MANAGEMENT OF ALTERNARIA BLIGHT OF RADISH (*Raphanus sativus* L.) SEED CROP WITH FUNGICIDES, BAU-BIOFUNGICIDE AND MICRO-NUTRIENTS

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A THESIS

BY

MST. SOHANA FERDOUSI

Student No. 0705017

Session: 2007-08

Semester: January-June 2008

MASTER OF SCIENCE (M.S.)

IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

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DEPARTMENT OF PLANT PATHOLOGY

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DEDICATED
TO
MY BELOVED PARENTS

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ABSTRACT

Radish *(Raphanus sativus* L., n = 9) belonging to the family cruciferae, is the third most important vegetable crop of Bangladesh. The high yielding tropical annual type Tasaki Mula was used in this study. The Dinajpur region is one of the most important seed growing regions of Bangladesh. Therefore, the present study has been carried out in Dinajpur region. The application of two foliar fungicides (Iprodione, Mancozeb), bioagent means (BAU-Biofungicide) and three micro-nutrients (Boron, Zinc and Magnesium) were applied in controlling the Alternaria blight on radish seed crop during rabi season of 2007-2008. Disease and yield data were assessed in terms of percent leaf area diseased, percent pod area diseased, 1000-seed weight (g) seed, yield per plant (g) and seed per hectare yield (t/ha). The percent diseased seed and germination percentage were recorded after harvest of the crops. Sprays were commenced from the first appearance of disease symptoms at 51 day old transplanted crop. Iprodione, Mancozeb and BAU-Biofungicide had significant effect on reduction of disease and increasing of seed yield. Among the fungicides, remarkable reduction of leaf area diseased was observed with Iprodione sprayed plots followed by BAU-Biofungicide but incase of pod area diseased, there was no significant difference between Iprodione and BAU-Biofungicide sprayed plots. The result of yield per hectare (1.18 t/ha) were found significantly higher in Iprodione sprayed plots followed by BAU-Biofungicide (1.07 t/ha) over control (0.47 t/ha). The foliar application of Iprodione had a significant effect on seed quality. The highest diseased seed (70.89%) was recorded in seed that control plots where the lowest (36.86%) was recorded in Iprodione sprayed plots that received seven sprays followed by BAU-Biofungicide (41.05%). Percent germination was significantly influenced by foliar spray with fungicides. The lowest germination (75.75%) was recorded in seed samples that were collected from control plots, but the highest (86.50%) was recorded where seven sprays of BAU-Biofungicide was applied. Incase of economic consideration, the plots of BAU-Biofungicide gave the maximum net return (Tk. 1,66,000/-) having BCR of 4.32. Therefore, it may be concluded that among the spray materials BAU-Biofungicide with seven sprays plays the best role in reducing the Alternaria blight and significantly increase the seed yield with good quality.

CAHPTER 1

INTRODUCTION

Radish *(Raphanus sativus* L., n = 9) belonging to the family Cruciferae, is a popular and widely grown vegetable in Bangladesh as well as in different parts of the world. Radish is the third most important vegetable crop next to potato and eggplant; and fifth most important vegetable seed crop next to onion, amaranth, eggplant and chili in respect of total acerage (44,000 ha) (Anon, 1997a). At present 445 tons of radish seeds are produced in 44 thousand hectors of land in the country. Total requirement of radish seed in Bangladesh is above 700 tons for vegetable purposes (Anon, 1997b).

The high yielding radish varieties popularly cultivated in Bangladesh are of biennial types which do not produce good seeds in field conditions. An open-pollinated tropical annual type variety named Tasaki Mula was developed by the Bangladesh Agricultural Research Institute, capable of producing seeds abundantly under the local climatic conditions (Rashid *et al.,* 1985).

Radish crop was attacked by a number of diseases in Bangladesh (Talukdar, 1974; Rashid, 2000). This crop is infected by at least 17 different diseases (Rashid, 2000). It has 14 seed-borne diseases (Richardson, 1990). Seed borne diseases are more destructive in nature and have worldwide distribution. In radish crops, main diseases are leaf spot (*Alternaria raphani/Alternaria alternata*), Grey leaf spot (*Alternaria brassicae*), Black leaf spot (*Alternaria brassicicola)*, grey mould (*Botrytis cinerea*), Anthracnose (*Colletotrichum higgisianum*), Root and stem rot (*Gibberella avenacea*), Black leg (*Leptosphaeria maculans*), Damping off (*Rhizoctonia *solani*), Leaf spot (*Sclerotinia sclerotiorum*), White rust (*Albugo candida*), Powdery mildew (*Oidium* sp.), Soft rot (*Erwinia carotovora* sub. *carotovora*), Bacterial spot (*Xanthomonas canpestris* pv. *raphani*), Cauliflower mosaic (Cauliflower Mosaic virus), Radish yellow edge (Radish yellow edge virus), Tobacco streak (Tobacco streak virous) and Turnip mosaic (Turnip Mosaic Virus) (Rashid, 2000). Alternaria leaf blight caused by *Alternaria brassicae* is the most destructive one which cause huge production losses as well as major constraint for high quality radish seed production in Bangladesh (Mondal *et al.*, 1989). Moreover, this pathogen affects most cruciferous crop, including broccoli and cauliflower (*Brassica oleracea* L. var. botrytis L), field mustard and turnip (*Brassica rapa*), leaf of chinese mustard (*Brassica juncea)*, Chinese cabbage (*Brassica pekinensis*), cabbage (*Brassica oleracea* var. *capitata*) and rape (*Brassica oleracea*) (Humpherson-Jones and Phelps, 1989). To prevent this disease, the use of resistant cultivars would probably be the most effective and economical control option. Unfortunately, such resistance is not usually expressed in commercially available varieties (Tewari, 1991). In Bangladesh, a number of chemicals have been evaluated against *Alternaria brassicae* in mustard with varying degree of success (Anon, 1981; Atika and Ahmed, 1985; Hug and Ahmed, 1985; Howlidar *et al.*, 1985; Meah *et al.*, 1986). But information on the control of Alternaria blight particularly on radish seed crop is limited in this country. Only two or three fungicides have been screened as effective against this disease (Atika and Ahmed, 1985). Rovral has been proved very effective against Alternaria blight in Bangladesh condition (Ferdous, 2002; Mondal *et al.,* 1989) tested some fungicides in radish (var. Tasaki Mula), among them, Rovral performed best followed by Dithane M-45, Dithane Z-78 and Captan. Rovral controlled the leaf spot severity on an average (two years data) of 84%, 91% and 95% and reduced siliquae spotting by 93% over the control. Single spray of Rovral (0.2%) in early sown crop significantly reduced leaf area infection by 24% and siliqua infection by 28% over untreated (control) late sown crop of mustard (Rashid *et al.,* 1995). Three consecutive sprays of Mancozeb 75WP (0.2%) at fortnightly intervals beginning at the disease initiation resulted the lowest leaf blight incidence and pod blight intensity in mustard (Singh and Singh, 2006).

Information on the control of Alternaria blight of radish by spraying micronutrient is rare. Foliar application of boric acid and zinc had been found most effective in increasing number of pods per plant, seed yield, 1000-seed weight and germination percentage of radish (Sharma *et al.,* 1999). Moreover, the analysis of soil tested before transplanting of the crop was found low of boron, zinc and magnesium.

