MANAGEMENT OF FOOT AND ROOT ROT DISEASE OF CHICKPEA (*Cicer arietinum*)

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CERTIFICATE

*This is to certify that the thesis entitled '**Management of Foot and Root Rot Disease of Chickpea (Cicer arietinum)**' submitted to the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in PLANT PATHOLOGY**, embodies the results of a piece of bona fide research work carried out by **MD. HABIBUR RAHMAN**, Registration No. **16-07545** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during December' 2017 to March'2018 for the management of foot and root rot disease of Chickpea. Variety BARI SOLA 5 was used as in this experiment. The experiment comprised of the following 9 treatments including control. The treatments were T_1: Control, T_2: Autostin (seed treatment + field sprays at 7 DAS intervals), T_3: Autostin (seed treat + field spray at 15 DAS intervals), T_4: Indofil (seed treat + field spray at 7 DAS intervals), T_5: Indofil (seed treat + field spray at 15 DAS intervals), T_6: *Trichoderma harzianum* (soil amendment + sprays Autostin at 7 DAS intervals), T_7: *Trichoderma harzianum* (soil amendment + sprays Autostin at 15 DAS intervals)T_8: Poultry waste (soil amendment + sprays Allamanda extract at 7 DAS intervals) and T_9: Poultry waste (soil amendment + sprays Allamanda extract at 15 DAS intervals). The field experiment was laid out in RCBD with three replications. Data on post emergence mortality in field condition, yield contributing characters and yield of chickpea were recorded and statistically analyzed for treatment variation. At 10 DAS, the lowest post-harvest mortality (4.42%) was recorded from T_6 treatment, whereas the highest post emergence mortality (20.53%) was observed from T_1 treatment. At 40 DAS, the lowest post-harvest mortality (1.13%) was recorded from T_6 treatment, whereas the highest post emergence mortality (32.12%) was observed from T_1 treatment. The longest plant (39.31 cm) was recorded T_6 treatment, whereas the shortest plant (25.94 cm) was observed from T_1 treatment. The highest seed yield (1.94 t ha^{-1}) was recorded T_6 treatment, whereas the lowest seed yield (1.19 t ha^{-1}) was observed from T_1 treatment. The highest stover yield (2.92 t ha^{-1}) was recorded T_6 treatment, whereas the lowest stover yield (2.11 t ha^{-1}) was observed from T_1 treatment. The highest biological yield (4.86 t ha^{-1}) was recorded T_6 treatment whereas the lowest biological yield (3.29 t ha^{-1}) was observed from T_1 treatment. From the above findings it can be concluded that among the treatments, T_6: *Trichoderma* (soil amendment) + Autostin (spray at 7 DAS) was the better followed by T_7: *Trichoderma* (soil amendment) + Autostin (spray at 15 DAS) in respect of reduction of foot and root rot disease and contributing towards yield of chickpea.

CHAPTER I

INTRODUCTION

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Chickpea (*Cicer arietinum* L.), commonly known as gram, is one of the important pulse crops in Bangladesh. Today, chickpea is the third most important pulse crop and about 15% of the world's total pulse productions belong to this crop. The crop is variously known as chola, boot or botjam in different parts of Bangladesh. It is generally grown under rain-fed or residual soil moisture conditions in rabi season. Among the major pulses that grown in Bangladesh chickpea ranked fifth in area and production but second in consumption priority. Chickpea occupies third position in terms of acreage (13,765 hectare) and production (10,000 metric ton) and contributes about 20% of total pulses. The acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to other crops and also due to increase in area under boro rice, maize and potato cultivation.

Chickpea plays a vital role in human and animal nutrition having 20.8% protein. It is a major source of dietary protein to the large vegetarian population of South Asian countries. Taking chickpea in "Iftar" during *Ramadan* is a common food in Bangladesh. According to the FAO (2012) yield of chickpea in Bangladesh is miserably low (761 kg ha^{-1}) as compared to that of other countries like India (833 kg ha^{-1}), Myanmar (1,106 kg ha^{-1}), Mexico (1,600 kg ha^{-1}), Israel (1813 kg ha^{-1}), Russian Federation (2,400 kg ha^{-1}), Kazakjhastan (3,000 kg ha^{-1}) and China (6,000 kg ha^{-1}). Yield of chickpea is very low in Bangladesh and such low yield however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of boro rice, fertilizer management, disease and insect attack and improper or limited irrigation facilities which causes flower and pod droppings. Among different factor various diseases is the most important one in relation to disease incidence as well as production.

Chickpea is affected by a wide range of fungal diseases. Productivity of chickpea is reduced by pathogens through infection and damage to leaves, stems, roots and pods. It also reduces marketability due to discoloration of the seeds. Chickpea suffer from attack of a number seed borne diseases such as vascular wilt, collar rot, root rot, stem rot, rust, powdery mildew and downy mildew, which are generally caused by *Fusarium oxysporumf*, *Sclerotium rolfsii*, *Rhizoctonia solani*, *Uromyces fabae*, *Erysiphe polygoni* and *Peronospora lentis* respectively. Foot rot is considered as an important and destructive disease of pulses in almost all legume-growing countries of the world. Foot and root rot of chickpea is considered as an important and destructive disease of pulse crops in Bangladesh and also in almost all legume growing countries of the world (Fakir, 1983; Ahmed, 1985). Field fungi associated with seed causes deterioration of quality, affect viability and reduce germination of seeds.

Among the different diseases, foot and root rot of chickpea caused by *Fusarium oxysporum* and *Sclerotium rolfsii* are common and the most serious disease in Bangladesh (Dey *et al*., 1993). It causes seedling death at early stage resulting very poor plant stand which ultimately produces very low yield. *Fusarium oxysporum* and *Sclerotium rolfsii* are soil-borne pathogens commonly occurs in the tropics and sub-tropics regions of the world causing foot and root rot of many crops especially pulse crops. The fungi can attack the crop during any time from seedling to flowering stage and are comparatively more destructive at the seedling stage. Foot and root rot diseases may cause 100% seedling mortality in monoculture under conducive weather conditions for disease development (Begum, 2003). Foot rot is considered as an important and destructive disease of pulses in almost all legume-growing countries of the world. Despite of the many achievements in modern agriculture, chemical control still holds a strong performance in combating certain destructive plant diseases. Farmers use chemicals for controlling the diseases of crop plants in Bangladesh, but limited information on the efficacy of these chemicals exists in our country (Hoque *et al*., 2014).

Foot and root rot disease is very difficult to control even by the use of chemical fungicide because the pathogens are soil and seed borne and can survive in the residual stubbles for more than three years (Nene *et al*., 1981). Though, some effective fungicides are available in the market but their number is limited (Nikam *et al*., 2005). Integrated use of Vitavax 200 and biocontrol agents was effective in improving seedling emergence and yield as well as in reducing wilt incidence of chickpea (Gupta, 2006). Treatment of seeds resulted in 73.1% reduction in death of plants due to infection by *Fusarium oxysporum* in chickpea (Hossain, 2000). Recently Botanical extracts are used to control the disease which are biodegradable and their use in crop protection is a practical sustainable alternative method (Devlin and Zettel, 1999). There are also some plant extracts, which have microcidal qualities and antagonistic effect to different pathogens (Hussain *et al*., 1993). Antifungal activities of garlic, neem, allamanda have also been reported by many researchers (Rahman *et al*., 1999). Khalequzzaman (2008) stated the best treatment for controlling foot and root rot of lentil and chickpea was dipping seeds in 0.25% suspension of Vitavax 200 for 3 hours. Provax 200 was the most effective followed by Bavistin 50 WP, Neem leaf extract and Garlic extract with respect to disease reduction and increase of seed yield (Rahman *et al*., 1992).

In view of the above facts, the present research work was undertaken to achieve the following objectives:

- To isolate and identify the causal organism(s) of foot and root rot of chickpea;
- To evaluate the efficiency of selective fungicides, plant extracts and bio-agents in combination with soil amendment against foot and root rot of chickpea; and
- To evaluate the yield and yield contributing characters of chickpea against the treatment applied.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Sclerotium rolfsii, the causal agent of foot rot or collar rot of many crops having wider host range attracted the attention of plant pathologist and professional researcher through the world. The pathogen is known to cause diseases of cereals, pulses, oil crops, betel vine, potatoes, vegetables, ornamentals and nursery seedlings of fruits and forest trees. In Bangladesh, disease caused by *Sclerotium rolfsii* in different crops has been reported by different plant pathologist. Evidences of research work regarding management of damping off betel vine are very limited. An attempt has been made to review the available literature about foot and root rot disease. Some important literatures supporting the symptom, effect of the diseases, method of inoculation of *Sclerotium roifsii,* host range of *Sclerotium roifsii,* histopathology is reviewed here. However, some available and important findings on various aspects for management of damping off seedlings has been compiled and presented in this chapter under the following headings:

2.1 Environmental factor

Epidemiological studies were reported that the maximum temperature, maximum relative humidity and rainfall played an important role in the development of both the diseases of betel vine *(Piper betel* L.) (Anonymous, 2006; Maiti and Sen, 1982).

According to Punja, Z. K. *and Grogan.* (1988), temperature is the principal limiting factor in the geographic distribution of *Sclerotium roifsii.* The disease rarely occurs where average daily minimum winter temperatures are below freezing (0^0C). Maximum disease occurs at 25-35^0C which is also optimum range for mycelia growth and *sclerotia* germination of the fungus.

Farr *et al.* (1989) found that, fungus *Sclerotium roifsii* attacks all plant parts in the contact with the soil under favorable environmental conditions including

stems , roots, and fruits. Chattopadhyay and Maiti (1990) observed that the plants of betel vine are cultivated in conservatories under shady and humid conditions that also favor the development of many diseases.

According to Jana (1995), in the areas with lower rainfall (1500- 1700 mm) the crop is cultivated with small and frequent irrigations, i.e. every day in summer and every 3-4 days in winter, whereas adequate drainage is required during the rainy season.

Guha and Jain (1997) observed that vines grows best under the shaded, tropical forest ecological conditions with a rainfall of about (2250-4750 mm), relative humidity and temperature ranging from 40-80% and 15- 40°C, respectively. A well-drained fertile sandy or sandy loam or sandy clay soil with pH range of 5.6 to 8.2 is considered suitable for its cultivation.

