MANAGEMENT OF FOOT AND ROOT ROT DISEASE OF LENTIL (*Lens culinaris*)

MRINAL KUMAR CHAKI

DEPARTMENT OF PLANT PATHOLOGY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA -1207

JUNE, 2018

MANAGEMENT OF FOOT AND ROOT ROT DISEASE OF LENTIL (*Lens culinaris*)

BY

MRINAL KUMAR CHAKI

REGISTRATION NO. 12-05133

A thesis
submitted to the faculty of Agriculture
Sher-e-Bangla Agricultural university, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
PLANT PATHOLOGY

SEMESTER: JANUARY-JUNE, 2016

Approved by:

Dr. Md. Rafiqul Islam
Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Supervisor

Dr. F. M. Aminuzzaman
Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Co-Supervisor

Prof. Khadija Akhter
Chairman
Department of Plant Pathology
Sher-e-Bangla Agricultural University

DEPARTMENT OF PLANT PATHOLOGY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka

Phone: 9134865

CERTIFICATE

*This is to certify that the thesis entitled "**MANAGEMENT OF FOOT AND ROOT ROT DISEASE OF LENTIL**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in the partial fulfilment of the requirements for the **MASTER OF SCIENCE IN PLANT PATHOLOGY**, embodies the result of a piece of bona fide research work carried out by **MRINAL KUMAR CHAKI**, Registration No. 12-5133, under my supervision and guidance. No part of this thesis has been submitted for any other degree in any other institutes.*

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

Dated:
June, 2018

(Prof. Dr. Md. Rafiqul Islam)
Supervisor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Dhaka, Bangladesh

ACKNOWLEDGEMENT

All praises to Almighty God who make me capable to materialize the research work and complete the thesis.

I am proud to pay respect and my heartfelt gratitude and immense indebtedness to my research supervisor Prof. Dr. Md. Rafiqul Islam, Department of Plant Pathology, Sher-e-Bangla Agricultural University, for his continuous supervision, innovative suggestions, intelligent guidance, inspiration, helpful comments and encouragement at the time of my research work and for preparation of the thesis.

I express my heartfelt appreciation, deep sense of gratitude, immense indebtedness and respect to the respected Co-supervisor Prof. Dr. F. M. Aminuzzaman, Department of Plant Pathology, Sher-e-Bangla Agricultural university, for his cordial help, scholastic advice, Constructive criticism, valuable suggestions, recurrent inspiration during the research work and preparation of the thesis.

I would like to express my respect and heartfelt gratitude to all the respected teachers, and stuffs of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207, for their helpful advices, gentle co-operation, support at the time of research work.

I am extremely thankful to all my friends and well-wishers specially those are the MS students of Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka.

I would like to express special gratitude to my father, mother and other relatives who encouraged me during the whole period of M.S. study.

June,2018 The Author

CONTENTS

CONTENTS (CONTINUED)

CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AEZ	**=**	Agro-Ecological Zone
BARI	**=**	Bangladesh Agricultural Research Institute
BAU	**=**	Bangladesh Agricultural University
et al.	=	And others
TSP	**=**	Triple Super Phosphate
MP	**=**	Murate of Potash
RCBD	**=**	Randomized Complete Block Design
DAS	**=**	Days After Sowing
SAU	**=**	Sher-e-Bangla Agricultural University
LSD	**=**	Least Significant Difference
CV%	**=**	Percentage of Coefficient of Variance
Viz.	**=**	Videlicet (namely)

MANAGEMENT OF FOOT AND ROOT ROT DISEASE OF LENTIL

ABSTRACT

Experiments were carried out at the central farm and Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from December 2017 to March 2018 to investigate the effect of different management options on the foot and root rot disease of lentil. The field experiment was conducted with RCB design with nine treatment and three replications. nine treatments were comprised of two chemicals viz. Autostin 50 WP and Indofil M-45, one bio-fungicide *Trichoderma harzianum*, one botanical fungicide Allamanda extract, A soil amendment by poultry manure and one control. The chemical fungicides, plant extracts, bioagent spore solution were applied as seed treatment as well as spraying at the basal part (root zone) of the plant. Data were collected at different days after sowing. Results showed that the yield and yield contributing characters as well as growth parameters had been significantly affected by different treatments applied. Among different management options the treatment comprising seed dressing with Indofil M-45 and field spraying with Autostin 50 WP gave the best results regarding the number of pods/ plant, plant height, 1000 seed weight/ plot and seed yield/ plot followed by *Trichoderma harzianum* spore solution. The height percentage of disease incidence has been recorded in case of control and showed the maximum amount of yield loss. The treatment where the lentil seed were treated with Autostin 50 WP (0.4%) followed by field application with Autostin 50 WP (0.2%) at 7 DAS gave the promising performance showing upto 56% higher effect of lentil.