Several fungicidal trials have been carried out to control the Alternaria blight of radish seed crop but biological control is not yet available. Biological control offers environmentally safe, durable and cost effective alternatives to chemicals (Papavizas and Lumsden, 1980). The fungicide application has a profound effect on environmental hazard. To combat the harmful effect of chemicals and to get desirable yield, scientists have been thinking to reduce pesticide use through biological control, the use of specific microorganisms that interfere with plant pathogens, is a nature-friendly and ecological approach to overcome the problems caused by standard chemical methods of plant protection. The fungi (*Trichoderma harzianum*) are known as antagonists and very potential bio-control agents of several plant pathogenic fungi. Moreover, it is beneficial microbes to contribute the plant health and vigour. At present few elementary studies of *Trichoderma harzianum* as BAU-Biofungicide is going on as seed treating as well as foliar application in Bangladesh. This antagonistic fungus had antifungal effect on Alternaria species as seed born as well as cause of leaf spot disease of radish (Hossain, 2007 and Shultana, 2007).

Cultivation of radish as seed crop has been becoming popular in the northern region of Bangladesh. Now a day, this crop is cultivating year round. In these contexts, the present study was undertaken for achieving the following objectives.

i) To find out the effective fungicide and micro-nutrients in controlling the Alternaria blight of Radish cv. Tasaki Mula.

ii) To find out the effectiveness of BAU-Biofungicide in controlling the Alternaria blight of Radish cv. Tasaki Mula.

iii) To find out the most effective control measures of Alternaria leaf blight of Radish in Bangladesh.

CHAPTER 2

REVIEW OF LITERATURE

Alternaria leaf blight of radish seed crop caused by *Alternaria brassicae* and *A. brassicicola* is a worldwide important disease. This disease is considered as the most devastating one and has profound effect on radish seed production in Bangladesh. Many workers and researchers are trying to control Alternaria leaf blight with fungicides. Related literatures of the present study were complied and presented below:

2.1. Effect of fungicides

Kolte *et al.* (1978) conducted an experiment on the efficacy of certain chemicals in controlling the Alternaria blight of Cruciferous vegetables in two successive cropping seasons. They used seven fungicides namely Dithane M-45 (0.2%), Dithane Z-78 (0.2%), Difolatan (0.2%), Bavistan (0.5%) and Thiophanate methyl (0.5%). TPTH, Difolatan and Mancozeb were used singly or in combinations following 7-day interval during 1976. They reported that TPTH (0.2%) or Difolatan (0.2%) significantly reduced the number of spots per siliqua, average number of infected siliqua per 30 cm top portion of a main rachis and increased seed yield per plant, 1000-seed weight and yield per plot.

Humpherson and Madhu (1983) applied three sprays of Iprodione (Rovral 50 W.P.) at 0.5-1.0 kg a. i. /ha on radish seed crops at three week intervals in controlling pod infection caused by *Alternaria brassicae* and *Alternaria brassicicola*. They found significantly higher seed yield and higher amount of germination over control. Bordeaux mixture also was found per with effective as Iprodione when disease levels were low but was ineffective when infection pressure was severe.

Tripathi *et al.* (1987) reported that *Alternaria brassicae* caused severe yield reduction in radish seed crop. A Captafol spray followed by a Mancozeb spray with 15-day interval gave effective disease control. A spray schedule involving four sprays of Mancozeb starting 30 days after sowing at 15-day intervals was the best combination for maintaining a disease free crop.

Orphan (1988) assessed the efficacy of certain fungicides to control leaf spot disease on cruciferous vegetables. Rovral at 30g/20 liter of water performed a good control of disease. The disease severity index was 2.7, 2.36 and 2.77 when the spraying intervals were 5, 10 and 15-day, respectively. The control plots showed their severity index between 5.56-5.83 while the maximum index of 6 was used. The seed yield from Rovral spraying plot was higher then the others. Captafal sprayed with intervals of 5 or 10-day performed a good control as well. According to the result of this experiment Rovral at the rate of 30g/20 liter of water sprayed with 10 to 15-day interval was recommended to control the disease.

Shivapuri *et al.* (1988) mentioned that during 1986-87, six fungicides viz. Rovral, Captafol, Dithane M-45, Thirum, Blitox-50 and Bavistin were applied to radish seed crop infected by *Alternaria brassicae* in a field trail in Rajastan, India. All of the fungicides controlled the disease but Blitox-50 was phytotoxic. The best treatment was Rovral followed by Captafol and Mancozeb. Rovral caused minimum defoliation.

Hussaini *et al.* (1989) reported that four fungicides applied at 10-day intervals from the 1st week of March, the most effective against *Alternaria brassicae* on pods and seeds was Dithane M-45 [Mancozeb] followed by Bordeaux mixture.

Mondal *et al.* (1989) reported that fungicides were applied to 55-day old radish seedling at 10-day intervals in Bangladesh. The most effective control of *Alternaria brassicae* was given by Iprodione (as Rovral). Mancozeb (as Dithane M-45), Zineb (as Dithane M-78), Captan, Benomyl (as Benlate), Thiophanate-methyl (as Topsin M) and Carbendazim (as Bavistin) were also effective.

Anonymous (1993) obtained minimum disease incidence in Rovral sprayed plot of radish and maximum in unsprayed (control) plots, which differed significantly. Rovral sprayed plot, on an average produced seed yield of 1291.11 kg/ha which was significantly higher than that of unsprayed plot.

Ayub *et al.* (1996) conducted an experiments to evaluate the efficacy of seven fungicides to control Alternaria blight of radish, caused by *Alternaria brassicae,* and *Alternaria brassicicola.* Carbendazim (Bavistin) and Benomyl (Benlate) at 0.1%, Ziram (Cuman L.), Mancozeb (Dithane M-45), Fentin hydrozide (Duter), Iprodione (Rovral) and copper salts + mancozeb (Trimiltox Forte) at 0.2%, were applied 3 times to plants which were 40, 50 and 60 days old plant. Experiments were carried out in Gazipur, Bangladesh during the Rabi season between 1986 and 1989. Iprodione reduced disease severity the most and increased seed weight and yield. Fentin hydroxide was the second best fungicides. Maximum reduction of disease severity and increased yield was achieved when the spraying was carried out on 40 days old plant.

Anonymous (1997a) described the effect of three different doses of Rovral (1 g/litre, 2 g/litre and 3 g/litre) at the spray programme (sprayed 35, 55 and 70 days after sprouting) on the development of Alternaria blight of *Raphanus sativus.* Rovral sprayed at 20-day interval starting after 35 days of sprouting with any tested doses of Rovral significantly reduced the development and severity of Alternaria blight. Fungicide and the commencement of the spray programme had no effect on leaf defoliation.

Rahman (2000) reported that Rovral 50W.P. @ 0.2% caused reduction of Alternaria blight severity by 42% and increased yield of radish by 46.5%. Plants raised from apparently healthy seeds when received 2 sprays of fungicide had reduction in Alternaria blight severity by 57-158%. Integration of the highest level of management i.e. apparently healthy seeds, one weeding, 2 sprays of insecticide and 2 sprays of Rovral 50W.P. caused reduction in Alternaria blight severity by 92% and increased seed yield by 276%.

Dey and Debata (2000) assessed the severe incidence of a leaf spot disease in the radish crops. The causal organism was identified as *Alternaria brassicae*. Disease was controlled tested with Bavistin (carbendazim 0.1%), Dithane M-45 (mancozeb 0.35%) and Blitox (copper oxychloride 0.3%). Bavistan was most effective followed by Dithane M-45.

