 2. Effect of different fungicides on mycelial growth of

***Stemphylium vesicarium* at different days after incubation (DAI).**

Fungicides	Radial mycelial growth (cm)				%Reduction in mycelial growth at 15 DAI
	6 DAI	**9 DAI**	**12 DAI**	**15 DAI**	
Rovral 50 WP	0.85 e	1.00 d	1.20 e	1.50 e	76.56
Dithane M-45	1.00 d	1.30 cd	1.60 d	1.80 d	71.87
Ridomil gold	1.30 c	1.60 bc	1.90 c	2.25 c	64.84
Cupravit	1.40 b	2.10 b	2.80 b	3.50 b	45.31
Control	1.80 a	4.00 a	5.10 a	6.40 a	-
CV (%)	2.40	2.60	1.92	1.25	
LSD	0.05954	0.4573	0.08420	0.05954	

4.2 Field experiment

4.2.1. Effect of different fungicides either alone or in combination with micronutrients on purple blotch complex of onion.

Efficacy of selected fungicides viz. Rovral 50 WP, Dithane M-45, Ridomil gold and Cupravit either alone or in combination with micronutrients ($ZnSO_4$ + Borax) were assessed against *A. porri* and *Stemphylium vesicarium* in controlling purple blotch complex of onion. The efficacy of the treatments were measured in respect of percent plant infection, percent leaf infection, percent leaf area diseased (LAD), growth and yield contributing characters and bulb yield.

4.2.1.1. Percent plant infection

Results obtained on the effect of spraying Rovral 50 WP, Dithane M-45, Ridomil gold and Cupravit alone and combination with micronutrients in controlling purple blotch complex of onion in terms of plant infection are presented in Table 3. The effects differed significantly among the treatments with some extent. The lowest plant infection (15.00%) was observed in the treatment Rovral + Micronutrients (15.33%), followed by Rovral 50 WP, Dithane M-45 + micronutrients (16.50%), Ridomil + Micronutrients (16.50%) and Dithane M-45 (17.00%). The moderate plant infection (18.00%) was observed in the treatment Ridomil gold, followed by Cupravit + Micronutrients (19.00%) and Cupravit (21.00%). The highest plant infection (25.50%) was observed in control treatment, closely followed by the treatment Micronutrients ($ZnSo_4$ + Borax).

Table 3. Effect of different treatments against Disease Incidence (Plant Infection) of purple blotch complex of onion

Treatments	% Plant Infection	% Reduction of plant infection over control
Control	25.50 a	-
Micronutrient ($Znso_4$ + Borax)	25.00 b	1.95
Rovral 50 WP + Micronutrients	15.00 h	41.18
Dithane M-45+ Micronutrients	16.50 f	35.29
Ridomil gold + Micronutrients	16.50 f	35.29
Cupravit + Micronutrients	19.00 d	25.43
Rovral 50 WP	15.33 i	39.88
Dithane M-45	17.00 g	33.33
Ridomil gold	18.00 e	29.41
Cupravit	21.00 c	17.64
CV(%)	4.97	
LSD (P=0.05)	0.09396	

4.2.1.2. Percent Leaf infection

Results obtained from the effect of spraying Rovral 50 WP, Dithane M-45, Ridomil gold, Cupravit individually and combination with micronutrients in controlling purple blotch complex of onion in terms of leaf infection was presented in Table 4. Different treatments showed statistically significant variation in respect of percent leaf infection. The lowest infection (40.33 %) was observed in the treatment of Rovral 50 WP + Micronutrients, followed by Rovral (42.00%), Dithane M-45 (43.80%) and Dithane M-45 + Micronutrients (43.00 %). The moderate leaf infection (46.00 %) was observed in the treatment Ridomil + Micronutrients, followed by Ridomil gold (47.00 %) and Cupravit + Micronutrients (48.00%). The highest leaf infection (51.00%) was observed in untreated control plot which was statistically similar to the treatment micronutrients ($ZnSo_4$ + Borax) and Cupravit (50.00 %).

