BULB YIELD LOSS ASSESSMENT FOR PURPLE BLOTCH COMPLEX OF ONION

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This is to certify that the thesis entitled **"BULB YIELD LOSS ASSESSMENT FOR PURPLE BLOTCH COMPLEX OF ONION"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN PLANT PATHOLOGY**, embodies the result of a piece of bonafide research work carried out by **Bobita Aktari**, **Registration No**. 06-02001 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.

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

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ABSTRACT

Experiments were conducted at the farm of Sher-e-Bangla Agricultural University and in the Seed Health Laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the Rabi season from November 2011 to April 2012 in order to study the bulb yield loss assessment for purple blotch complex of onion. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications. Multiple treatments viz. T_0 (Control), T_1 (One field spraying), T_2 (Two field spraying) , T_3 (Three field spraying), T_4 (Four field spraying), T_5 (Five field spraying), T_6 (Six field spraying), T_7 (Seven field spraying), T_8 (Eight field spraying) and T_9 (Nine field spraying) with Rovral 50 WP @ 0.2% were applied in the experiments to make variation in the disease severity and respective bulb yield of treated plot. Different treatments comprising different number of spraying had remarkable effort making variation in the disease severity and bulb yield. The lowest (0.0%) Percent Disease Index (PDI) and the highest bulb yield (6575.50 kg/ha) was recorded in treatment T_9 where 9 spraying were applied with Rovral 50 WP @ 0.2%. The highest PDI (75%) and the lowest bulb yield (3269.8 kg/ha) was counted in case of treatment T_0 (control). Using the variation of disease severity (PDI) and corresponding bulb yield, the yield loss assessment was done by regression equation $\hat{Y} = 0.00 + 0.67Xi$.

CONTENTS

LIST OF TABLES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) rightly called as “queen of kitchen” is one of the oldest and an important spice crop grown in Bangladesh as well as in the world. It belongs to the family Alliaceae. According to Vavilov (1951) the primary center of origin of onion lies in central Asia. The near east and Mediterranean are the secondary centers of origin. The genus *Allium* is very large comprising of more than 500plant spp, usually perennial bulbous plants. Out of these, *Allium cepa* (onion) is the major cultivated spice grown all over the world.

Spices are important constituents in preparation of food items in Bangladesh. A good number of spices crops are grown in Bangladesh. The major ones are onion, garlic, zinger, turmeric, coriander, chili, etc. The major onion producing countries like Korea Republic tops the list with 65.25t/ha followed by USA 53.91t/ha, Spain 52.06t/ha, Japan 47.55t/ha (FAO, 2008), where as the productivity of onion in Bangladesh is 8.95t/ha (AIS, 2011) which is remarkably lower than other onion producing countries.

Onion bulb provides vitamin C 19.7%, fiber 10.8%, molybdenum 10.6%, manganese 10.5%, vitamin B 69.5%, potassium 6.6%, and tryptophan 6.2%. Onions are very low in calories (just 40 cal per 100 g) and fats but rich in soluble dietary fiber. Onion is one of the most widely used vegetable due to its flavoring and seasoning the food, both at mature and immature bulb stage. Besides, it is being used in the manufacture of soups, ketchups, salad and pickles. To a lesser extent, it is used by processing industry for dehydration in the form of onion flakes and powder, which are in great demand in the world market.

In Bangladesh, onion bulbs are grown almost in all districts and its cultivation in commercial scale is found in the greater Faridpur, Pabna, Jessore, Rajshahi,

Dhaka, Mymensingh, Comilla and Rangpur (Anon. 2003). The local varieties namely Faridpuri and Taherpuri are commonly grown in Bangladesh. The demand of onion bulb is increasing every year in Bangladesh but the rate of production is not increasing as per demand due to several factors.

In the world, onion is attacked by 66 diseases including 10 bacterial, 38 fungal, 6 nemic, 3 viral, 1 mycoplasmal, 1 parasitic plant and 7 miscellaneous diseases and disorders (Schwartz and Mohan, 2008, Schwartz, 2010).

Several factors have been identified for the low productivity of onion in Bangladesh. The most important factors are the diseases like purple blotch, downy mildew, *Stemphylium* blight, basal rot and storage rots and non availability of varieties resistant to biotic and abiotic stresses. Among the foliar diseases, purple blotch is one of the most destructive disease prevailing in almost all onion growing pockets of the world, which causes heavy loss in onions under field conditions. The name "Purple blotch" for this disease was proposed by Nolla (1927). He named the causal organism as *Alternaria alli* which was later amended to *Alternaria porri.*

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

Now a days *Stemphylium vesicarium*, the causal agent of white blotch of onion are being considered as an organism involved indirectly with the development of purple blotch of onion. It is considered that *Stemphylium vesicarium* initiate

the infection, which facilitates subsequent infection of *Alternaria porri* causing purple blotch and hence the disease is designated as Purple blotch complex.

Bulb and seed yields of onions cv. “Nasik Red” were significantly reduced by purple blotch caused by *Alternaria porri* (Gupta and Pathak, 1988). In Bangladesh the cultivars Faridpuri and Taherpuri are susceptible to the disease (Rahman *et al*., 1989; Islam *et al* ; 2001).

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

Now a day’s farmers are not interested to onion cultivation that affect the national production which make the country demand for importing enormous quantity of onion bulb every year at the cost of huge foreign exchange. Unstable price of onion in the local market, especially in the month of Ramadan is mainly due to the shortage of onion production and lack of information about the total national yield losses for purple blotch complex. But no initiatives had yet been taken to estimate the crop loss assessment for purple blotch complex of onion.

The Government need to have the picture about national yield status of onion prior to harvesting the crops to take necessary step to meet up the national demand.

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

i. To make variation in the disease severity of purple blotch complex of onion by applying multiple treatments.

ii. To estimate the bulb yield loss by regression equation between disease severity and corresponding bulb yield.

CHAPTER II

REVIEW OF LITERATURE

Onion (*Allium cepa L*) is called the **queen of kitchen**, one of the most important and widely used vegetables and spices crop in Bangladesh as well as many countries all over the world . Researcher throughout the world has been carrying out investigations on the purple blotch complex of onion, its epidemiology and the management of the disease. In Bangladesh very few works have been done in this respect. The available information in this connection over the world has been reviewed in this chapter.

2.1. Varietal Resistance

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

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

Alves *et al* (1983) studied the incidence of purple spot (*Alternaria porri*) 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 II) in most cases ; only the hybrids Px76 having plants in class I (0-10%).

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.

Bhonde *et al* (1992) conducted a field trial during 1987-1988 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.

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.

Das (2010) recorded the lowest disease incidence and highest yield in BARI piaz-3, Indian big and Indian small among nine onion cultivars viz. BARI piaz-1, BARI piaz-2, BARI piaz-3, Thakurgong local, Foridpur local, Manikgong local, Indian big, Indian small and Taherpuri. BARI piaz-1 showed lower performance in respect of all parameters.

