MANAGEMENT OF PURPLE BLOTCH OF ONION FOR SEED PRODUCTION

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CERTIFICATE

This is to certify that the thesis entitled "*MANAGEMENT OF PURPLE BLOTCH OF ONION FOR SEED PRODUCTION*" 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 ***K. M. Kawsher Hossain, Registration No. 00901***, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

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Dedicated To

My Beloved Parents

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BY

K. M. KAWSHER HOSSAIN

ABSTRACT

The experiments were conducted both in Seed Health Laboratory, Department of Plant Pathology and in the farm of the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the winter cropping season 2007-2008 to determine the efficacy of fungicides, botanicals and micronutrients against purple blotch of onion. Initially, five chemical fungicides and two botanicals were assayed for the efficacy against *Alternaria porri* by *in vitro* test. Among the fungicides, Rovral 50 WP @ 0.2% reduced the highest mycelial growth of *Alternaria porri* followed by Ridomil Gold MZ-72 @ 0.2% and Dithane M-45 @ 0.45% compared to control. Between two botanicals, Neem leaf extract (1:6 w/v) gave better result than Allamanda leaf extract (1:6 w/v). A field experiment was laid out using onion variety Taherpuri to evaluate the nine (9) different treatments viz. Allamanda leaf extract (1:6 w/v) + micronutrients, Neem leaf extract (1:6 w/v) + micronutrients, Cupravit 50 WP @ 0.7% + micronutrients, Rovral 50 WP @ 0.2% + micronutrients, Dithane M-45 @ 0.45% + micronutrients, Ridomil Gold MZ-72 @ 0.2% + micronutrients, Bavistin 50 WP @ 0.1% + micronutrients, Only micronutrients and Untreated Control (No fungicides, botanicals & micronutrients). A positive and significant effect of fungicides, botanicals and micronutrients was found in respect to % leaf infection, % leaf area diseased (LAD), PDI (leaf & stalk), % seed stalk infection and % stalk area diseased (SAD). The highest performance in reducing disease incidence and severity of purple blotch of onion was found by the application of Rovral 50 WP @ 0.2% + micronutrients followed by Ridomil Gold MZ-72 @ 0.2% + micronutrients. The seed yield and yield contributing characters also influenced by the application of the treatments. The highest onion seed yield (650 kg/ha) was recorded in case of application of Rovral 50 WP @ 0.2% + micronutrients followed by Ridomil Gold MZ-72 @ 0.2% + micronutrients. Between two botanicals, Neem leaf extract performed better than Allamanda leaf extract in reducing the disease incidence, severity and in improving seed yield and yield contributing characters.

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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 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	=	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
ZnO	=	Zinc Oxide
^{0}C	=	Degree Centigrade
%	=	Percent

Chapter 1

Introduction

CHAPTER – 1
INTRODUCTION

Onion (*Allium cepa* L.) is an important and widely used spice of Bangladesh. It is also used as vegetable all over the world. It belongs to the family Alliaceae. It grows extensively during winter season in Bangladesh but at present it grows in the summer season also. Its commercial cultivation is concentrated in the greater districts of Faridpur, Comilla, Jessore, Pabna, Rajshahi, Dinajpur, Mymensingh, Dhaka and Rangpur (BBS, 2006). Recently, bunching onion (*Allium fistulosum*) is coming up as a popular vegetable too. It does not form bulbs but grow in clusters with long white stems. Onion has manifold uses; such as spice vegetable, salad-dressing etc. It is also used as condiments for flavoring a number of foods and medicines (Vohora *et al.* 1974).

In terms of global vegetable production nearly 28 million tons per annum, next to tomatoes and cabbages bears importance (FAO, 1991). In Bangladesh, the present production of onion is around nearly 7,69,000 tons from 115742 hectares of land (BBS, 2006). The annual yield is only 6.644 tons/ha in Bangladesh (BBS, 2006) which is quite low compared to other onion growing countries of the world. Our requirement of onion per year is around 14,00,000 tons/year (BBS, 2006).

The local varieties namely Faridpur bhati, Taherpuri, Jitka, Salta and Kalasnagari are commonly grown in Bangladesh. 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.

Onion suffers from several diseases (Meah and Khan. 1987; Ahmed and Hossain, 1985; Munoz *et al.*, 1984). Among them purple blotch of onion caused by *Alternaria porri* (Ellis) Cif. is the most important fungal disease (Munoz *et al.*, 1984; Bose and Som, 1986). This disease commonly known as leaf blotch and is noted as the major disease throughout the world including Bangladesh (Ahmed and Hossain, 1985; Munoz *et al.*, 1986; Meah and Khan, 1987; Bose and Som, 1986 and Castellanos-Linares *et al.*, 1988).

The disease is considered as a serious problem for seed production in tropical countries like Bangladesh (Rahman *et al.*, 1988; Anonymous, 1985). In primary stage the symptoms appear on leaves or seed stalks as small water-soaked lesion that quickly develops white centre. As lesions enlarge, they become zonate and brown to purple, and are surrounded by a yellow zone. The lesion extends upward for some distance. A few large lesions have formed in a leaf or seed stalk, which may coalesce and girdle the leaf or seed stalk and tissues distal to the lesions will die.

Seed production is severely affected 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 are common (Munoz *et al.*, 1984; Ashrafuzzaman and Ahmed, 1976). The infected seed stalks break at the point where the blotch lesion is developed (Singh, 1987). Under favorable environmental conditions, complete failure of the crop may take place if proper control measures are not employed (Sharma, 1986). 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, both the cultivars Faridpuri and Taherpuri are susceptible to the disease (Rahman *et al.*, 1988). The cultivation area of onion is increasing but its rate of production per unit area in Bangladesh is gradually decreasing due to disease problem (BBS, 2006). As a result Bangladesh has to import a large quantity of onion every year to fulfill the national demand at the cost of foreign currency.

Temperature, humidity and host nutrition play an important role for infection of onion caused by *Alternaria porri* (Gupta *et al.*, 1993; Everts and Lacy, 1990; Lacy, 1990; Mondol *et al.*, 1989; Khare and Nema, 1981). Many 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. (Srivastava *et al.*, 1991; Banks and Edgington, 1989; Mishra, 1989; Mondal *et al.*, 1989; Yazawa, 1989; Abd-Elrazik *et al.*, 1988; Gupta and Pathak, 1988; Gupta and Pathak, 1987; Martnez-Reyes *et al.*, 1987; Miller *et al.*, 1986; Sharma, 1986; Vishwakarma, 1986; Sandhu *et al.*, 1982). In Bangladesh, reports on successful production of onion seed are scantly (Rahim and Siddique, 1991; Rahman *et al.*, 1988). Ashreafuzzaman and Ahmed (1976) tested some foliar fungicides against the disease. Little information is available in Bangladesh on the use of fertilizers, time of planting and protective spraying of fungicides on onion seed production (Rahim and Siddique, 1991; Bokshi *et al.*, 1989). Use of plant extracts is however as a recent approach to plant diseases management and it has drowned 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 (Ahmed, 2007; Assadi and Behroozin, 1987; Miah *et al.*, 1990; Fakir, 1999; Suratuzzaman, 1995; Hossain *et al.*, 1997).

Considering the above facts, the present investigations were undertaken with the following objectives:

- To determine the effect of plant extract and fungicide against *Alternaria porri* both *in-vitro* and *in-vivo*.
- To determine the effect of micronutrient in controlling the purple blotch of onion.

Chapter 2

Review of Literature

CHAPTER – 2

REVIEW OF LITERATURE

Purple blotch of onion caused by *Alternaria porri* is considered as a serious disease that reduces the seed and bulb yield of onion. Now it is an acute problem in this country both for the researchers and the onion growers. Researchers all over the world have been carrying out their investigations on the Purple blotch of onion, its epidemiology and the management of the disease. Literatures in relation to purple blotch of onion in respect of its management are presented in this chapter:

2.1. Varietal Resistance

Sharma (1997) studied onion genotypes grown in Himachal Pradesh, India, for resistance to *Alternaria porri* during 1991-92. The lines IC48059, IC48179, IC39887, IC48025 and ALR found resistant and another 10 lines were moderately resistant.

Bhonde *et al.* (1992) conducted a field trial during 1987-88 on 8 onion cultivars (Agrifound Light Red, Arka Niketan, L-102-1, Nasik Red and Pusa Red, Agrifound Dark Red, Arka Kalyan and Kharif Local). Agrifound Light Red had a good yield, and had the highest DM content and the lowest incidence and intensity of purple blotch in all cultivars.

Perez-Moreno *et al.* (1992) evaluated three commercial onion cultivars (Geminis, Blanca and Conjumatlan Morada), two hybrids (PVM-7 and PVM-3). Conjumatlan Blanca was the most susceptible cultivar, compared with the most tolerant hybrid PVM- 7. Highest economic yield was obtained with Geminis and the lowest with PVM- 3.

Gupta and Pathak (1988) studied 21 indigenous and exotic cultivars screened at 2 locations in India under artificial inoculations. All the exotic lines, except 2 from the Sudan, were highly resistant to *Alternaria porri* while all the indigenous lines were susceptible. It is suggested that susceptible cultivars should be replaced by the resistant Pusa Red.

Alves *et al.* (1983) studied the incidence of purple spot (*Alternaria porri* Ell. Cif.) on onion cultivars and hybrids in Manaus, Amazonia. Plants were divided into five classes on the basis of natural infection in the field. Incidence was 30-50% (class III) in most cases; only the hybrid Px76 having plants in class I (0-10%).

Sandhu *et al.* (1982) reported that the 90 out of 102 genotypes of onion they screened were resistant to *Alternaria porri.* However, they could locate 12 genotype which showed moderately resistance. All the latter genotypes had flat erect leaves where as all those with curved, drooping leaves were susceptible.

2.2. Epidemiology

Lakra (1999) reported that the purple blotch of onion caused by *Alternaria porri* was a serious constraint in onion seed production. This disease reached epidemic proportions every year during March. In experimental plots at the Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India, 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°C with >18 hr favorable temperature (10-30°C) duration. Exposure of leaf and/or escape to wetness for 8 hr was a pre-requisite for conidial germination. With increasing disease intensity, every yield component was adversely affected; the most severe infection reduced the number of escapes/plant, the height of escape, 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.

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

Hossain *et al.* (1993) reported 41-44% loss of seed crop in Bangladesh due to purple blotch of onion. Under favorable environmental conditions of the disease, complete failure of onion seed crop was observed (Sharma, 1986). The disease causes 20-25 percent loss in seed yield in India (Thind and Jhooty, 1982).

Chawda and Rajasab (1992) conducted a field and laboratory experiment on *Colletotrichum gloeosporioides* (*Glomerella cingulata*) and *Alternaria porri*. *Glomerella cingulata* was present on plants after the 3-leaf stage of growth. Water splashing was the chief form of dispersal within and between plants. Conidia on leaves stored in the laboratory remained viable for 4 months. Conidia of *Alternaria porri* were readily dispersed by air currents.

Gupta *et al.* (1991) reported that purple blotch of onion is an important, widespread disease and is prevalent in almost all the onion-growing areas of India. According to them the characteristic feature of the disease are the small, whitish, sunken lesion with purple centre which rapidly enlarge and eventually girdle the leaf or seed stalk of onion. Usually the affected leaves or seed stalks fall down and die within 3 or 4 weeks if the environment favors the disease.

Rodriguez *et al.* (1991) studied that the intensity and dynamics of *Alternaria porri* conidial germination at 5, 10, 15, 20, 25, 30, 35, 37.5 and 40°C and RH 76-100%. Conidia developed at 5 - 37.5°C, with an optimum temperature of 30°C. Germination started within 1 h of incubation at 20-35°C and in 4 hr. 50% of the conidia had germinated. The min. threshold for RH at 20°C was between 76-78%.

Everts and Lacy (1990) conducted a study to determine the influence of weather variables on conidial concentration of *Alternaria porri* in air above an onion field for two years (1986-87). Weather instruments and a spore trap were placed in the centre of an unsprayed 15×30 m plot of field. In both the years, the natural logarithm of numbers of airborne conidia sampled during the current day (D) was positively correlated with (1) the max. hourly vapor pressure deficit (VPD) (saturation-ambient vapor pressure) on D, and (2) the logarithm of the conidial concentration sampled on D-1. A regression equation was developed to predict relative conidial concentration on day D in 1987 that explained 59% of the variability. Purple blotch lesions were counted weekly at the same site in 1986 and 1987. In 1987, counts of lesions were also made on onion trap plants placed in the field plot at weekly intervals. Large concentration of conidia of *Alternaria porri* did not always precede increases in lesions.

Formation of conidia by *Alternaria porri* was examined under variable dew duration and controlled relative humidity (RH) by Everts and Lacy (1990). Viable conidia produced on lesions increased from 26% after 9 hours of dew to 72, 91, 93, 96 and 96% after 12, 15, 18, 21 and 38 hours of dew, respectively. Conidia formed during dew duration of 12 hours caused flecks when used to inoculate healthy plants, and those formed during dew duration of 16 hours caused typical lesions. Conidia were formed at all RH 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 at 25^0C. Conidia formed repeatedly (up to eight cycles) on lesions exposed to alternating low (35-50%) and high (100%) RH in a dew chamber at 25^0C.

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.

Among the factors reducing yield and limiting the production of onion seed in Cuba were breaking of floral stalks due to injuries caused by *Alternaria porri* was reported by Munoz *et al.* (1986).

Ahmed and Hossain (1985) recorded purple blotch of onion from all onion growing regions of Bangladesh. Ashrafuzzaman and Ahmed (1976) also reported that the damage of foliage and breaking of floral stalks due to the disease resulting in failure of seed production are common.

Miller (1983) reported that measurements of infected leaves were taken weekly from bulb initiation time to bulb maturity. They observed that the leaf damage levels were significantly lowered on younger than on older leaves. Leaves emerging 9, 8, 7, 6 and 5 week before bulb maturity required 5.5, 5, 4.5, 3.5 and 2.5 weeks, respectively to reach 50% leaf damage, whereas those emerging later exceeded 50% damage within 2 weeks.

Attack by *Thrips tabaci* predisposed plants to infection by *Alternaria porri* and severe purple blotch occurred on plants in which the insects were uncontrolled reported by Thind and Jhooty (1982).