CHAPTER 1

INTRODUCTION

Lentil (*Lens culinaris*) holds a unique position in the world of different crops. In Bangladesh, it also holds a vast position in consuming pulses like crops (Sattar *et.al*., 1996). In our country pulses constitute a remarkable part of daily diet as a direct source of protein like nutrients for our countrymen. Lentil is one of the oldest crops cultivated in our country and is a familiar one to the farmers of Bangladesh. It has been taken the place of 2^{nd} most important pulses crop in terms of total area cultivated (154000 ha) and production (116000 ton) but ranks the highest in terms of consumption rate and total consumption (BBS. 2011; Sattar *et al*., 1996). Lentil has been consumed with smaller grains as a healthy diet. It is not only a cheap source of protein for humans but also for animals. Lentil helps in crop diversification in the cropping system of our country. As the animal protein price gets higher and higher day by day, most of the people of our country meet the demand of storage protein through lentil cultivation. The yield of lentil in our country is much lower than other countries like Syria, Turkey, Canada, U.S.A, Ethiopia (Hossain *et al*. 1999). The lower yield quality of lentil is because of poor management practices, scarcity of good quality seeds and improper plant disease management. Diseases play an important role in yield reduction in crop plants. Lentil is affected by wide range of diseases like fungal, bacterial etc. The most dangerous enemy of lentil (*Lens culinaris*) plant is fungus (BARI,2005). Lentil is affected by wide range of fungal diseases (Agrawal,1979). The productivity of lentil reduces because of infection through roots and collars of the plant. The market value of products is hampered due to the discoloration of seeds.

A number of soil borne diseases have been enlisted through observation and some of them are vascular wilt, collar rot, root rot, stem rot, rust, powdery mildew and downy mildew which are caused by *Fusarium oxysporum f.sp. lentis*, *Sclerotium rolfsii*, *Rhizoctonia solani*, *Uromyces fabae*, *Erysiphe polygoni* and *Peronospora lentis* respectively (Singh,1999). Among them foot and root rot caused by *Fusarium oxysporum* or *Sclerotium rolfsii* is considered as the most destructive and important disease of pulses crops like lentil in our country as well as all over the world (Begum 2003). This disease is one of the most devastating diseases in the legume growing countries. Mainly the disease is caused by *Fusarium oxysporum* or *Sclerotium rolfsii* which are fungal pathogens usually thrive on the soil because of their saprophytic behavior (Begum, 2003). The pathogen attacks at the seedling stages of lentil plant and causes seedling death by rotting the rot and foot area of the plant (Anonymous. 1986). The disease severity and disease incidence approaches at higher level by keeping pace with days after sowing. seedling mortality rate is higher at the early growing stages of the crop. In Bangladesh about 44% lentil plants are affected by foot and root rot disease (Anonymous. 1986). Sometimes it can cause up to 100% mortality in case of foot and root rot and wilt of infected plants (Fakir, 1983). Very poor plant stand after seedling stage has been reported because of this disease (Begum 2003). The ultimate result of plants affected by this disease are lower yield. People interested in pulse crops gets disappointed by the lower yield of lentil for the recent years that has been observed by many GO’s and NGO’s present in our country. Despite of many achievements in modern agriculture, chemical control still holds a strong performance in combating certain destructive plant diseases like foot and root rot diseases. Using botanicals as well as biopesticides with chemicals would be an intelligent approach in controlling this kind of diseases more effectively and efficiently (Benítez *et al.*, 2004).

The sustainability of the various approaches needed to be demonstrated so that farmers as well as growers can choose the proper management strategies for getting higher yield in lentil like crops.

Specific objectives of the research work are-

- To isolate and identify the causal organism of foot and root rot disease of lentil
- To evaluate the effectiveness of fungicides and botanicals in combination of soil amendment like poultry waste for the management of foot & root rot of lentil.

CHAPTER 2

REVIEW OF LITERATURE

Foot and root rot disease of lentil caused by *Fusarium oxysporum* and *Sclerotium rolfsii* is a common and most important disease in our country. This disease causes serious yield loss of the crop. Researchers all over the world have carried out intensive investigation on the foot & root rot of mustard. Literature in relation to management, severity and yield loss assessment of foot & root rot disease of lentil is reviewed and presented in this chapter.