Anonymous (2002) conducted an experiment with a susceptible variety Tori-7 of mustard and sprayed garlic extract and Rovral 50W.P. @ 0.2% for three times. The lowest leaf blight severity (3.3) was recorded from Rovral sprayed plot which was statistically similar with garlic extract sprayed plot in respect of disease severity. The highest seed yield (1152 kg/ha) was obtained from Rovral sprayed plot which was statistically similar with garlic extract sprayed plot in respect of seed yield. The control plot produced the lowest seed yield of 867 kg/ha.

Kumar *et al.* (2003) conducted pot experiment to determine the efficacy of 0.2% Captan, Iprodione, Ridomil MZ [Mancozeb + Metalaxyl], Achook [*Azadirachta indica*], Zineb, Ziram and Blitox-50 [Copper oxychloride] applied at recommended rates against Alternaria blight (caused by *Alternaria* *brassicae*) infecting radishes (cv. Kalyanpur No.1). The fungicides were sprayed immediately after the appearance of initial symptoms and 10 and 20 days later. Plants sprayed with water served as the control. Observations on disease intensity and percentage disease reduction were recorded 15 days after the last spray. All fungicides significantly reduced disease incidence; the best control of the disease was obtained by spraying plants with Iprodione, followed by Mancozeb, Achook and Ridomil-MZ.

Chattopadhyay and Bhunia (2003) reported that seven fungicides viz. Mancozeb 0.2%, Captan 0.2%, Metalaxyl MZ 0.25%, Rovral 0.2%, Bayletan 0.5% (triadimefon), Copper oxychloride 0.3% and Antracol 0.2% (propineb) were tested against Alternaria leaf blight of Cruciferous plants caused by *Alternaria brassicae* and *Alternaria brassicicola.* Best control of disease was observed in case of Rovral followed by Mancozeb. Highest seed yield and significant increase of 1000-seed weight were also recorded from single spray of Rovral at post-flowering stage. But maximum economic return was obtained from two spraying of Mancozeb at 45 DAS and 60 DAS.

Khoda *et al.* (2003) conducted an field experiment from October 2002 to October 2003 in Gazipur, Bangladesh to evaluate the effectiveness of 5 fungicides to control Alternaria blight (*A. brassicae* and *A. brassicicola*) of cauliflower seed crop. They were Rovral 50WP (0.20% iprodione), Dithane M-45 (0.25% mancozeb), Ridomil (0.10% metalaxyl). Bavistin (0.25% carbendazim) and Knowin (0.25% carbendazim). The fungicides were applied as foliar sprays for 4 times with 10-day intervals starting from the development of curd. The maximum reduction in severity of stalk rot and pod blight and the highest increase in seed yield over control were achieved with Rovral 50WP (0.20%), followed by Dithane M-45 (0.25%). Other fungicides were also effective in decreasing disease severity and increasing seed yield.

Yadav (2003) assessed the efficacy of non systemic and systemic fungicides including mancozeb against Alternaria leaf and pod blight. All the fungicidal treatments were significantly superior to the control in reducing leaf or pod infection and increasing yield of mustard by 1900kg/ha.

Amaresh and Nargund (2004) estimated the yield loss due to Alternaria blight in cruciferous crop. The treatments were imposed by selecting three fungicides viz., Tridemorph (0.1%), Iprodione (0.2%) and Chlorothalonil (0.2%) in order to create different levels of percent disease index of both diseases. Fungicides were applied as a 2, 3 and 4 sprays at 35, 45, 55 and 65 days after sowing (DAS) of crop growth stages. One untreated control was maintained and seed yield losses 43.90 and 32.65 percent was recorded during 1988-99 and 1999-2000, respectively in the absence of control measures of the disease.

Singh and Singh (2006) conducted a field experiment in Uttar Pradesh, India during 2002-03 and 2003-04 to develop spray schedule(s) for the management of blight caused by *Alternaria brassicae* and *A. brassicicola* in mustard (*Brassica juncea*) cv. Narendra Rai sown on 15 and 30 October, and 15 November. Mancozeb and Ridomil were sprayed in spray schedule combinations. Sowing on 15 October resulted in the lowest incidence of leaf blight, pod blight and white rust intensity and the highest 1000-seed weight and yield. Three consecutive sprays of Mancozeb 75 WP (0.2%) at fortnightly intervals, beginning at the disease initiation resulted in the lowest leaf blight incidence and pod blight intensity. This spray schedule with benefit: cost ratio of 4.35, 3.98 and 3.33, respectively, under the first second and third dates of sowing and highest net returns of Rs. 6316 and Rs. 5612 for the first and second dates, respectively, proved most economical. Seed yield and 1000-seed weight under all the dates of sowing were highest with 2 consecutive sprays of Mancozeb followed by a third spraying with Ridomil

Hossain (2003) reported that the yield of the crops can be increased by 25-80% over the untreated control by using BAU-Biofungicide and can be applied for controlling seed-borne diseases of vegetables by treating seeds.

Naznin (2004) conducted an experiment on biological control of seedlings diseases of some vegetables and found 7.92% to 50.80% higher germination over untreated control of sweet gourd, snake gourd, cowpea, cucumber and okra.

Bhuiyan (2005) determined the effectiveness of bioagent as BAU-Biofungicide in controlling seedling diseases of winter vegetables. In field experiment, he found higher germination (12.52%) over control when radish seed was treated with BAU-Biofungicide.

Shultana (2007) conducted a field experiment on leaf spot of Wheat and observed remarkable reduction of leaf blight severity in foliar spray of Amistar (0.05%) followed by foliar spray of BAU-Biofungicide (2%). Significantly highest grain yield was found in Amistar (0.05%) sprayed plot followed by BAU-Biofungicide sprayed plot that resulted 49.43% and 33.36%, respectively higher yield over control.

Sharma *et al.* (1999) reported that during the winter season of 1995-96 and 1996-97 at Nauni with four rates of boron (0, 10 and 20 kg borax per hectare in soil and a foliar spray of 0.1% boric acid) and three rates of zinc (0 and 10 kg $ZnSO_4$/hectare in soil and a foliar application of 0.1% $ZnSO_4$) to study the growth, yield and seed quality of radish cv. Japanese White. The foliar spray of 0.1% boric acid and a soil application of 10 kg $ZnSO_4$/ hectare were found most effective in increasing number of pods per plant, diameter of the main shoot, seed yield, 1000-seed weight and germination percentage.

CHAPTER 3

MATERIALS AND METHODS

3.1. Experimental site

The experiment was conducted in BRAC farm, Basherhat, Kotwali, Dinajpur district during rabi season of 2007-2008 which stands at 25°40′ North latitude and 89°00′ East longitude having an elevations of about 46 m above the sea level. The experimental field was medium high land and soil belonged to agro-ecological zones (AEZ) No. 1 namely Old Himalayan Piedmont plain (UNDP and FAO, 1988). The soil type and health status are given below:

Land type	:	Medium high land	
Texture	:	Sandy loam	
pH	:	5.95	(Slightly acidic)
Organic matter (%)	:	0.74	(Very low)
% Nitrogen	:	0.037	(Very low)
Phosphorus	:	0.05μg g^{-1}	(Very low)
Potasium	:	0.001 meq 100 g^{-1}	(Very low)
Sulphur	:	6.95 μg g^{-1}	(Very low)
Zinc	:	0.448 μg g^{-1}	(Very low)
Boron	:	0.410 μg g^{-1}	(Medium)
Magnesium	:	0.316 meq 100 g^{-1}	(Very low)

3.2. Collection of seed samples

The seed crop was radish and the variety was Tasaki Mula. The seeds were collected during the harvesting time (March-April, 2006) from local market, Dinajpur town. The sample was analyzed for initial moisture content by Low Constant Oven Method (ISTA, 1993) and stored in the refrigerator at 5-7°C until sowing in the experimental field. The seeds were healthy, vigorous, plumy, well matured and free from mixture of other seeds and refuges.