Table 4. Effect of different treatments against Disease Incidence (Leaf Infection) of purple blotch complex of onion

Treatments	% Leaf Infection	% Reduction of leaf infection over control
Control	51.00 a	-
Micronutrient (Znso$_{4}$ $_{+}$Borax)	50.00 b	1.96
Rovral 50 WP + Micronutrients	40.33h	20.92
Dithane M-45+ Micronutrients	43.00 f	15.68
Ridomil gold + Micronutrients	46.00 e	9.80
Cupravit + Micronutrients	48.00 c	5.88
Rovral 50WP	42.00 g	17.64
Dithane M-45	43.80 g	14.11
Ridomil gold	47.00 d	7.84
Cupravit	50.00 b	1.96
CV (%)	3.40	
LSD (P=0.05)	0.3116	

4.2.1.3. Percent Leaf Area Diseased (LAD)

Results obtained from the effect of spraying Rovral 50 WP, Dithane M-45, Ridomil gold, Cupravit and application of micronutrients in controlling purple blotch complex of onion in terms of leaf area diseased was presented in Table 5. The treatments showed statistically significant variation in respect of percent leaf area diseased (%LAD). The treatment Rovral + micronutrients gave the best performance (14.33%) in minimizing percent leaf area diseased of purple blotch of onion, which was statistically similar to Rovral 50 WP (15.00%), Dithane M-45 + Micronutrients (15.00%) and Dithane M-45 (17.00 %). The treatment Ridomil gold resulted moderate performance (21.00 %) in controlling percent leaf area diseased. The highest % LAD was observed in control treatment (26.00 %), where only water was sprayed, which was preceded by Ridomil gold, Micronutrients (24.00 %) and Cupravit + Micronutrients (23.00 %).

Table 5: Effect of dfferent treatments on disease severity (%Leaf Area Diseased) of purple blotch complex of onion

Treatments	% Leaf Area Diseased	% Reduction of leaf area diseased over control
Control	26.00 a	-
Micronutrient (Znso$_4$ $_+$Borax)	24.00 b	7.69
Rovral 50 WP+ Micronutrients	14.33 h	44.88
Dithane M-45 + Micronutrients	15.00 g	42.30
Ridomil gold + Micronutrients	19.00 e	26.92
Cupravit +Micronutrients	23.00 c	11.53
Rovral 50 WP	15.00 g	42.30
Dithane M-45	17.00 f	34.61
Ridomil gold	21.00 d	19.23
Cupravit	24.00 b	7.69
CV (%)	3.92	
LSD (P=0.05)	0.5146	

4.2.1.4. Plant height

The effect of micronutrients and fungicides on plant height differed significantly that ranged from 30.00 cm to 50.00 cm (Table 6). The highest plant height (50.33cm) was recorded in the treatment of Rovral + Micronutrients, followed by Ridomil + Micronutrients (48.00 cm), Rovral 50 WP (46.00 cm) and Ridomil gold (45.00 cm). The moderate plant height was recorded in the treatment Dithane M-45 + Micronutrients (44.00 cm) which was statistically identical with the treatment Dithane M-45 and followed by Micronutrient (35.00cm) and Cupravit (35.00 cm). The lowest plant height (30.00 cm) was recorded in the control treatment.

4.2.1.5. Dry matter

The effect of micronutrients and fungicides on dry matter of plant differed significantly of each other (Table 6). Rovral + Micronutrients gave the best performance (10.33gm) in dry matter contents of plant, followed by Dithane M -45 + Micronutrients 9.00gm that was statistically identical with Rovral. The dry matter content of plant in case of application was 8.50gm which was statistically followed by Ridomil + Micronutrient (8.00 gm), Ridomil gold (7.50 gm), Micronutrient ($ZnSo_4$ + Borax) and Cupravit (7.00 gm). The lowest dry matter content of plants was recorded in control treatment (5.00 gm).