Khare and Nema (1982) reported that the temperature range between 22^0C to 25^0C not only suitable for growth and sporulation of *Alternaria porri* but also optimum for spore germination as well as for infection. They also argued that spore germination on leaves decreased with increase in the nitrogen doses to the host.

Khare and Nema (1981) studied sporulation of conidia of *Alternaria porri* on host and its dispersal. Maximum sporulation of *Alternaria porri* in the field was at 8 a.m. and mostly occurred immediately after the rains. In the laboratory sporulation was best at 22^0C and 90% RH. Most conidia were trapped at 12 hours noon and the least at 8 am. (mean temp.>18^0C).

2.3. Chemical Control

Ayub *et al.* (2008) was conducted an experiment in field of Plant Pathology Division, BARI, Joydebpur to evaluate the efficacy of some fungicides in controlling purple blotch of onion in variety Taherpuri. Among the treatments fungicides Evaral (Iprodione) showed the best performance in reducing the disease as well as increasing yield.

Sultana *et al.* (2008) conducted an experiment in the field of Plant Pathology Division, BARI, Joydebpur to assess yield loss of onion bulb due to purple blotch disease. The design was paired plot technique having 5 replications using variety Taherpuri. Result indicate, 71.95% disease reduce in the fungicide spraying plot over control. Weight of 10 bulb (g) and yield/plot (kg) also increased 10.6% and 50.9% in fungicide sprayed plot over control.

An experiment was conducted in the laboratory of BARI, Gazipur during 2004-2005 taking seventeen fungicides namely Mancovit, Indofil, Rovral, Propicon, Pestozeb, Dentol, Contaf, Edvistin, Haymoxyl, Proven, Controll, Knowin, Flowin, Metaril, Score, Pharzeb and Orion against purple blotch of onion (*Alternaria porri*). The fungicides Rovral, Propicon, Contaf, Proven, Controll, and Score totally inhibited the mycelial growth of the fungi. The fungicides Pharzeb, Orion, Metaril, Pestcozeb and Mancovit appeared moderately effective in reducing mycelial growth of *Alternaria porri*. Indofil and Dentol were less effective and Edvistin, Knowin and Flowin were ineffective against the fungus under laboratory condition.

Rahman (2004) conducted a field experiment during February-April, 2004 at BAU farm for the management of purple blotch disease of onion (*Alternaria porri*) with fungicides. Eight sprays of Rovral or Ridomil at 7 days interval minimized disease incidence and increase yield. Rovral 0.2% sprayed at 7 days interval was the best, which gave the highest reduction in disease incidence and severity of leaf blotch and eventually increased the yield of onion.

Islam *et al.* (2001) conducted an experiment to evaluate the efficacy of eight fungicides against the purple blotch of onion caused by *Alternaria porri* viz. Score (Difenconazole), Tilt 250 EC (Propiconazole), Folicur (Tebuconazole), Rovral 50 WP (Iprodione), Knowin (Carbendazim), Macuprax (Bordeaux mixture + cufraneb), Ridomil MZ-72 (Metalaxial + mancozeb) and Bavistin 50 WP (Carbendazim). Among the fungicides, Rovral 50 WP as the most effective fungicide next to score in reducing radial mycelial growth of *Alternaria porri* in *in-vitro* and disease incidence and severity of purple blotch of onion in field.

Memane *et al.* (2001) conducted an experiment in the rainy seasons (June-August) of 1996, 1997 and 1998, in Maharashtra, India, to determine the efficacy of combinations of fungicides and insecticides on the control of thrips (*Thrips tabaci*) and leaf blight (*Alternaria porri*) on onion cv. Baswant 780. Spraying of mancozeb at 0.3% with monocrotophos at 0.05% or cypermethrin at 0.01% was the best treatment for controlling leaf blight and thrips incidence on onion.

Ahmed *et al.* (1999) conducted an experiment to evaluate the efficacy of six fungicides against the purple blotch of onion caused by *Alternaria porri* viz. Rovral 50 WP (0.2%), Ridomil MZ-72 (0.2%), Folicur 250 EC (0.1%), Dithane M-45 (0.2%) and Tilt 250 EC (0.1%). Among the fungicides Rovral 50 WP and Ridomil MZ-72 found to be effective in controlling the disease incidence and disease severity with corresponding increase in seed yield by 100% when they were used alone or in combination of 1:1.

An experiment was conducted at Kashimpur during Kharif-I season (April-July), 1999 having 10 treatments to produce healthy bunching onion through IDM. The treatments were: i) Mustard oil cake @ 1 ton/ha; ii) Furadan 5G @ 60 kg/ha + Rovral (0.2%) spray; iii) Poultry refuse @ 15 ton/ha; iv) Furadan 5G @ 60 kg/ha; v) Rovral spray; vi) Poultry refuse + Rovral spray; vii) Score (0.05%) spray; viii) Control; ix) Farmer's practice + Poultry refuse @ 15 ton/ha

+ Rovral spray; and x) Farmer's practice. Results indicated that poultry refuse and the treatment having Poultry refuse + Rovral influenced on growth parameters and yield of bunching onion and decreased disease incidence of the crops.

Srivastava *et al.* (1999a) conducted a field experiment at Nashik, India, during the Rabi seasons from 1994 to 1998, using onion cv. Agrifound Light Red. Integrated weed and disease management were tested with pendimethalin (0 or 3.5 litres/ha), nitrogen (0, 50 or 100 kg/ha), mancozeb (0.25%), copper oxychloride (0.3%) or no fungicide application. Purple blotch incidence was the lowest in the 100 kg N/ha treatment, but N had no significant effect on weeds. Of the fungicide treatments, the lowest purple blotch incidence was recorded with mancozeb. The most effective combination of treatments for controlling weeds and purple blotch and increasing yield was concluded to be 3.5 liters pendimethalin/ha, 100 kg N/ha and 0.25% mancozeb.

Srivastava *et al.* (1999b) conducted experiments consecutively for (1995-1998) to find out the effective and economical spray schedule for control of purple blotch disease in onion. The treatment evaluated were sprays of mancozeb and chlorothalonil at 10 and 15 days intervals, starting after appearance of purple blotch disease. A total of 4 sprays were given. Mancozeb @ 0.25% at 10 days interval was the most effective in reducing purple blotch disease incidence and intensity, as well as increasing yield and gave a higher cost benefit ratio.

Singh *et al.* (1997) studied the onion seed production in India. South West Punjab has been identified as a suitable area for seed production. Results of experiments have shown planting of bigger bulbs (80-100 g) in the last 2 weeks of October, at a spacing of 45 cm between the rows and 30 cm within the rows gave high seed yields. Herbicide treatment (Pendimethalin and Fluchloralin at 2.5 liters/acre) and fungicide sprays (0.3% Dithane M 45 (mancozeb) + 0.5% Monocrotophos) at 10-day intervals to control purple blotch (*Alternaria porri*) also increased yield and quality.

Datar (1996) tested the fungicides, carbendazim, copper oxichloride, zineb, mancozeb, iprodione, thiophanate methyl, dithianon and ziram at 100, 250 and 500 ppm which significantly reduced the mycelial growth of *Alternaria porri*. All except thiophanate methyl, dithianon and copper oxychloride significantly reduced the mycelial growth over control in the laboratory.

Gupta *et al.* (1996a) reported that Stemphylium blight (*Stemphylium vesicarium*) and purple blotch (*Alternaria porri*) are important diseases causing considerable damage to onion crops in India. Diseases are severe during the season especially when thrips are also associated with the crop. Studies were undertaken in Karnal, Haryana, India, during kharif, 1994 and 1995 to determine an effective and economical spray schedule for disease control. Treatments comprised of 5, 4 and 3 sprays of mancozeb, chlorothalonil and fosetyl (as aliette) starting at 40 DAP at intervals of 10 days. It was shown that 3-4 sprays of 0.25% mancozeb at 10 day intervals starting at 50 DAP reduced infection by *Stemphylium vesicarium* and *Alternaria porri*. Three sprays of 0.25% Kavatch at 10 day intervals starting 60 days after transplanting was also effective.

Gupta *et al.* (1996b) reported that Purple blotch (*Alternaria porri*) and Stemphylium blight (*Stemphylium vesicarium*) are 2 major diseases causing serious losses of onion crops in India. To determine effective control measures of the diseases, studies were undertaken in Karnal, Haryana, India, during kharif, 1993, 1994 and 1995. Three sprays each of iprodione (as Rovral), fosetyl (as Aliette), chlorothalonil, metalaxyl (as Ridomil), iprobenfos (as Kitazin) and benomyl and 4 sprays of mancozeb (as a control) were applied after disease onset. Results from a 3-year study revealed that 3 sprays of chlorothalonil (0.2%) or iprodione (0.25%) were alternatives for controlling both *Alternaria porri* and *Stemphylium vesicarium*.

Srivastava *et al.* (1996) reported that Purple blotch (*Alternaria porri*) and basal rot (*Fusarium oxysporum* f.sp. *cepae*) play a major role in limiting the yield and quality of onion bulb crops during the kharif season. An experiment was conducted at Nasik, Maharashtra, India, during kharif 1993, 1994 and 1995 to test the efficacy of new fungicides against both the diseases. Treatments comprised of seedling dips in carbendazim and thiophanate-methyl along with 4 sprays of iprodione (as Rovral), fosetyl (as Aliette), chlorothalonil, metalaxyl (as Ridomil) and mancozeb and also 4 sprays of mancozeb at fortnightly intervals after disease appearance. Three years pooled data revealed that a seedling dip with carbendazim and 4 sprays of metalaxyl reduced basal rot. Seedling dip in carbendazim was economical as it reduced basal rot and gave good yields.

Borkar *et al.* (1995) tested the fungicides chlorothalonil, mancozeb, ziram, captafol and carbendazim 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 the other fungicides.

The efficacy of 10 fungicides in controlling downy mildew caused by *Peronospora 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 litres were started 45 days after planting and repeated fortnightly until harvesting. Metalaxyl 8% + Mancozeb 64% (as Ridomil MZ 72%) and Metalaxyl 10% + Mancozeb 48% (as 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. Oxadixyl 8% + Mancozeb 56 % (as Sandofan M8) was also effective against these pathogens giving 76 and 79% reduction in disease severity on seed and bulb onions, respectively, and 137% increase in seed and bulb yields compared to control.

Srivastava *et al.* (1995) conducted a field trial on the management of Stemphylium blight (*Stemphylium vesicarium*) and purple blotch (*Alternaria porri*) cause total failure of the onion seed crop in Karnal, Haryana, India. During Rabi 1992-93 and 1993-94, onions cv. Agrifound Light Red were treated with iprobenfos (as Kitazin), iprodione (as Rovral), fosetyl (as Aliette), Kavatch, thiophanate-methyl (as Topsin M), benomyl, metalaxyl (as Ridomil) and mancozeb. Observations on disease intensity/PDI were recorded at fortnightly intervals just before each spray and a total of 5 sprays were applied. Seed yield was improved following treatment with iprodione but when cost benefit ratio was considered, none of the fungicides could perform better than 0.25% mancozeb. It is concluded 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.*

Sugha (1995) conducted a field trial on the management of Purple blotch of garlic caused by *Alternaria porri* during winter season of 1989-1990, 1990-1991 and 1991-1992 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 day intervals resulted in 53.5 - 62% protection to the crop. Clove dip in iprodione 0.25% for 1 hour 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 in providing protection to garlic from purple blotch in Himachal Pradesh.

Upadhyay and Tripathi (1995) conducted a field trial to determine the effect of Bavistin (Carbendazim), Blitox (Copper oxychloride), Calixin (Tridemorph), Captafol, Dithane M-45 (Mancozeb), Dithane Z-78 (Zineb), Jkstein (Methyl benzimidazole carbamate), Karathane EC (Dinocap) and Topsin M-70 (Thiophanate-methyl) for control of *Alternaria porri* on onions (*Allium cepa*). All treatments significantly reduced disease intensity and gave increased yields over the control. The best results were obtained with Captafol.

Sastrahidayat (1994) studied the purple blotch caused by *Alternaria porri* and reported that the disease is a major one of onion and caused crop losses of 50% in Indonesia. Treatments of Difenoconazole + Triton and 80% Mancozeb were compared at Wonosari, Nongkojajar Pasuruan and at Bumiaji, Batu-Malang. Fungicides were sprayed 2 weeks after planting at weekly intervals and stopped 2 weeks before harvest. Difenoconazole was more effective than 80% Mancozeb in controlling *Alternaria porri* on onion. During the rainy season the efficacy increased if Triton X-114 was added to Difenoconazole as a sticker. The optimum concentration of difenoconazole was 80 ml/100 litres water.

Sugha and Tyagi (1994) conducted experiments with the acylalinide fungicides (Benalaxyl, cymoxanil, metalaxyl and oxadixyl) compared with recommended fungicides (chlorothalonil, copper oxychloride, captafol and mancozeb) for the control of purple blotch (*Alternaria porri*) of onion and garlic in a field trial at Malan, Himachal Pradesh, India, during 1989-91. It is concluded that 3 sprays of metalaxyl + mancozeb at 15 days intervals is more effective than currently recommended fungicides for the control of *Alternaria porri*.

Sugha *et al.* (1993) conducted an experiment 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 hours 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 0.2% and mancozeb 0.25%.

During survey in the Cape Provine of South Africa, Aveling *et al.* (1993) reported *Alternaria porri* and *Stemphylium vesicarium* to be destructive seed-borne pathogens of onion. Six fungicides were evaluated for their efficacy in reducing pathogens both on seed and in culture. These fungicides included anilazine, benomyl, a carbendazim / flusilazole mixture, procymidone, tebuconazole and thiram. An untreated control, hot water soak (50^0C for 20 minute), and a sodium hypochlorite treatment were also included for comparison. Treated seeds were rated for germination by the blotter method and by emergence and seedling growth in seedling trays in the glasshouse. None of the treatments eradicated *Alternaria porri* and *Stemphylium vesicarium* from onion seeds. The hot water soak proved to be the best treatment for reducing these pathogens, although the percentages of germination and emergence of onion seeds were reduced compared to the control.