Kibria (2010) reported that BARI piaz-3 gave lowest disease incidence and highest yield (12.67 t/ha) against purple blotch of onion (*Alternaria porri*) among nine onion cultivars viz. BARI piaz-1, BARI piaz-2, BARI piaz-3, Thakurgaon local, Foridpur local, Manikgong local, Indian big, Indian small and Taherpuri. In case of disease reaction 8.00% observed in BARI piaz-3 and was graded as resistant.

Kumari and Singh (2012) conducted an experiment in the Department of Plant Pathology, Bihar Agricultural College, Sabour to locate the sources of resistance of *Alternaria porri*. 45 days old seedlings were inoculated by spraying the spore suspension (1×10^6 spores/ml) of *Alternaria porri*. Seedlings in pots were subjected to humid chamber for about 24 hours before

and after inoculation. The variety Arka Kalyan appeared most resistant recording the least disease intensity (5.53 percent only), although being statistically *at par* with Arka Niketan and Agri. Foundation Dark Red recording 6.36 percent and 6.33 percent disease intensity.

Abubakar and Ado (2013) conducted an experiment on five onion cultivars Red Creole, Kaharda, Koumassa, Sokoto local and ori to find out the variability pattern for resistance to purple blotch disease of onion. Analysis of the variance component for the combined seasons and locations indicated that genotypic variance was greater than the environmental variance for all characters under consideration with exception of bulb weight. Disease incidence recorded 31.20%, 30.58% and 5.42% as phenotypic, genotypic and environmental coefficients of variability. Disease severity recorded 34.96%, 32.84% and 11.00% as phenotypic, genotypic and environmental coefficients of variability. With respect to fresh bulb yield 94.90%, 93.53% and 15.78% were observed as phenotypic, genotypic and environmental coefficients of variability for the genotypes. Cured bulb yield recorded 103.47%, 102.27% and 14.96% respectively as phenotypic, genotypic and environmental coefficients of variability. Similarly 29.43%, 24.79% and 17.91% were observed for days to maturity, as phenotypic, genotypic and environmental coefficients of variability.

2.2 Epidemiology and management

Miller (1983) reported that measurements of infected leaves were taken weekly from bulb initiation to bulb maturity. They observed that the leaf damage levels were significantly lowered on younger than older leaves. Leaves emerging 9, 8,

7, 6 and 5 week before bulbing maturity required $5^1/_2$, 5, $4^1/_2$, $3^1/_2$ and $2^1/_2$ weeks, respectively to reach 50% damage.

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

Miura (1985) found that *Alternaria porri, A. alternata* and *Fusarium* are predominated among the fungi isolated from onion seeds. *In vitro* products based on iprodione gave the best results resulting 97.4% control of the fungi with 81.4% germination against 54.8% germination of untreated seeds.

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

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

Prateung and Sangawonge (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 2nd applications of fungicides indicated that rnyclobutanil, iprodione, and imazalil gave the lowest percentage of disease infection. Triphenyl tin acetate and myclobutanil + mancozeb gave the second best result.

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

Srivastava *et al.* (1995) conducted trials with Iprobenfos (Kitazin), Iprodione (Rovral), Fosetyl (Aliette), Kavatch, Thiophanate-methyl (Topsin M), Benomyl, Metalaxyl (Ridomil) and Mancozeb. Observation on disease intensity/PDI was recorded at fortnightly intervals, just before each spray, and a total of 5 sprays were applied. They recommended that seed growers in North India should apply fortnightly sprays of 0.25% Mancozeb or 0.25% Iprodione to control onion seed diseases caused by *Stemphylium vesicarium* and *Alternaria porri*.

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

Gupta *et al*. (1996) reported that Purple blotch (*Alternaria porri*) and Stemphylium blight (*Stemphylium vesicarium*) are 2 rnajor 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.

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

Islam *et al.* (2001) conducted an experiment to evaluate the efficacy of eight fungicides viz. 'Score (Difenconazole), Tilt 250 EC (Propiconazole),Folicur (Tebuconazole), Rovral 50wp (Iprodione), Knowin (carbendazim), Macuprax.(Borcleaux mixture + curfanex), Bavistin 50WP(carbendazim), Ridornil MZ-72 (Metalaxial + Mancozeb) against the purple blotch of onion caused by *Alternaria porri* Among the fungicides, Rovral 50WP was 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.

Rahman (2004) observed the effect of three fungicides viz., Ridomil, Rovral and Tilt 250 EC (0.2%) comprising 13 treatments in field experiment. Eight sprays of Rovral or Ridomil at 7 days interval minimized disease incidence and

increased yield. Rovral 0.2% 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.

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

Uddin (2005) reported bulb treatment followed by six foliar spraying at 10 days interval starting from 20 days after bulb sowing with Dithane M-45 (0.45%) or Rovral (0.2%) minimized disease incidence and severity and increased seed yield. The least seed infection by *Alternaria porri* and the highest seed germination was recorded in the seed sample picked up from Dithane M-45 and Rovral 50WP treated plot in a post harvest seed health test.

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

Ali (2008) reported in the field experiment, The lowest disease incidence and disease severity observed in Rovral 50WP @ 0.2% + micronutrients followed by Rovral 50WP @ 0.2% alone, Dithane M-45 @ 0.45% + micronutrients and

Dithane M-45 @ 0.45% alone. The highest disease incidence and disease severity were recorded in control treatment.

Hossain (2008) conducted an experiment to evaluate the effect of selected fungicides and micronutrients against *Alternaria porri and Stemphylium vesicarium* causing purple blotch complex of onion and he found that Rovral 50 WP (0.2%) + Micronutrients reduced the disease incidence (% Leaf infection) and disease severity (% Leaf area diseased) by 20.92% and 44.88%, respectively followed by Rovral 50 WP (0.2%) alone, Dithane M-45 (0.45%) + Micronutrients and Dithane M-45 (0.45%) alone. The bulb yield and yield contributing characters viz. plant height, plant dry matter, root length and weight were found significantly higher in case of application of Rovral 50 WP (0.2%) + Micronutrients where yield was increased by 36.88% over control.

Hafiz (2009) found that disease incidence and disease severity of purple blotch of onion was reduced by using combination of poultry manure and fungicide. He found that when soil was amended with poultry manure and onion seedlings were dipped in Rovral 50WP solution followed by foliar spraying of same fungicide at 7 days interval gave the best result. The highest onion bulb yield (5.063 t/ha) was also recorded from this treatment.