Mollah (2012) found that 29^0C and 85% RH, the disease incidence and severity of foot and root rot of betel vine was the highest and it was the lowest when the temperature laid around 18.7^0C and the RH laid around 75%. Al-Askar *et al.* (2013) found that sclerotial diseases caused by *Sclerotium rolfsii* occur primarily in warm climates, especially at high temperatures.

2.2 Symptom and effect of the disease

Das *et al.* (2000) found that the disease symptoms of foot and tuber rot of tuberose caused by *Sclerotium rolfsii* is preceded by the appearance of prominent coarse mycelia masses on leaf surfaces at or near the soil surface. The infected leaves detached from the plant fall on the soil surface. More or less round sclerotia, brown in colour, are formed on and around the infected leaves. As a result the infected plants become weak and send out few or none of the flowering shoots in case of severe damage.

According to Chet *et al.* (1994), *Sclerotium rolfsii* Sacc. causes the disease known as southern blight in wide variety of crops. *Sclerotium rolfsii* form brownish sclerotia that can survive in the soil for longer period of time.

Punja *et al.* (1988) reported that root-rot disease caused by *Sclerotium rolfsii* being one of the most important diseases of crops. Ahmed (1980) reported that collar rot, foot and root rot disease caused by *sclerotium rolfsii* caused considerable damage both in seedling and adult stages of Indian spinach, and there existed variations in the incidence of the disease in different parts of Bangladesh.

Chakravarty and Bhowmik (1983) studied on symptoms and techniques of inducing collar-rot of sunflower caused by *Sclerotium rolfsii* Sacc. The fungus caused pre- and post-emergence damping off of sunflower seedling and collar rot of adult plants. Disease development was highest in 60 day old plants, with maximum rotting in internal tissues and highest incidence.

Gurkins and Jenkins (1985) reported that carrot became diseased by *Sclerotium rolfsii* about 90-100 days of planting when the plant canopies shade the soil surface and create a micro environment suitable for southern blight development in the North Carolina.

Yasmin-Ahmed *et al.* (1988) reported that *Sclerotium rolfsii* caused collar rot of maize. The pathogen was isolated from infected maize and pure culture was subsequently inoculated into Maize cv. Shaheen sown in soil infested with the pathogen. Within 15 days of seedling emergence, sclerotia were seen on the soil surface and around the seedling. Seedlings were killed within 10-15 days.

Wangihar *et al.* (1988) reported that an outbreak of collar and root rot was observed on Capsicum in Maharastra, India during the first week of October, 1985.The disease was most severe on cultivars Jurala and CA-960. The causal agent was identified as *Sclerotium (Corticium) rolfsii.*

Montealegre and Esterio (1989) reported that outbreak of *Sclerotium rolfsii* affected more than 150 hectares of *Phaseolus vulgaris* occurred in Chile in January 1987.The disease was unequally distributed with large area of dead plants and patches of small plants showed wilt and chlorosis, Adult plants which

were infected but did not die produced fewer fruits and smaller seeds than uninfected plants.

Mridha and Alamgir (1989) observed sclerotial wilt of betel vine in thirty selected gardens in Chittagong. Plants showed decay at the collar region and below the soil level. It has been reported that infected plants lost luster, leaves turned yellow and the whole plant wilted and died. The infected portion of stem was covered with white cottony mycelia strands with small, light to deep brown sclerotia on the stem as well as adjacent soil surface.

Okoli *et al.* (1991) reported that *Sclerotium rolfsii* caused heavy infestation on sunflower, plants wilted and dried out with basal stem dry rot. Symptoms included an initial acropetel wilting of the entire plants. Affected plants gradually dry-out but remained green and attached to stem. They found that within 24 hrs of wilt onset, a white mat of mycelia formed around the discolored site on the stem base. Within 1-2 days, the mat had rounded off into small white balls and characteristics brown mature sclerotia within 24 hrs.

Sugha *et al.* (1993) reported that *Sclerotium rolfsii* caused collar rot of chickpea. A total of 210 lines and cultivars of chickpea tested by placing one wheat grain fully covered with mycelium of *S. rolfsii* at the collar rot of 7 days old seedling in pot of sterilized garden soil. All were find to be susceptible to collar rot.

Khanna and Jyotsama Sharma (1993) described the symptoms of *Sclerotium* rot of potato as dark brown lesions appearing on the stem just below the soil surface followed by wilting of lower leaves and gradually drying of the entire plant. Such wilted plants showed white cover of fungal threads, girdling the basal part of stem, which moved above and below to the stem and roots. Sclerotia resembling mustard seeds, developed on infected plant parts and also on soil.

Alexander and Stewart (1994) worked on *Sclerotium rolfsii* (Telemorph; *Athelia rolfsii)* and found it causes serious root and stem rots of a range of economically important fruit and vegetable crops. Sclerotia are the important propagules for

the survival of this pathogen. Under favorable conditions, sclerotia may germinate to cause infection usually occurs at or just below the soil surface and symptoms includes yellowing, browning and wilting of entire plants.

Kulkarni *et al.* (1994) reported that, the pathogen affected either stem or root or tubers. The infected stem produced dark brown lesions at collar region causing wilting and ultimately plants dried up. Brownish sclerotia resembling mustard seed developed at later stages on the root and collar regions of the infected plants. After that, tubers get infected and rotten in the field.

The pathogens of sclerotial diseases cause damping-off of seedlings, stem canker, crown blight, root-rot, crown rot, bulb, tuber and fruit rots. These diseases frequently affect a wide variety of plants, including most vegetables, flowers, legumes, cereals, forage plants and weeds (Agrios, 1997).

Mullen (2001) reported Southern blight, Southern stem blight, White mold caused by *Sclerotium rolfsii.* Anahosur (2001) observed the dark brown lesion on the stem just below the surface followed by drooping and wilting of infected leaves and gradually wilting of the entire plant. Such wilted plants showed whitish mycelia growth with sclerotial bodies resembling mustard seeds on collar region and also roots.

Lievens *et al.* (2004) studied that a severe rot and collar/foot rot was observed on two month old wilted tomato *(Lycopersicum esculentum)* plants in a large scale (2.5 ha) commercial green house setting in Belgium. Symptom development was restricted to lower plant parts with severe rotting of the entire root system and dark lesions girdling the stem base.

Yaqub and Shahzad (2005) proved *Sclerotium rolfsii* highly pathogenic on sunflower, and mildly pathogenic on tomato, lentil, sweet pumpkin and cabbage and non-pathogenic on cauliflower plant in a pot experiments. Increase in inoculum density of *Sclerotium rolfsii* caused gradual relation in growth

parameters of sunflower and mungbean plants where as a positive correlation was observed between root colonization and population of *Sclerotium rolfsii*.

Garibaldi *et al.* (2006) observed severe basal rot symptoms of potato *(Solanum tuberosum* L.) in a commercial field near Alessandria (northern Italy). According to Daami-Remadi *et al.* (2007), potato tubers showing a fan-like mycelia growth at their surface and severe soft rot symptoms were observed in traditional potato storage at Essaida (North of Tunisia).

2.3 Method of inoculation of *Sclerotium rolfsii*

Islam (2008) inoculated the eggplants following soil inoculation technique using the barley culture of the pathogen *(Sclerotium rolfsii).* All the varieties were infected ranging from 66.66 to 100%. Varieties varied in percent mortality.

Kashem (2005) used soil infestation method for inoculation of *S. rolfsii.* He found that soil infestation with grain culture at the rate of 0.1% weight basis of dry soil before sowing seeds caused heavy infestation.

Babar (1999) used 10 g of colonized dried oat grains or pouring fungal suspension with soil near plant base for inoculation and covered with moist cotton. Older plants (60-90 days age) developed infections quicker (8-10 days) and larger sized lesions than that in younger ones (10-45 days age).

Hiremath *et al.* (1998) compared 5 methods of inoculation of *S. rolfsii.* Soil infestation technique was the most efficient for inducing infection of seedlings by *S. rolfsii.* Incorporation of 2% inoculum with soil was sufficient to produce high disease levels. Disease incidence on plants inoculated at 30 and 60 days by toothpick method increased with plant age.

Waraitch *et al.* (1986) used soil mixing method of inoculation of *S. rolfsii* (multiplied on sterilized sorghum seeds pre-soaked in 2% sucrose solution) was mixed in soil near the plants @ three 500 ml flask per 100 m.

2.4 Pathogenicity

Thammsak-Sommat *et al.* (1982) made an investigation on the pathogenicity of *Sclerotium rolfsii,* and reported that the pathogen could infect its host cotton severly; disease severity in average was 84%. The pathogen caused pre and post emergence damping off symptoms of cotton seedlings. They also found the soil amendment by crop refuses, nitrogen fertilizers and lime decreased disease intensity.

Palakshappa (1986) observed considerable foot rot infection when betel vine were inoculated with two and three percent inoculum of *S. rolfsii.*

Siddaramaiah (1988) confirmed the pathogenicity of *Sclerotium rolfsii* on *Desmodium uncimatum* Desv. and *Cotonoris ainesii* Eckl and Zeyh, two important forage legumes of hill zone by similar producer.

Siddaramaiah and Chandrapa (1988) proved the pathogenicity of *Sclerotium rolfsii* on cardamon in pot culture studies by inoculating 25 days old sclerotial cultures which was grown on sand corn meal medium and observed the symptoms a week inoculation.

Fakir *et al.* (1991) reported that sowing of lentil during third week of November was found to reduce the incidence of collar rot and root rot caused by *Sclerotium rolfsii and Fusarium oxysporum* compared to early sowing. Artificial inoculation often selected genotypes of lentil to collar rot pathogen, *Sclerotium rolfsii* showed that all the lines were susceptible to the test pathogen.

2.5 Incidence and severity of *Sclerotium rolfsii*

Meah (2007) tested the pathogenecity of 10 isolates of *Sclerotium rolfsii* on eggplant (var. Dohazari) and he found that all the isolates of *S. rolfsii* significantly affected the seed germination, pre-emergence death, damping off, foot rot and plant stand.

Palakshappa (1986) surveyed the incidence of *S. rolfsii* on *Piper betle* L. in different areas of Karnataka state during 1984-85 and recorded 35 to 39 percent disease incidence.