Srivastava and Gupta (1993) presented a paper at the 45^{th} Annual Meeting of the Indian Phytopathological Society on 19-21 January 1993. Three fungicides (0.25% mancozeb, 0.3% copper oxychloride and 0.25% captan) in combination with 2 insecticides (0.05% monocrotophos and 0.05% demeton-methyl) were assessed against *Alternaria porri* and *Thrips tabaci* on onions in Maharashtra, India, in 1988-91. Mancozeb at 0.25% + monocrotophos at 0.05% reduced infection and infestation and increased seed yield and improved the cost-benefit ratio.

Gupta *et al.* (1992) reported that *Alternaria porri* and *Stemphylium vesicarium* cause the most important diseases of this 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.

Moreno *et al.* (1992) conducted an experiment with three fungicides (Iprodione, fosetyl-aluminum and mancozeb) to control *Alternaria porri* on three commercial cultivar of onion in Mexico. They opined that iprodione performed excellent in reducing diseases intensity and gave the highest yield.

Gupta *et al.* (1991) studied in a field trials to find out the economic spray schedule of mancozeb at the Regional Research Station, Karnal, Haryana, India, during 1987-89, 3 sprays of mancozeb at 0.25% applied at 7-d intervals after the appearance of disease symptoms provided good control of *Alternaria porri* on onions (Disease intensity = 8.73%) and resulted in maximum yield (280 q/ha).

Prateung and Sangawongse (1991) conducted a field trial to determine the efficacy of nine (9) fungicides for controlling purple blotch of onion caused by *Alternaria porri* during January-April 1989. The first spray was made 40 days after transplanting the onion seedlings, and the second and third sprays at weekly intervals. The fourth spray was made 12 days after the third. The results after 2 applications of fungicides indicated that myclobutanil, iprodione, and imazalil gave the lowest percentage of disease infestation. Triphenyl tin acetate and myclobutanil + mancozeb gave the second best result.

Srivastava *et al.* (1991) reported that 4 fungicides (Copper oxychloride, mancozeb, carbendazim and thiram) were applied to control purple blotch (caused by *Alternaria porri*) on onion seedlings in field experiments in Maharashtra, India during 1982-84. All the fungicides significantly reduced disease incidence and intensity as preventative and curative treatments. Minimun disease and maximum crop yield were recorded following treatment with mancozeb. Chemical treatments were found to have a varied effect on yield in different years.

Tahir *et al.* (1991) reported the effectiveness of 7 fungicides in a field experiment against *Alternaria porri* which were Daconil (Chlorothalonil), followed by Cupravit (Copper oxychloride), Ridomil MZ-72 (Metalaxyl + Mancozeb) and Penncozeb (Mancozeb). Treatments increased bulb yields by 8.4 - 19.9% over control.

Yazawa (1990) conducted a preliminary trial on onion seed production carried out in Srilanka on red-skinned mother bulbs of Bombay onion (*Allium cepa*) cv. Poona Red, weighing 50-100 gm. Captan, Dithane and Benlate were sprayed at 10 days intervals. The use of the store house with a plastic film roof and fungicide application prevented purple blotch (*Alternaria porri*) and rain damage to flowers although devernalization did occur to an extent (75% bolting occurred). It was suggested that decreasing the plant spacing, shading of the roof, use of jungle bees as pollinators and the selection of fully mature bulbs as mother bulbs could improve seed yield.

Barnoczki-stoilova *et al.* (1989) made trials with onion cv. Makoi Brons to determine the least harmful amongst 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 health. Spraying at full bloom (50-60% open flowers) should be avoided but if essential, Curzate super CZ (Cymoxanil + Zineb) and Rovral 50WP (Iprodione) were the least harmful treatments. At the end of flowerings (5-10% open flower), spraying did not reduce seed yield and improved seed health. Ridomil plus 50 WP (Methyl + Copper oxychloride) and Rovral 50WP were the most effective fungicides.

Mishra *et al.* (1989) conducted a field trials with 7 fungicides, the disease, caused by *Alternaria porri* was controlled best by Dithane M-45 (Mancozeb) at 0.2%, followed by Jkstein. Disease intensity and number of infected leaves/plant were reduced and bulb yields were increased by 25.73 and 17.6%, respectively, over the untreated control.

Rahman *et al.* (1989) evaluated six fungicides Antracol 65 WP (Propined), Bordeaux mixture (Copper sulfate and lime), Cupravit 50 WP (Copper oxychloride), Dithane M-45 (Mancozeb), Rovral 50 WP (iprodione) and Trimiltox forte 47 WP (Cu-salt and Mancozeb) for their efficacy against leaf blotch (*Alternaria porri*) of onion (*Allium cepa*). For preliminary evaluation, bioassay of the chemicals was performed against fungus in cup and paper disc method. All the concentrations of Rovral and Dithane M-45 gave significant reduction in the growth of the fungus. All of the fungicides were evaluated against leaf blotch of onion under natural field conditions. All of the fungicides gave significant reduction in disease severity but increase of onion yield was achieved with only Rovral 50 WP, Dithane M-45 and Bordeaux mixture and they caused 61, 36 and 29% yield increase, respectively.

Ahmed and Goyal (1988) reported that Nasik Red onion seedling with 85 % natural infection by *Alternaria porri* were dipped in suspensions of Aureofungin (Parnino occtophenone), Bavistin (Carbendazim), Brassicol (Quintogene), B-stem 50 (Carbendazim), Cuman (Ziram), Difoltan (Captafol), Dithane M-45 (Mancozeb), Dithane Z-78 (Zineb) and Topsin-M (Thiophanate 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, best control and maximum bulb yield resulted from a seedling dip followed by a foliar spray of 0.2% copper oxychloride.

Sharma (1987) evaluated some fungicides against purple blotch of onion under field condition at Uttar Pradesh. He reported that five sprays of Difolatan (Captafol) or Dithane Z-78 (Zineb) were the most effective treatments for the control of *Alternaria porri*.

Sharma (1986) reported that the best control of *Alternaria porri* under field conditions was achieved by Dithane M-45 (Mancozeb) at 0.2% applied 6 times from the onset of infection; however 3 sprays were found optimum for maximizing bulb yields.

Georgy *et al.* (1983) observed the effect of several fungicides which were tested against *Peronospora destructive* and *Alternaria porri* on onion at Sakha, Kaha, Sids Malaway and Shandwii research stations, during the growing seasons of 1979-80, 1980-81 and 1981-82. Under natural infection, they found that, disease severity reached 100% on plants in non sprayed plots and some treatments especially at Sakha plants failed to produce seeds for most of the treatments. Fungicides were found significantly different in their effectiveness. The Iprodione group and Ridomil MZ (Metalazyl + Mancozeb), proved most effective, reducing disease severity and increasing bulb and seed yield.

Qadri *et al.* (1982) reported that out of eight fungicides, Difolation (Captafol), Dithane M-45 (Mancozeb) and Bavistin (Carbendazim) gave the best control (*in vitro*) of *Alternaria porri.*

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

Padule and Utikar (1977) found the best control and 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.*

Patil *et al.* (1977) evaluated different fungicides against leaf blotch of onion. In culture, the fungus was inhibited by Kitazin, Cuman, Difolatan, Vitavax, Cantan, Hinosan, Dutex, Miltox, and Aureofungin. As a prophylactic spray, kitazin was proved to be superior to all the other fungicides tried.

Ashrafuzzaman and Ahmad (1976) tested effectiveness of five fungicides in different concentration. They reported that Benlate (Benomyl) at 500 ppm or Dithane M-45 (Mancozeb) at 500 ppm gave the best control of *Alternaria porri* on onion and significantly increased the yield. Lower concentrations (125 or 250 ppm) were less effective.

2.4. Botanical Control

Ahmed (2007) conducted an experiment in the field of Plant Pathology Division, BARI, Joydebpur to determine the effect of some plant extract (Marigold flower & leaf, Neem leaf, Onion and Garlic), ditergent, baking soda and *Trichoderma* in controlling purple blotch disease and seed yield of onion. The design was RCBD having 4 replications using variety Pibali. Among the 8 treatments, *Trichoderma* spore spray, spraying baking soda and onion bulb extract reduced disease up to some extent and yield was increased more than 50%. The highest seed yield (44.56 kg/ha) was obtained by spraying *Trichoderma* spore flowed by baking soda spray and onion bulb extract spray. The lowest yield (14.42 kg/ha) was obtained from control plot. The highest percent yield increase (67.63%) was observed in *Trichoderma* spore sprayed plot.

Akter (2007) conducted a field experiment at the research farm of Sher-e-Bangla Agricultural University, Dhaka during the rabi season of 2006-07 to study the management of purple blotch of onion through chemicals and plant extracts. Eleven treatments comprising Dithane M-45, Rovral 50WP, Bavistin 50 WP, Cupravit 50 WP, Proud 250 EC, Champion, Tilt 250 EC, Ridomil Gold, Neem extract, Allamanda 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 50 WP treated plot. The percent plant infection, percent leaf infection, percent Leaf Area Diseased (% LAD) and Percent Disease Index (PDI) were found 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.

Prasad and Barnwal (2004) reported the effects of leaf extracts of *Azadirachta indica, Pongamia pinnata*, *Datura metel*, *Ocimum sanctum* (*Ocimum tenuiflorum*), *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 extract 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 of were the highest in plots sprayed with 20% leaf extract 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.

Tiwari and Srivastava (2004) studies on the efficacy of some plant extracts, i.e. neem (*Azadirachta indica*), eucalyptus (*Eucalyptus globutens* [*Eucalyptus globulus* x *Eucalyptus nitens*]), bougainvillea (*Bougainvillea spectabilis*), mint (*Mentha arvensis*), datura (*Datura alba* [*Datura metel*]), lantana (*Lantana camara*), ramphal (*Annona reticulata*), sitaphal (*Annona squamosa*), mehandi (*Lawsonia inermis*), tulsi (*Ocimum sanctum* [*Ocimum tenuiflorum*]) and ginger (*Zingiber officinale*) extracts against the onion pathogens *Fusarium oxysporum* (damping off and basal rot), *Alternaria porri* (Purple blotch), *Stemphylium vesicarium* (Blight), *Aspergillus niger* (Black mould) and *Sclerotium cepivorum* (white rot) in the laboratory. The antifungal activity of the extracts at 5, 10 and 20% was evaluated by measuring mycelial growth in potato dextrose agar. All extracts exhibited significant antifungal activity. Neem, Mehandi, ginger, lantana and mint inhibited the growth of all pathogens, while bougainvillea, ramphal and sitaphal did not inhibit the growth of *Alternaria porri* and *Fusarium oxysporum*.

Mohan *et al.* (2001) conducted of a field experiment in Tamil Nadu, India in the rabi seasons of 1998 and 1999 to investigate the effects of plant extracts (from *Pithecellobium dulce* and *Prosopis juliflora* leaves), plant oils

(Palmarosa oil at 0.1% and 0.0 5% and neem oil at 3%) and biological control agents (*Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus subtilis*) in controlling leaf blight in onion caused by *Alternaria porri*. The lowest disease percentage was obtained with palmarosa oil at 0.1%, sprayed at the first appearance of disease symptoms and 15 days after the appearance of the disease. This treatment produced yield at 7650 kg/ha, which was higher than the control.

2.5. Effects of Nutrients on the Incidence of Purple Blotch of Onion

Bhonde *et al.* (2001) reported the effects of varying irrigation frequencies and N fertilizer levels on onion cv. Agrifound Dark Redseed production during rabi 1998/99 and 1999/2000 at Nasik, Maharashtra, India. The N fertilizer treatments included: (N_1) 80 kg N/ha applied in 2 splits, 50% at planting and 50% at 45 days after planting (DAP); (N_2) 100 kg N/ha applied in 2 splits, 50% at planting and 50% at 45 DAP; and (N_3) 120 kg N/ha applied in 3 splits, 33% at planting, 33% at 45 DAP and 33% at 60 DAP. No significant differences were observed as a result of varying N levels.

An experiment was conducted at Manikgonj during 1996-97 with different components (fertilizers, micronutrients and fungicides). Five treatments were taken. Incidence of disease was recorded following a 0-5 scale. All the treatments showed significant effect in reducing the incidence of disease and producing higher seed yield over control. The lowest incidence (1.46%) was recorded in the treatment T_2 (N_{150}, P_{200}, K_{100}, S_{20}, Zn_4, B_1 + Bulb 70 nos./kg + Rovral @ 0.2% + Ridomil @ 0.2%).

An experiment was conducted at BARI, Gazipur during 1995-96 different components fertilizers, micronutrients and fungicides. Ten treatments were applied. At the treatments showed significant effect in reducing the incidence of disease over control. The lowest incidence (9.33%) was recorded in treatment T_3 Rovral (.02%). The highest yield of seed (712.00 gm/plot) was recorded in Rovral (.02%) + Ridomil MZ-72 (.02%) + NPKS + Zn + B + 70 bulbs/kg + 15 cm plant spacing + cowdung followed by T_5 (670.07 gm/plot), T_7 (635.00 gm/plot) and T_3 (620.67 gm/plot).

Bhargava and Sing (1992) worked on the effect of nitrogenous fertilizers and trace elements on the severity of Alternaria blight of bottle gourd. The incidence of blight (*Alternaria cucumerina*) on bottle gourd increased with the amount of nitrogen fertilizer applied to the soil. The maximum disease intensity (58.7%) was recorded after N application as urea at 100 kg N / ha. Lower doses of urea fertilizer also induced higher disease intensity than the other forms of N fertilizer assessed (ammonium sulfate and calcium ammonium nitrate). Foliar sprays with 2.5 or 25 ppm Cu, B or Zn significantly reduced disease intensity, while 25 ppm Fe and Mn were phytotoxic. Zn and Cu provided good disease control at each concentration tested (25, 2.5 and 0.25 ppm) compared with an untreated control.

Mondal *et al.* (1989) reported that the higher doses of N (150 or 200 kg urea/ha) in combination with higher doses of P (Triple superphosphate) 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, increasing yields by up to 234% over control.

Chapter 3

Materials and Methods

CHAPTER – 3

MATERIALS AND METHODS

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.

3.1.1. Collection of botanicals

Leaf of Allamanda and Neem were collected from the Sher-e-Bangla Agricultural University campus (Plate 1).