4.2.1.6. Root length

The root length as influenced by the application of different treatments varied significantly of each other (Table 6). The treatment, Rovral + Micronutrients gave the best performance (8.10 cm) in increasing root length which was statistically similar with the treatment Dithane M-45 + Micronutrients (8.00 cm). The treatment Ridomil gold + Micronutrients (7.50 cm) was statistically identical with the treatment Micronutrients ($ZnSo_4$ + Borax) regarding root length.The effect of Cupravit + Micronutrient was statistically identical with Rovral (7.00 cm). The lowest growth of root (4.00 cm) was recorded in case of control treatment which was preceded by Dithane M-45 (5.50 cm), Ridomil gold (6.00 cm) and Cupravit (6.00 cm).

4.2.1.7. Root weight

The treatments showed significant variation in terms of root weight (Table 6). The treatment Rovral 50 WP+ Micronutrients gave the best performance (8.63gm) in increasing of root weight which was statistically similar with the treatment Dithane M-45 + Micronutrients (7.50 gm). The treatment Cupravit + Micromutrients was statistically identical with the treatment Micronutrients alone ($ZnSo_4$ + Borax). The effect of Cupravit + Micronutrients was statistically identical with Rovral 50 WP (6.50 gm). The lowest weight of root (3.50 gm) was recorded in case of control treatment which was preceded by Ridomil gold, (4.00 gm) and Dithane M-45 (4.50 gm).

Table 6. Effect of different treatments and treatment combinations on

growth parameter of onion

Treatments	Plant height (cm)	Dry matter of plants (gm)	Root length (cm)	Root weight (gm)
T_0	30.00 i	5.00 h	4.00 a	3.50 h
T_1	35.00 h	7.00 g	7.50 e	5.50 e
T_2	50.33 a	10.33 a	8.10 g	8.63 a
T_3	44.00 b	9.00 b	8.00 f	7.50 b
T_4	48.00 e	8.00 d	7.50 e	5.50 e
T_5	40.00 g	7.00 g	7.00 d	6.50 c
T_6	46.00 d	9.00 b	7.00 d	6.50 c
T_7	44.00 b	8.50 c	5.50 b	4.50 g
T_8	45.00 f	7.50 e	6.00 c	4.00 h
T_9	35.00 h	7.00 g	6.00 c	5.25 ef
CV (%)	2.41	1.15	2.86	1.28
LSD (P=0.05)	0.1715	0.3431	0.0214	0.4131

Treatments:

T_0 = Control

T_1=Micronutrient ($ZnSO_4$+Borax)

T_2 = Rovral 50 WP +Micronutrient

T_3 = Dithane M-45 +Micronutrient

T_4 = Ridomil gold +Micronutrient

T_5 = Cupravit +Micromutrient

T_6=Rovral 50WP

T_7 = Dithane M-45

T_8 = Ridomil gold

T_9 = Cupravit 50 WP

4.2.1.8. Effect of different treatments on bulb yield of onion.

The bulb yield was found to increase from 11.67 t/ha (Control Plot) to 18.49 t/ha (Rovral + Micronutrients) due to application of fungicides and Micronutrients (Table 7). The combination of Rovral + Micronutrients, Rovral alone, Dithane M-45+Micronutrients and Dithane M-45 alone gave promising bulb yield (18.49 t/ha, 18.34 t/ha, 18.00 t/ha and 17.67 t/ha, respectively) in comparison to other treatments which were significantly similar. The effect of Ridomil gold alone (16.67 t/ha), Ridomil gold + Micronutrient (17.50 t/ha), Cupravit alone and Cupravit +Micronutrients (16.34 t/ha), gave comparatively lower yield than that of Rovral +Micronutrients, Rovral, Dithane M-45+ Micronutrients, Dithane M-45. The lowest yield was obtained from the control treatment.