Meah (1994) reported the incidence and severity of collar rot of sunflower in fifteen (15) varieties which were grown at 2 (two) agro-ecological zones (AEZ) of Bangladesh. Survey was conducted during (Kharif-I) July, 1994. He observed that almost all the varieties were affected by collar rot. At Bangladesh Agricultural University (BAU), Mymensingh collar rot was prevalent throughout the crop season. All varieties at BAU were heavily affected with collar rot. Some 3.0-5.0% plants were killed at flowering stage.

Khan (1996) reported the incidence and severity of collar rot of sunflower in fifteen (15) varieties which were grown at 3 agro-ecological zones (AEZ) of Bangladesh. He observed that young plants were more susceptible to collar rot. Incidence of the disease were minimum in Rabi season and a higher percentage of plants were killed in Kharif-I season.

Further report of Meah (1997) includes the incidence and severity of collar rot of sunflower in thirty (30) varieties which were grown at 2 (two) agro ecological zones (AEZ) of Bangladesh. Survey was conducted during March, 1997. He observed that collar rot affected almost all the sunflower varieties except MSFH-17 and MSFH-592.

Rahman and Sultana (2011) found that, in Jamalpur region, the incidence and severity of Sclerotial rot of betel vine was more or less highest and lowest throughout the year.

Mollah (2012) found that, in case of foot and root rot of betel vine in Satkhira district, highest disease incidence were found in August (12.50% to 32.50%) and lowest disease incidence was found in December (0% to 8.33%) in 2010. The highest disease incidence was found in August (18.75% to 50%) and the lowest disease incidence were found in December (0% to 2.08%) in 2011.

2.6 Management of foot and root rot by *Trichoderma* based bio-pesticide

Kumar (2013) reported that, *Trichoderma* is a genus of asexually reproducing fungi that is present in all types of soils. Recent reports show that they are opportunistic, avirulent plant symbionts, as well as become parasites on other fungi. A number of successful bio-control products based on different species of *Trichoderma* have been commercialized in India, USA and elsewhere in the world.

Kashem *et al*. (2011) conducted a series of experiments to assess the effect of 14 isolates of *Trichoderma* spp. (*Trichoderma harzianum* and *T. viride*) for controlling foot and root rot of lentil caused by *Fusarium oxysporum*. The pathogenecity of 12 isolates of *F. oxysporum* and the mass production of an isolate of *T. harzianum* on 25 substrates are also studied. *Trichoderma* isolates inhibited the growth of *F. oxysporum* up to 92.07 % on agar plates.

Pandya *et al*. (2011) reported that, soil-borne pathogens in fungi cause important losses, being the most aggressive. The distribution of several phytopathogenic fungi, such *as Pythium, Phytophthora, Botrytis, Rhizoctonia* and *Fusarium* have widely spreaded during the last few years due to change of intensive farming crops culture and environment. *Trichoderma* as a bio-control agent (BCAs) is well recognized due to their high reproductive capability and show strong aggressiveness against phytopathogenic fungi and efficiency in promoting plant growth and defense mechanisms.

Amin *et al*. (2010) carried out a study on six isolates of *Trichoderma* spp. for their ability to inhibit soil borne pathogens of different vegetables viz., *Rhizoctonia solani* (isolates from tomato), *Sclerotium rolfsii* (causing collar rot of tomato) and *Sclerotinia sclerotiorum* under in vitro conditions. Dual culture of pathogens and *Trichoderma* spp. revealed that *T. viride* highly inhibited (65.71%) mycelial growth of *Rhizoctonia solani* over control. In case of *Sclerotium rolfsii* and *Sclerotinia sclerotiorum*, *T. viride* proved to be potential inhibiting mycelial growth of that pathogens.

Hossain and Hossain (2010) formulate a *Trichoderma* based BAU-bio fungicide that was found very much effective agent several tikka disease of groundnut, foot and root rot of pulses and diseases of some vegetable crops. BAU-bio fungicide also helpful to control seed borne mycoflora, increasing seed germination and seedling vigour of some vegetables. Management of seedling diseases are successfully possible by using BAU-Biofungicide, biofertilizer and cowdung in blackgram, mungbean and lentil.

Tran (2010) conducted surveys on food crops, industrial crops, vegetable crops and fruit crops in the north and south of Vietnam and reported that *Trichoderma* can be isolated easily from soil, root and plant organic matters. *Trichoderma viride, T. harzianum, T. hamatum* were predominant species in Vietnam. Laboratory and field trials proved that *Trichoderma* species had ability to suppress growth of fungal plant pathogens and enhance plant growth and development. He reported that, *Trichoderma* products have been commercially developed by several companies, institutes and universities such as: BIMA, Trico-ĐHCT, Promot Plus WP, Vi DK, NLU-Tri, Bio – Humaxin and are available in markets. *Trichoderma* product can be used in many ways including: seed treatment, applied direct to the soil before planting and added to organic fertilizers.

Chandrasehar *et al*. (2005) conducted lab and green house experiments to determine the antagonistic effect of *Trichoderma harzianum* against *S. rolfsii* that caused tomato collar rot. They found that *Trichoderma harzianum* in in vitro condition completely suppressed the growth of *S. rolfsii* and in green house condition in pot culture increased the percent survival of treated seedling applied as seed treatment and soil drenching.

Islam (2005) also reports while working on controlling of seedling diseases of eggplant that *Trichoderma harzianum* T22 effectively controlled damping off disease of seedlings.

Kashem (2005) used soil infestation method for inoculation of *Sclerotium rolfsii*. He found that soil infestation with grain culture at the rate of 0.1% weight basis of dry soil before sowing seeds caused heavy infestation.

Meah *et al*. (2004) reported that *Trichoderma harzianum* cp and *Trichoderma harzianum* T22 grown on peat soil based black gram bran was found effective in controlling nursery diseases like damping off, tip over and seedling blight of eggplant and promoted seed germination.

Meah (2003) listed a number of diseases of eggplant caused by fungi, bacteria, virus, nematode and mycoplasma. Of them, collar rot caused by *Sclerotium rolfsii* is damaging to the crop.

Shamsuzzaman *et al*. (2003a) studied for mass production of *Trichoderma harzianum*. Of them, rice straw chick pea bran, rice course with 3% chickpea powder, rice straw with 5% sucrose black gram bran, grass pea bran and peat based wheat bran supported best in mass production of conidia (42.93×107/g culture). Shamsuzzaman *et al*. (2003b) further reported that seed treatment with *Trichoderma harzianum* grown on black gram resulted up to 16.66% higher seed germination, 266.33% fresh shoot weight, 157.14% fresh root weight and 98.55 vigor index of cucurbits over control.

Howlader (2003) reported that *Trichoderma harzianum* cp yielded good result against phomopsis blight and foot rot of eggplant in the field. Islam *et al*. (2002) evaluated nine organic substrates for their suitability for mass culture of an isolate (GT-1) of *Trichoderma harzianum*, a potential bio-control agent. They found that maize meal was the best substrate for maximum spore production also colony diameter, mycelial growth was fast compared to others.

Sultana *et al*. (2001) observed growth and storability of *Trichoderma harzianum* and its effect on germination of egg plant seeds. They found that *Trichoderma* treated seed resulted up to 48.62% higher germination than that of control (untreated).

Chowdhury *et al*. (2000) reported that seed treatment with *Trichoderma harzianum* and *Gliocladium viride* against *Sclerotium rolfsii* resulted up to 21.61% and 48.43% increase in germination in mungbean, black gram, pigeon pea and tomato, respectively and showed good effect on seed born mycoflora. Moreover, significant growth enhancements of mungbean, blackgram and tomato have been achieved by treating seeds with antagonists. The antagonists were found effective against *Sclerotium rolfsii.*

Rettinassababady and Ramadoss (2000) reported that *Trichoderma* spp. were mass multiplied in black ash, coir waste, farmyard manure, rice husk, spent straw from mushroom bed, sugarcane bagasse, talc and vermiculite. *Trichoderma* growth and spore production was maximum in farmyard manure and coir waste (474 x 105, 263 × 105 spore/g) in 3 weeks in culture.

Sultana and Hossain (1999) evaluated *Trichoderma harzianum* for controlling foot and root rot (*Fusarium oxysporum* and *Sclerotium rolfsii*) of Lentil cv. BARI Masur-1 under field condition. Seeds of lentil treated with *Trichoderma harzianum* contributed 47.85% to 112.49% reduction of foot and root rot diseased plants over control. *Trichoderma harzianum* treated seeds increased germination up to 13.37% and resulted up to 3.69% more field emergence over control. *Trichoderma harzianum* treated seeds resulted yield up to 1783.33 kg/ha that accounted 81.60% higher seed yield.

Shamarao *et al*. (1998) tried mass multiplication and sporulation of *Trichoderma viride* using different substrates like oil cake, farmyard manure, wheat bran, poultry manure, dung, jaggery, groundnut cake, neem cake and pongamia. Wheat bran was the most suitable substrate for sporulation of the antagonists.

Begum (1997) selected four *Trichoderma* spp. and evaluated their antagonistic potential against the major soil-borne plant pathogens *Sclerotium rolfsii, Fusarium oxysporum* and *Macrophomina phaseolina*. Two induced mutants of *Trichoderma* spp. showed better performances than control strain in reducing the

seedling mortality in chickpea and lentil caused by *Fusarium oxysporum* and *Sclerotium rolfsii* under glasshouse condition.

Das *et al*. (1997) screened five media (wheat bran, rice bran, maize meal, sand medium, potato dextrose agar and saw dust) for mass multiplication of *Trichoderma viride*, *T. harzianum* and *T. koningii* in vitro. Wheat bran proved to be more promising for the growth and sporulation of the fungi. Growth and sporulation of *Trichoderma* spp. were significantly higher after 14 days, than after 7 days of inoculation.

Roberti *et al*. (1996) investigated the activity of *Trichoderma harzianum* 74 on bean (*Phaseolus vulgaris*) rot caused by *Scelorotium rolfsii* when applied to seeds. *Trichoderma* strains were active in bean root rot ensuring control of *Scelorotium rolfsii*. *Trichoderma harzianum* reduced the growth of *Scelorotium rolfsii* and parasitized *Scelorotium rolfsii*, hyphae by direct contact, forming coils, short contact branches and hook-shaped hyphal tips. Mukherjee *et al*. (1995) observed that *Trichoderma harzianum* was effective in suppressing *Sclerotium rolfsii* and *Rhizoctonia solani*. *Trichoderma harzianum* was found to be effective in destroying the sclerotic of both fungi.