The botanicals used in this study

Common name	English name	Scientific name	Plant parts used
Allamanda	Allamanda	*Allamanda cathartica*	Leaf
Neem	Margosa	*Azadirachta indica*	Leaf

3.1.2. Collection of chemicals

All Chemicals (fungicides) viz. Cupravit 50 WP, Rovral 50 WP, Dithane M-45, Rodimil Gold MZ-72 and Bavistin 50 WP were collected from Krishibid Nursery, Mirpur-11, Dhaka, Bangladesh.

The chemicals (fungicides) used in this study

Trade Name	Chemical Name	Active ingredient
Cupravit 50 WP	Copper oxychloride ($CuOCl_2$)	50 % Copper oxy-chloride
Rovral 50 WP	3-(3,5 dichlorophenyl)-N-(1 methyl ethyl)-2,4 dioximidazo-lidene carboxamide -$(C_{13}H_{13})_3N_3Cl_2$	50 % Iprodione
Dithane M-45	Manganese ethylene bisdi-thiocarbamate ($C_4H_6N_2S_4$)	80 % Mancozeb
Rodimil Gold MZ-72	N-(2,6 dimethyl phexyl)-N-(methoxyacetyl)-alanine methyl ester ($C_{14}H_2NO_4$)	72 % Metalaxil
Bavistin 50 WP	Methyl-2-benzimidazole carbamate	50 % Carbendazim

Allamanda (*Allamanda cathartica*)

Neem (*Azadirachta indica*)

Plate 1. Botanicals used to test antifungal activity against *Alternaria porri*

3.1.3. Preparation of leaf extracts solution

The extracts were prepared by using the method of Ashrafuzzaman and Hossain, 1992. For preparation of extracts, collected leaves were weighted in an electric balance and then washed in water. After washing the big leaves were cut into small pieces. For getting extract, weighted plant parts were blended in an electric blender and then required amount of distilled water was added into the jug of the blender. The pulverized mass was squeezed through 3 folds of steam sterilized cotton cloth. For getting 1:6 (w/v) ratio, 600 ml of distilled water was added with 100 g leaves.

3.1.4. Preparation of chemical 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 and 1 gm/liter of Bavistin 50 WP for preparation of solution with respective concentration.

3.1.5. Isolation of *Alternaria porri*

Alternaria porri was isolated from onion seed by using the blotter method of ISTA. In this method 3 layers of blotter was soaked in sterilized water and placed at the bottom of the sterilized plastic petridish. Then 25 seeds were plated on the blotting paper (Whatman) in a petridish maintaining equal distance and covered with the lid. The petridish were incubated in an air cooled room at about 20° C temperature for 7 days maintaining 12 hr/12 hr alternative cycle of NUV light and darkness in the laboratory. After 7 days of incubation the seed were observed under the stereoscopic binocular microscope and the presence of *Alternaria porri* was confirmed by preparing temporary slides and examined under the compound microscope (Plate 2) with the help of relevant taxonomic books (Booth, 1971 and Ellis 1971). Then the conidia of *Alternaria porri* were carefully picked up and transferred on to fresh PDA plate and incubated at 20° C for 7 days. The pure culture of *Alternaria porri* was preserved in refrigerator at 4° C for future use.

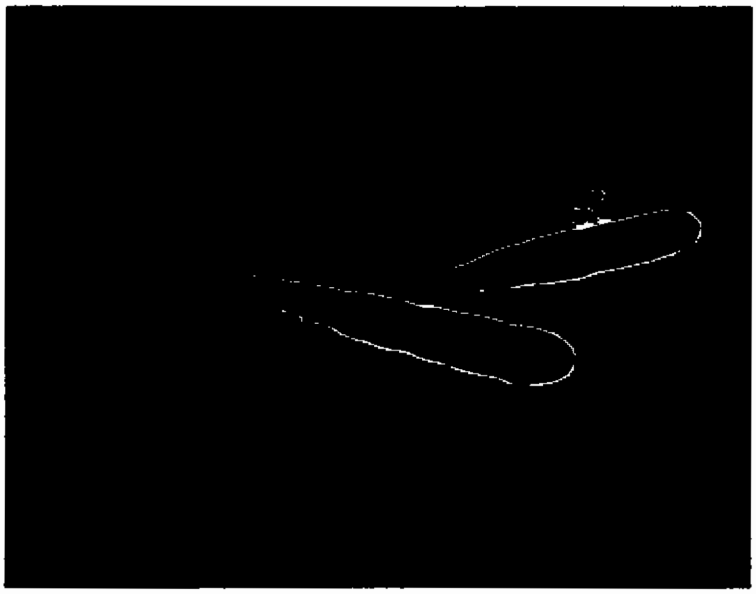


Plate 2. Conidia of *Alternaria porri* (X 750)

3.1.6. Bioassay of plant extracts and fungicides against *Alternaria porri*

3.1.6.1. 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 of plant extract & 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 or plant extracts. 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 and micronutrients (Gypsum, Zinc oxides and Boric acids) was conducted in the Rabi season (November, 2007 to March, 2008) to control the Purple Blotch of Onion for seed production.

3.2.1. Experimental site

The Research was conducted at the experimental field 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. The land was medium high and well drained.

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.

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. The later period is favorable for onion cultivation.

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 site 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:

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 & 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) were 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. 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/200 m^2 land)	Rest installments (kg/200 m^2 land)		
			1st	2nd	3rd
Urea	320	1.6	1.6	1.6	1.6
TSP	415	8.3	-	-	-
MP	168	3.36	-	-	-
Gypsum	100	2	-	-	-
ZnO	5	0.1	-	-	-
Boric powder	5	0.1	-	-	-

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 : 200 m^2
- No. of plot : 27
- Plot size : $(2 \times 1.5)\ m^2$
- Block to block distance : 0.75 m
- Plot to boundary distance : 1 m
- Plot to plot distance (Length wise) : 0.5 m
- Plot to plot distance (Breath wise) : 1 m
- Plant to plant spacing : 15 cm
- Row to row spacing : 25 cm

3.2.7. Treatments of experiment

Altogether there were 9 different treatments as stated bellow:

Treatments

T_1 = Allamanda leaf extract-1:6 (Bulb treatment + Foliar spraying) + micronutrients * (Applied as basal dose)

T_2 = Neem leaf extract-1:6 (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_3 = Cupravit 50 WP @ 0.7% (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_4 = Rovral 50 WP @ 0.2% (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_5 = Dithane M-45 @ 0.45% (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_6 = Ridimil Gold MZ-72 @ 0.2% (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_7 = Bavistin 50 WP @ 0.1% (Bulb treatment + Foliar spraying) + micronutrients (Applied as basal dose)

T_8 = Only micronutrients (Applied as basal dose)

T_9 = Untreated Control (Bulb treated and foliar spraying with plain water and no micronutrient)

* Micronutrients are Gypsum, Zinc oxide and Boric acid.

3.2.8. Collection of onion bulb

The experiment was conducted with a local onion variety Taherpuri, collected from Machpara bazaar, Rajbari. This Onion variety is most popular in Bangladesh and its quality is more standard than other local or high yielding variety.

3.2.9. Bulb treatment

According to the spacing of sowing bulb in the experiment, 198 bulbs were required for each of the treatment for 3 unit plots. So, 198 bulbs were treated for each treatment with the respective plant extracts and fungicidal solution by dipping the bulbs in the suspension for 20 minutes. The bulbs were than drained off, shade dried and sown in the field without delay.

3.2.10. Planting date of onion bulb

Bulbs of onion were planted on 1st November, 2007 maintaining row spacing (30 cm) and bulb spacing (15 cm) in each plot as per experimental treatments.

3.2.11. Planting procedure

Before planting, the onion bulbs were treated with different plant extracts and fungicides. The bulbs were treated with plain water for control treatment.

3.2.12. Intercultural operations

3.2.12.1. Irrigation

Irrigation was given as per requirement of the land with regular intervals. First irrigation was given after 7 days of sowing of bulbs and continued up to harvesting of crop. Water cane with perforated mouthpiece was used for soft discharged of water. Irrigation was generally followed the each weeding of the crops.

3.2.12.2. Weeding and mulching

Weeding and mulching were done as and when required to keep the crop free from weeds and for better soil aeration and conservation of soil moisture. The common weeds were Dubra grass (*Cynodon dactylon*), Mutha (*Cyperus rotundus* L.) and Bathua (*Chenopodium album* L.). Weeding was done carefully keeping the delicate young plants undisturbed.

3.2.13. Field spray of fungicides and plant extracts

Fungicides and plant extracts spraying were started from 34 days after bulb planting. Totally 8 spraying were done at 7 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.

3.3. Isolation and identification of pathogens from leaf tissue

Isolation and identification of pathogen were made in two ways-

3.3.1. By direct inspection.

3.3.2. By inoculating diseased tissues on Potato Dextrose Agar (PDA) medium.

3.3. 1. By direct inspection

The diseased leaves of onion plants were collected and kept in polythene bags and tagged. The samples were than taken to the seed health laboratory of the Department of Plant Pathology, SAU, Dhaka. Then slides were prepared from the diseased samples, observed under microscope and identify the pathogen according to CMI Description (Vol. No. 338).

3.3.2. By growing on potato dextrose agar (PDA) medium

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 to CMI Description (Vol. No. 338).

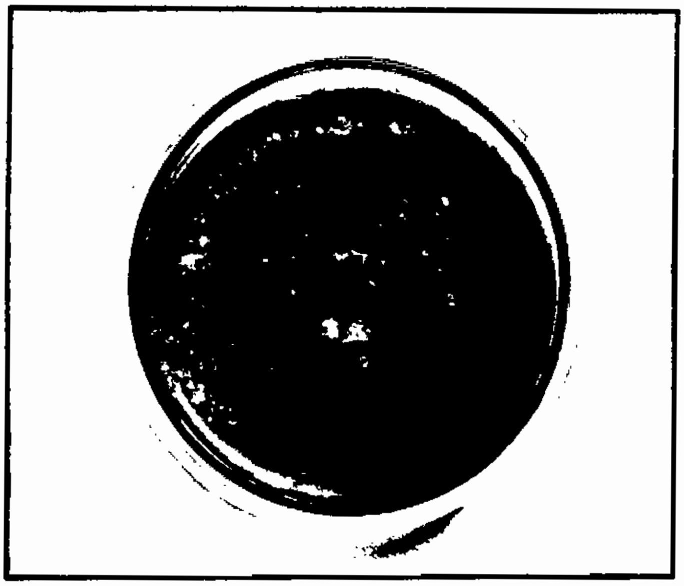


Plate 3. Pure culture of *Alternaria porri*

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 contained up to maturity with 7 days intervals. Data were collected on the following parameters:

3.4.1. Number of infected leaf per plant

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

Calculation of disease incidence

The percent disease incidence was calculated using the following formula (Wheleer, 1969):

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

3.4.2. Leaf area diseased (LAD)

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

3.4.3. 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):

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

3.4.4. 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.

3.4.5. Estimation of PDI

Diseased scoring scale '0 – 5' was used to estimate the disease severity (PDI) of purple blotch of onion for each unit plot under each treatment (Plate 4 & 5). Percent leaf area diseased (LAD) and stalk area diseased (SAD) were used '0 – 5' disease scoring scale (Sharma, 1986) for estimation of PDI (Leaf & Stalk).

0 = No disease symptoms

1 = A few spots towards the tip, covering less than 10% leaf/stalk area

2 = Several dark purplish brown patches covering 10% to less than 20% leaf/stalk area