Reddy *et al.* (1988) determined in field trials during 1983-1984 and 1984-1985, used Bavistin [carbendazim], Blitox [copper oxychloride] and Dithane M-45 [Mancozeb] alone or in combination with pruning for control of lime twig blight caused by *Colletotrichum*, *Diplodia* and *Fusarium* spp. in Chittoor, Andhra prodesh, India. Carbendazim in combination with pruning gave the best disease control.

Singh (1990) evaluated six systemic and non-systemic fungicides as drenching for two consecutive years (1987-88 and 1988-89) in artificially created sick plot with *Sclerotium sclerotiorum* in pea under field conditions. He observed that drenching of Bavistin at 0.1% checked the disease and significant increase in yield followed by Topsin M and Hexacap while Dithane M-45 was the least effective fungicide.

Asgari and Mayee (1991) reported that application of *Trichoderma harzianum* and soil drenching with 0.2% Carbendazim reduced stem rot by 44-60% in groundnut infected by *Sclerotium rolfsii* (*Corticium rolfsii*). Treatment increased pod yield by 17-47% and seed wt by 29-33%.

Saxena and Saxena (1993) reported infection caused by *Fusarium oxysporum* f. sp. *lentis*, *Sclerotium rolfsii* [*Corticium rolfsii*], *Rhizoctonia bataticola* and *Macrophomina phaseolina* on lentil was reduced by seed treatment with Thiram + Carbendazim (2:1, 2.5 g/kg seed), Thiram + quintozene (1:1, 2.5 g/kg) or Benomyl (1 g/kg seed).

Rahaman *et al*. (1994) studied the effect of Vitavax-200 [Carboxin], Apron-TZ [Metalaxyl], Dithane M-45 [mancozeb], Thiram, Captan and Baytan 10DS [Triadimenol], on foot and root rot disease (*Sclerotium rolfsii*) on cowpea (*Vigna unguiculata*). They have treated seeds of a susceptible variety before sowing. Vitavax-200 was the best fungicide with respect to controlling seeding mortality. Crop yield was also significantly increased due to treatment with fungicides. Highest seed yield was achieved after application of Vitavax-200.

Ganeshan (1994) screened eleven fungicides *in-vitro* against *Sclerotium rolfsii* Sacc which causes basal stem rot in cluster bean (*Ciamopsin tetragonaloba* (L) *Taub*. *Cv. Pusa Naubahar*). He found that Brassicol at 0.2%, Dithane M-45 at 0.1%, Foltaf at 0.2% and Thiride at 0.2% were effective in completely inhibiting the fungal growth. He also observed that seed treatment by soaking seed overnight in 0.2% solution of Dithane M-45 produced a good crop stand of 43%, Soil drenching with Dithane M-45 and Foltaf controlled stem rot up to 75 and 77%, respectively.

Srivastava and Tripathi (1998) studied the effectiveness of 5 combinations (2 fungicides in each combination) of 4 compatible fungicides , Quintozene (Brassicol), Thiram (TMTD), Carboxin (Vitavax) and Carbendazim (Bavistin) at the rate of 2.5 g/kg seed (mixed in equal proportion), against a seedling disease complex of sugarbeet caused by *Sclerotium rolfsii* [*Corticium rolfsii*]. Seed pelleted with all combinations of fungicides provided better disease control. Of the combinations used, Carbendazim +Thiram were the most effective in reducing seedling mortality.

Hossain *et al*. (1999) treated lentil seeds with Bavistin at 0.1% and 0.2% by dry wt and *Rhizobium leguminocearum* inoculants at 30, 50, 70 g/kg of seeds to control foot and root rot of lentil caused by *Fusarium oxysporum*. They found the seed treated with Bavistin at 0.2% increased germination by 39% over control and maximum grain yield in lentil also obtained when seed treated with 0.2% Bavistin.

Khatun (2005) conducted an experiment on the efficacy of chemicals for the management of foot and root rot of lentil in the field of SAU, Sher-e-Bangla Nagar, Dhaka. using RCBD with seven treatments and three replications. Result showed that the growth parameters like plant height, number of branches per plant were increased in addition with the yield and yield contributing characters owing to seed treatment followed by field spraying with Bavistin 50 WP.

Mollah (2012) conducted an experiment in the experimental field of Plant Pathology Division, Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahamatpur, Barisal following RCBD design to determine the resistance source against foot and root rot disease of lentil and to find out integrated management package in controlling the disease. 25 lentil lines with two check varieties were evaluated in the experiment. Among 25 lines only two lines namely BD-3916 (38.17%) and BD-3920 (33.85%) showed moderately performance. He also reported that among the management options, Straw burning + Poultry refuse + Provax 200 showed the best performance in respect of yield and yield contributing characteristics followed by Poultry refuse + Provax 200 in controlling foot and root rot disease of lentil.