Biswas *et al.* (2010) conducted an experiment to investigate the level of leaf purple blotch incidence by different levels of irrigation and its effect on the bulb yield of onion (Allium cepa L.). Four irrigation levels comprised of: irrigation at 10- (I_1), 15- (I_2), 20- (I_3) and 30-day (I_4) intervals along with a non-irrigated control (I_0) treatment were tested. A small difference in the score of leaf purple blotch disease in onion was found between the irrigated and non-irrigated plots. The highest level of disease infection (score: 1.96) was recorded

in I_0, and the lowest score (1.45) was found in I_1. There was a trend to decrease the disease incidence with increasing number of irrigations.

Sultana (2013) conducted an experiment to assess the yield loss of onion bulb due to purple blotch. A total of 5 sprays were applied from the onset of the disease symptom in experimental plots at an interval of 7 days. Fungicidal spray was done in mixture of Ridomil gold (0.2%) and Rovral (0.2%). Rovral sprayed plot was showed the better performance in Percent disease index (PDI) and spot diameter compare to unsprayed control. Taller plants having higher number of leaves were recorded in sprayed plot. Length and breadth of bulb were also high in sprayed plot.

2.3 Crop loss assessment

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

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 l0 bulb (g) and yield/plot (kg) also increased 10.6% and 50.9% in fungicide sprayed plot over control.

CHAPTER III

MATERIALS AND METHODS

The details of the materials and methods of this research work are described in this under the following headings and sub-headings:

3.1 Experimental sites

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka. The experimental field is located at the $23^0$74 N latitude and 90^o 35 E longitude with an elevation of 8.2 meter from sea level.

3.2 Experimental period

The experiment was carried out during the Rabi season from November 2011 and to April 2012.

3.3 Soil type

The soil of the experimental site belongs to the Agro-ecological region of "Madhupur Tract" (AEZ No.: 28). It is Deep Red brown Terrace soil and belongs to "Nodda" cultivated series. The top soil is 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 (Appendix-II)

3.4 Weather

The monthly mean of daily maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental site during the period of the study was collected from Bangladesh Meteorological Department, Agargaon, Dhaka (Appendix-III)

3.5 Land preparation

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

3. 6 Application of fertilizers

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),Sulfur (in the form of Gypsum), Zink (in the form of ZnO) and Boron(in the form of Boric powder). As per the treatment, whole quantity of TSP, MP, Gypsum, ZnO, Boric powder and one fourth of Urea were applied at final plot preparation. The rest of the urea was applied later in three installments on (40, 60 and 80 days after planting).

Fertilizer was applied as per recommended doses (BARC,1997). Applied doses of chemical fertilizer were as follows:

Name of the nutrient element	Name of the Fertilizer	Fertilizer dose (kg/ha)	Fertilizer applied during final land preparation (kg/240 m^2 land)	Rest installments (Urea)(kg/240m^2 land)		
				1^{st}	2^{nd}	3^{rd}
N	Urea	320	1.92	1.92	1.92	1.92
P	TSP	415	9.96	-	-	-

K	MP	168	4.03	-	-	-
S	Gypsum	100	2.4	-	-	-
Zn	ZnO	5	0.12	-	-	-
B	Boric powder	5	0.12	-	-	-
	Manure	10000	240			

3.7 Experimental design and layout

The experimental plots were arranged in Randomized Complete Block Design (RCBD) with four (4) replications (Appendix-IV). The experiment details were given bellow:

- Total plot area : 240 m^2
- Number of plot : 40
- Plot size : 6 m^2
- Block to block distance : 1.0 m
- Plot to boundary distance : 0.5 m
- Plot to plot distance(Lengthwise) : 1 m
- Plot to plot distance(breath wise) : 0.5 m
- Plant to plant spacing : 15 cm
- Row to row spacing : 30 cm

3.8 Multiple treatment of the experiment

Multiple treatments were applied in the experiment to make variation in the disease severity of purple blotch complex of onion. Altogether 10 treatments were applied comprising different number of sprays as follows.

T_0 = No field spraying with fungicide

T_1 = One field spraying with Rovral 50 WP @ 0.2%

T_2 = Two field spraying with Rovral 50 WP @ 0.2%

T_3 = Three field spraying with Rovral 50 WP @ 0.2%

T_4 = Four field spraying with Rovral 50 WP @ 0.2%

T_5 = Five field spraying with Rovral 50 WP @ 0.2%

T_6 = Six field spraying with Rovral 50 WP @ 0.2%

T_7 = Seven field spraying with Rovral 50 WP @ 0.2%

T_8 = Eight field spraying with Rovral 50 WP @ 0.2%

T_9 = Nine field spraying with Rovral 50 WP @ 0.2%

3.9 Variety Selection

The experiment was conducted with a local onion variety "Taherpuri". This onion variety is most popular in Bangladesh and its quality is more standard than other local or high yielding varieties.

3.10 Collection of onion seedling

Seedling of onion were collected from Gourango bazaar, Manikgonj.

3.11 Transplanting date of onion seedling

Uniform seedling were transplanted in the experimental plot in 30th November 2011.

3.12 Transplanting procedure

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

following days up to establishment of seedling. A good number of seedlings were transplanted at the border for later use as gap fillers.

3.13 Intercultural operation

3.13.1 Irrigation

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

3.13.2 Gap filling

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

3.13.3 Weeding and mulching

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

3.14 Preparation and application of spray solution

The fungicidal suspension was prepared by mixing with required amount of fungicide (Rovral 50 WP @ 0.2%) with tap water. The number of sprays varied with the treatment applied. The lowest number of spray was 1 and the highest number of sprays was 9. The first spray was done at 20 days after transplanting and others were sprayed with 7 days interval. The last spray was done at 75

days after transplanting. Every time the fungicide was freshly prepared prior to application and the spray tank was thoroughly cleaned before filling with materials. The insecticide (Ektara) was applied to control thrips but not in the same days of fungicide sprays. Adequate precaution was taken to avoid drifting of spray materials from one plot to neighboring ones by polythine barier.

3.15 Tagging of plants

Ten (10) plants were selected randomly from each plot and tagged for data collection and mean values were determined to get rating score of each treatment.

3.16 Isolation and identification of pathogens

Diseased leaves of onion were collected and cut into pieces (4 diameter) and surface sterilized with H_gCl_2 (1:1000) for 30 seconds. Then the cut pieces were washed in sterile water thrice and then placed into acidified PDA in petridish. The plates containing leaf pieces were placed at room temperature for seven days. When the fungus grew well, and sporulated, then the slide was prepared from the PDA and observed under compound microscope and identified with the help of relevant literature (photograph 3,4,5 and 6)

3.17 Collection of data

The following parameters were considered for data collection.