3.3. Treatments

The following treatment combinations were used to achieve the objectives of:

T_0 = Control (no spray)

T_1 = Iprodione seven sprays

T_2 = Mancozeb seven sprays

T_3 = BAU-Biofungicide seven sprays

T_4 = Boron seven sprays

T_5 = Zinc seven sprays

T_6 = Magnesium seven sprays

3.4. Raising of stickling (syn. seedling)

For raising of stickling, root to seed method was followed. The length and width of the seed bed was 10m × 1m. The soil was prepared by spading. The seed bed was cleaned by removing the weeds, stubbles and crop residues. No fertilizers and manures were used in the seed bed. In case of moisture deficiency irrigation was given through drain. Radish seeds were sown 12 September, 2007 at 20 cm apart in both ways (line to line and seed to seed). Three seeds were sown per hill, after germination single plant was kept per hill. Seeds were sown in the bed @ 5kg/ha.

3.5. Intercultural operations in the seed beds

Two weeding and three irrigation were given at due time after sowing. Plant protecting pesticides was not applied.

3.6. Stickling preparation for transplanting

Fully matured roots at forty-four day old matured roots (before pith development) were harvested, true-to-type roots were selected and giving 1/4th root cut and 2/3rd shoot cut. The selection and roguing were done on the basis of shape, size, color and bolting behavior. Small, deformed, diseased and other undesirable roots were discarded. Hairy, forked roots and early or late bolters were also removed.

3.7. Main plot preparation

The land was prepared by tractor and power tiller. Four plowing and cross plowing followed by three laddering were done during the course of land preparation. Weeds and other rubbishes were removed. Then the unit of experimental plot was prepared. Recommended manures and fertilizers were applied. The entire amount of compost, TSP, gypsum, zinc, boron and half of the urea and MOP were applied during experimental plot preparation while rest of the urea and MOP were used as top dressing at flowering formation stage.

Manures and fertilizers used in radish seed production

Manures/Fertilizers	Application rate (ha^{-1})
Cowdung	25 ton
Urea	300 kg
TSP	200 kg
MOP	150 kg
Gypsum	100 kg
Zinc	15 kg
Boron	10 kg

3.8. Design and layout

The field experiment was conducted in Randomized Block Design (RCBD) with three replications and seven treatments. Each plot size was 2.5m × 2m with line to line spacing 50cm, plant to plant distance 50cm and plot to plot distance 1m. The total number of plants in a single plot was 20.

3.9. Transplanting of stickling in the main plots

Stickling of 40 days old was transplanted in the main field. Twenty stickling was transplanted in each subplot maintaining the plant to plant and line to line distance 50cm and 50cm respectively on 25 November, 2007.

3.10. Intercultural operations

Intercultural operations were done to maintain the maximum hygienic conditions in the crop field. Six weeding were done at 15 days interval after transplanting. For proper development of vegetative and reproductive structure, experimental plot was irrigated three times after transplanting of the crops. The first irrigation was done at 20 DAT, second 35 DAT and third 50 DAT. The insecticide Acephate (Asataf 75SP) @ 12 ml 10 L^{-1} was applied in the field in controlling the aphid as required.

3.11. Spray materials:

3.11.1. Fungicides and micro-nutrients used in the management of Alternaria blight were as shown below:

Sl No.	Fungicides/ bio-agent /micro-nutrients	Trade name	Chemical name	Active ingradient	Conc. (%)
1	Iprodione	Rovral	3-(3,5 dichlorophenyl)-N-(1 methyl ethyl)-2,4 dioxuimidazolidene Carbosxamide $(C_{12}H_{13})_3N_3C_{l2}$	50%	0.25
2	Mancozeb	Dithane M-45	Manganous ethylene bisdithio carbamate-ion $(C_4H_6N_2S_4)$	80%	0.30
3	*Trichoderma harzianum*	BAU-Bio fungicide		2.0%	2.0
4	Boron	Foliarel (Solubor boron)	Borax (H_3BO_3)	-	0.20
5	Zinc	Mukta plus	Zinc sulphate monohydrate $[Zn(HSO_4)_2]$	-	0.10
6	Magnesium	Aungkur	Mangnesium sulphate $(MgSO_4)$	-	0.30

3.11.2. Preparation and application of fungicides, BAU-Biofungicide and micro-nutrient solution

Iprodione (Rovral), Mancozeb (Dithane M-45), BAU-Biofungicide, Boron (Foliarel), Zinc (Mukta Plus) and Magnesium (Angkur) were poured in 10 L Knap Sac sprayer machine and dissolved in water taking recommended concentration. In case of BAU-Biofungicide, it was sieved with cheese cloth. The application of micronutrient, BAU-Biofungicide and fungicidal solution was started at the time of disease initiation 51DAT for ten day interval and the control plot was sprayed with plain water by Knap Sac sprayer. The spray time in every spraying was 3:00 pm to 4:00 pm.

3.12. Data collection

The total of 6 plants out of 20 plants from each plot were randomly selected and tagged for recording data.

Data were recorded on the following parameters

a) % LAI (Leaf area infected)

b) % PAD (Pod area diseased)

c) 1000-seed weight (g)

d) Yield per plant (g)

e) Yield (t/ha)

f) Diseased seed (%)

g) Germination (%)

Percent leaf area diseased (LAD) and pod area diseased (PAD) were measured following eye estimation (plate 1 and 2). Area of a single leaf or pod was considered as 100%. Deducting the healthy area, the diseased area was estimated following the formula (Islam *et al.*, 2001):

$$\%\,\text{leaf or pod area diseased} = \frac{\text{Area affected}}{\text{Total assessed area}} \times 100$$