Table 7. Effect of different treatments on bulb yield of onion

Treatments	Bulb yield /Plot (kg)	Bulb yield (ton/ha)	Increase of yield over control (%)
Control	3.50 g	11.67 i	-
Micronutrient ($ZnSO_4$ + Borax)	4.00 f	13.34 h	27.04
Rovral 50 WP + Micronutrients	5.63 b	18.49 a	36.88
Dithane M-45+ Micronutrients	5.40 bc	18.00 c	34.23
Ridomil gold + Micronutrients	5.25 cd	17.50 e	31.53
Cupravit + Micronutrients	4.90 e	16.34 g	25.25
Rovral	5.50 a	18.34 b	36.07
Dithane M-45	5.30 c	17.67 d	32.44
Ridomil gold	5.00 de	16.67 f	27.04
Cupravit	4.90 c	16.34 g	25.04
CV (%)	2.74	3.51	
LSD (P=0.05)	0.2544	0.0185	

Plate 8. A view of the experimental field showing healthy plant

(Treated with Rovral 50 WP + Micronutrients).

Plate 9. A view of the experimental field showing infected plant (Control).

CHAPTER 5
DISCUSSION

5.1. Laboratory experiment

The *in-vitro* test revealed that all the chemical fungicides significantly retarded the mycelial radial growth of *Alternaria porri* over control. The lowest radial mycelial growth (1.86 cm) of *Alternaria porri* was recorded in Rovral 50 WP @ 0.2% followed by Dithane M-45 @ 0.45%. The results showed that Rovral 50 WP reduced the mycelial growth of *Alternaria porri* by 69% followed by Dithane M-45 (65%) at 15 DAI. The present findings were well supported by the results obtained by the previous researchers (Annon, 2005; Rahman *et al.*, 1989; Islam *et al.*, 2001; Datar, 1996).BARI (2004-2005). It was reported that Rovral totally inhibited the mycelial growth of *Alternaria porri*. Datar (1996) reported that iprodione (Rovral) at 500 ppm significantly reduced the mycelial growth of *Alternaria porri*. Rahman *et al.* (1989) found Rovral 50 WP as a promising fungicide in reducing the mycelial growth of the fungus. Islam *et al.* (2001) also found Rovral 50 WP as the most effective fungicide next to Score in reducing mycelial growth of *Alternaria porri in vitro*.The fungicides assayed against *Stemphylium vesicarium in vitro* showed promising result in reduction of mycelial growth. The *in vitro* result showed that Rovral 50 WP (0.2%) retarted the mycelial growth of *Stemphylium vesicarium* by 76.56% while Dithane M-45 reduced mycelial growth by 71.87%. The present findings corroborate with the findings of

Hoque (2008) who reported that Rovral 50 WP was effective to inhibit the mycelial growth of *Stemphylium vesicarium in vitro.*

5.2. Field experiment

In the present experiment, the effect of treatments in controlling purple blotch complex of onion caused by *Alternaria porri* and *Stemphylium vesicarium* was assessed on the basis of percent leaf infection, percent plant infection, percent leaf area diseased (% LAD), growth parameters and yield of onion. The effect of Rovral 50 WP (0.2%) along with micronutrients against purple blotch complex of onion in terms of percent leaf infection, percent plant infection and percent leaf area diseased (% LAD) was found promising. The highest reduction of plant infection (41.18%), leaf infection (20.92%), leaf area diseased (44.88%) was recorded in case of Rovral 50 WP + Micronutrients followed by Rovral 50 WP alone and Dithane M-45 (0.45%) + Micronutrients. The results showed that application of Micronutrients in combination with fungicides had contributory effect in reducing the disease incidence and disease severity. The present findings was supported by the reports of the previous researches (Ahmed *et al.*, 1999; Sugha, 1995; Rahman, 2004; Srivastava *et al.*, 1994; Islam *et al.*, 2001; Khatun, 2007 and Hoque, 2008). Ahmed *et al.* (1999) reported that the fungicides Rovral 50 WP (0.2%) and Ridomil MZ-72 (0.2%) were effective in reducing incidence and severity of purple blotch of onion. Sugha (1995) reported that Iprodione (0.2%) proved to be highly effective against purple blotch of onion resulting 79.6 - 84.9% control of the disease.

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) also reported that Rovral 50 WP gave promising effect in reducing the disease severity of purple blotch of onion. Khatun (2007) reported that 6 foliar spraying at 10 days interval starting from 20 DAP with Rovral 50 WP (0.2%) or Dithane M-45 (0.45%) successfully minimized disease incidence and severity of stemphylium blight of onion caused by *Stemphylium vesicarium.* Hoque (2008) also 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.