3 = Several patches with paler outer zone, covering 20% to 40% leaf/stalk area

4 = Long streaks covering 40% to 75% leaf/stalk area or breaking of leaf/ stalk

5 = Complete blotching of leaf / stalk

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

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

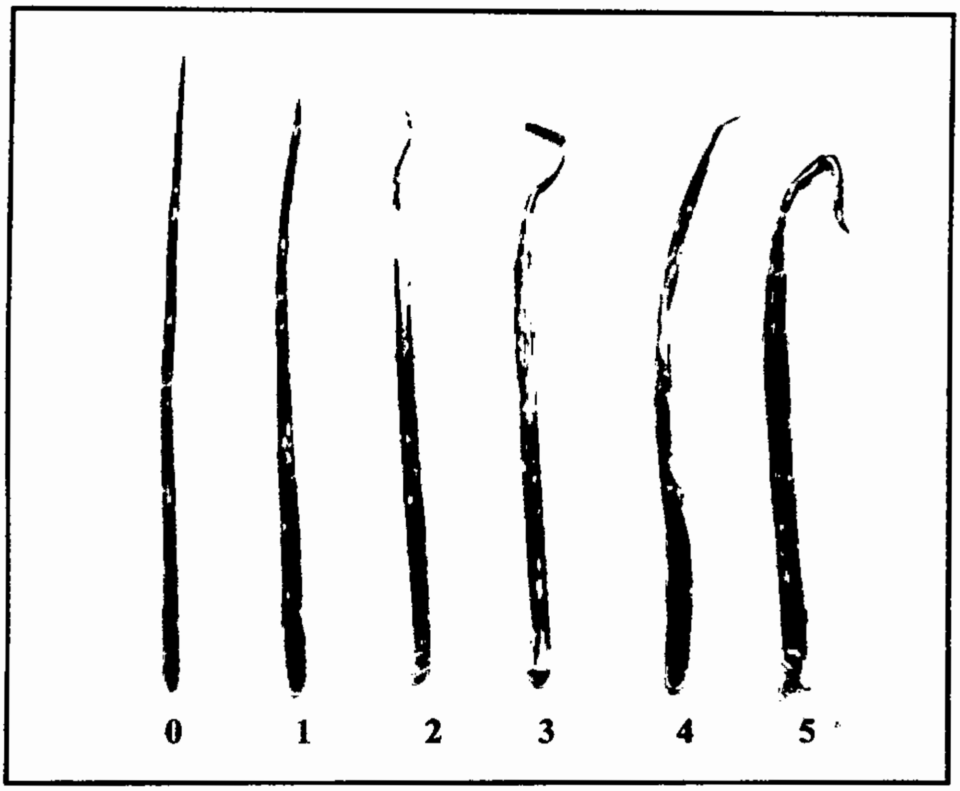


Plate 4. Purple blotch severity of onion leaf showing '0 – 5' rating scale

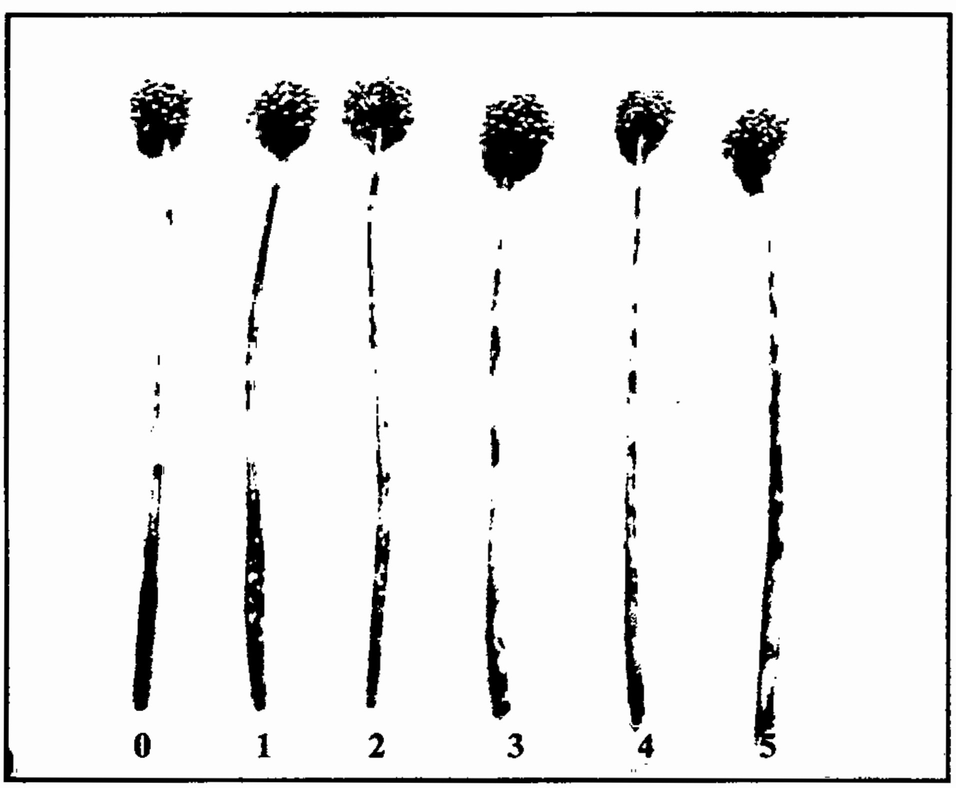


Plate 5. Purple blotch severity of onion seed stalk showing '0 – 5' rating scale

3.4.6. Harvesting of seeds and data collection

Onion seeds were harvested on 28^{th} February 2008 at which the umbel had been showing the sign of ripen and black seeds were seen from outside by umbels eruption. Cutting stalks remaining 2 cm collected the umbels. Then drying, threshing winnowing and cleaning were done. Later weight of seed for each unit plot under each treatment was taken separately and recorded.

3.4.7. Number of umbel per plot

Numbers of umbels per plot were recorded.

3.4.8. Diameter of umbel

Diameter of the ten selected umbel in every unit plot under each treatment were measured and recorded.

3.4.9. Weight of 1000 seed per plot of different treatments

Weight of 1000 seeds per plot was recorded individually by digital balance (0.001 g) for each treatment.

3.4.10. Seed yield

Seed yield was recoded under each treatment and converted in kg/ha.

3.5. Data analysis

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

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.

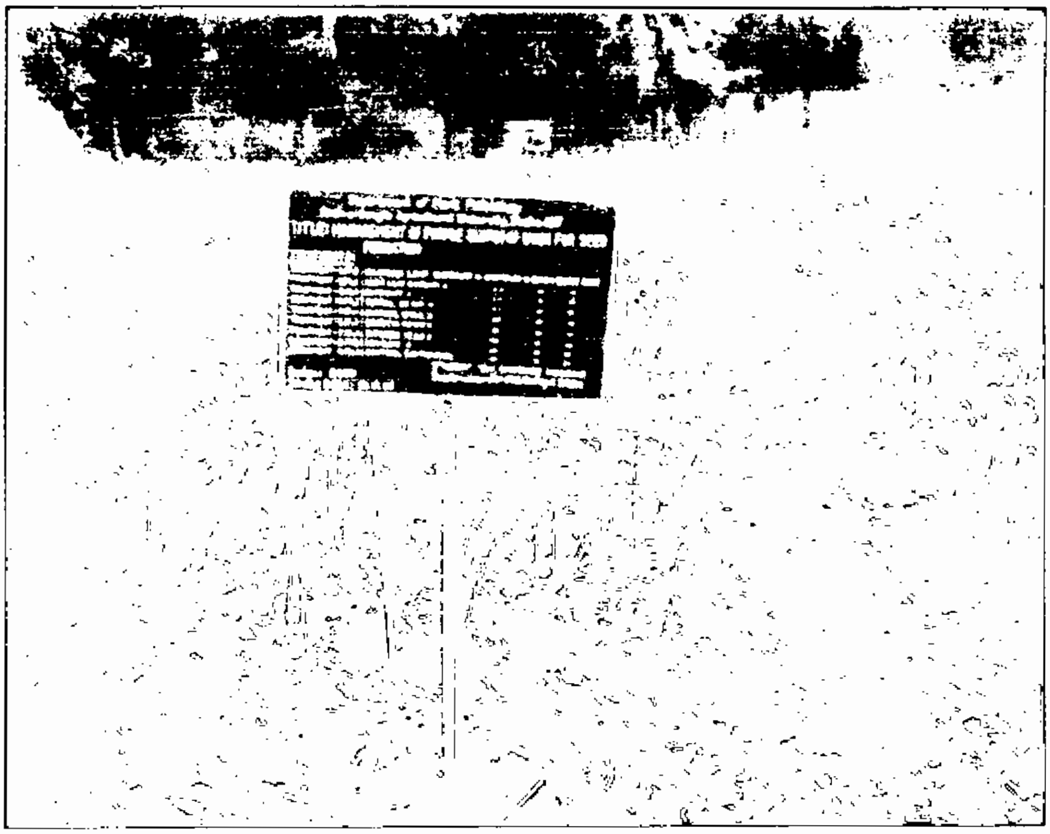


Plate 6. Photograph showing the field view of the experiment

Plate 7. Photograph showing typical symptom of Purple blotch of onion on leaf

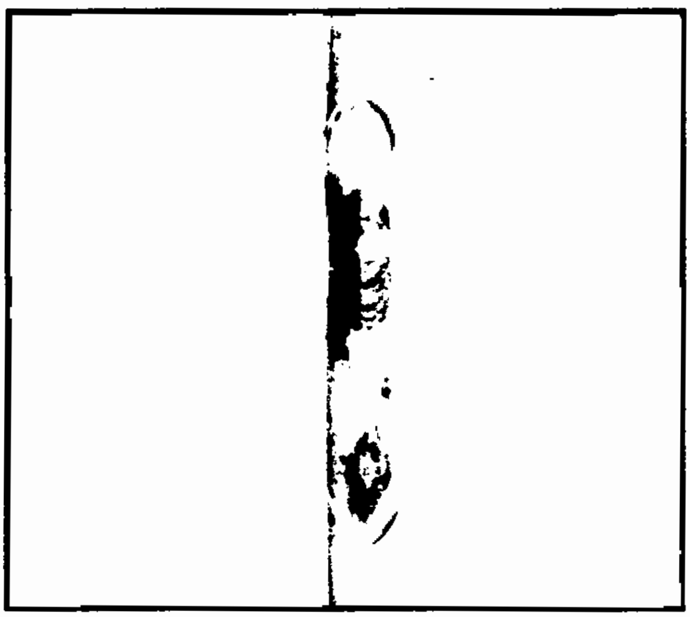


Plate 8. Photograph showing the typical symptom of purple blotch of onion on seed stalk

Chapter 4

Results

CHAPTER – 4
RESULTS

The present experiment was conducted for the management of purple blotch of onion for seed production through some fungicides, botanicals and micronutrients. 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 characters were done (Appendix III-X). The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1. Laboratory experiment

4.1.1. Effect of different fungicides and botanicals on radial mycelial growth of *Alternaria porri in-vitro* (Poisoned food technique)

Effect of fungicides and botanicals on radial mycelial growth of *Alternaria porri* is shown in Table 1. Fungicides have profound effect on inhibition of mycelial growth of the fungus. All the tested fungicides significantly reduced radial mycelial growth of the fungus. The effect of botanicals to reduce the mycelial growth of the fungus was not promising. Radial mycelial growth for all the tested fungicides and botanicals ranged from 2.733 cm to 8.873 cm in 15 DAI (Table 1). Significantly the lowest radial mycelial growth (2.733 cm) of *Alternaria porri* was recorded in treatment T_4 (Rovral 50 WP) and the highest radial mycelial growth (8.873 cm) was recorded in Treatment T_8 (Control) at 15 DAI. Treatment T_6 (Ridomil Gold MZ-72) was also found promising in reducing the mycelium growth of the fungus in the laboratory. Between two botanicals, Neem leaf extract gave better result than Allamanda leaf extract.

Table 1. Effect of different fungicides and botanicals on radial mycelial growth of *Alternaria porri in-vitro* (Poisoned food technique) at different days after inoculation (DAI)

Treatments	Radial mycelial growth of *Alternaria porri*				
	Different days after inoculation (DAI)				
	3 DAI	6 DAI	9 DAI	12 DAI	15 DAI
T_1	3.11 b	3.93 b	4.83 b	5.99 b	6.98 b
T_2	2.49 c	3.62 c	4.70 b	5.79 c	6.63 c
T_3	1.22 d	2.15 d	3.34 c	4.35 d	5.19 d
T_4	0.58 f	1.25 g	1.78 f	2.33 g	2.73 g
T_5	1.19 d	1.72 f	3.43 c	3.84 e	4.63 e
T_6	0.89 e	1.09 h	2.14 e	3.30 f	4.07 f
T_7	1.17 d	1.98 e	2.74 d	3.90 e	5.08 d
T_8	3.28 a	4.19 a	5.62 a	6.78 a	8.87 a
LSD $_{(0.05)}$	**0.14**	**0.15**	**0.40**	**0.18**	**0.24**
CV (%)	**4.38**	**3.26**	**6.23**	**2.27**	**2.46**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v)

T_2 = Neem leaf extract-1:6 (w/v)

T_3 = Cupravit 50 WP @ 0.7%

T_4 = Rovral 50 WP @ 0.2%

T_5 = Dithane M-45 @ 0.45%

T_6 = Ridomil Gold MZ-72 @ 0.2%

T_7 = Bavistin 50 WP @ 0.1%

T_8 = Control (Plain water)

4.2. Field experiment

4.2.1. Effect of different fungicides, botanicals and micronutrients on percent (%) infected leaf regarding purple blotch of onion

The effect of different fungicides, botanicals and micronutrients that were used as treatments for the management of purple blotch of onion in this trial were observed and % infected leaf recorded at 34, 41, 48, 55, 62, 69, 76 and 83 DAP are shown in Table 2. Percent infected leaf did not vary significantly at 34 DAP. With the advancement of the effect of different treatments become distinct and were differed significantly. At 83 DAP the treatments effect in respect of % infected leaf differed significantly. The lowest infected leaf was recorded for the treatment T_4 (54.33%) followed by treatment T_6 (64.57%), T_5 (67.48%) and T_3 (67.77%) while the highest infected leaf was recorded for the treatment T_9 (81.93%). In case of micronutrients, treatment T_8 showed significantly better performance in controlling purple blotch of onion compared to control. Between the botanicals, Neem leaf extract (T_2) gave better result for controlling purple blotch of onion. It was noted that the percent infected leaf was gradually increased with the age of the crop and increasing rate was much slower in T_4, T_6, and T_5 treated plot compared to control.

4.2.2. Effect of different fungicides, botanicals and micronutrients on percent (%) leaf area diseased (LAD) of purple blotch of onion

The disease severity of purple blotch of onion in respect of % LAD caused by *Alternaria porri* differed significantly due to the application of different fungicides, botanicals and micronutrients under field condition (Table 3). The effect of the treatments differed sharply with the increase of time in reducing % LAD of purple blotch of onion. The results showed that at different DAP treatment T_4 performed better in suppressing % LAD followed by treatments T_6, T_5, and T_3. Again Neem leaf extract (T_2) had significantly better effect compared to Allamanda leaf extract (T_1) in controlling purple blotch of onion.