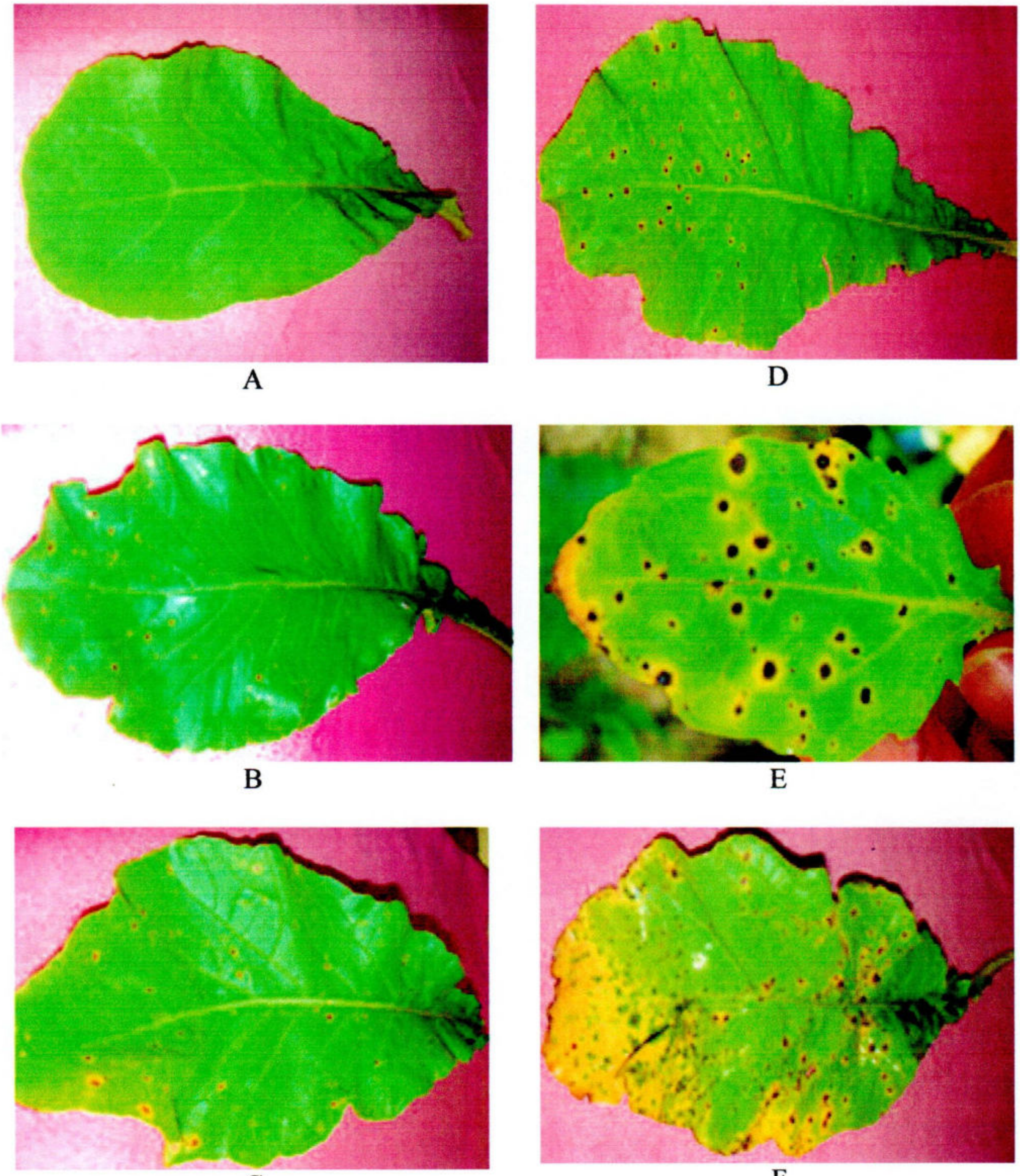

Plate 1. Healthy leaf (A) and different percent leaf area diseased (B-F)

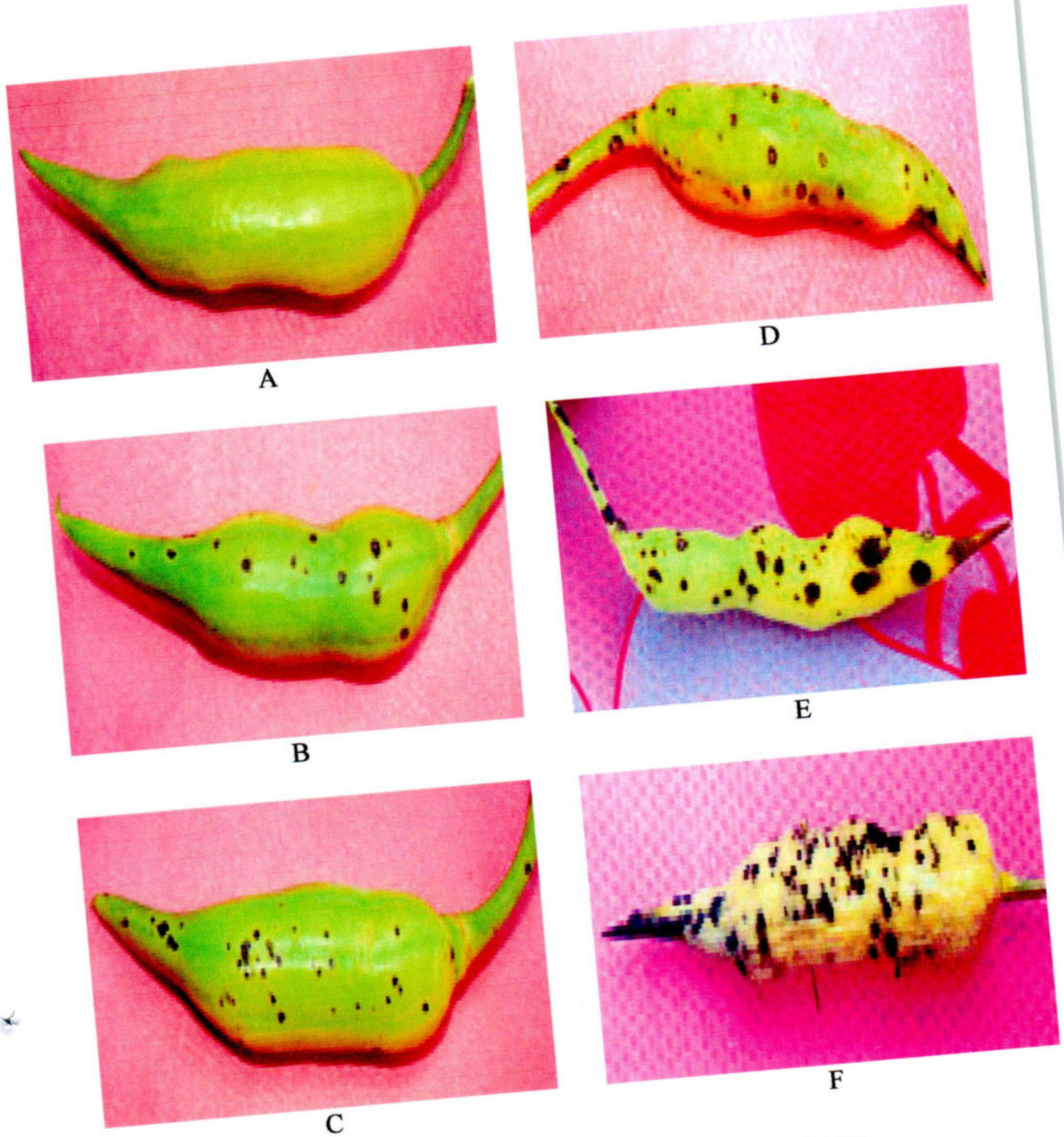

Plate 2. Healthy pod (A) and different percent pod area diseased (B-F)

Percent leaf area infection per plant was recorded from all leaves within 30cm above from the soil level and percent pod area infection was recorded from all pods bearing on three branches of central seed stalk. In this case 30 cm from the base of the branches and main stalk were considered for pod assessment. Leaf area and pod area infection data were recorded at an interval of seven and fifteen days, beginning from first day of disease initiation.

3.13. Harvesting, threshing and weighing

The seed crop was harvested after 137 DAT when the pods turned into brown color. During harvesting the tagged and non-tagged plants per plot were bundled separately and threshed carefully. After proper processing, seeds were seen dried. Clean dried seeds were then counted and weighed by using an electrical balance. Weight of 1000-seeds were taken at 14% moisture content after drying. The yield of tagged plant of each plot was measured by electrical balance. After recording the data, it was averaged and find out yield per plant. Yield per plot was calculated adding the seed yield of tagged plants with the yield of rest of the plants in a specific plot. After that recorded yield per plot convert into yield per hectare.