Disease incidence and severity

a. Percent plant infection
b. Percent leaf infection

c. Percent leaf area diseased (% LAD)

3.18 Procedure of data collection

3.18.1 Total no. of plants / plot

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

3.18.2 Healthy plants / plot

Number of healthy plants was counted at different vegetative stages

3.18.3 Number of symptom bearing plant / plot

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

3.18.4 Number of leaf / plant

Number of leaves per plant was counted from randomly selected 10 plants from each plot at different dates as scheduled

3.18.5 Number of infected leaf / plant of different treatment

Number of leaves infected per plant were recorded and used for calculation of diseased incidence

3.18.6 Percent Plant Infection

Data on percent plant infection were recorded at 80 days after transplanting by visual observation of symptom. Percent plant infection was calculated by following formula.

$$\% \text{ plant infection} = \frac{\text{Number of infected plant}}{\text{Number of total inspected plant}} \times 100$$

3.18.7 Percent leaf infection

Ten plants per plot were selected and tagged for collection of data. Data on percent leaf infection were recorded at 80 days after transplanting by visual observation of symptoms. Percent leaf infection was calculated by the following formula.

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

3.18.8 Percent leaf area diseased

Data on percent leaf area diseased (LAD) were recorded at 80 days after transplanting by visual observation of symptoms. Percent leaf area diseased was calculated by the following formula.

$$\% \text{ Leaf area diseased} = \frac{\text{Leaf area infected}}{\text{Total leaf area inspected}} \times 100$$

3.18.9 Estimation of percent disease index (PDI)

Percent disease index (PDI) was measured by the following formula-

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of total disease ratting}}{\text{Total no. of observation X Maximum grade in the scale}} \times 100$$

Disease severity scale

Using "0-5" scale (Horsfall and Barratt, 1945) we calculated the disease severity. "0-5" scale is given bellow-

% Leaf Area Diseased (LAD)	Grade / rating
0	0
0.1 - 5.0	1
5.1 - 12.0	2
12.1 - 25.0	3
25.1 - 50.0	4
>50.0	5
Total	

3.18.10 Harvesting and recording data on yield

Onion bulbs were harvested on 4th April, 2012, at which the plant have been showing the sign of drying out most of the leaves. Onion bulbs were carefully lifted with the help of khupry. To avoid injury, care was taken during harvesting. Then the stalks were cut at 2cm above bulbs and dried in the sun and later weight was taken.

Construction of regression equation

For simulation of mathematical point model for estimation of yield loss, regression equation was used as shown bellow

$\bar{X} = \frac{\sum X}{N}$ (N= No. of observation).

$\bar{Y} = \frac{\sum Y}{N}$ (N= No. of observation)

We know, Regression equation

Y = a+bX

$\hat{Y} = \bar{Y} + b\ (Xi - \bar{X})$ (working formula)

Here, $\hat{Y}$ = Predicted yield loss (%)

$\bar{Y}$ = Estimated yield loss (%)

Xi = Disease severity (i = 1, 2, 3,……n)

b = Regression co-efficient

$$b = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sum (Xi - \bar{X})^2}$$

3.19 Experimental design and statistical analysis

The collected data for different parameters were compiled and tabulated in proper form. Appropriate statistical analysis was made by MSTAT computer package program. The treatment means were compared by Duncan's Multiple Range Test (DMRT). ANOVA table was shown in appendix-IV.

CHAPTER IV

RESULTS

The present experiment was conducted for assessment of the bulb yield loss for purple blotch complex of onion" through multiple treatment experiment with application of Rovral 50 WP @ 0.2%. Data were recorded on % plant infection, % infected leaf, disease severity (leaf) and yield of onion bulb 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 drawn under the following headings:

4.1 Percent plant infection

The effect of different treatments on plant infection of onion at different days after transplanting summarized and presented in Table 2. Different treatments had significant influence on percent plant infection of onion (Taherpuri). At 80 days after transplanting, the highest percent plant infection (79.04%) was found in T_0 (control) and no plant infection (0.00%) was recorded in treatment T_9 where nine spraying were done with Rovral 50 WP (0.2%). The inhibition of plant infection was 100% in case of T_9 where 09 sprays were applied. The inhibition of plant infection gradually decreased with the decrease of number of sprays. (Table 1)

4.2 Percent leaf infection

The effect of different treatments on leaf infection of onion at different days after transplanting summarized and presented in Table 3. Different treatments had significant influence on percent leaf infection of onion (Taherpuri). At 80 days after transplanting. the highest percent leaf infection (75.68%) was found in T_0 (control) and no leaf infection (0.00%) was recorded in treatment T_9 where nine spraying were done with Rovral 50 WP (0.2%). The inhibition of leaf infection was 100% in case of T_9 where 09 sprays were applied. The inhibition of leaf infection gradually decreased with the decrease of number of sprays. (Table 2)

4.3 Percent leaf area diseased

The effect of different treatments on leaf area diseased (LAD) of onion at different days after transplanting, summarized and presented in Table 4. Different number of sprays had significant influence on percent leaf area diseased of onion (Taherpuri). At 80 days after transplanting, the highest percent leaf area diseased (71.76 %) was found in T_0 (control) and the lowest percent leaf area diseased (0.00%) was recorded in treatment T_9 where nine field spraying were applied with Rovral 50 WP (0.2%). The reduction of leaf area diseased (LAD) was stood cent percent while 09 sprays with Rovral 50 WP (0.2%) were done and the LAD was found to be decreased gradually with the increase of number of sprays (Table3)

Table.1 Effect of different treatments on percent Plant Infection of onion at 80 days after planting (DAP)

Treatments	% Plant Infection at 80 DAP	% Inhibition of plant infection over control at 80 DAP
T_0	79.04 a	0
T_1	70.85 b	10.36
T_2	56.25 c	28.83
T_3	46.03 d	41.76
T_4	36.35 e	54.01
T_5	21.88 f	72.31
T_6	10.27 g	87.01
T_7	4.290 h	94.57
T_8	1.580 i	98.00
T_9	0.0000 j	100
LSD	1.434	
% CV	3.74	

In a column means having same letter(s) do not differed significantly at 5% level.

Treatment

T_0=Control

T_1= One field spraying with Rovral 50 WP

T_2 =Two field spraying with Rovral 50 WP

T_3=Three field spraying with Rovral 50 WP

T_4=Four field spraying with Rovral 50 WP

T_5=Five field spraying with Rovral 50 WP

T_6=Six field spraying with Rovral 50 WP

T_7=Seven field spraying with Rovral50WP

T_8=Eight field spraying with Rovral 50WP

T_9=Nine field spraying with Rovral 50 WP

Table.2 Effect of different treatments on percent leaf Infection of onion at 80 days after planting (DAP)

Treatments	% Leaf Infection at 80 DAP	% Inhibition of leaf infection over control at 80 DAP
T_0	75.68 a	0
T_1	60.57 b	19.97
T_2	55.94 c	26.08
T_3	45.06 d	40.45
T_4	37.10 e	50.97
T_5	22.33 f	70.49
T_6	11.84 g	84.35
T_7	7.060 h	90.67
T_8	1.903 i	97.49
T_9	0.0000 j	100
LSD	1.725	
% CV	3.74	

In a column means having same letter(s) do not differed significantly at 5% level.