Mukhopadhyay (1995) stated that two bio-agents viz., *Gliocladium virens* and *Trichoderma harzianum* were used for treating seeds of various crops, like chickpea, lentil, groundnut, tomato and cauliflower for protection against wide range of soil brone pathogens viz., *Rhizoctonia solani*, *Sclerotium rolfsii*, *Pythium* spp. and *Fusarium oxysporum*. Such biological treatment was also integrated with suitable fungicide in view of the insensitivity of the bio-agents to some chemicals. The treatment was found highly effective and resulted in enhanced crop performance when compared with biological or chemical treatment alone.

Inber *et al*. (1994) used *Trichoderma harzianum* to cucumber seedlings as a peat-bran preparation incorporated into the propagation mixture in a commercial

plant production nursery. Increase of 23.8% in seedlings height and 96.1% in leaf area were recorded. On marketing day (after 18 and 30 d) recorded significant DW compared with untreated control plants. Trichoderma-treated plants. However, significant reductions in damping-off by 67% and 52% were obtained in middle and border, respectively, during the 2nd growing cycle compared with untreated controls.

Chet and Inbar (1994) studied on biological control of fungal pathogens and reported that *T. harzianum* as effective bio-control agent of soil-borne plant pathogenic fungi. Lectins were found to be involved in the recognition between *Trichoderma* spp. and its host fungi, where as Chitinase is involved in the degradation of the host wall.

Sugha *et al*. (1993) reported that conidial coating of the antagonistic *Trichoderma harzianum* and *T. viride* on seeds significantly reduce seedling mortality (47-65%) infected by *Sclerotium rolfsii* compared with untreated controls.

Sangeetha *et al*. (1993) found farmyard manures as the best for formulation of *Trichoderma viride* and *Trichoderma harzianum* followed by wheat bran and rice bran. Peat soil alone and rice straw were found as poor substrates.

Xu *et al*. (1993) observed that both isolates of *Trichoderma* T82 and NF9 inhibited hyphal growth of *Sclerotium rolfsii, Rhizoctonia solani, Pythium aphanidermatum, P. spinosum* and *Fusarium oxysporum*. In greenhouse experiments, soil treatment with 0.6 % (w/w) T82 bran culture (107CFU /g) reduced incidence of disease caused by *S. rolfsii, R. solani* and *P. aphanidermatum* by 46.5%, 28.4% and 81.2% respectively, 20 days after inoculation with the pathogens. Seed treatment with T82 or NF9 spore suspension (108 CFU /ml) increased emergence of cucumber seedlings by 14% and 20%, respectively, 11 days after inoculation with *S. rolfsii*.

Kaur and Mukhapadhyay (1992) reported that integrated use of *Trichoderma harzianum* with fungicidal seed treatments in the fields significantly reduced the incidence of chickpea wilt complex and increased crop yield. Seed treatment with vitavax-200 (Carboxin + Thiram) and Ziram resulted 29.9% disease control. This control increased to 63.3% when *Trichoderma harzianum* was added.

Monaco *et al*. (1991) used for treating seeds as bio-control agents of *Fusarium* and *Sclerotium*. They isolated *Trichoderma harzianum, Trichoderma koningii* and *Trichoderma aureoviride* from tomato fields in the horticultural area of Laplanta, Argentina, naturally infected with *Fusarium* spp. and *Sclerotium* (Corticum) *rolfsii*. All 3 species of *Trichoderma* were effective against *Fusarium* spp. and *Corticium rolfsii* in vitro and in subsequent field trials. Seedling emergence was significantly increased when *Trichoderma harzianum* were applied to seeds sown in soil infected with the pathogens. They also reported that each *Trichoderma* spp. was effective against *C. rolfsii*.

Haque *et al*. (1990) used *Trichoderma harzianum* as bio-control agent for controlling root rot diseases of okra, sunflower, soybean and mungbean. *Trichoderma harzianum* used as seed treatments or as soil drenches for the control of root rot caused by *Macrophomina phaseolina, Rhizoctonia solani* of sunflower, soybean and *Vigna radiate* under field conditions. *Trichoderma* showed excellent inhibitory effect of controlling *Fusarium* and *Rhizoctonia*.

Kumar and Khare (1990) found *Trichoderma harzianum* as antagonistic to *Sclerotium rolfsii* when soybean seed were treated with *Trichoderma harzianum*, *Gliocladium virens, Bacillus subtilis* and *Streptomyces* spp. They also showed that Fusarium infection of sunflower was reduced by *Trichoderma harzianum*.

Krishnamoorthy and Bhoskaran (1990) reported that soil inoculation with *Trichoderma harzianum* and *Trichoderma viride* gave good control of

Sclerotium rolfsii and in treated pots gave 78.2% and 72.2% egg plant seed germination respectively compared to 19.3% in the control.

Harman *et al*. (1989) reported on combining effective strains of *Trichoderma harzianum* and solid matrix priming to improve biological seed treatments. They developed progeny strains (T12 and T95) by fusing two strains of *Trichoderma harzianum* and two of which were selected for further study. Seeds of cotton, cucumber, pea, snap bean, maize and wheat were also planted in soil infested with *Pythium ultimum* and *Rhizoctonia solani*. In all crop pathogen combinations, seed treatments with parental and progeny *Trichoderma* strs with or without solid matrix priming increased stands relative to the untreated control and were as effective as vitavax-200 (Carboxin + Thiram).

Shin *et al*. (1987) found that soil treated with *T. viride* reduces damping off of sesame seedlings. The sesame seedlings on beds treated with the antagonist grew better than seedlings in untreated soil. Soil and seed treated with *T. viride* reduced sunflowers infection (*S. sclerotiorum* and *B. cinerea*) in the glasshouse and prevented infection also in the field. Jabos and Kamoen (1986) found that *Trichoderma harzianum* produced cell wall lysine enzymes which developed antagonism against plant pathogens and improved biological control.

Sivan and Chet (1986) prepared wheat bran / peat mixture (1:1v/v) adjusted to 40% moisture (w/w) autoclaved for 1hr at 121^0C. The substrate mixture was inoculated with a conidial suspension of *Trichoderma* and incubated in an illuminated chamber at 30^oC. This preparation of *Trichoderma* was mixed with soil (5g/kg soil) before sowing seeds of the test plants.

Strashnow *et al*. (1985) reported that application of *T. harzianum* to soil or by coating tomato fruits was found to reduce *R. solani* fruit rot by up to 43% and 85% respectively under laboratory conditions. When it was mixed with naturally infested soil. *T. harzianum* reduced the *R. solani* inoculum potential of soil by 86% and fruit rot by(27-51%).

Sivan *et al*. (1984) used wheat bran/peat preparation of *Trichoderma harzianum* mixed with loamy sand (5g/kg soil) artificially infested with *Pythium aphanidermatum* significantly reduced disease incidence caused by this pathogen in cucumber, pea and tomato at 69,81 and 85% respectively.

Mirkova (1982) studied the antagonistic activity of *Trichoderma* spp. against some pathogens and reported that among 5 *Trichoderma* spp, 3 isolates of *Trichoderma harzianum* were most antagonistic.

Elad *et al*. (1982) studied on the prevention of plant infection by biological means. *Trichoderma harzianum* isolated from the soil showed on antibiotic activity against *Sclerotium rolfsii* when grown on cell walls of the pathogens. It produced extra cellular B (1-3) glucose and chitinase when applied in the form of wheat bran culture to soil infested with *Sclerotium rolfsii* in the glass house. *Trichoderma harzianum* effectively controlled damping off of eggplant.

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CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted for the management of foot and root rot disease of Chickpea. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that were used, experimental treatment and design, growing of crops, data collection and analysis procedure that followed for the conduction of this experiment has been presented under the following headings and sub-headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period of December, 2017 to March 2018.

3.1.2 Experimental location

The present research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al.*, 1979). During the study period the maximum temperature (31.4^0C) and highest rainfall (18 mm) was recorded in the month of March, 2018 and highest relative humidity (78%) in the month of December, 2017, whereas the minimum temperature (12.2^0C), minimum relative humidity (64%) and no rainfall was recorded in the month of January, 2018. Details of the meteorological data during experimental period have been presented in Appendix II.

3.1.3 Soil characteristics

The soil belonged to "The Modhupur Tract", AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Appendix III. The soil was having a texture of sandy loam with pH and organic matter 5.9 and 1.15%, respectively. The results showed that the soil composed of 26% sand, 43% silt and 31% clay. Details morphological, physical and chemical properties presented in Appendix III.

3.2 Experimental details

3.2.1 Planting material

Checkpea variety BARI SOLA 5 was used as the test crop in this experiment. The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Life cycle of this variety ranges from 125 to 130 days. Maximum seed yield is 1.5 to 2.0 t ha^{-1}.

3.2.2 Treatment of the experiment

The experiment comprised of the following 9 treatments including control condition:

T_1: Control

T_2: Autostin (seed treat + field spray at 7 DAS)

T_3: Autostin (seed treat + field spray at 15 DAS)

T_4: Indofil (seed treat) + Autostin (field spray at 7 DAS)

T_5: Indofil (seed treat) + Autostin (field spray at 15 DAS)

T_6: Trichoderma (soil amendment) + Autostin (spray at 7 DAS)

T_7: Trichoderma (soil amendment) + Autostin (spray at 15 DAS)

T_8: Poultry waste (soil amendment) + Allamanda extract (spray at 7 DAS)

T_9: Poultry waste (soil amendment) + Allamanda extract (spray at 15 DAS)

3.3 Growing of crops

3.3.1 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 02^{th} and 10^{th} December, 2017, respectively. Experimental land was divided into unit plots following the design of the experiment.

3.3.2 Fertilizers and manure application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were used as a source of nitrogen, phosphorous, potassium, gypsum, sulphur and boron, respectively. Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were applied at the rate of 50, 90, 40, 110, 7 and 10 kg hectare^{-1}, respectively as following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers except urea were applied during final land preparation.

3.3.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The entire experimental area was divided into three equal blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into 9 unit plots demarked with raised bunds and thus the total numbers of plots were 27. The unit plot size was 4.0 m × 0.8 m. The distance maintained between two blocks and two plots were maintained 1.0 m and 0.5 m, respectively. The layout of the experimental plot was presented in Figure 1.