3.14. Germination test

Four hundred seeds were taken at randomly from the well mixed pure seed. Four replicates of 100 seeds were used for this study. Before arranging the seeds, the 2 layer of blotter papers were taken and were made wet and squeezed removed excess water. After that 100 seeds from each replicate from the radish seed lots were placed on the top of paper. The papers placed in transparent plastic boxes with room temperature. The first count was taken at 4th day and final count was done at 10th day of setting the test. Average of 100×4 replicates were calculated and percentage by number of germination was reported (Anon, 2006).

3.15. Counting of percent apparently healthy seed and diseased seed

The apparently healthy seed and diseased seed were determined by composition of number of the sample being tested and identify of the seed with naked eye as a dry inspection method. The working samples (30g) of pure seed was taken from each treatment and separated into the above two grades (healthy and diseased seeds) and then percentage of each grade was made by counting the seeds. The grades of seeds were:

i) Apparently healthy seed: Seeds were sorted from the pure seed fraction sample having normal shape, size and color and,

ii) Diseased seed: Seeds, which were dark brown to black, spotted, discolored, shriveled and suspicious to be infected.

3.16. Cost-benefit analysis

The cost of production was analyzed with a view to find out the most profitable treatment combination (Islam *et al.*, 2004 and Gittinger, 1982). In this case, all the non-materials and materials input costs were considered for calculating the cost of production. Benefit cost ratio was calculated following the formula:

$$\text{BCR} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

3.17. Analysis of data

The collected data on different parameters were statistically analyzed following MSTAT software package program and then treatment means of different parameters were compared following Duncan's Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS

4.1. Effect of fungicides, BAU-Biofungicide and micro-nutrients on percent leaf area diseased (LAD) at different days after transplanting (DAT) in 2007-2008

The foliar application of two fungicides (Iprodione and Mancozeb), BAU-Biofungicide and three micronutrients (Boron, Zinc and Magnesium) were studied in controlling the Alternaria blight of radish and the findings are presented in Table 1. At 51 DAT, the LAD remained statistically similar, but at 58 DAT the LAD ranged from from 6.61% to 25.75%, where the significantly highest LAD (25.75%) was obtained in the control plots and the lowest (6.61%) was recorded in Iprodione sprayed plots which was statistically similar with Mancozeb (7.44%) sprayed plots. BAU-Biofungicide showed the third lowest LAD (10.39%). At 65 DAT, the LAD ranged from from 10.73 to 46.00, where the significantly highest LAD (46.00%) was in the control plots and the lowest (10.73%) in Iprodione sprayed plots which was followed by Mancozeb sprayed plots (12.22%). At 72 DAT, the LAD ranged from from 15.05% to 76.17%, where the significantly highest LAD (76.17%) was recorded in control plots and the lowest (15.05%) was obtained in Iprodione sprayed plots which was followed by BAU-Biofungicide sprayed plots (21.44%). At 79 DAT, the LAD ranged from 22.39% to 95.72%, where the significantly highest LAD (95.72%) was recorded in the control plots and the lowest (22.39%) was found in Iprodione sprayed plots and BAU-Biofungicide was found the second lowest LAD (27.17%). At 86 DAT, the LAD ranged from 30.44% to 100%, where the significantly highest LAD (100.00%) was obtained in the control plots and the lowest (30.44%) was recorded in Iprodione sprayed plots which was followed by BAU-Biofungicide sprayed plots (34.28%).

Table 1. Effect of fungicides, BAU-Biofungicide and micro-nutrients on percent leaf area diseased (LAD) at different days after transplanting (DAT) of Radish cv. Tasaki Mula

Treatments	51DAT	58DAT	65DAT	72DAT	79DAT	86DAT
Control	1.00 a	25.75 a	46.00 a	76.17 a	95.72 a	100 a
Iprodione	1.05 a	6.61 d	10.73 d	15.05 c	22.39 d	30.44 d
Mancozeb	1.00 a	7.44 d	12.22 d	22.83 b	29.12 c	35.72 b
BAU-Biofungicide	1.05 a	10.39 c	25.61 c	21.44 b	27.17 c	34.28 c
Boron	1.00 a	23.22 b	43.05 b	74.83 a	92.22 b	99.05 a
Zinc	1.00 a	25.11 a	45.94 a	74.00 a	94.72 ab	99.72 a
Magnesium	0.94 a	22.44 b	43.33 b	75.11 a	92.27 b	99.44 a
Lsd ≥ 0.05	0.1125	1.130	1.978	3.641	2.727	1.105

Data represents the mean of 3 replications.

4.2. Effect of fungicides, BAU-Biofungicide and micro-nutrients on percent pod area diseased (PAD) at different days after transplanting (DAT) in 2007-2008

The effect of fungicides, BAU-Biofungicide and micro-nutrients on percent pod area diseased (PAD) is presented in Table 2. At 74 DAT, the PAD ranged from from 0.62% to 1.16%, where the significantly highest PAD (1.16%) was observed in the control plots and the lowest (0.62%) was recorded in Iprodione sprayed plots which was followed by Mancozeb (0.79%). At 89 DAT, the PAD ranged from 2.20 to 5.61, where the significantly highest PAD (5.61%) was recorded in the control plots and the lowest (2.20%) was found in Iprodione sprayed plots which was followed by BAU-Biofungicide (2.44%). At 104 DAT, the PAD ranged from 6.55% to 33.05%, where the significantly highest PAD (33.05%) was recorded in the control plots and the lowest (6.55%) was obtained in Iprodione sprayed plots and BAU-Biofungicide has been shown (6.59%) the second lowest. At 119 DAT, the PAD ranged from 16.38% to 58.44%, where the significantly highest PAD (58.44%) was found in the control plots and the lowest (16.38%) was recorded in Iprodione sprayed plots. The PAD 16.39% was obtained in BAU-Biofungicide sprayed plot that was the second lowest (plate 3).

Table 2. Effect of fungicides, BAU-Biofungicide and micro-nutrients on percent pod area diseased (PAD) at different days after transplanting (DAT) Radish cv. Tasaki Mula

Treatments	74DAT	89DAT	104DAT	119DAT
Control	1.16 a	5.61 a	33.05 a	58.44 a
Iprodione	0.62 d	2.20 c	6.55 c	16.38 c
Mancozeb	0.79 cd	3.38 b	12.22 b	25.66 b
BAU-Biofungicide	0.94 bc	2.44 bc	6.59 c	16.39 c
Boron	1.05 ab	5.49 a	32.44 a	57.67 a
Zinc	1.05 ab	5.27 a	32.17 a	57.71 a
Magnesium	1.05 ab	5.16 a	32.22 a	57.22 a
Lsd ≥ 0.05	0.186	1.02	5.00	7.71

Data represents the mean of 3 replications.