Treatment

T_0=Control

T_1= One field spraying with Rovral 50 WP

T_2 =Two field spraying with Rovral 50 WP

T_3=Three field spraying with Rovral 50WP

T_5=Five field spraying with Rovral 50 WP

T_6=Six field spraying with Rovral 50 WP

T_7=Seven field spraying with Rovral 50WP

T_8=Eight field spraying with Rovral 50 WP

T_4=Four field spraying with Rovral 50 WP

T_9=Nine field spraying with Rovral 50 WP

Table.3 Effect of different treatments on percent leaf area disease (%LAD) of onion at 80 days after planting (DAP)

Treatments	% Leaf area diseased (LAD) at 80 DAP	% Inhibition of leaf area diseased over control at 80 DAP
T_0	71.76 a	0
T_1	60.57 b	15.59
T_2	52.12 c	27.37
T_3	40.89 d	43.02
T_4	30.63 e	57.31
T_5	17.77 f	75.23
T_6	8.960 g	87.51
T_7	4.465 h	93.77
T_8	1.517 i	97.88
T_9	0.0000 i	100
LSD	1.748	
% CV	4.17	

In a column means having same letter(s) do not differed significantly at 5% level.

Treatment

T_0=Control

T_1= One field spraying with Rovral 50 WP

T_2 =Two field spraying with Rovral 50

T_5=Five field spraying with Rovral 50 WP

T_6=Six field spraying with Rovral 50 WP

T_7=Seven field spraying with

WP

T_3=Three field spraying with Rovral 50 WP

T_4=Four field spraying with Rovral 50 WP

Rovral50WP

T_8=Eight field spraying with Rovral50WP

T_9=Nine field spraying with Rovral 50 WP

4.4 Effect of different treatments on bulb yield of onion.

A significant variation of bulb yield was observed which was ranged from 3269.8 kg/ha to 6575.50 kg/ha due to application of different treatments. The highest yield (6575.50 kg/ha and 101.07 % increased over control) was recorded in case of treatment T_9 where Rovral 50WP @0.2% sprayed nine times at 7 days interval (Table 4) and The lowest yield 3269.8 kg/ha was obtained from T_0 (control)

Table. 4 Effect **of different treatment on bulb yield of onion**

Treatment	Yield	% increase of yield over control
T_0	3269.80 j	0
T_1	3754.64 i	14.83
T_2	3975.02 h	21.55
T_3	4283.55 g	31.00
T_4	4812.46 f	47.15
T_5	5165.07 e	57.95
T_6	5649.90 d	72.78
T_7	6046.58 c	84.92
T_8	6355.12 b	94.95
T_9	6575.50 a	101.07
LSD	64.69	
% CV	0.89	

In a column means having same letter(s) do not differed significantly at 5% level.

Treatment

T_0 = Control

T_5 = Five field spraying with Rovral 50

WP

T_1 = One field spraying with Rovral 50 WP

T_2 =Two field spraying with Rovral 50 WP

T_3=Three field spraying with Rovral 50WP

T_4=Four field spraying with Rovral 50 WP

T_6 = Six field spraying with Rovral 50 WP

T_7 = Seven field spraying with Rovral50WP

T_8 =Eight field spraying with Rovral 50 WP

T_9=Nine field spraying with Rovral 50 WP

4.5. Assessment of yield loss

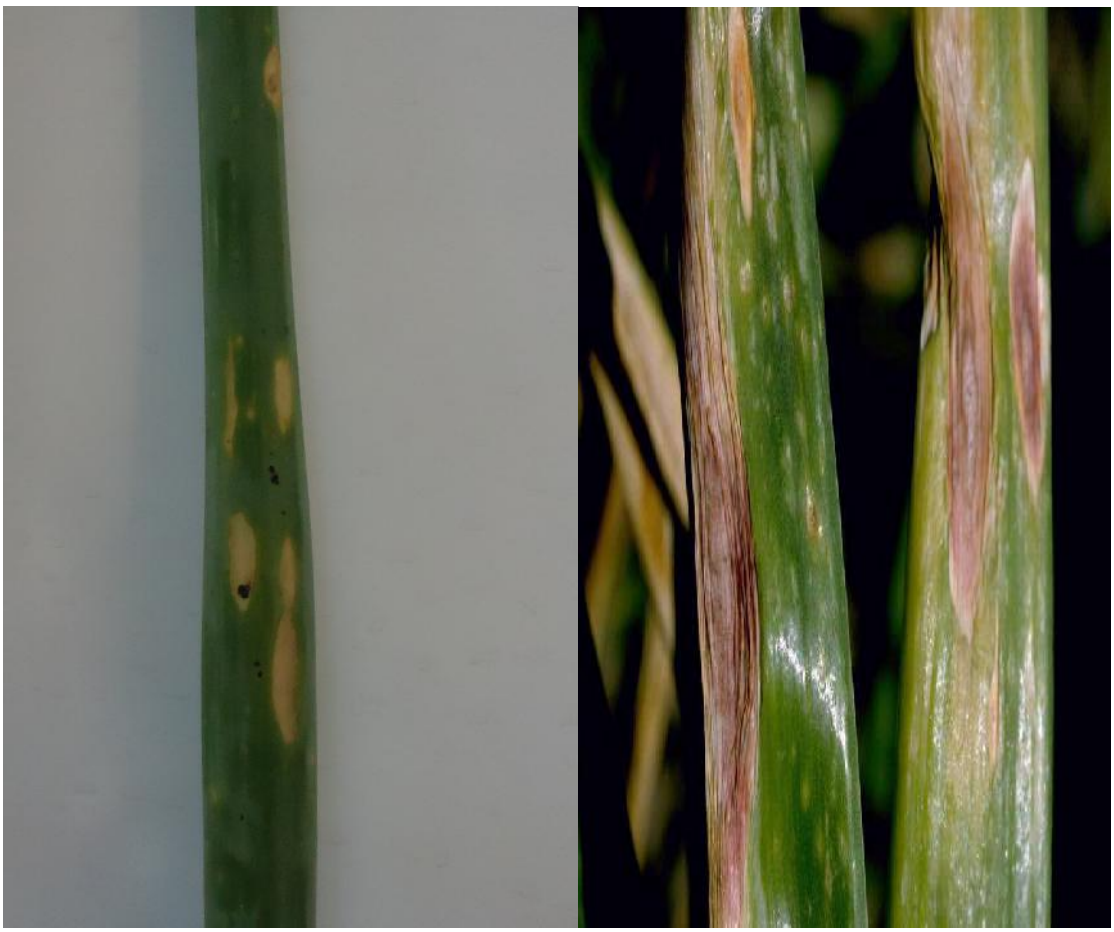
Using the variation of Percent Disease Index (PDI) and corresponding yield loss from multiple treatment experiment, the predicted yield loss ($\hat{Y}$) was calculated using the regression equation between PDI and bulb yield loss and presented in Table 5. Using the variation of predicted yield loss and corresponding disease severity the yield loss assessment was made as $\hat{Y}$= 0.00+0.67Xi. By setting any Xi's value (PDI) in the equation, the yield loss of onion due to purple blotch complex disease could be estimated