3.3.4 Sowing of seeds in the field

The seeds of chickpea were sown on December 11, 2017 in solid rows in the furrows having a depth of 2-3 cm and row to row distance was 40 cm.

3.4 Application of treatment

3.4.1 Selective fungicides

Selective fungicides Autostin and Indofil were used for seed treatment and subsequently sprayed at 7 and 15 days after seed germination.

3.4.2 Sterilization of Substrates and Inoculation of *Trichoderma* in the multiplication

The requisite amount of materials for each substrate was thoroughly mixed in a 1000 ml Erlenmeyer flask and autoclaved at 121^0C for 15 minutes for sterilization. The sterilized substrates allowed to cool down and then inoculated with 5 mm diameter disc of 7 days old *Trichoderma* culture. Seven discs for each flask were used for inoculation. Inoculated flasks were then incubated at room temperature $(25\pm2)^0$C.

3.4.3 Application of *Trichoderma* based bio-pesticide

A 4.0 × 0.8 m^2 sized chickpea plot established for working area was prepared in the farm of the Department of Plant Pathology Sher-e-Bangla Agricultural University (SAU). Spore solution of *Trichoderma harzianum* was prepared from 10 days old culture was applied in the root zone of chickpea plant for the management of *Sclerotium rolfsii*.

3.5 Collection/isolation and maintenance of *Sclerotium rolfsii*

The pathogen was isolated from naturally infected chickpea plant grown in the experimental plot of the Department of Plant Pathology, SAU, Dhaka. The typical foot and root rot symptoms of chickpea plant was still alive with pale green, and reduced sized leaves. Number of round brown to black sclerotia were found. The infected tissue of the collar region of the plant was collected and repeatedly washed in fresh water and surface was sterilized with 10% Clorox for 1 minute followed by three times washing in distilled water. Then the pieces of infected tissue were placed on PDA acidified with one drop of 5% lactic acid and inoculated at 22± 2^0C for 7 days. After incubation, white mycelia and sclerotia were formed (Plate 1). The pathogen was purified and multiplied subsequently through hyphal tip culture on PDA, for preparation of inocula.

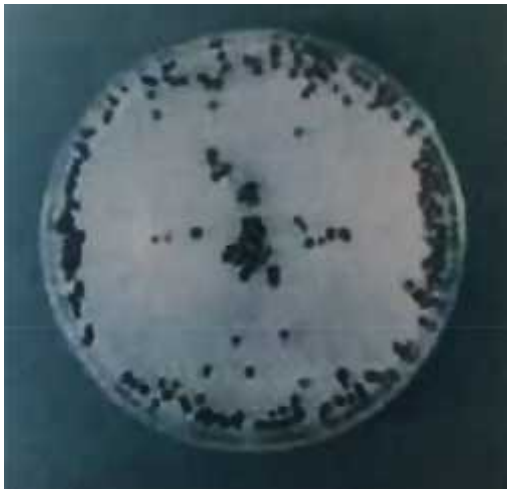


Fig: 1. Pure culture of *Sclerotium rolfsii*

3.6 Intercultural operations

3.6.1 Thinning

Seeds started germination of four Days After Sowing (DAS). Thinning was done two times; first thinning was done at 8 DAS and second was done at 15 DAS to maintain optimum plant population in each plot.

3.6.2 Irrigation and weeding

Irrigation was provided before flowering for two times for vegetative growth for the all experimental plots equally. But additionally supplementary irrigation was provided as per treatment before flowering. The crop field was weeded as per necesity.

3.7 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card and following data were recorded.

3.7.1 Plant height

The plant height was measured at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.7.2 Number of branches plant^{-1}

The number of branches plant^{-1} was counted at harvest from selected plants. The average number of branches plant^{-1} was calculated.

3.7.3 Number of pods plant^{-1}

Number of total pods of selected plants from each plot were counted and the mean numbers was expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.7.4 Pod length

Pod length was taken of randomly selected ten pods and the mean length was expressed on pod^{-1} basis.

3.7.5 Weight of 1000 seeds

One thousand cleaned, dried seeds were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram.

3.7.6 Seed yield

The seeds collected from 3.2 (4.0 × 0.8) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.7.7 Stover yield

The stover collected from 3.2 (4.0 × 0.8) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.7.8 Biological yield hectare^{-1}

Seed yield and stover yield together was regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.8 Assessment of disease incidence and severity

Disease incidence was calculated by the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Number of total plant inspected}} \times 100$$

Fig: 2. Field view of the experiment

3.9 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant differences (if any) among different treatments. The mean values of all the characters were calculated and analysis of variance was performed by using MSTAT-C software. The significance of the difference among the means values was estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to assess the management of foot and root rot disease of Chickpea applying different treatments. Data on post emergence mortality yield contributing characters and yield of chickpea are presented. The results have been presented and discussed under the following headings:

Fig: 3. Field view of the treated and untreated plots/plants

4.1 Post emergence mortality

Selective fungicides, plant extracts and bio-agents in combination with soil amendment on post emergence mortality of chickpea due to foot and root rot diseases caused by *Sclerotium rolfsii* showed statistically significant differences in terms of post emergence mortality. After 10 DAS, the lowest post-harvest mortality (4.42%) was recorded from T_6 treatment which was followed (5.88% and 6.02%, respectively) by T_7 and T_4 treatment, whereas the highest post emergence mortality (20.53%) was observed from T_1 treatment (Table 2). At 20 DAS, the lowest post-harvest mortality (2.20%) was recorded from T_6 treatment which was followed (2.60% and 2.76%, respectively) by T_7 and T_4 treatment, whereas the highest post emergence mortality (25.00%) was observed from T_1 treatment (Table 2). At 30 DAS, the lowest post-harvest mortality (1.80%) was recorded from T_6 treatment which was statistically similar (2.13% and 2.15%) with T_7 and T_4 treatment, whereas the highest post emergence mortality (28.60%) was observed from T_1 treatment (Table 2). At 40 DAS, the lowest post-harvest mortality (1.13%) was recorded from T_6 treatment which was followed (1.40% and 1.47%, respectively) by T_7 and T_4 treatment, whereas the highest post emergence mortality (32.12%) was observed from T_1 treatment (Table 2).

4.2 Yield contributing characters and yield of chickpea

4.2.1 Plant height

Statistically significant differences was recorded in terms of plant height of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The longest plant (39.31 cm) was recorded T_6 treatment which was statistically similar (37.89 cm, 37.47 cm and 37.37 cm, respectively) with T_7, T_4 and T_5 treatment, whereas the shortest plant (25.94 cm) was observed from T_1 treatment.

Fig: 4.Treated healty plants by T_6 Trichoderma (soil amendment) + Autostin (spray at 7 DAS)

Fig: 5. Untreated diseased plants in control plot

Table 1. Efficiency of selective fungicides, plant extracts and bio-agents in combination with soil amendment on post emergence mortality of chickpea due to foot and root rot diseases caused by *Sclerotium rolfsii*

Treatments	Post emergence mortality (%)			
	10 DAS	20 DAS	30 DAS	40 DAS
T_1	20.53 a	25.00 a	28.60 a	32.12 a
T_2	7.45 d	3.40 e	2.87 de	1.87 cd
T_3	8.51 cd	3.80 d	3.20 cd	1.89 cd
T_4	6.02 e	2.76 g	2.15 f	1.47 e
T_5	6.12 e	3.00 f	2.53 e	1.73 cd
T_6	4.42 f	2.20 h	1.80 f	1.13 f
T_7	5.88 e	2.60 g	2.13 f	1.40 e
T_8	8.28 cd	4.20 c	3.40 bc	2.00 bc
T_9	9.36 c	4.40 c	3.53 bc	2.07 b
$LSD_{(0.05)}$	1.10	0.40	0.33	0.18
Level of significance	0.05	0.05	0.01	0.05
CV(%)	6.93	5.55	5.80	5.32

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

T_1: Control

T_2: Autostin (seed treat + field spray at 7 DAS)

T_3: Autostin (seed treat + field spray at 15 DAS)

T_4: Indofil (seed treat) + Autostin (field spray at 7 DAS)

T_5: Indofil (seed treat) + Autostin (field spray at 15 DAS)

T_6: Trichoderma (soil amendment) + Autostin (spray at 7 DAS)

T_7: Trichoderma (soil amendment) + Autostin (spray at 15 DAS)

T_8: Poultry waste (soil amendment) + Allamanda extract (spray at 7 DAS)

T_9: Poultry waste (soil amendment) + Allamanda extract (spray at 15 DAS)

Table 2. Efficiency of selective fungicides, plant extracts and bio-agents in combination with soil amendment on yield contributing characters of chickpea

Treatments	Plant height at harvest (cm)	Number of branches plant^{-1}	Pods plant^{-1} (No.)	Pod length (cm)
T_1	25.94 e	4.20 e	24.57 e	1.45 e
T_2	36.65 b	5.53 b-d	26.68 a-e	1.75 cd
T_3	37.47 ab	5.53 b-d	26.68 a-e	1.70 d
T_4	37.37 ab	5.93 bc	27.22 a-e	1.90 ab
T_5	36.08 bc	5.67 b-d	27.96 a-d	1.88 ab
T_6	39.31 a	6.53 a	28.80 a	1.96 a
T_7	37.89 ab	6.00 b	28.46 ab	1.93 a
T_8	33.99 cd	5.40 cd	25.53 b-e	1.83 bc
T_9	32.45 d	5.13 d	25.13 de	1.79 c
$LSD_{(0.05)}$	2.262	0.528	2.683	0.077
Level of significance	0.01	0.05	0.05	0.01
CV(%)	3.72	5.50	5.78	2.49

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

T_1: Control

T_2: Autostin (seed treat + field spray at 7 DAS)

T_3: Autostin (seed treat + field spray at 15 DAS)

T_4: Indofil (seed treat) + Autostin (field spray at 7 DAS)

T_5: Indofil (seed treat) + Autostin (field spray at 15 DAS)

T_6: Trichoderma (soil amendment) + Autostin (spray at 7 DAS)

T_7: Trichoderma (soil amendment) + Autostin (spray at 15 DAS)

T_8: Poultry waste (soil amendment) + Allamanda extract (spray at 7 DAS)

T_9: Poultry waste (soil amendment) + Allamanda extract (spray at 15 DAS)

4.2.2 Number of branches plant^{-1}

Statistically significant differences was recorded in terms of number of branches plant^{-1} of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest number of branches plant^{-1} (6.53) was recorded in T_6 treatment which was followed (6.00, 5.93 and 5.67, respectively) with T_7, T_4 and T_5 treatment, whereas the lowest number (4.20) was observed from T_1 treatment (Table 3).