Table 2. Effect of different fungicides, botanicals and micronutrients on % infected leaf of purple blotch of onion at different days after planting (DAP)

Treatments	% Infected leaf							
	Different days after planting (DAP)							
	34 DAP	**41 DAP**	**48 DAP**	**55 DAP**	**62 DAP**	**69 DAP**	**76 DAP**	**83 DAP**
T_1	29.70 a-c	42.36 b	52.42 bc	64.90 b	69.81 b	72.26 a	76.03 a	77.73 b
T_2	28.41 a-c	41.74 bc	51.07 cd	58.48 c	63.07 c	65.42 bc	68.34 c	71.35 d
T_3	27.64 a-c	40.00 bc	48.64 c-e	55.00 d	58.39 de	61.54 d	65.70 c	67.77 e
T_4	23.51 c	35.67 c	40.92 f	45.17 f	48.53 f	50.33 e	52.79 e	54.33 g
T_5	33.65 a	40.81 bc	47.32 de	56.60 cd	59.62 d	63.12 cd	66.34 c	67.48 e
T_6	25.89 bc	35.79 c	45.30 e	51.06 e	55.47 e	59.86 d	62.65 d	64.57 f
T_7	29.56 a-c	41.24 bc	49.71 cd	57.43 cd	64.24 c	68.29 b	71.75 b	74.23 c
T_8	32.19 ab	46.17 ab	55.41 b	65.16 b	69.68 b	72.33 a	77.34 a	78.99 b
T_9	33.65 a	48.72 a	60.62 a	68.67 a	73.33 a	73.62 a	78.02 a	81.93 a
LSD (0.05)	**5.91**	**5.81**	**4.08**	**2.51**	**3.19**	**3.12**	**2.72**	**2.46**
CV (%)	**11.63**	**8.11**	**4.69**	**2.50**	**2.95**	**2.77**	**2.29**	**2.00**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

Table 3. Effect of different fungicides, botanicals and micronutrients on % leaf area diseased (LAD) of purple blotch of onion at different days after planting (DAP)

Treatments	% Leaf area diseased (LAD) of onion							
	Different days after planting (DAP)							
	34 DAP	41 DAP	48 DAP	55 DAP	62 DAP	69 DAP	76 DAP	83 DAP
T_1	16.87 bc	20.25 bc	24.03 c	27.59 c	32.01 c	36.89 c	44.79 c	54.14 c
T_2	14.77 cd	17.41 cd	20.91 cd	23.89d	28.86 cd	31.87 d	39.90 d	48.92 d
T_3	14.44 cd	16.87 cd	20.10 cd	23.94 d	27.21 d	31.13 d	39.59 d	47.21 d
T_4	11.96 d	14.53 d	16.84 d	19.37 e	21.66 e	25.17 e	27.18 f	29.17 f
T_5	14.09 cd	16.76 cd	19.61 d	23.04 d	26.05 d	32.15 d	37.33 de	41.99 e
T_6	12.54 d	15.20 d	17.98 d	22.07 de	27.83 d	32.68 cd	36.38 e	40.39 e
T_7	14.25 cd	17.04 cd	20.46 cd	24.16 d	28.76 cd	33.43 cd	39.15 de	45.88 d
T_8	19.05 b	23.35 b	28.15 b	33.18 b	38.54 b	44.24 b	54.75 b	65.63 b
T_9	24.58 a	29.65 a	35.19 a	38.25 a	46.11 a	52.31 a	61.34 a	71.42 a
LSD (0.05)	**2.92**	**3.43**	**3.66**	**3.04**	**3.55**	**4.25**	**2.96**	**3.35**
CV (%)	**10.66**	**10.43**	**9.37**	**6.70**	**6.67**	**6.91**	**4.05**	**3.95**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

4.2.3. Effect of different fungicides, botanicals and micronutrients on PDI (Leaf) of purple blotch of onion at different DAP

There were significant differences among the effect of fungicides, botanicals and micronutrients on Percent Disease Index (PDI-leaf) of purple blotch of onion at different DAP compared to control (Table 4). Remarkable differences among the effect of different treatments in reducing the PDI (leaf) were observed at the advanced growth stage of the crop. At 83 DAP, the effectiveness of the treatments in reducing PDI of purple blotch of onion, treatment T_4 showed the highest performance followed by treatments T_6, T_5, and T_3. The rest of the treatments showed significantly similar result but better than control. The result showed that with increasing the age of onion the PDI was increased but in every cases, control treatment showed the highest PDI.

4.2.4. Effect of different fungicides, botanicals and micronutrients on percent (%) infected stalk of purple blotch of onion

Different fungicides, botanicals and micronutrients that were used as treatments for the management of purple blotch of onion in this trial were found effective significantly in reducing % infected stalk recorded at 76, 83, 90, 97, 104, 111, 118 and 125 DAP (Table 5). Percent infected stalk did not vary significantly at 76 DAP. But a remarkable variation was noticed for % stalk infection from 83 DAP and the variation become gradually widen with the day come among the treatment compared to control. At 125 DAP the lowest infection (67.53%) was found in treatment T_4 followed by T_6 (72.50%), T_5 (78.10%). The highest stalk infection (100.00%) was recorded in control treatment (T_9) which was similar to treatment T_8. Between the botanicals, Neem extract along with micronutrient (T_2) showed better performance than Allamanda extract (T_1) in controlling purple blotch of onion. It was noted that the percent stalk infection was gradually increase with the age of the crop and increasing rate was much slower in T_4, T_6, and T_5 treated plot compared to control.

Table 4. Effect of different fungicides, botanicals and micronutrients on PDI (Leaf) of purple blotch of onion at different days after planting (DAP)

Treatments	Percent disease index (PDI-leaf) of onion							
	Different days after planting (DAP)							
	34 DAP	**41 DAP**	**48 DAP**	**55 DAP**	**62 DAP**	**69 DAP**	**76 DAP**	**83 DAP**
T_1	41.33 c	51.33 b	57.33 b	60.00 bc	60.00 c	66.00 c	74.67 b	80.00 b
T_2	40.00 cd	44.00 c	52.00 c	59.33 bc	60.00 c	61.33 d	66.67 cd	80.00 b
T_3	38.67 cd	40.67 cd	45.33 de	57.33 c	59.33 c	60.00 d	68.00 c	80.00 b
T_4	36.00 d	38.67 d	41.33 e	48.00 d	53.33 d	57.33 d	59.33 e	60.67 e
T_5	40.00 cd	41.33 cd	47.33 cd	58.00 c	60.00 c	60.00 d	64.00 d	73.33 c
T_6	40.00 cd	43.33 c	49.33 cd	60.00 bc	60.00 c	60.00 d	64.00 d	69.33 d
T_7	40.00 cd	40.67 cd	50.67 c	60.00 bc	60.00 c	60.67 d	66.67 cd	79.33 b
T_8	49.33 b	52.67 b	58.67 b	63.33 b	69.33 b	72.00 b	79.33 a	80.00 b
T_9	55.33 a	61.33 a	66.00 a	71.33 a	80.00 a	78.67 a	80.00 a	86.00 a
LSD (0.05)	**3.86**	**4.22**	**4.93**	**4.45**	**4.72**	**3.65**	**3.45**	**3.55**
CV (%)	**5.28**	**5.30**	**5.48**	**4.26**	**4.37**	**3.29**	**2.88**	**2.68**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

Table 5. Effect of different fungicides, botanicals and micronutrients on % infected stalk of purple blotch of onion at different days after planting (DAP)

Treatments	% Infected stalk of onion							
	Different days after planting (DAP)							
	76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
T_1	6.13 a	18.46 b	29.48 bc	40.90 b	46.51 b	62.48 b	77.56 bc	90.94 b
T_2	6.33 a	14.36 bc	26.29 c	34.88 c	44.38 bc	57.89 c	73.94 cd	85.98 c
T_3	6.12 a	12.28 c	22.06 d	30.50 d	39.61 d	50.98 d	70.05 de	83.81 c
T_4	5.23 a	12.47 c	13.48 f	17.78 f	21.34 e	36.91 f	47.83 g	67.53 f
T_5	5.47 a	10.67 c	17.34 e	27.99 d	41.84 cd	49.48 df	64.19 ef	78.10 d
T_6	6.11 a	10.14 c	15.52 ef	20.90 e	38.72 d	45.93 e	59.26 f	72.50 e
T_7	5.50 a	11.37 c	21.64 d	28.75 d	40.54 d	51.37 d	65.96 e	81.45 cd
T_8	6.67 a	23.36 a	32.52 ab	45.32 a	54.43 a	65.57 ab	82.60 ab	100.00 a
T_9	6.65 a	25.06 a	33.85 a	47.15 a	56.84 a	66.75 a	85.25 a	100.00 a
LSD (0.05)	**1.31**	**4.30**	**3.55**	**2.46**	**3.17**	**3.86**	**5.63**	**4.62**
CV (%)	**12.51**	**16.17**	**8.70**	**4.34**	**4.29**	**4.12**	**4.67**	**3.16**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

4.2.5. Effect of different fungicides, botanicals and micronutrients on percent (%) Stalk Area Diseased (SAD) of purple blotch of onion

The disease severity of purple blotch of onion in respect of % Stalk Area Diseased (SAD) caused by *Alternaria porri* suppressed significantly due to the application of different fungicides, botanicals and micronutrients under field condition (Table 6). The variations among the treatments in respect of reducing % stalk Area Diseased (SAD) were not remarkable at the early stages of stalk formation. But with the following days, the % stalk Area Diseased (SAD) gradually increased irrespective of different DAP, though the increasing rate of % SAD was much slower in case of treatment T_4, T_6, T_5, and T_7 showing their positive performance. At 125 DAP, the lowest % SAD (11.11%) was recorded in T_4 followed by T_6 (17.51%), T_5 (20.67%), T_7 (21.29%) and T_3 (21.54%). The highest % SAD (51.10%) was recoded in control irrespective of DAP. Between two botanicals, the performance of Neem extract along with micronutrient was significantly better than Allamanda extract. The effect of micronutrient alone was not so promising but statistically better than control.

4.2.6. Effect of different fungicides, botanicals and micronutrients on PDI (Stalk) of purple blotch of onion

There were significant differences among the effect of fungicides, botanicals and micronutrients on Percent Disease Index (PDI-stalk) of purple blotch of onion compared to control (Table 7). At 76 DAP the highest PDI was observed for control treatment T_9 (4.00%) and T_8 (4.00%) while the rest of the treatments showed statistically similar and better performance in reducing the severity of purple blotch of onion compare to control. The variations among the treatments regarding the controlling of purple blotch severity of onion become conspicuous with advancement of the growth stage of the crop. The effects of different treatments become prominent in 125 DAP. At 125 DAP; the highest performance of treatment i.e. the lowest PDI-stalk (28.00%) was recorded in case of treatment T_4 followed by treatment T_6, T_5 and T_7.

Table 6. Effect of different fungicides, botanicals and micronutrients on % stalk area diseased (SAD) of purple blotch of onion at different days after planting (DAP)

Treatments	% Stalk area diseased (SAD) of onion							
	Different days after planting (DAP)							
	76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
T_1	0.18 b	0.70 b	1.69 b	3.46 b	6.27 b	9.48 b	17.52 c	28.81 c
T_2	0.23 b	0.57 bc	1.157 c	3.26 b	5.93 b	8.31 c	14.25 d	22.96 d
T_3	0.22 b	0.43 cd	1.48 bc	2.65 c	4.43 c	6.84 d	12.54 e	21.54 de
T_4	0.13 b	0.28 d	0.68 d	1.03 e	1.71 e	2.80 f	5.384 g	11.11 g
T_5	0.21 b	0.53 bc	1.35 bc	2.43 cd	4.05 c	6.41 d	13.32 df	20.67 e
T_6	0.17 b	0.52 c	1.26 c	1.95 d	3.10 d	5.01 e	10.22 f	17.51 f
T_7	0.18 b	0.56 bc	1.34 bc	2.61 c	4.31 c	6.82 d	12.06 e	21.29 de
T_8	0.34 a	1.12 a	2.57 a	5.90 a	10.51 a	15.98 a	29.45 b	46.72 b
T_9	0.36 a	1.25 a	2.76 a	6.10 a	10.48 a	15.92 a	31.74 a	51.10 a
LSD (0.05)	**0.10**	**0.16**	**0.38**	**0.48**	**0.78**	**0.85**	**1.37**	**1.10**
CV (%)	**25.36**	**13.86**	**13.83**	**8.53**	**7.96**	**5.72**	**4.85**	**4.29**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

Table 7. Effect of different fungicides, botanicals and micronutrients on PDI (Stalk) of purple blotch of onion at different days after planting (DAP)

Treatments	Percent Disease Index (PDI-stalk) of onion							
	Different Days After Planting (DAP)							
	76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
T_1	2.00 b	4.67 ab	6.00 b	12.00 b	18.67 b	24.67 b	39.33 b	54.00 c
T_2	2.67 b	4.00 bc	6.00 b	10.00 bc	17.33 b	21.33 c	31.33 c	46.00 d
T_3	2.67 b	2.67 cd	5.33 bc	8.67 cd	14.00 c	20.00 cd	28.67 cd	46.00 d
T_4	2.00 b	2.00 d	4.00 c	4.00 e	6.00 e	10.00 f	14.67 e	28.00 f
T_5	2.67 b	3.33 b-d	4.67 bc	8.67 cd	13.33 c	18.00 de	28.67 cd	42.67 d
T_6	2.00 b	3.33 b-d	4.00 c	6.67 d	10.67 d	15.33 e	25.33 d	37.33 e
T_7	2.00 b	3.33 b-d	5.33 bc	8.00 cd	12.67 cd	18.67 cd	31.33 c	42.67 d
T_8	4.00 a	6.00 a	8.67 a	18.00 a	23.33 a	34.00 a	50.00 a	66.67 b
T_9	4.00 a	6.00 a	9.33 a	18.00 a	24.67 a	34.00 a	51.33 a	72.00a
LSD (0.05)	**1.15**	**1.33**	**1.56**	**2.20**	**2.14**	**2.97**	**3.48**	**3.95**
CV (%)	**25.00**	**19.61**	**15.23**	**12.15**	**7.93**	**7.88**	**6.01**	**4.72**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

The highest PDI-stalk (72.00%) was recorded in control (T_9). The Neem extract (T_2) showed better performance (46.00%) than Allamanda extract (T_1) in minimizing PDI-stalk which was statistically identical with T_3, T_5 and T_7. The use of micronutrient failed to show promising performance but statistically better than control regarding % PDI-stalk.

4.2.7. Effect of different fungicides, botanicals and micronutrients on the yield and yield contributing characters of onion

4.2.7.1. Height of onion seed stalk (cm)

The effect of fungicides, botanicals and micronutrients on height of seed stalk of onion was slightly different among the treatments and that ranged from 51.76 cm to 65.63 cm (Table 8). Significantly the highest height of seed stalk (65.63 cm) was recorded under treatment T_4 followed by treatment T_6 (60.14 cm), T_5 (59.63 cm) and T_7 (56.70 cm). The lowest height of seed stalk was recorded under treatment T_9 (51.76 cm) followed by treatment T_8 (54.59 cm). Treatment T_3 (56.43 cm), T_2 (56.40 cm) and T_1 (55.71 cm) showed statistically similar height of seed stalk.

4.2.7.2. Number of onion seed stalk/hill

There were significant differences observed among the effect of fungicides, botanicals and micronutrients on number of onion seed stalk/hill (Table 8). The highest number of onion seed stalk was observed under treatment T_4 (1.540) which is statistically similar to treatment T_6 (1.480). The 3rd highest number of seed stalk was recorded in treatment T_5 (1.383) followed by T_7 (1.313) and T_3 (1.280). Again treatment T_2 (1.193) and T_1 (1.147) showed statistically similar result. The lowest number of onion seed stalk/hill was recorded under treatment T_9 (0.983) which was statistically similar with treatment T_8 (1.060).