Table. 5: Predicted yield loss calculated by percent disease index (PDI) and corresponding yield loss from multiple treatment experiment

Multiple Treatments	Percent Disease Index (PDI) X	Yield (kg/ha)	Yield loss (kg/ha)	% Yield loss (Y)	(PDI) X (% Yield Loss) (XY)	Predicted % yield loss
T_0	Xi = 75	3269.8	3305.7	Yi =50.27	3770.25	50.25
T_1	Xii = 64	3754.64	2820.86	Yii =42.89	2744.96	42.88
T_2	Xiii = 59	3975.02	2600.48	Yiii =39.55	2333.45	39.53
T_3	Xiv = 52	4283.55	2291.95	Yiv =34.85	1812.2	34.84
T_4	Xv = 40	4812.46	1763.04	Yv =26.81	1072.4	26.8
T_5	Xvi = 32	5165.07	1410.43	Yvi =21.45	686.4	21.44

T_6	Xvii =21	5649.90	925.59	Yvii =14.07	295.47	14.07
T_7	Xviii =12	6046.58	528.91	Yviii =8.04	96.48	8.04
T_8	Xix = 5	6355.12	220.38	Yix =3.35	16.75	3.35
T_9	Xx = 0	6575.50	0	Yx = 0	0	0.00
Total	∑X = 360			∑Y = 241.28	∑XY = 12828.36	

Photograph 1. Field view of vegetative stage of onion



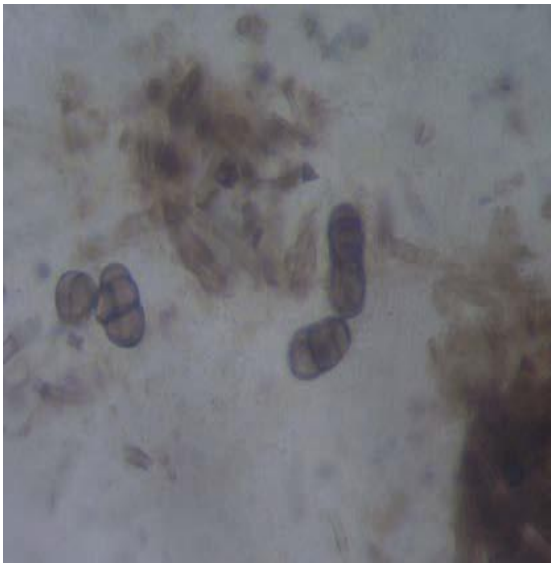
a. b

Photograph 2. (a) Initial stage of purple blotch complex of onion and (b) advanced stage of the disease

Photograph 3. Pure culture of *Alternaria porri*

Photograph 4. Conidia of *Alternaria porri* observed under Compound microscope(40X)

Photograph 5. Pure culture of *Stemphylium vesicarium*



Photograph 6. Conidia *Stemphylium vesicarium* observed under Compound microscope (40X)

CHAPTER V

DISCUSSION

In the present study, the effect of treatments in controlling purple blotch complex of onion caused by *Alternaria porri* and *Stemphylium vesicarium* was assessed based on the result of percent plant infection, percent leaf infection, percent leaf area diseased (% LAD) and bulb yield.

In the field experiments the application of fungicides with different spray schedule had significant effect in reducing the disease incidence, severity and increasing the bulb yield. Among the treatments, nine field spraying with Rovral 50 WP @ 0.2% at 7 days interval completely controlled the disease which was statistically identical. It was observed that the incidence and severity of the disease increased gradually with the decreasing number of spraying of Rovral 50 WP @ of 0.2 %.

The highest bulb yield (6575.50kg/ha) was obtained from the plot where nine field spraying was applied with Rovral 50 WP @ 0.2% against the disease that increased bulb yield by 50.25% compared to control. The second highest bulb yield (6355.12kg/ha) was obtained from the plot where eight field spraying was applied with Rovral 50 WP @ 0.2% that increased bulb yield by 42.88 % compared to control. It was observed that bulb yield incrased gradually with the increase of number of spraying of Rovral 50 WP @ of 0.2%.

The findings of the field experiments are well supported by the previous researchers. Sultana *et al*. (2008) conducted an experiment in the field of Plant Pathology Division, BARI, Joydebpur to assess yield loss of bulb onion for purple blotch disease. She reported that 71.95% disease reduced in the fungicide spraying plot over control. Weight of l0 bulb (g) and yield/plot also increased by 10.6% and 50.9% in fungicide sprayed plot over control.

The finding also keeps in with the findings of Rahman (2004) and Ali (2008). Rahman (2004) reported that eight spraying of Rovral 50WP (0.2 %) or Ridomil MZ-72 (0.2) with 7 days interval minimized the disease incidence and disease severity of purple blotch complex of onion and increased the bulb yield. Ali (2008) reported that spraying of Rovral 50WP (0.2%) along with application of micronutrients remarkably reduced the incidence and severity of purple blotch of onion.

The yield loss assessment was made by the regression equation $\hat{Y}$= 0.00+0.67Xi

Where $\hat{Y}$ stands for percent predicted yield loss and Xi stands for the disease severity (PDI) of purple blotch complex of onion in the standing crop. It is revealed from the regression equation that each % increase of disease severity is responsible for decreasing 0.67 % bulb yield. Calculating the disease severity in the standing crop and putting it in the regression equation, the percent yield loss could be calculated prior to harvest. Thus, in case of epidemic outbreak of purple blotch complex of onion, the Government will receive the information about the national yield loss and will able to take the necessary initiatives to meet up the national demand of onion and thus the production rate of onion will boost up. The market crisis of onion will be minimized and dependence for importing onion from the neighboring countries will be rational.

CHAPTER VI

SUMMARY AND CONCLUSION

Onion (*Allium cepa* L.) is one of the important major spice crops in Bangladesh. Production of bulb onion is affected by different disease in Bangladesh. Purple blotch complex of onion that caused by of *Alternaria porri* and *Stemphylium vesicarium* is one of the top five infectious diseases.

The experiment was laid out in a RCBD (one factor) with four replications. There were ten treatments, Viz. T_0 (No field spraying with Rovral 50 WP @ 0.2%); T_1 (One field spraying with Rovral 50 WP @ 0.2%); T_2 (Two field spraying with Rovral 50 WP @ 0.2%); T_3 (Three field spraying with Rovral 50 WP @ 0.2%); T_4 (Four field spraying with Rovral 50 WP @ 0.2%); T_5 (Five field spraying with Rovral 50 WP@ 0.2%); T_6 (Six field spraying with Rovral 50 WP@ 0.2%); T_7 (Seven field spraying with Rovral 50 WP@ 0.2%); T_8 (Eight field spraying with Rovral 50 WP@ 0.2%) and T_9 (Nine field spraying with Rovral 50 WP@ 0.2%) . Data were collected on percent plant infection, percent infected leaf, disease severity (leaf) and yield of onion. Data were analyzed and the mean value was adjudged with Duncan Multiple Ranges Test (DMRT).