Parvin (2013) conducted an experiment on the management of foot and root disease of betel vine caused by *Sclerotium rolfsii*. The experiment was conducted in the laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka. Treatments comprising Bavistin, Topgan, Tilt 250 EC, Garlic clove extracts, Neem leaf extracts, *Trichoderma harzianum* based BAU-bio fungicides and control. A remarkable reduction of the severity of foot and root rot was achieved by treating with fungicides.

The lowest severity (0.71%) was found in the Bavistin followed by Topgan (0.94%) whereas the highest severity was recorded under the untreated control treatment.

Hoque *et al*. (2014) evaluated the efficacy of fungicides in controlling foot and root rot of lentil under field condition. The fungicides were Rovral (0.2%), Secure 600 WG (0.2%), Bavistin 70 WP (0.2%) and Captan 50 WP (0.2%). Bari masur-1 has been used for this experiment. Tested fungicides significantly decreased disease incidence of foot & root rot of lentil & increased yields. Among all fungicides effective performance was recorded with Secure 600 WG (0.2%) in controlling the incidence of foot and root rot.

Sultana *et al*. (2015) carried out an experiment to evaluate six selected isolates of three bio-control agents against foot and root rot pathogens. The pathogens, *Fusarium oxysporum* and *Sclerotium rolfsii* were isolated from foot & root rot infected seedlings of lentils. Four isolates of *Rhizobium leguminosarum*, one isolate of *Pseudomonas fluorescens* & one isolate of *Trichoderma harzianum* were used as bio-control agents. Using dual culture method, the highest zone of inhibition of *F. oxysporum* (57.37%) was recorded against *R. leguminosarum* isolate 3 & isolate 4. In case of *S. rolfsii,* 80% & 37.85% inhibition zone were measured against *P. fluorescens* & *T. harzianum*, respectively. In paper towel & water agar test tube tests, minimum number of deed seeds (9.00), no abnormal & infected seedlings were counted from *R. leguminosarum* applied seeds. In water agar test tube test, lowest number of deed seed (12.00) & abnormal seedlings (2.00) were counted from *R. leguminosarum* incorporated seeds. No diseased seedling was found from *T. harzianum* treated seeds.

Faruk *et al*. (2016) reported that, Tricho-compost & seed treating chemicals fungicides have promising effects on pathogens causing foot and root rot disease of lentil. Different bio-fungicides and chemicals had been tested against *Fusarium* spp & *Sclerotium* spp in two different agro-ecological zones of Bangladesh. Among the treatments tricho-compost was found more effective in reduction of seedling mortality & acceleration of plant growth with raised grain yield of lentil under *S. rofsii, F. oxysporum* inoculated pot culture as well as field inquiry.

Khalequzzaman (2016) conducted an experiment at the sick plot, Pulses Research Centre, Ishurdi, Pabna, Bangladesh during 2011-12 to find out the effect of chemical, botanicals, biocontrol agents & healthy seeds against foot & root rot of lentil. The lowest foot & root rot (21.67%) was obtained from seed treatment with Provax 200 (2.5 g/kg seed) followed by seed treatment with *Trichoderma harzianum* compost (1:5) and apparently healthy seeds, while the highest incidence (41.5%) was obtained from untreated control. The highest number of pod/plant (45.26), number of seeds/plant (87.80), weight of 100 seeds/ plant (2.44 g) and yield (1845 kg/ha) were recorded in case of seed treatment with Provax 200 (2.5 g/kg seed) which were followed by seed treatment with *Trichoderma harzianum* compost (1:5) and apparently healthy seeds.

Hasan *et al*. (2016) conducted an experiment on the experimental field of Sylhet Agricultural University, Sylhet to evaluate the effects of different chemical and botanical fungicides in controlling foot and root rot disease of chickpea. Seven different treatments were sprayed as suspension into the experimental plot. The minimum disease severity (33.37%) and the highest yield (1600 kg/ha) were recorded by spraying Bavistin 70 WP at 1gm/liter with an increase of 52.38% grain yield.

CHAPTER 3

MATERIALS AND METHODS

The methods followed and materials used in the present research work were stated in this chapter. The experimental site, weather, land preparation, experimental design, lay out, growth parameters, data collection on disease incidence & severity, yield and yield contributing characters were stated in the chapter.

3.1. Experimental site

The experiment was implemented in the central farm of Sher-e-Bangla Agricultural University, Dhaka. The location for the experimentation site was 23°75N latitude and 90°35E longitude with an elevation of 8.3 meter from sea level.