Table 8. Effect of different fungicides, botanicals and micronutrients on the yield and yield contributing character of onion

Treatments	Height of onion seed stalk (cm)	No. of onion seed stalk/hill	No. of umbel/plot	Umbel diameter (cm)	Thousand (1000) seed weight (g)	Seed yield (kg/ha)
T_1	55.71 b-d	1.15 d	76.00 d	5.44 de	3.05 ef	470.00 e
T_2	56.40 b-d	1.19 d	79.00 d	5.54 d	3.10 de	480.00 e
T_3	56.43 b-d	1.28 c	85.00 c	5.69 c	3.15 c-e	520.00 d
T_4	65.63 a	1.54 a	102.00 a	6.28 a	3.50 a	650.00 a
T_5	59.63 b	1.38 b	91.67 b	5.97 b	3.27 bc	573.30 b
T_6	60.14 b	1.48 a	98.00 a	6.03 b	3.32 b	590.00 b
T_7	56.70 bc	1.31 bc	87.00 bc	5.72 c	3.18 cd	540.00 c
T_8	54.59 cd	1.06 e	70.00 e	5.37 e	2.96 f	419.30 f
T_9	51.76 d	0.98 e	65.33 e	5.33 e	2.95 f	410.00 f
LSD (0.05)	**4.35**	**0.08**	**4.77**	**0.15**	**0.11**	**16.84**
CV (%)	**4.38**	**3.28**	**3.29**	**1.45**	**1.92**	**1.88**

Note:

T_1 = Allamanda leaf extract-1:6 (w/v) + micronutrients *

T_2 = Neem leaf extract-1:6 (w/v) + micronutrients

T_3 = Cupravit 50 WP @ 0.7% + micronutrients

T_4 = Rovral 50 WP @ 0.2% + micronutrients

T_5 = Dithane M-45 @ 0.45% + micronutrients

T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients

T_7 = Bavistin 50 WP @ 0.1% + micronutrients

T_8 = Only micronutrients

T_9 = Control (No chemicals, botanicals and micronutrients)

* Gypsum @ 100 kg/ha, Zinc oxide (ZnO) @ 5 kg/ha and Boric powder @ 5 kg/ha were used as micronutrients as basal dose.

4.2.7.3. Number of umbel/plot

Different fungicides, botanicals and micronutrients that were used as treatments for controlling purple blotch of onion in this trial were shown statistically different performances for number of umbel/plot (Table 8). The highest number of umbel/plot was recorded under treatment T_4 (102.00) which were statistically similar with treatment T_6 (98.00). The 3rd highest result was observed for treatment T_5 (91.67) followed by treatment T_7 (87.00) and T_3 (85.00). Treatment T_2 (79.00) and T_1 (76.00) were found statistically similar result and the lowest number of umbel/plot was recorded under treatment T_9 (65.33) which was statistically similar with treatment T_8 (70.00).

4.2.7.4. Umbel diameter (cm)

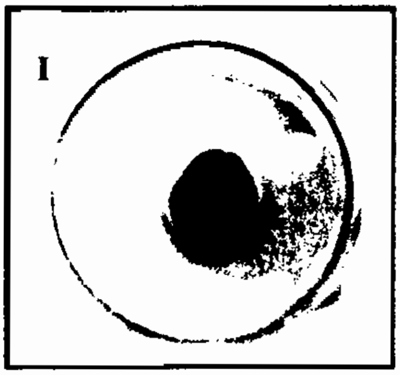
The effect of fungicides, botanicals and micronutrients on umbel diameter (cm) of onion was slightly different among the treatments that ranged from 5.333 cm to 6.277 cm (Table 8). Significantly the highest umbel diameter (6.277 cm) was recorded under treatment T_4 followed by treatment T_6 (6.033 cm), T_5 (5.967 cm), T_7 (5.717 cm) and T_3 (5.690 cm). The lowest umbel diameter was recorded under treatment T_9 (5.333 cm) which was statistically similar with treatment T_8 (5.373 cm).

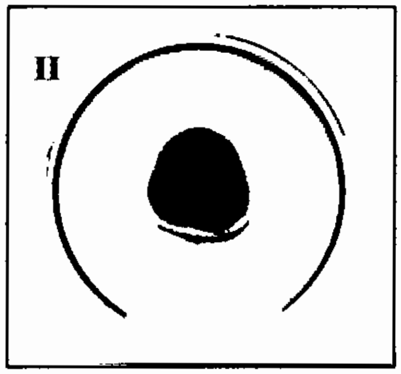
4.2.7.5. Thousand (1000) seed weight (g)

Different treatment such as fungicides, botanicals and micronutrients that were used for controlling purple blotch of onion in this trial showed statistically significant variation for thousand (1000) seed weight (g) of onion (Table 8). The highest thousand seed weight was recorded under treatment T_4 (3.500 g) followed by treatment T_6 (3.307 g), T_5 (3.267 g), T_7 (3.177 g) and T_3 (3.153 g). The lowest thousand seed weight was recorded under treatment T_9 (2.950 g) which was statistically similar with treatment T_8 (2.960 g).

4.2.7.6. Seed yield (kg/ha)

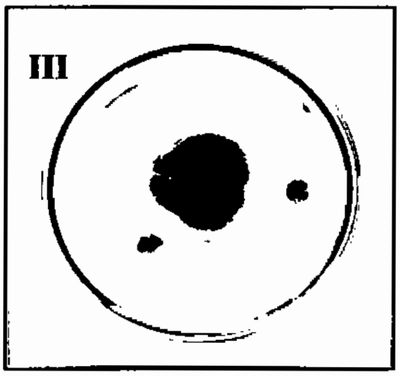
There were significant differences observed among the treatments on onion seed yield (Table 8). The highest onion seed yield was recorded under treatment T_4 (650.0 kg/ha) followed by treatment T_6 (590.0 kg/ha) which was statistically similar with treatment T_5 (573.0 kg/ha). The 3rd highest onion seed yield was recorded under treatment T_7 (540.0 kg/ha) followed by treatment T_3 (520.0 kg/ha). Treatment T_2 (480.0 kg/ha) and T_1 (470.0 kg/ha) showed statistically similar result. The lowest onion seed yield was recorded under treatment T_9 (410.0 kg/ha) which was statistically similar with treatment T_8 (419.3 kg/ha). Between two plant extract, Neem leaf extract + micronutrients given higher seed yield compared to Allamanda leaf extract + micronutrients but the yield difference was insignificant. Among all the treatments, Rovral 50 WP + micronutrients were revealed the best for reducing purple blotch disease of onion and increasing onion seed production followed by Ridomil Gold MZ-72 + micronutrients.

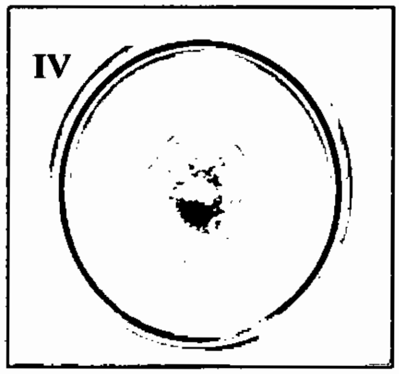




I. 15 days after inoculation (Rovral 50 WP @ 0.2%)

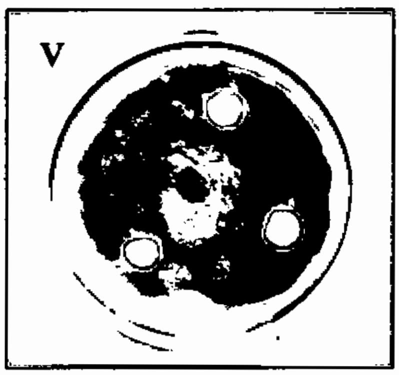
II. 15 days after inoculation (DithaneM-45@ 0.45%)





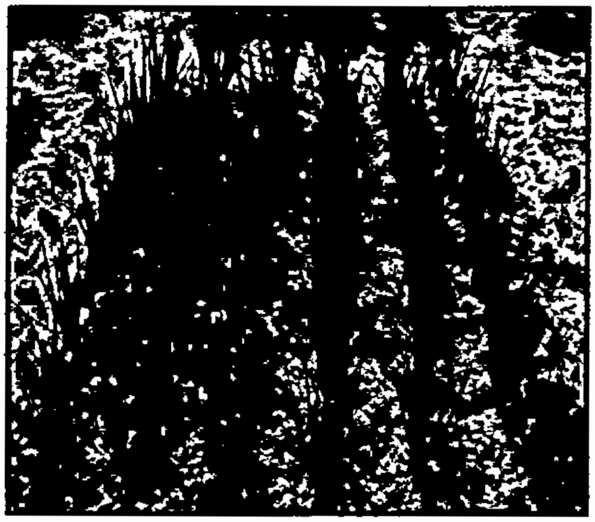
III. 15 days after inoculation (Ridomil Gold MZ-72 @ 0.2%)

IV. 15 days after inoculation (Bavistin 50 WP @ 0.1%)

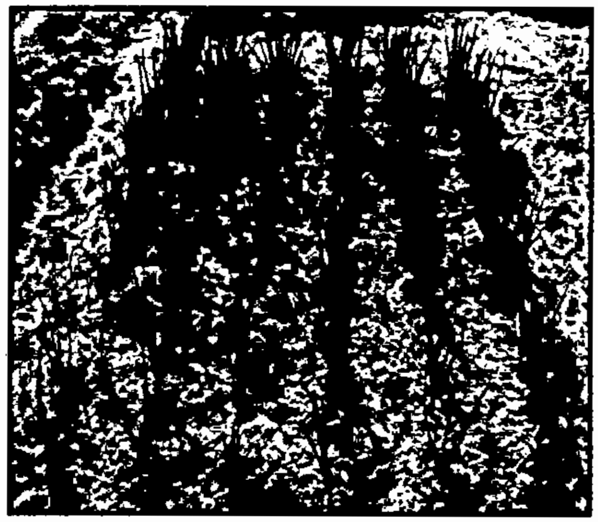


V. 15 days after inoculation (Control- Plain water)

Plate 9. Evaluation of fungicides and plant extracts against *Alternaria porri* by Cup method

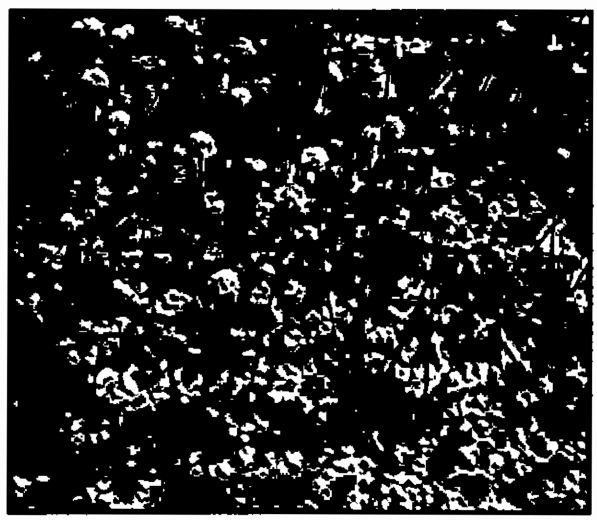


Plot treated with Rovral 50 WP @ 0.2%



Untreated control plot

Plot treated with Rovral 50 WP @ 0.2%



Untreated control plot

Plate 10. Photograph showing the Rovral 50 WP treated plot compared to untreated control plot

Chapter 5

Discussion

CHAPTER – 5
DISCUSSION

5.1. Laboratory experiment

The *in-vitro* test with 8 treatments revealed that all chemical fungicides and botanicals significantly retarded the mycelial radial growth of *Alternaria porri* over control. The lowest radial mycelial growth (2.27 cm) of *Alternaria porri* was recorded in Rovral 50 WP @ 0.2% followed by Ridomil Gold MZ-72 @ 0.2% (4.07 cm). The present findings were well supported by Annon. (2005), Rahman *et al.* (1989) and Islam *et al.*, 2001.

In an experiment conducted at 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) essayed six fungicides against *Alternaria 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 Rovral 50 WP as the most effective fungicide next to score in reducing mycelial growth of *Alternaria porri*.

The Allamanda leaf extract and Neem leaf extract significantly reduced the mycelial growth of *Alternaria porri* in comparison to control where Neem leaf extract performed better than Allamanda leaf extract. The findings corroborate with the findings of Tiwari and Srivastava (2004). They reported that neem extract showed antifungal activity against *Alternaria porri in-vitro*.

5.2. Field experiment

In the present experiment, the effect of treatments in controlling purple blotch of onion caused by *Alternaria porri* was assessed based on the result of percent leaf infection, percent leaf area diseased (% LAD), percent disease index (PDI-leaf), percent infected seed stalk, percent stalk area diseased (% SAD), percent disease index (PDI-stalk), height of seed stalk (cm), number seed stalk/hill, number of umbel/plot, umbel diameter (cm), thousand (1000) seed weight (g) and seed yield (kg/ha).

The effect of Rovral 50 WP @ 0.2% among the chemical fungicides against purple blotch of onion in terms of percent leaf infection, percent leaf area diseased (% LAD) and percent disease index (PDI) was found promising. The lowest percent leaf infection, percent leaf area diseased (% LAD) and percent disease index (PDI-leaf) were found in Rovral 50 WP @ 0.2% + micronutrients while highest percent leaf infection, percent leaf area diseased (% LAD) and percent disease index (PDI) were observed in control treatment. In case of percent infected seed stalk, percent stalk area diseased (SAD) and PDI (stalk), the minimum infections were observed in the Rovral 50 WP @ 0.2% + micronutrients treated plot irrespective of days after planting (DAP). The maximum infections were also noted in control plot at all DAP. The present findings supported by the reports of the previous researches (Ahmed *et al.*, 1999; 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%), Ridomil MZ-72 (0.2%) found to be effective in reducing incidence and severity of purple blotch of onion. Sugha (1995) reported that Ridomil MZ-72 (0.25%) or Iprodione (0.2%) proved highly effective against purple blotch of onion giving 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 dips in carbendazim and thiophanate methyl followed by 4 sprays of Rovral 50 WP found effective against purple blotch of onion. Islam, *et al.* (2001) also reported that Rovral 50 WP showed promising effect in reducing the disease severity of purple blotch of onion.