4.2.3 Pods plant^{-1}

Statistically significant differences was recorded in terms of pods plant^{-1} of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest number of pods plant^{-1} (28.80) was recorded in T_6 treatment which was statistically similar with other treatments except T_1, T_8 and T_9 treatment, whereas the lowest number (24.57) was observed from T_1 treatment (Table 3).

4.2.4 Pod length

Statistically significant differences was recorded in terms of pod length of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The longest pod (1.96 cm) was recorded in T_6 treatment which was statistically similar (1.93 cm, 1.90 cm and 1.88 cm, respectively) with T_7, T_4 and T_5 treatment, whereas the shortest pod (1.45 cm) was observed from T_1 treatment (Table 3).

4.2.5 Weight of 1000-seed

Statistically significant differences was recorded in terms of weight of 1000 seeds of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest weight of 1000-seeds (275.54 g) was recorded in T_6 treatment which was statistically similar with other treatment except T_1, T_8 and T_9, whereas the lowest weight (234.08 g) was observed from T_1 treatment (Table 4).

Table 3. Efficiency of selective fungicides, plant extracts and bio-agents in combination with soil amendment on yield of chickpea

Treatments	Weight of 1000-seed (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})
T_1	234.08 c	1.19 e	2.11 e	3.29 e
T_2	261.14 ab	1.65 bc	2.61 a-d	4.26 bc
T_3	261.63 ab	1.55 cd	2.68 a-c	4.23 bc
T_4	272.46 ab	1.74 a-c	2.76 a-c	4.49 ab
T_5	268.99 ab	1.69 a-c	2.69 a-c	4.38 ab
T_6	275.54 a	1.94 a	2.92 a	4.86 a
T_7	275.42 a	1.87 ab	2.85 ab	4.72 ab
T_8	236.54 c	1.33 de	2.50 cd	3.84 cd
T_9	250.27 bc	1.32 de	2.33 de	3.66 de
$LSD_{(0.05)}$	20.92	0.263	0.284	0.474
Level of significance	0.05	0.05	0.01	0.05
CV(%)	4.70	9.73	6.33	6.60

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

T_1: Control

T_2: Autostin (seed treat + field spray at 7 DAS)

T_3: Autostin (seed treat + field spray at 15 DAS)

T_4: Indofil (seed treat) + Autostin (field spray at 7 DAS)

T_5: Indofil (seed treat) + Autostin (field spray at 15 DAS)

T_6: Trichoderma (soil amendment) + Autostin (spray at 7 DAS)

T_7: Trichoderma (soil amendment) + Autostin (spray at 15 DAS)

T_8: Poultry waste (soil amendment) + Allamanda extract (spray at 7 DAS)

T_9: Poultry waste (soil amendment) + Allamanda extract (spray at 15 DAS)

4.2.6 Seed yield

Statistically significant differences was recorded in terms of seed yield of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest seed yield (1.94 t ha^{-1}) was recorded in T_6 treatment which was statistically similar (1.87 t ha^{-1}, 1.74 t ha^{-1} and 1.69 t ha^{-1}, respectively) with T_7, T_4 and T_5 treatment, whereas the lowest stover yield (1.19 t ha^{-1}) was observed from T_1 treatment (Table 4).

4.2.7 Stover yield

Statistically significant differences was recorded in terms of stover yield of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest stover yield (2.92 t ha^{-1}) was recorded T_6 treatment which was statistically similar with other treatment except T_1, T_8 and T_9 treatment, whereas the stover lowest yield (2.11 t ha^{-1}) was observed from T_1 treatment (Table 4).

4.2.8 Biological yield

Statistically significant differences was recorded in terms of biological yield of chickpea for some selective fungicides, plant extracts and bio-agents in combination with soil amendment. The highest biological yield (4.86 t ha^{-1}) was recorded T_6 treatment which was statistically similar (4.72 t ha^{-1}, 4.49 t ha^{-1} and 4.38 t ha^{-1}, respectively) with T_7, T_4 and T_5 treatment, whereas the lowest stover yield (3.29 t ha^{-1}) was observed from T_1 treatment (Table 4).

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka was conducted during December, 2017 to March 2018 for the management of foot and root rot disease of Chickpea. Checkpea variety BARI SOLA 5 was used as the test crop in this experiment. The experiment comprised of the following 9 treatments including control condition: T_1: Control, T_2: Autostin (seed treat + field spray at 7 DAS), T_3: Autostin (seed treat + field spray at 15 DAS), T_4: Indofil (seed treat) + Autostin (field spray at 7 DAS), T_5: Indofil (seed treatment) + Autostin (field spray at 15 DAS), T_6: Trichoderma (soil amendment) + Autostin (spray at 7 DAS), T_7: Trichoderma (soil amendment) + Autostin (spray at 15 DAS), T_8: Poultry waste (soil amendment) + Allamanda extract (spray at 7 DAS) and T_9: Poultry waste (soil amendment) + Allamanda extract (spray at 15 DAS). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different In-vitro evaluation of against mycelial growth of *Sclerotium rolfsii*, post emergence mortality yield contributing characters and yield of chickpea were recorded and statistically significant variation was recorded for different treatments.

At 10 DAS, the lowest post-harvest mortality (4.42%) was recorded from T_6 treatment, whereas the highest post emergence mortality (20.53%) was observed from T_1 treatment. At 20 DAS, the lowest post-harvest mortality (2.20%) was recorded from T_6 treatment, whereas the highest post emergence mortality (25.00%) was observed from T_1 treatment. After 30 days of sowing, the lowest post-harvest mortality (1.80%) was recorded from T_6 treatment, whereas the highest post emergence mortality (28.60%) was observed from T_1 treatment. After 40 days of sowing, the lowest post-harvest mortality (1.13%) was recorded from T_6 treatment, whereas the highest post emergence mortality (32.12%) was observed from T_1 treatment.

The longest plant (39.31 cm) was recorded in T_6 treatment, whereas the shortest plant (25.94 cm) was observed from T_1 treatment. The highest number of branches plant^{-1} (6.53) was recorded in T_6 treatment, whereas the lowest number (4.20) was observed from T_1 treatment. The highest number of pods plant^{-1} (28.80) was recorded in T_6 treatment, whereas the lowest number (24.57) was observed from T_1 treatment. The longest pod (1.96 cm) was recorded in T_6 treatment, whereas the shortest pod (1.45 cm) was observed from T_1 treatment. The highest weight of 1000-seeds (275.54 g) was recorded in T_6 treatment, whereas the lowest weight (234.08 g) was observed from T_1 treatment. The highest seed yield (1.94 t ha^{-1}) was recorded in T_6 treatment, whereas the lowest stover yield (1.19 t ha^{-1}) was observed from T_1 treatment. The highest stover yield (2.92 t ha^{-1}) was recorded in T_6 treatment, whereas the stover yield (2.11 t ha^{-1}) was observed from T_1 treatment. The highest biological yield (4.86 t ha^{-1}) was recorded in T_6 treatment whereas the lowest stover yield (3.29 t ha^{-1}) was observed from T_1 treatment.

From the above findings it can be concluded that among the treatments, T_6: *Trichoderma* (soil amendment) + Autostin (spray at 7 DAS) was the better followed by T_7: *Trichoderma* (soil amendment) + Autostin (spray at 15 DAS) in respect of reduction of foot and root rot disease and also yield contributing characters and yield of chickpea.

RECOMMENDATIONS

Considering the findings of the present experiment, further studies in the following areas may be suggested:

1. This experiment may be conducted in different agro-ecological zones of Bangladesh for regional trial before final recommendation.
2. Other chemical with non-chemical components of control measures may be used for further study.

REFERENCES

REFERENCES

Agrios, G. N. (1997). Plant Pathology. 4th ed. London: Academic Press. 592p.

Ahmed, F. (1980). Control of foot and root rot disease of wheat. M.S. Thesis, Dept. of Plant Pathology Department, Bangladesh Agricultural University (BAU), Mymensingh.

Al-Askar, A.A., Rashad, Y.M. and Absulkhair, W.M. (2013). Antagonistic activity on an endemic isolate of Streptomyces tendae RDS 16 against phytopathogenic fungi. African J. of Mycobiology Res., 7(6): 509-516.

Alexander, B.J.R. and Stewart, A. (1994). Survival of sclerotia of Sclerotinia and *Sclerotium* Spp. in New Zealand Horticultural Soil. Soil Biology and Biochemistry. 26: 1323-1329.

Amin, F., Razdanl, V.K., Mohiddin, F.A., Bhat, K.A. and Banday, S. (2010). Potential of *Trichoderma* species as Bio control Agents of Soil Borne Fungal Propagules. J. Phytol. 2(10): 38–41.

Anahosur, K.H. (2001). Integrated management of potato Sclerotium wilt caused by *Sclerotium rolfsii*. Indian Phytopath.54: 158-166.

Anonymous, (2006). Asiatic society of Bangladesh.

Babar, H. M. (1999). Studies on collar rot of sunflower. Ph. D. Thesis, Dept. Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 153 p.

Begum, M.M. (1997). Efficacy of *Trichoderma harzianum* as a biocontrol agent for controlling *Fusarium spp*. and *Sclerotium rolfsii* in food legumes. MS

thesis, Dept. of Plant Pathology. Bangladesh Agricultural University, Mymensingh. Bangladesh. P.61.

Chakravarty, S. and Bhowmik, T. P. (1983). Symptoms and techniques of inducing collar rot of sunflower caused by *Sclerotium rolfsii* Sacc. Indian J. Agric. Sci. 53(7): 570-573.

Chandrasehar, G., Ayyappan, S. and Eswaran, A. (2005). Management of tomato collar rot caused by *Sclerotium rolfsii* by antagonistic microorganisms. J. Ecobiology. 17(3): 261-264.

Chattopadhyay, S. B. and Maiti, S. (1990). Diseases of Betelvine and Spices. Indian Council of Agricultural Research, New Delhi. 160p.