The application of fungicide (Rovral 50 WP @ 0.2 %) significantly influenced almost all of the parameters like disease incidence, disease severity and bulb yield. The lowest percent of plant infection (0.0%), percent leaf infection (0.0%) and percent leaf area diseased (0.0%) were recorded from the field where 9 sprayings with Rovral 50 WP @ 0.2% was done. The highest percent of plant infection (79.04%), percent leaf infection (75.68%) and percent leaf area diseased (71.76%) were recorded from control (T_0). Percent of plant infection, leaf infection, leaf area diseased decreased with the increasing number of spraying with Rovral 50 WP @ 0.2%.

The highest bulb yield (6575.50 kg/ha) was obtained from the plot where 9 field spraying with Rovral 50 WP @ 0.2% was applied. The lowest bulb yield (3269.8 kg/ha) was obtained from the plot of control (T_0). It is revealed that yield increased with the increasing number of spraying with Rovral 50 WP @ 0.2%.

The yield loss assessment was made by using regression equation $\hat{Y}$= 0.00 + 0.67Xi. It indicated that each percent increase of disease severity (PDI) decreased 0.67 % yield. On the basis of present findings of the study it may be concluded that onion grower may be suggested to apply Rovral 50WP @ 0.2% in controlling purple blotch complex of onion for increasing production of onion. However the multiple treatment experiments need to be carried out at different Agro-Ecological Zones (AEZ) for at least 3 consecutive years to justify the findings of present experiment.

CHAPTER VII

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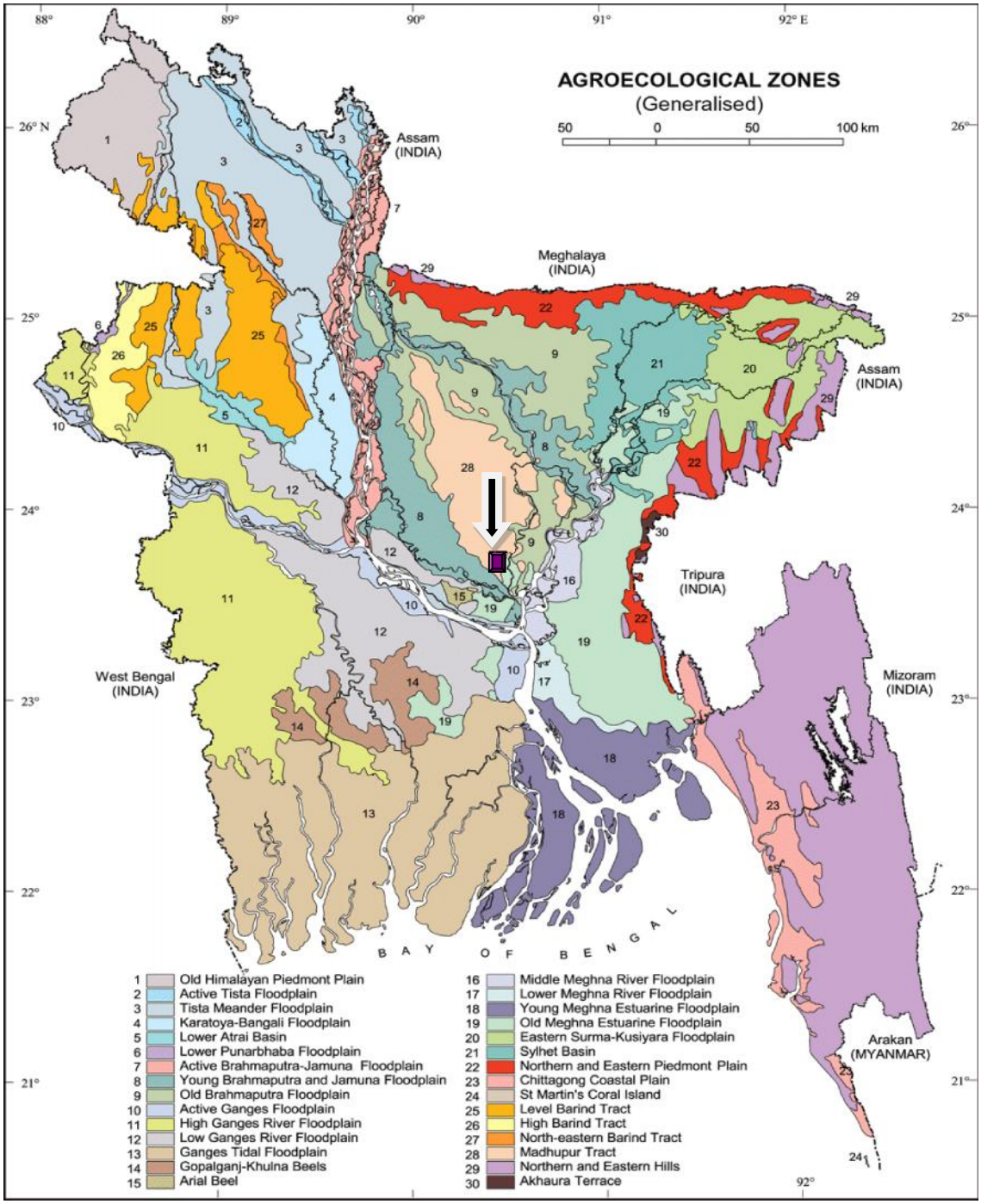
CHAPTER VIII

APPENDICES

Appendix I: Experimental location in the map of Agro-Ecological Zones of Bangladesh



Appendix-II: Particulars of the Agro-ecological Zone of the Experimental site

Agro-ecological region	: Madhupur Tract (AEZ-28)
Land Type	: Medium high land
General soil type	: Non- Calcareous Dark gray floodplain soil
Soil series	: Tejgaon
Topography	: Up land
Location	: SAU Farm, Dhaka
Field level	: Above flood level
Drainage	: Fairly good
Firmness(consistency)	: Compact to friable when dry.