Between two botanicals, Neem leaf extract gave the better result than Allamanda leaf extract in respect of infected seed stalk, percent stalk area diseased (SAD) and PDI (stalk). The present findings were supported by Prasad and Barnwal (2004). They reported the effects of leaf extracts of *Azadirachta indica, Pongamia pinnata*, *Datura metel*, *Ocimum sanctum* (*Ocimum tenuiflorum*), *Eucalyptus citriodora* and *Mentha arvensis* on Stemphylium blight and purple blotch of onion (cv. N-53). In *in vivo* evaluation, disease intensity was lowest with 20% leaf extract of *A. indica* followed by 20 % leaf extract of *Datura metel*.

There were significant differences among the effect of fungicides, botanicals and micronutrients on the yield and yield contributing characters of onion. Rovral 50 WP @ 0.2 % + micronutrients gave the best performances in controlling purple blotch of onion and as well as increasing onion seed production. These findings were well supported by Barnoczki-stoilova *et al.* (1989) and Georgy *et al.* (1983).

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 reducing the disease severity and increasing bulb and seed yield.

Between the two botanical treatments, Neen leaf extract (1:6 w/v) + micronutrients gave the better result compared with Allamanda leaf extract (1:6 w/v) + micronutrients for controlling purple blotch of onion and increasing onion seed production. The present findings were well supported by Prasad and Barnwal (2004). They reported that bulb yields were highest in plots sprayed with 20 % leaf extract of *Datura metel* (177.8 and 173.3 q/ha), followed by sprays of 20 % *A. indica* (Neem) leaf extract (172.2 and 168.9 q/ha) during 1998-99 and 1999-2000 crop seasons, respectively.

Thus the results of present investigation confirm the promising fungicidal effects of Rovral 50 WP @ 0.2 % spraying at 7 days interval to controlling purple blotch of onion in promoting yield contributing characters and increasing onion seed production. Between the two botanical treatments, Neem leaf extract (1:6 w/v) + micronutrients gave the better result compared with Allamanda leaf extract (1:6 w/v) + micronutrients to controlling purple blotch of onion and increasing onion seed yield.

Chapter 6
Summary and Conclusion

CHAPTER - 6

SUMMARY AND CONCLUSION

Onion (*Allium cepa* L.) is the most important spice crop in Bangladesh as well as in all over the world. Purple blotch of onion caused by *Alternaria porri* 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, micronutrients and botanicals for controlling purple blotch of onion for seed production.

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 November, 2007 to March, 2008. Nine (9) different treatments viz. T_1 = Allamanda leaf extract (1:6 w/v) + micronutrients; T_2 = Neem leaf extract (1:6 w/v) + micronutrients; T_3 = Cupravit 50 WP @ 0.7% + micronutrients; T_4 = Rovral 50 WP @ 0.2% + micronutrients; T_5 = Dithane M-45 @ 0.45% + micronutrients; T_6 = Ridimil Gold MZ-72 @ 0.2% + micronutrients; T_7 = Bavistin 50 WP @ 0.1% + micronutrients; T_8 = Only micronutrients and T_9 = Control (No fungicides, botanicals & micronutrients).

In the present study, all the tested chemical fungicides significantly reduced mycelial growth of fungus *in vitro*. Among the fungicides, Rovral 50 WP @ 0.2% reduced the highest radial mycelial growth of *Alternaria porri* followed by Ridomil 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, and disease severity, seed yield and seed yield contributing characters. The lowest disease incidence and disease severity were observed in

Rovral 50 WP @ 0.2% + micronutrients followed by Ridomil Gold MZ-72 @ 0.2% + micronutrients and Dithane M-45 @ 0.45% + micronutrients. The highest disease incidence and disease severity were recorded in control treatment. Between two botanical treatments, Neem leaf extract (1:6 w/v) + micronutrients gave slightly better result than Allamanda leaf extract (1:6 w/v) + micronutrients.

Irrespective of different days after planting (DAP), the leaf and seed stalk infection were the lowest for the application of Rovral 50 WP @ 0.2% + micronutrients followed by Ridomil Gold MZ-72 @ 0.2% + micronutrients. The control treatment showed the highest leaf and seed stalk infection. Similarly the % LAD, PDI-leaf, % SAD and PDI-stalk were the lowest in case of application of Rovral 50 WP @ 0.2% irrespective of DAP.

The highest seed yield (650 kg/ha) was recorded in case of Rovral 50 WP @ 0.2 % followed by Ridomil Gold MZ-72 @ 0.2 %. The seed yield and yield contributing characters also influenced by the application of Rovral 50 WP @ 0.2 %. The height of seed stalk, number of seed stalk/hill, number of umbel/plot, umbel diameter and thousand seed weight were highest in case of application of Rovral 50 WP @ 0.2 % which was followed by Ridomil Gold MZ-72 @ 0.2 %. The effect of micronutrients alone in reducing the disease incidence and severity of purple blotch of onion was quantitatively better but statistically identical in comparison to control. Neem leaf extract and Allamanda leaf extract were not proved to effective against purple blotch of onion.

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

Chapter 7
Literature Cited

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LITERATURE CITED

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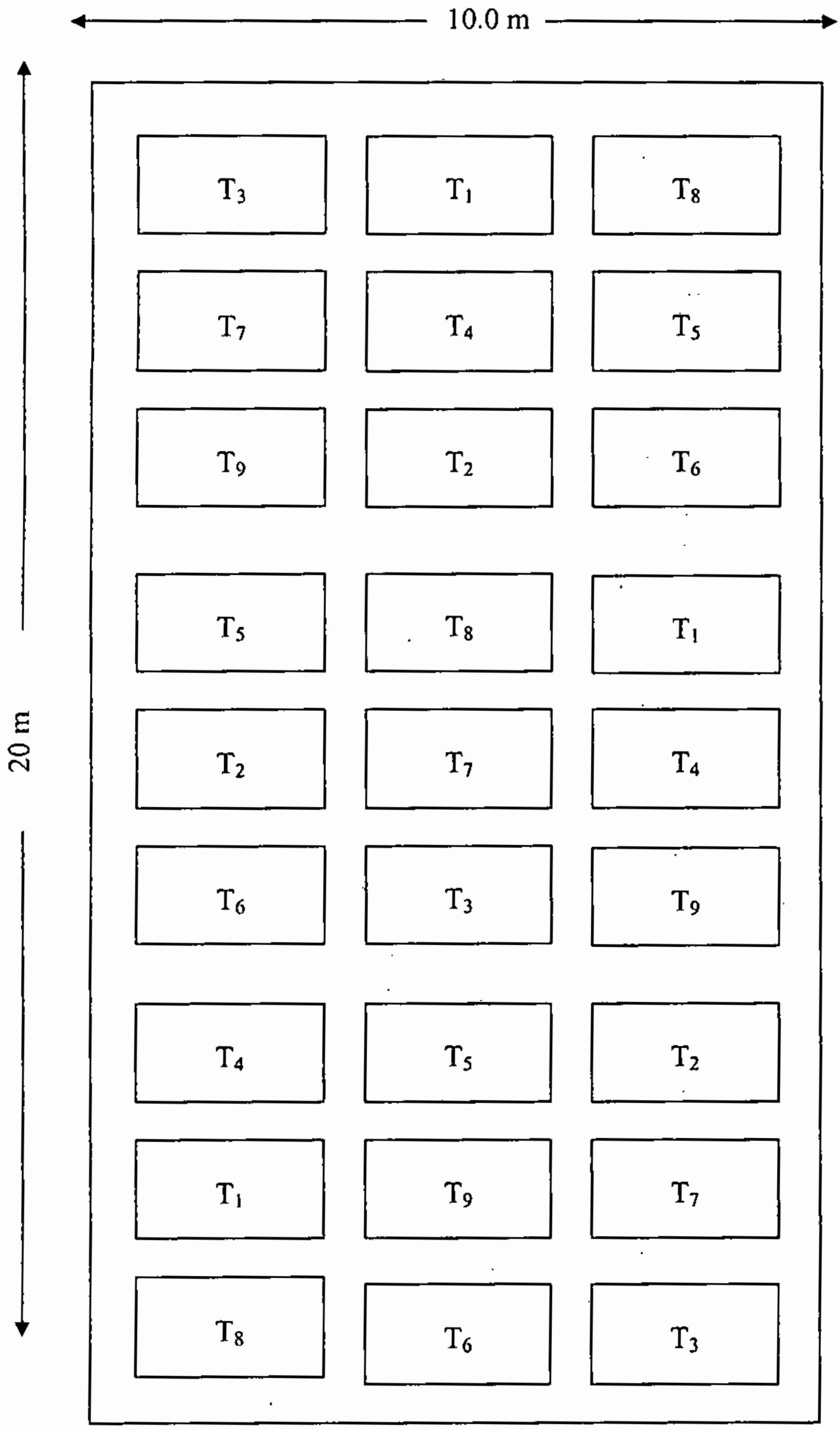
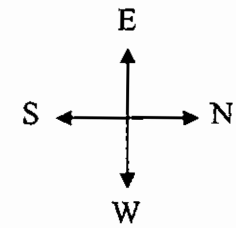
Appendices

APPENDICES

Appendix I. Design of the experimental plot





- Total area : 200 m^2
- No. of plot : 27
- Plot size : (2×1.5) m^2
- Block to block distance 0.75 m
- Plot to boundary distance 1 m
- Plot to plot distanc (Length wise) : 0.5 m
- Plot to plot distanc (Breath wise) : 1 m

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.

Appendix III. Analysis of variance of the data on radial mycelial growth of *Alternaria porri in-vitro* (Poisoned food technique) in different treatments at different days after inoculation (DAI)

Source of variation	Degrees of freedom	Mean square				
		Radial mycelial growth (cm)				
		3 DAP	6 DAP	9 DAP	12 DAP	15 DAP
Replication	2	0.010	0.008	0.042	0.001	0.009
Treatment	7	3.330 **	4.594 **	5.717 **	6.883 **	10.949 **
Error	14	0.006	0.007	0.052	0.011	0.018

^{NS} = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix IV. Analysis of variance of the data on percent infected leaf of onion as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		% infected leaf of onion							
		34 DAP	41 DAP	48 DAP	55 DAP	62 DAP	69 DAP	76 DAP	83 DAP
Replication	2	24.17	66.49	15.42	36.50	32.30	25.44	10.89	5.25
Treatment	8	35.62 NS	54.03 **	98.44 **	163.9 **	185.8 **	167.9 **	198.3 **	217.9 **
Error	16	11.65	11.28	5.543	2.104	3.39	3.25	2.472	2.01

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix V. Analysis of variance of the data on percent leaf area diseased (LAD) of onion as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		% Leaf area diseased (LAD)							
		34 DAP	41 DAP	48 DAP	55 DAP	62 DAP	69 DAP	76 DAP	83 DAP
Replication	2	7.68	8.43	18.04	13.591	31.99	32.43	19.10	14.37
Treatment	8	45.88 **	69.11 **	100.74 **	106.56 **	161.74 **	196.25 **	313.13 **	499.97 **
Error	16	2.85	3.93	4.45	3.08	4.21	6.03	2.93	3.74

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix VI. Analysis of variance of the data on percent disease index (PDI) of onion leaf as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		Percent disease index (PDI) of onion leaf							
		34 DAP	41 DAP	48 DAP	55 DAP	62 DAP	69 DAP	76 DAP	83 DAP
Replication	2	25.48	27.11	16.44	13.48	16.44	21.78	10.81	7.70
Treatment	8	110.37 **	169.33 **	171.67 **	110.37 **	179.33 **	147.67 **	155.59 **	172.25 **
Error	16	4.98	5.94	8.11	6.48	7.44	4.44	3.98	4.20

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix VII. Analysis of variance of the data on percent infected seed stalk of onion as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		Percent infected seed stalk of onion							
		76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
Replication	2	1.16	0.59	3.49	11.85	1.86	0.38	81.76	57.93
Treatment	8	0.80 NS	94.33 **	168.79 **	316.65 **	315.76 **	291.43 **	419.97 **	377.56 **
Error	16	0.57	6.16	4.21	2.02	3.35	4.97	10.58	7.13

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix VIII. Analysis of variance of the data on percent stalk area diseased (SAD) of onion as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		Percent stalk area diseased (SAD) of onion							
		76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
Replication	2	0.003	0.014	0.044	0.230	1.218	1.475	4.632	13.321
Treatment	8	0.018 **	0.308 **	1.346 **	8.709 **	28.266 **	62.475 **	230.307 **	537.895 **
Error	16	0.003	0.008	0.048	0.078	0.202	0.243	0.622	1.328

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix IX. Analysis of variance of the data on percent disease index (PDI) of onion seed stalk as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square							
		Percent disease index (PDI) of onion seed stalk							
		76 DAP	83 DAP	90 DAP	97 DAP	104 DAP	111 DAP	118 DAP	125 DAP
Replication	2	0.444	1.926	0.148	3.111	9.037	13.778	18.370	19.704
Treatment	8	2.000 *	5.815 **	10.815 **	69.333 **	107.704 **	193.00 **	413.148 **	576.704 **
Error	16	0.444	0.593	0.815	1.611	1.537	2.944	4.037	5.204

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

Appendix X. Analysis of variance of the data on yield and yield contributing characters of onion as influenced by different treatments used for managing purple blotch of onion (var. Taherpuri)

Source of variation	Degrees of freedom	Mean square					
		Height of onion seed stalk (cm)	No. of onion seed stalk/hill	No. of umbel/plot	Umbel diameter (cm)	Thousand (1000) seed weight (gm)	Seed yield (kg/ha)
Replication	2	4.205	0.004	16.000	0.005	0.007	162.159
Treatment	8	46.925 **	0.105 **	458.167 **	0.318 **	0.093 **	19235.84 **
Error	16	6.322	0.002	7.583	0.007	0.004	94.624

NS = Non significant; * = Significant at 5% level of probability; ** = Significant at 1% level of probability