4.3. Effect of fungicides, BAU-Biofungicide and micro-nutrients on 1000-seed weight, seed yield per plant and yield per hectare in 2007-2008

The 1000-seed weight, yield per plant and yield per hectare were significantly influenced by the spray materials (Iprodione, Mancozeb, BAU-Biofungicide, Boron, Zinc and Magnesium) are presented in the Table 3. Spraying of Iprodione significantly increased the 1000-seed weight of radish. There was no significant effect of different treatment on 1000-seed weight of radish seed crop. Seed yield per plant was significantly different among the sprays (Table 3). The lowest yield per plant (11.42 g) was recorded in control plots where the highest (24.12 g) was obtained in BAU-Biofungicide

A

B

C

Plate 3. Control plot (A), Iprodione (B) and BAU-Biofungicide (C) seven sprayed plot

spray plots which were followed by Iprodione sprayed plots (23.68 g). The lowest seed yield per hectare (0.47 t) was found in control plots where the highest (1.18 t) was recorded in Iprodione sprayed plots which was followed by BAU-Biofungicide sprayed plots (1.07 t). In this studies Iprodione, BAU-Biofungicide and Mancozeb ranked first, second and third, respectively regarding the seed yield per hectare.

Table 3. Effect of fungicides, BAU-Biofungicide and micro-nutrients on seed yield of Radish cv. Tasaki Mula

Treatments	1000-seed weight (g)	Yield/plant (g)	Yield (t/ha)	Yield per hectare increase (+) over control
Control	13.03 a	11.42 c	0.47 c	-
Iprodione	14.28 a	23.68 a	1.18 a	+151.06
Mancozeb	13.66 a	19.65 b	0.92 b	+95.74
BAU-Biofungicide	14.30 a	24.12 a	1.07 ab	+127.65
Boron	13.59 a	13.33 c	0.54 c	+14.89
Zinc	13.57 a	12.72 c	0.52 c	+10.63
Magnesium	13.33 a	13.13 c	0.55 c	+17.02
Lsd ≥ 0.05	3.19	4.00	0.168	-

Data represents the mean of 3 replications.

4.4. Effect of fungicides, BAU-Biofungicide and micro-nutrients on percent diseased seed and percent germination increase in 2007-2008

The foliar application of Iprodione had a significant effect on seed quality. The highest diseased seed (70.89%) was recorded in seed that was collected from control plots where the lowest (36.86%) was recorded in Iprodione sprayed plots which was followed by BAU-Biofungicide sprayed plots (41.05%). Percent of germination was significantly influenced by foliar spray with fungicides and biofungicides. The lowest germination (75.75%) was recorded in seed samples that were collected from control plots, but the

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highest (86.50%) was recorded where six sprays of BAU-Biofungicide was applied. Iprodione (84.50%) sprayed plots ranked second in this case.

Table 4. Effect of fungicides, BAU-Biofungicide and micro-nutrients on seed qualities of Radish cv Tasaki Mula

Treatments	Diseased seed (%)	Percent diseased seed decrease (-) over control	*Germination (%)	Percent germination increase (+) over control
Control	70.89 a	-	75.75 e	-
Iprodione	36.86 c	-48.00	84.50 b	+11.55
Mancozeb	55.07 b	-22.31	82.00 c	+8.25
BAU-Biofungicide	41.05 c	-42.09	86.50 a	+14.19
Boron	64.98 a	-8.33	78.25 d	+3.30
Zinc	63.38 a	-10.59	78.00 d	+2.97
Magnesium	64.71 a	-8.71	77.50 d	+2.31
Lsd $\geq$ 0.05	8.26	-	0.8785	-

* Data represents the mean of 4 replications.

4.5. Benefit Cost Ratio (BCR) of management practices in controlling Alternaria blight in production of Radish seed cv. Tasaki Mula

The benefit cost analysis regarding the use of fungicides, BAU-Biofungicide and micro-nutrients in comparing with control has been studied and the results are presented in Table 5. Estimation showed that application of BAU-Biofungicide was yielded the highest return (BCR=4.32). Second highest BCR (3.61) was obtained in Iprodione sprayed plots. The lowest BCR (2.01) was earned from the control (non-sprayed) plots in Radish seed crops.

Table 5. Benefit Cost Ratio (BCR) of management practices for micronutrients application in controlling Alternaria Blight of Radish cv. Tasaki Mula seed production 2007-2008

Treatment combination	Average yield (t/ha) seed + plant	Price (Tk/kg) seed + plant	Gross return (Tk)	Total cost (Tk)	Gross margin (Tk)	BCR
Control	0.47 + 2.0	150/- + 1.0/-	72,500/-	36,000/- (a)*	36,500/-	2.01
Iprodione	1.18 + 2.0	200/- + 1.0/-	2,38,000/-	65,750/- (a+b)*	1,72,250/-	3.61
Mancozeb	0.92 + 2.0	200/- + 1.0/-	1,86,000/-	57,000/- (a+c)*	1,29,000/-	3.26
BAU-Biofungicide	1.07 + 2.0	200/- + 1.0/-	2,16,000/-	50,000/- (a+d)*	1,66,000/-	4.32
Boron	0.54 + 2.0	150/- + 1.0/-	83,000/-	39,920/- (a+e)*	43,080/-	2.07
Zinc	0.52 + 2.0	150/- + 1.0/-	80,000/-	36,840/- (a+f)*	43,160/-	2.17
Magnesium	0.55 + 2.0	150/- + 1.0/-	84,500/-	36,840/- (a+g)*	47,660/-	2.29

* Information lied in Appendices I and II.

CHAPTER 5

DISCUSSION

Alternaria leaf blight of radish caused by *Alternaria brassicae* and *A. brassicicola* is one of the most common and destructive disease worldwide and serious threats to the radish seed crop. *Alternaria* species are spread by several means; including wind-borne spores and adherence of soil to seedlings, farm equipment or animals (Ojiambo, 1997). This may be an important means of spread of the pathogen from infested to non-infested areas within a field, or from infested fields to non-infested fields (Melouk *et al.*, 1989). Irrigation water has also been shown to be involved in spread of *Alternaria* species (Carson, 1985). Over long distances, the greatest potential disseminator of *Alternaria* species is probably by seed infected with mycelia or contaminated with conidia (Yu *et al.*, 1982).

In this present study an investigation has been carried out in controlling the Alternaria blight of radish seed crop cv. Tasaki Mula. The disease was found to appear on lower older leaves of 51-day old transplanted plants. To avoid yield and quality loss two fungicides (Iprodione and Mancozeb), one bioagent (BAU-Biofungicide) and three micro-nutrients (Boron, Zinc and Magnesium) were sprayed at the beginning of disease symptoms appear on the radish seed plants. Plants sprayed with water served as the control. Observations on leaf area diseased and pod area diseased were recorded at 7 and 15-day intervals, respectively. Out of the fungicides, Iprodione was found better than the Mancozeb. Significant reduction in leaf area diseased, pod area diseased, increase 1000-seed weight, seed yield per plants and yield per hectare were found in the plots which were sprayed with Iprodione

The highest seed yield (1.18 t/ha) was recorded in Iprodione spraying plots where Alternaria blight disease incidence was controlled, where the lowest yield (0.47 t/ha) was recorded in control plot. Iprodione showed 151.06% higher seed yield over control plots, where 127.65% higher seed yield was found in BAU-Biofungicide sprayed plots. This findings are supported by Anon.(2003) and Hossain (2003). In this study, spraying of Mancozeb (95.74%), Boron (14.89%), Zinc (10.63%) and Magnesium (17.02%) provided the higher seed yield over control plots but they appeared as less effective.

Seed samples of different treatments collected from research field were varied in seed quality. All the seed samples were found to be diseased which is supported by Humperson-Jones *et al.* (1989) The effect of BAU-Biofugicide and Iprodione spraying were found very effective in upgrading the quality of the seed. The inferior quality seed was found in the control plots, where the superior quality seeds were found in the plots which received Iprodione and BAU-Biofungicide seven sprays. This results are supported by Babadoost *et al.*(1993). He explained that thrice aerial application of Iprodione reduced the incidence of *Alternaria* in seed of cabbage. However, the results of present investigation indicated that seven sprays of Iprodione or BAU-Biofungicide were not enough to produce completely disease free seeds of radish.