Chet, I. and Inbar, J. (1994). Biological control of fungal pathogens. Applied Biochem. Biotech. 48(1): 37-43.

Chet, I., and Inbar, A. (1994). Genetic diversity and vegetative compatibility among *T. harzianum* isolates. Molecular General Genetics. 256: 127135.

Chowdhury, M.S.M., Hossain, I., Fakir, G.A., Aminuzzaman, F.M. and Islam, M.R. (2000). Tolerance of *Trichoderma harzianum* and Gliocladium viride to agrochemicals and their antagonistic effect on seed born mycoflora of Pigeon Pea. Bangladesh J. Seed Sci. & Tech. 4(1&2): 8386.

CSIR (Council of Scientific and Industrial Research, New Delhi) (1969). The Wealth of India, CSIR, New Delhi. 8: 84-94.

Daami-Remadi, M., Jabnoun-Khiareddine, H., Ayed, F., Hibar, K., and Mahjoub, M. (2007). First report of *Sclerotium rolfsii* causing a typical soft rot on potato tubers in Tunisia. Tunisian J. Plant Protection. 2: 59-62.

Das, B.C., Dutta, P., Devi, G. and Dutta, P. (2000). Management of *Sclerotium rolfsii* in tomato by fungal antagonists. J. Agril. Sci. Society of North East India. 13(1): 101-103.

Das, B.C., Roy, S.K. and Bora, L.C. (1997). Mass multiplication of *Trichoderma* species on different media. J. Agril. Sci. Society of North East India. 10(1): 95-100.

Dey, T. K., M. S. Ali and N. Chowdhury. 1993. Vegetative growth and sporangia production in *Phytophthora colocaseae*. Indian J. Root Crops 17(2): 142-146.

Dasgupta, B. and Sen, C. (1997). Betel vine diseases and their management. A retrospect in perspective. In M. K. Dasgupta(Ed.) Pest management in Changing Agricultural Situation, Viswa Bharati: Sriniketan.43- 50pp.

Elad, Y., Chet, I. and Katan, J. (1982). *Trichoderma harzianum*: A biocontrol agent effective against *Sclerotium rolfsii* and *Rhizoctonia solani.* Phytopathology. 70: 119-121.

Fakir G. A.; Rahman, M. M. and Islam, M. F. (1991). Occurrence of diseases on lentil and country bean germplasms and their reaction to the selected major pathogens. Proc. Bangladesh Agricultural University Research Progress, Mymensingh, Bangladesh, 1-10 pp.

Farr, D. F., Bills, G. F., Chamuris, G. P., & Rossman, A. Y. (1989). Fungi on plants and plant products in the united states. American Phytopathology Society, pp.12-52.

Garibaldi, A., Gilardi, G. and Gullino, M.L. (2006). First report of southern blight incited by *Sclerotium rolfsii* on Potato (*Solanum tuberosum*) in Northern Italy. V 90 (8): 1-114.

Guha, P. and Jain, R.K. (1997). Status Report On Production, Processing and Marketing of Betel Leaf (Piper betle L.). Agricultural and Food Engineering Department, IIT, Kharagpur, India.15-22 pp.

Gurkins, R.A and Jenkins, S.F. (1985). Influence of cultural practices, fungicides and inoculums placement on the southern blight and *Rhizoctonia* crown rot of carrot. Plant Dis. 69p.

Haque, E.S.A., Ghaffar, A. and Zaki, M.J. (1990). Biological control of root rot disease of okra, sunflower, soybean and mungbean. Pakistan J. Botany. 22(2): 212-214.

Hiremath, P. C.; Kulkarni, S. A.; Radder, G. D., Gidnavar, V. S., Chittapur, B. M., Itnal, C. J.; Patal, B. N. and Babalad, H. B. (1998). Production of

biocontrol agent for plant pathogens. Organic sustaining soil fertility productivity. 291-293 pp.

Hossain, I. and Hossain, M.H. (2010). Status of tikka disease of groundnut in Bangladesh and effect of BAU-Biofungicide on improving seed quality. BAU Res. Prog. 20: 29-30.

Howlader, M. (2003). Plant growth promoting fungi from Trufgrass rhizosphere with potential for disease suppression soil organisms. 44: 33-38.

Inbar, J., Abramsky. M., Cohen, D. and Chet, I. (1994). Plant growth enhancement and disease control by *Trichoderma harzianum* in vegetable seedlings grown under commercial conditions. European J. Pl. Pathol. 1000: 337346.

Islam, M. (2005). Country news, Holiday Publication Limited. 8: 3-4.

Islam, M. S. (2008). Incidence and severity of foot/collar rot in some varieties of eggplant and its control by *Trichoderma* based biopesticide. MS Thesis, Dept. Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 60-61 p.

Jana, B. L. (1995). Gram Banglar Arthakari Phasal-Paan (In Bengali). “Betel Leaf: A Cash Crop of Villages of Bengal”.Asaboni, Flat 203, 184, B. B. Chatterji Road, Calcutta.

Kashem, A. (2005). Trichoderma in controlling foot and root rot and collar rot of lentil. Ph. D. thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. Bangladesh. 192 p.

Kashem, M.A., Hossain, I. and Hasna, M.K. (2011). Use of Trichoderma in biological control of foot and root rot of lentil (Lens culinaris Medik). Int. J. Sustain. Crop Prod. 6(1), 29-35.

Kaur, N.P. and Mukhapadhyay, A.N. (1992). Integrated control of chickpea with complex by Trichoderma and chemical methods in India. Tropical Pest management. 38(4): 372-375.

Khan, M. H. (1996). Regional and seasonal influence on varietal reaction to Alternaria blight and collar rot of sunflower. MS thesis, Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. 77 p.

Khanna, R.N. and Jyotsana Sharma. (1993). Soil and tuber brone diseases. In: Advances in Horticulture, Vol-7, Potato (eds. Chanda, K.I. and Grewal, J.S.), Melhotra Publishing House, New Delhi, pp. 463-490.

Krishnamoorthy, A.S. and Bhoskaran, R. (1990). Biological control of damping off disease of tomato caused by Pythium indicum. Balakrisham. J. of biological control. 4(1): 52-54.

Kulkarni, S. A. and Kulkarni, S. (1994). Biological control of *Sclerotium rolfsii*, a causal agent of collar rot of groundnut. Karnataka J. Agril. Sci. 7(3): 365-367.

Kumar, S.M. and Khare, M.N. (1990). Studies on the antagonistic relationship of soybean sperm sphere microflora with *Rhizoctonia bataticola* and *Sclerotium rolfsii.* J. Biological control. 4(1): 72-74.

Kumar. S. (2013). Trichoderma: a biological weapon for managing plant diseases and promoting sustainability. Int. J. Agrl. Sc. & Vet. Med. 1: 3.

Lievens, B., Hanssen, I. R. M., Vanachter, A. C. R. C., Cammue, B. P. A. and Thomma, B. P. H. J. (2004). Root and foot rot on tomato caused by Phytophthora infestans detected in Belgium. Plant Disease. 88(1): 86.

Maiti, S. and Sen, C. (1982). Incidence of major diseases of betelvine in relation to weather. Indian Phytopath. 35:14-17.

Meah M. B. (2003). Devlopment of an integrated approach for management of phomopsis blight of and fruit rot of eggplant in Bangladesh. Annual research report (2002-2003). 57pp. Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangadesh.

Meah, M. B. (1994). Diseases in Kharif crops under crop diversification programme report. Crop Diversification Programme, Dept. Agric. Ext.Dhaka. 11p.

Meah, M. B. (1997). Diseases in Rabi crops under crop diversification programme Report. Crop Diversification Programme, Dept. Agric, Ext. Dhaka. 10 p.

Meah, M. B. (2007). Formulation of bio-pesticides in controlling phomopsis rot, foot/collar rot and shoot and fruit borer of eggplant. Annual research report, USDA-Bangladesh collaborative research. 4-11pp.

Mirkova, E. (1982). In vitro study of the antagonistic activity of *Trichoderma* spp. towards some soil pathogens. Gradinarskai. I. Lozarska Nauka. 19(1): 73-81.

Mollah, M.I. (2012). Investigation on The Leaf Rot and Foot and Root Rot of Betel vine (Piper betel L.) in Satkhira district of Bangladesh. MS Thesis, Dept. of Plant Pathology, Sher-e-Bangla Agricultural University, Sher-eBangla Nagar, Dhaka-1207.

Monaco, C.A., Alippi, H.E. and Pasquare, A.O. (1991). *Trichoderma* spp. a biological agent of *Fusarium* spp. and *Sclerotium rolfsii*. Adv.Hort. Sci. 5(3): 92-95.

Montealegre, A. J. R. and Esterio, G. M. (1989). Presence of *Sclerotium rolfsii* sacc. in Bean fields (*Phaseolus vulgaris* L.) located in the V Reione, Chile. Agricultura-Techica. 49(1): 66-68.

Mridha, M. A. U. and Alamgir, S. M. (1989). Prevalence of sclerotial wilt of Betel vine (Piper betle L.) caused by *Sclerotium rolfsii*. Bangladesh J. Plant Pathol. 5(1&2) 107-108.

Mukharjee, PK., Sarmah, D.K. and Shrestha, S.M. (1995). Comperative antagonism properties of *Gliocladium virens* and *Trichoderma harzianum* on *Sclerotiorum rolfsii* and *Rhizoctonia solani*-its relevens to understanding the mechanisms of biocontrol. J. Phytopathol. 143(5): 275-279.

Mukhopadhyay, A.N. (1989). National seminar and 7th Workshop of AICRP on Biological Control, Lucknow. Oct. 23-25 pp.

Mullen, J. (2001). Southern blight, Southern stem blight, White mold. The Plant Health Instructor. 10(1):104.

Okoli, C. A. N., Erinle, I. D., Misari, S. M., Poswal, M. A. T. and Emechebe, A. M. (1991). Basal stem rot and wilt of sunflower in Nigeria caused by *Sclerotium rolfsii.* Plant Disease. 75(7): 750.

Palakshappa, M.G, (1986). Studies on foot rot of betel vine caused by *Sclerotium rolfsii* Sacc. in Karnataka. M.Sc.(Agri.) Thesis, University of Agricultural Sciences, Bangalore.

Pandya, J.R., Sabalpara, A.N. and Chawda, S.K. (2011) *Trichoderma*: a particular weapon for biological control of phytopathogens. J. of Agril. Tech. 7(5): 1187-1191.