There were significant differences among the effect of fungicides and micronutrients on the yield and yield contributing characters of onion. Rovral 50 WP (0.2 %) and Rovral 50 WP @ 0.2 % + micronutrients showed the best performances in controlling purple blotch complex of onion and increasing yield. These findings were well supported by Barnoczki-stoilova *et al.* (1989) and Georgy *et al*. (1983). Hoque (2008) also reported that micronutrients along without spraying of fungicides had significant effect compared to control. Barnoczki-stoilova *et al.* (1989) conducted a field experiment spraying with fungicides at different blooming stages of flowers and reported that Rovral 50 WP (Iprodione) and Ridomil plus 50 WP (Methyl + Copper oxychloride) showed less harmful and effective in controlling disease in onion seed production. Georgy *et al*. (1983) also reported that the Iprodione group and Ridomil MZ (Metalaxyl + Mancozeb) proved most effective in reducing the disease severity and increasing bulb and seed yield. Hoque (2008) reported that Rovral 50 WP effectively controlled Stemphylium blight of onion.

CHAPTER 6

SUMMARY AND CONCLUSION

Onion (*Allium cepa* L.) is considered as one of the most important spices crop and that ranked top of the list as per consumer's preference in Bangladesh as well as in all over the world. Usually onion production is affected by different diseases worldwide. Among the five diseases, purple blotch complex, incurred tremendous yield loss in the country. Purple blotch complex of onion caused by *Alternaria porri* and *Stemphylium vesicarium* is a limiting factor of onion production. The fungus reduces the bulb yield, seed yield and quality of onion seeds. The present research program was conducted to determine the effect of some selected chemical fungicides and micronutrients on purple blotch complex of onion for bulb yield.

The experiments were carried out in the Seed Health Laboratory, Department of Plant Pathology and at the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period December, 2007 to March, 2008. Ten (10) différent treatments viz. T_0 = Control, T_1 = Micronutrients ($ZnSO_4$ + Borax), T_2 = Rovral 50 WP + Micronutrients, T_3 = Dithane M-45 + Micronutrients, T_4 = Ridomil gold + Micronutrients, T_5 = Cupravit +Micromutrients, T_6 = Rovral 50 WP, T_7 = Dithane M-45, T_8 = Ridomil gold and T_9 = Cupravit were included in the study.

In the laboratory study, all the tested chemical fungicides significantly reduced mycelial growth of *Alternaria porri* and *Stemphylium vesicarium*. Among the fungicides, Rovral 50 WP @ 0.2% reduced the highest radial mycelial growth of *Alternaria porri* and *Stemphylium vesicarium* followed by Dithane M-45 @ 0.45% and Ridomil Gold MZ-72 @ 0.2% compared to control.

In the field experiment, the treatments showed significant effect in reducing disease incidence, and disease severity increasing bulb yield and yield contributing characters. The lowest disease incidence and disease severity were observed in Rovral 50 WP (0.2%) + micronutrients followed by Rovral 50 WP (0.2%) alone, Dithane M-45 @ 0.45% + micronutrients Dithane M-45 (0.45%) alone. The highest disease incidence and disease severity were recorded in control treatment.

On the basis of present findings it may be concluded that the onion growers may by suggested to apply Rovral 50 WP (0.2 %) along with micronutrients in controlling purple blotch complex of onion for bulb and seed production. However, further studies need to be carried in different Agro-ecological zones taking more options to justify the present findings.