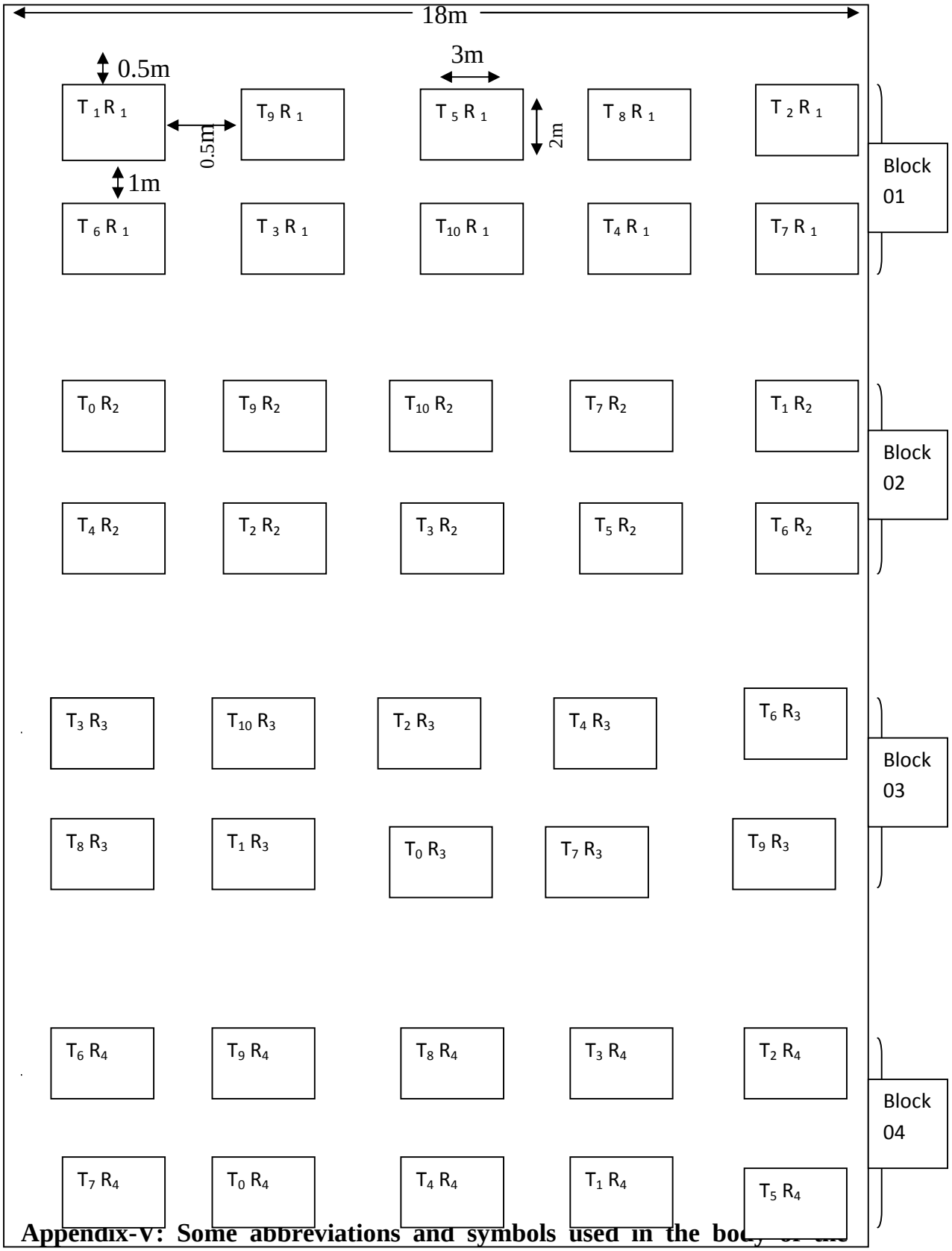
Appendix III: Monthly mean weather of the experimental site

Monthly mean of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours during November/2011 to March/2012 are given bellow:

Year	Month	Air temperature(0^0)			Relative Humidity (%)	Rainfall (mm)	Wind Speed (km/hr)
		Max.	Min.	Average			
2011	November	31.2	17.3	23.4	66.6	0.00	0.6
	December	25	15.7	19.5	68	0.00	1.3
2012	January	24.4	16.4	19.6	72.2	1.27	1.2
	February	29.5	16.9	22.4	51.3	0.00	1.4
	March	32.5	20.4	26.45	66.4	0.00	1.45
	April	39.5	25.7	32.6	75.2	0.50	1.5

Source: Bangladesh Meteorological Department (Climate Division), Agargoan, Sher- e-Bangla Nagar, Dhaka-1207

Appendix IV: Layout of the field experiment: (RCBD)



Appendix-V: Some abbreviations and symbols used in the body of the thesis

Abbreviations	Full word
%	Percent
@	At the rate of
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BSMRAU	Bangladesh Sheikh Mujibur Rahman Agricultural University
CEC	Cation Exchange Capacity
cm	Centi-meter
CV%	Percentage of coefficient of variation
DAI	Days After Incubation
DAS	Days After Sowing
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
EC	Emulsifiable concentration
et al.	and others
etc.	Etcetera
FAO	Food and Agricultural Organization
g	Gram
hr.	Hours

	kiligrams per hectare
kg	kilogram

LAD	Leaf area diseased
m	Meter
m^2	Square meter
MOA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
NUV	Near Ultra Violet
PDI	Percent disease index
PDA	Potato dextrose agar
SAD	Stalk Area Diseased
ppm	Parts per million
RCBD	Randomized complete block design
Rep.	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error
Univ.	University
var.	variety
WP	Wetable Powder
J.	Journal

Appendix-VI: ANOVA table of the experiment

Table .01: Effect of treatment on Percent plant infection at 80 DAP

Source of variance	Degree of freedom	Sum of squares	Mean square	F value	Probablity
Replication	3	3.32	1.107	1.33	0.2858
Treatment	9	30283.45	3364.828	4036.83	0.0000
Error	27	22.51	0.834		
Total	39	30309.28			
Coefficient of Variation: 2.76%					

Table. 2: Effect of treatment on Percent leaf infection at 80DAP

Source of variance	Degree of freedom	Sum of squares	Mean square	F value	Probablity
Replication	3	1.14	0.381	0.27	0.8466
Treatment	9	26178.41	2908.713	2058.15	0.0000
Error	27	38.16	1.413		
Total	39	26217.72			
Coefficient of Variation: 3.74%					

Table. 3: Effect of treatment on Percent leaf area disease at 80DAP

Source of variance	Degree of freedom	Sum of squares	Mean square	F value	Probablity
Replication	3	4.22	1.407	0.97	0.4215
Treatment	9	24917.68	2768.631	1908.17	0.0000
Error	27	39.18	1.451		
Total	39	24961.07			
Coefficient of Variation: 4.17%					

Table. 4: Effect of treatment on bulb yield (kg/ha)

Source of	Degree	Sum of	Mean square	F value	Probablity

variance	of freedom	squares			
Replication	3	1184.03	394.677	0.20	0.8965
Treatment	9	48023178.13	5335908.681	2683.67	0.0000
Error	27	53683.84	1988.290		
Total	39	48078046			
Coefficient of Variation: 0.89%					