Cost analysis of treatments applied for controlling the Alternaria blight in field experiment revealed that the BCR of BAU-Biofungicide based treatment was the highest (4.32:1) due to less cost of fungicide and effective management practice for Alternaria leaf blight which was followed by Iprodione (3.61:1). The Benefit Cost Ratio of control plots was lowest (2.01:1). Considering the Bio-safety measures, BAU-Biofungicide would be

CHAPTER 6

SUMMARY AND CONCLUSION

Radish *(Raphanus sativus* L., n = 9) belonging to the family cruciferae, is the third most important vegetable crop of Bangladesh. The high yielding tropical annual type Tasaki Mula was taken in this study. The Dinajpur region is one of the most important seed growing regions of Bangladesh. Therefore, the present study has been carried out in Dinajpur region.

The application of two foliar chemical fungicides (Iprodione, Mancozeb), one bioagent (BAU-Biofungicide) and three micro-nutrients (Boron, Zinc and Magnesium) were applied in controlling the Alternaria blight on radish seed crop during rabi season of 2007-2008. Disease and yield data were assessed in terms of percent leaf area diseased, percent pod area diseased, 1000-seed weight (g) seed, yield per plant (g) and seed per hectare yield (t/ha). The percent diseased seed and germination percentage were recorded after harvest of the crops. Sprays were commenced from the first appearance of disease symptoms at 51 day old transplanted crop.

Iprodione, Mancozeb and BAU-Biofungicide had significant effect on reduction of disease and increasing of seed yield. Among the fungicides, remarkable reduction of leaf area diseased was observed with Iprodione sprayed plots followed by BAU-Biofungicide but incase of pod area diseased, there was no significant difference between Iprodione and BAU-Biofungicide sprayed plots. The result of yield per hectare (1.18 t/ha) were found significantly higher in Iprodione sprayed plots followed by BAU-Biofungicide (1.07 t/ha) over control (0.47 t/ha).

The foliar application of Iprodione had a significant effect on seed quality. The highest diseased seed (70.89%) was recorded in seed that was sprayed with plain water (control plots) where the lowest (36.86%) was recorded in Iprodione spray plots that received seven sprays followed by BAU-Biofungicide sprayed plots (41.05%). Percent of germination was significantly influenced by foliar spray with fungicides. The lowest germination (75.75%) was recorded in seed samples that were collected from control plots, but the highest (86.50%) was recorded where seven sprays of BAU-Biofungicide was applied.

Regarding the economic consideration, the plots of BAU-Biofungicide foliar application gave the maximum net return (Tk. 1,66,000/-) having BCR of 4.32 while the control showed the lowest net return (Tk. 36,500/-) having BCR of 2.01.

Therefore, it may be concluded that among the spray materials BAU-Biofungicide with seven sprays plays the best role in reducing the Alternaria blight and significantly increase the seed yield with good quality. Before making any final recommendations to the farmers, the present research work should be repeated in other agro-ecological zones of the country.

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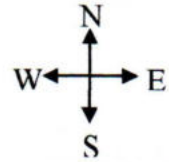
APPENDICES

Appendix I: Analysis of cost of application of common cultural practices per hectare in production of Radish seed cv. Tasaki Mula in 2007-2008

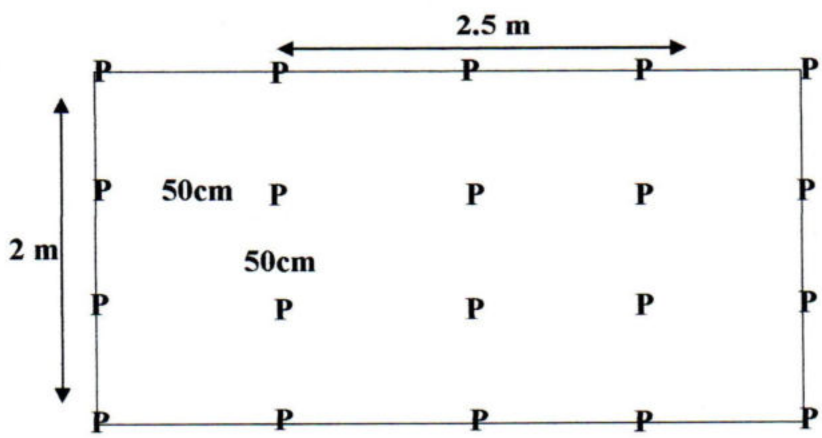
Sl no.	Operation items	Per hectare cost in Tk.				
		Unit	Quantity	Cost/unit	No. of operation	Total cost
1	Seed	Kg	5	200/-		1,000/-
2	Land preparation, plowing (tractor, power tiller, spade)	Tractor + power tiller	2+2	500/- +300/-		1,600/-
	Labor	Man $^{-1}$	5	120/-		600/-
3	Stickling plantation					
	Labor	Man $^{-1}$	15	120/-		1,800/-
4	Fertilization and Manures					
	Urea	Kg	300	6/-		1,800/-
	TSP	Kg	200	16/-		3,200/-
	MOP	Kg	150	16/-		2,400/-
	Borax	Kg	10	280/-		2,800/-
	Gypsum	Kg	100	7/-		700/-
	Zinc oxide	Kg	15	120/-		1,800/-
	Cow dung	Ton	25	200/-		5,000/-
	Labor	Man $^{-1}$	4	120/-		480/-
5	Weeding, Irrigation			500/-	3	1,500/-
	Labor	Man $^{-1}$	10	120/-	2	2,400/-
6	Supporting + fenching	Pieces Bamboo	15	60/-		900/-
	Beehives (hiring)	One	1	200/-		200/-
	Labor (gaurd)	Man $^{-1}$	20	120/-		2,400/-
7	Insecticide spraying (Acephate)	Litre	1	1,000/-	2	2,000/-
	Labor	Man $^{-1}$	2	120/-	2	480/-
	Sprayer (hired)	Sprayer	1	20/-	2	40/-
8	Harvesting, threshing, cleaning and drying etc.					
	Labor	Man $^{-1}$	20	120/-		2,400/-
9	Miscellaneous cost					500/-
					Total (a)	**36,000/-**

Calculated on the basis of market price of 2007-2008

Appendix III. Layout of the experiment field



R_1		R_2		R_3
0.5 m drain		0.5 m drain		0.5 m drain
T_0		T_6		T_2
0.5 m drain		0.5 m drain		0.5 m drain
T_3		T_2		T_3
0.5 m drain		0.5 m drain		0.5 m drain
T_4		T_0		T_1
0.5 m drain	0.5 m drain	0.5 m drain	0.5 m drain	0.5 m drain
T_2		T_3		T_4
0.5 m drain		0.5 m drain		0.5 m drain
T_5		T_4		T_0
0.5 m drain		0.5 m drain		0.5 m drain
T_1		T_5		T_6
0.5 m drain		0.5 m drain		0.5 m drain
T_6		T_1		T_5
0.5 m drain		0.5 m drain		0.5 m drain



Plot =2.5 × 2 m²

Replication = 3
Treatment = 7
No of Plots = 21

Plot-Plot =0.5 m
Plant – Plant = 50 cm
Row – Row = 50 cm