CHAPTER 6

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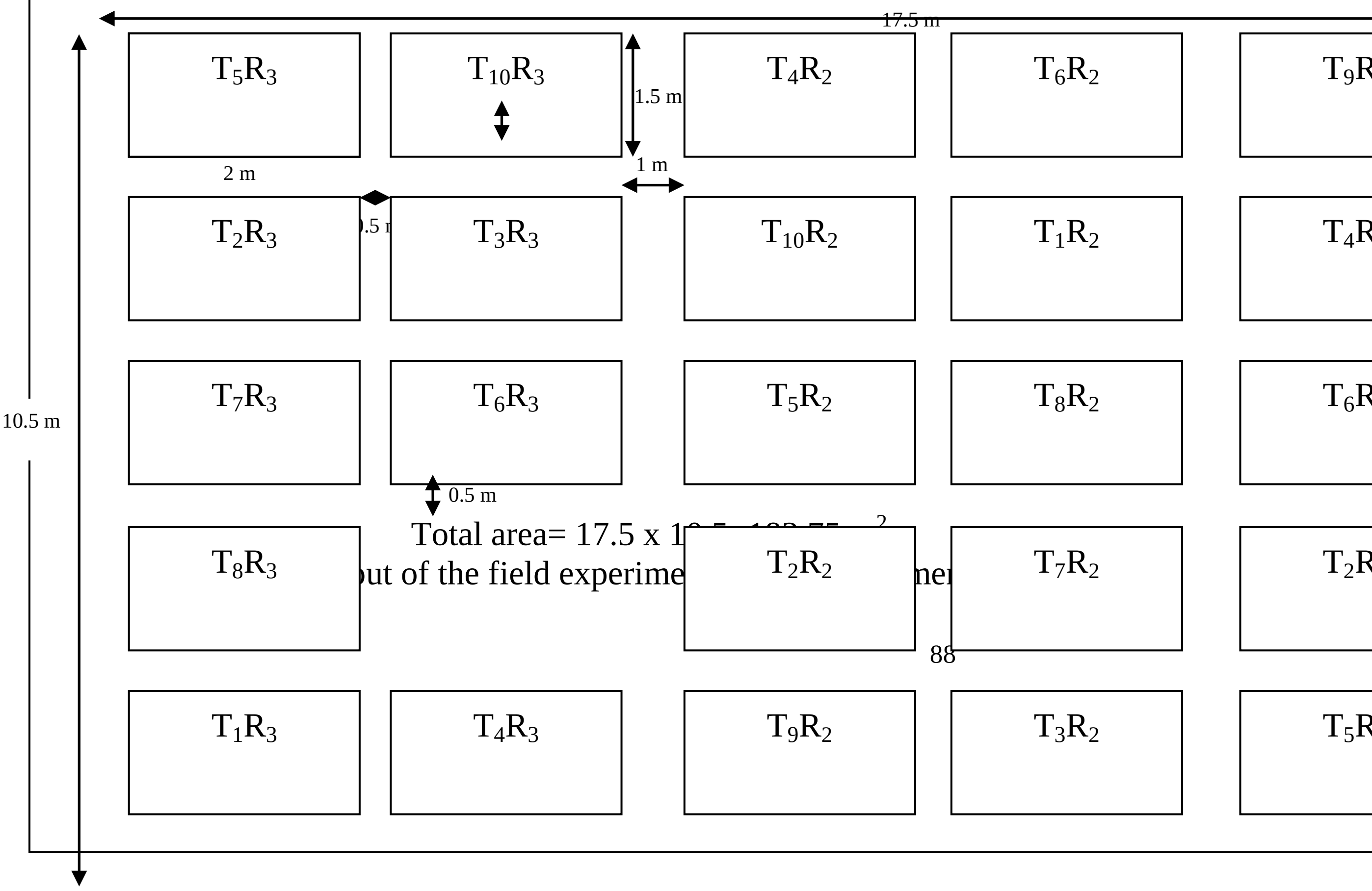
APPENDICES

Appendix I. Layout of the experimental field (RCBD)



Total area= 17.5 x 1

out of the field experime

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November, 2007 to March, 2008

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
November, 2007	29.0	19.8	24.40	73.90	3.0
December, 2007	27.0	15.7	21.35	62.79	0.0
January, 2008	24.9	13.2	19.05	67.5	3.0
February, 2008	28.1	17.8	22.95	61.5	4.0
March, 2008	32.5	22.6	27.55	66.6	155.0

Source: Bangladesh Metrological Department (Climate division), Agargoan, Dhaka-1207.