Punja, Z. K, (1988). The biology, ecology and control of *Sclerotium rolfsii*, Annual Review of Phytopath. 23: 57-127.

Rahman,M.M. and Sultana,N. (2011). Annual report. Research Management Information System, Bangladesh Agricultural Research Council.

Rangasami, G. (1988). Disease of crop plant of India. Printice-Hall of India Private Limited. New Delhi. 101p.

Rettinassababady, C. and Ramadoss, N. (2000). Effect of different substrates on the growth and sporulation of *Trichoderma viride* native isolates. Agril. Sci. Digest. 20(3): 150-152.

Roberti, R., Flori, P. and Pisi, A. (1996). Biological control of soil brone *Sclerotium rolfsii* infection by treatment of bean seeds with species of *Trichoderma. Petria.* 6(2): 105-116.

Samanta, C. (1994). A Report on the Problems and Solutions of Betel Vine Cultivation. A booklet published by Mr. H. R. Adhikari, C-2/16, Karunamoyee, Salt Lake City, Kolkata-64 (WB), India.

Sangeetha, P. Jeyarajan, R. and Panicher, S. (1993). Mass multiplication of biocontrol agent *Trichoderma* spp. Indian J. Mycol. Plant Pathol. 23(3): 328-330.

Sayeduzzaman, M. (1988). An economic geographical study of betel leaf cultivation in Bangladesh. A M.Sc. thesis submitted to Geography, University of Dhaka. 45-47pp.

Shamarao, J., Siddaramaidah, A.L., Narayanaswamy, H. and Jahagirdar, S. (1998). Screening of substrates of mass multiplication of *Trichoderma viride*. Karnataka J. Agril. Sci. 11(1): 233-236.

Shamsuzzaman., Islam, S.M.A. and Hossain, I. (2003a). Production of *Trichoderma* conidia in agro-waste. Bangladesh J. Environ. Sci. 9: 146150.

Shamsuzzaman., Islam, S.M.A. and Hossain, I. (2003b). *Trichoderma* culture and germination of sweet gourd seed. Bangladesh J. Seed Sci. & Tech. 7(1&2): 91-95.

Shin, G.C., Im. G.J., Yu, S.H. and Park, J.S. (1987). Biological control of sesame soil-borne disease by antifungal micro-organisms. Korean J. Plant Protec. 26 (4): 229-237.

Siddaramaiah, A.L. (1988). Stem, sheath and leaf rot disease of cardomum caused by *Sclerotium rolfsii* from India. Curr. Res., 16: 82.

Siddaramaiah, A.L. and Chandrapa, H.M. (1988). New collar rot disease on *Desmodium uncinatum* and *Lutononis bainesii* from India. Curr. Res., 16: 83.

Sivan, A. and Chet, I. (1986). Biological control of *Fusarium* spp. in cotton, wheat and muskmelon by *Trichoderma harzianum*. J. Phytopathol. 116(1): 3947.

Sivan, A., Elad, Y. and Chet, I. (1984). Biological control effects on a new isolate of Trichoderma harzianum on Pythium aphanidermatum. Phytopathology. 74: 498-501.

Strashnow, Y., Elad, Y., Sivan, A., Rudich, Y. and Chet, I. (1985). Control of *Rhizoctonia solani* fruit rot of tomatoes by *Trichoderma harzianum*. Crop Protec. 4(3): 359-364.

Sugha, S. K., Sharma, B. K. and Tyagi, P. D. (1991). A modified Technique for screening chickpea (*Cicer arietinum*) varieties against collar rot caused by *Sclerotium rolfsii*. Indian J. Agril. Sci. 61(4): 289-290.

Sugha, S.K. Sharma, B.K. and Tyagi, P.D. (1993). Factors affecting development of collar rot of gram (*Cicer arietinum*) caused by *Sclerotium rolfsii*. Indian J. Agril. Sci. 63(6): 382-385.

Sultana, N. and Hossain, I. (1999). Biological control of foot and root rot of lentil with *Trichoderma harzianum*. Bangladesh J. Seed Sci. & Tech. 3(1&2): 107-111.

Sultana, N., Chowdhury, M.S.M. and Hossain, I. (2001). Growth and storability of *Trichoderma harzianum* and its effect on germination of tomato seeds. Bangladesh J. Seed Sci. & Tech. 5(1&2): 117-121.

Thammasak-Sommat, Witcha-Chaliphom and Kitti-Chunnaha Wong. (1982). Studies on damping off of cotton caused by Sclerotium rolfsii sacc., Bangkok (Thailand) 33 leaves. Kasetsart university, Bangkok, 69 p.

Tran, N.Ha. (2010). Using *Trichoderma* species for biological control of plant pathogens in Viet Nam. J. ISSAAS . 16(1):17-21.

Wangihar, P. D., Somani, R. B. and Bobade, K. P. (1988). Sclerotium collar rot a new menace to chilli in vidarbha. PKVRes. J. 12(1) 88-89.

Waraitch, K.S., Kanawer, R.S., Bipen, K. and Kumar, B. (1986). Fungicidal control of Sclerotium root rot of sugar beet (Beta vulgaris) caused by *Sclerotium rolfsii*. Indian Phytopathol. 39(1): 100-102.

Xu, T., Zhong, J.P. and Li, D.P. (1993). Antagonism of *Trichoderma harzianum* T82 and *Trichoderma* species NF9 against soil and seed borne pathogens. Acta. Phytopathol. Ca. Scinica, 23(1): 63-67.

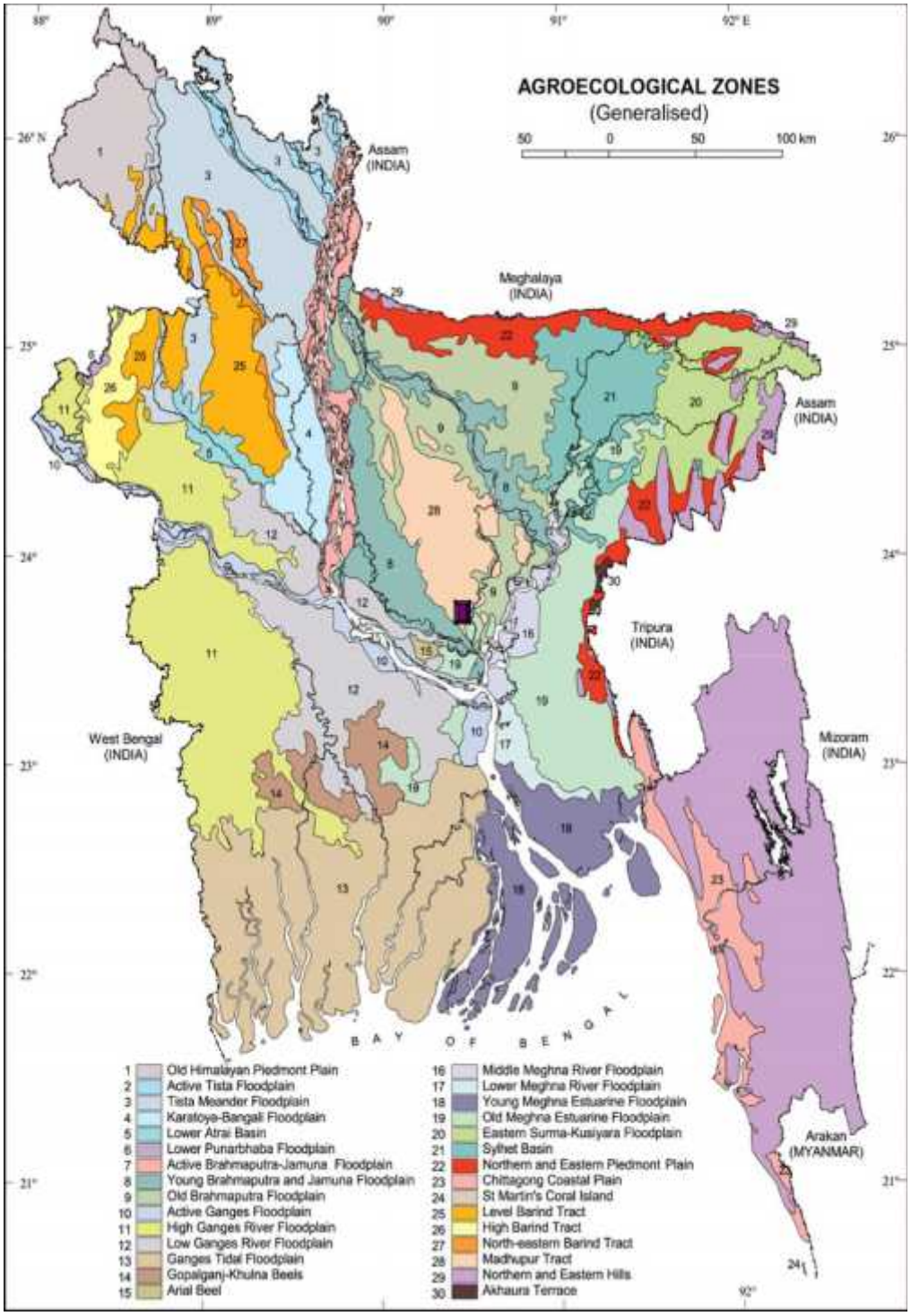
Yaqub, F. and Shahzad, S. (2005). Pathogenicity of *Sclerotium rolfsii* on different crops and effect of inoculums density on colonization of mungbean and sunflower roots. Pak. J. Bot. 37: 175-180.

Yasmin-Ahmed, Mirza, M. S., Aslam, M. and Ahmad, Y. (1988). Collar rot of maize caused by *Sclerotium rolfsii* in Pakistan. Pakistan J. Agril. Res. 9(4): 604-605.

APPENDICES

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from December 2017 to March 2018

Month	Air temperature (°c)		Relative humidity (%)	Total Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
December, 2017	22.6	13.4	78	05	6.6
January, 2018	24.9	12.2	64	00	5.8
February, 2018	27.7	16.9	69	30	6.7
March, 2018	31.4	19.6	67	18	8.4

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka-1212

Appendix III. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	26
% Silt	43
% clay	31
Textural class	Sandy loam
pH	5.9
Catayan exchange capacity	2.64 meq 100 g/soil
Organic matter (%)	1.15
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45