3.2. Experimental period

The experiment was conducted during the Rabi season from December 2017 to March 2018. The seeds of lentil were sown on 1st December 2017 and harvested on 28th February 2018.

3.3. Soil type

The area of the experimental site was in the sub-tropical zone. The soil of experimental site belongs to the agro-ecological regions of "Madhupur Tract" under AEZ No.28 (Appendix II). The top soil of the region is clay loam in texture and olive gray with common fine to medium distinct black yellow brown mottles. The pH of the soil was 4.47 to 5.55 and organic carbon contents is 0.82 (Appendix I)

3.4. Weather

The monthly mean for daily maximum, minimum and average temperature, relative humidity (RH%), monthly total rainfall and sunshine hours received at the experimental field during the period of the experiment have been collected from Bangladesh Meteorological Department, Agargaon, Dhaka (appendix III).

3.5. Planting materials

The lentil (*Lens culinaris*) variety BARI Masur 5 released from Bangladesh Agricultural Research Institute, Joydevpur, Gazipur was used for the experiment. Seeds were collected from Pulses wing, BARI, Joydevpur, Gazipur.

3.6. Treatments of the experiment

Treatments holding differences from each other were applied in the experiment. Total 9 treatments were applied comprising difference in their appearance as follows:

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Field spray with Autostin at 7 DAS

T_5= Indofil (Seed treatment) + Field spray with Autostin at 15 DAS

T_6=*Trichoderma harzianum* (Spore solution) + Field Spray with Autostin at 7 DAS

T_7= *Trichoderma harzianum* (Spore solution) + Field Spray with Autostin at 15 DAS

T_8=Poultry waste (Soil amendment) + Field Spray with Allamanda extract at 7 DAS

T_9= Poultry waste (Soil amendment) +Field Spray with Allamanda extract at 15 DAS

3.7. Experimental design and layout

After final land preparation, the field layout was done. The experiment was set in a Randomized Complete Block Design (RCBD) with three replications. The total plot was divided into three blocks each comprising nine (9) plots of 4m X 1m size, giving 27 plots. The spaces were kept between blocks was 1m and 0.5m between plots. We planted seeds in three rows per unit plot and the row to row distance was kept 30 cm. The plant to plant distance was maintained as 5 cm and the seeds were sown in lines in the experimental plots. The seeds were planted at about 4 cm depth in the soil.

3.8. Land preparation

The experimental land had been properly ploughed and cross ploughed and cleaned before seed sowing and application of fertilizers and manuring was done in the field. The experimental land was ploughed thoroughly followed by laddering to have a good tilth. Finally, the field was properly leveled before seed sowing. At last the experimental design was followed for final preparation.

3.8.1. Application of manure and fertilizers

According to the standard recommendations, manures and fertilizers were applied. The following doses were used for carrying out the field experiment

Table 1: List of manures and fertilizers

Manures and fertilizers	Rates/ha
Cow dung	5000 kg
Urea	200 kg
TSP	100 kg
MP	75 kg
Gypsum	100 kg
Zinc oxide	5 kg
Poultry manure	500 kg
Boric acid	10 kg

Urea fertilizer was applied with all other fertilizers as full doses at the time of final land preparation as a basal dose.

3.8.2. Intercultural operation

Intercultural operations like weeding, thinning, mulching, irrigation, pest management, etc. were done specifically in the plots. First irrigation was done immediately after seed sowing. After germination, the irrigation was done for several times at 7 to 15 days intervals through sprinkler. Proper drainage system was maintained to release excess water created by rainfall immediately after stagnation. Two weeding was done. Where first weeding was done at 15 days after sowing and another was done at 30 days after sowing. At the time of thinning proper distance was maintained and this was done at 15 days after sowing. The crops were protected by spraying insecticide named Ektara @ 2 ml/L of water from insects like aphid attack. The insecticide was applied after dilution with water at 20 days after sowing. The time of spraying of insecticide was evening and not coincided with fungicidal application.

3.8.3. Preparation and application of spray solution

Fungicidal suspension was prepared by mixing required amount of fungicides. We used different types of treatments based on different types of chemicals and biological agents (*Trichoderma harzianum*) and different types of botanicals, as an integrated management. We had sprayed three times for the entire research period. We used chemicals as well as botanicals and biological agent suspension for seed treatment and after that we applied those treatments as spray consequently. The consequent sprays were applied at 7 DAS there after 15 DAS and at last 30 DAS.

Each chemicals and botanicals were diluted with water and the suspension of biological agent (*Trichoderma harzianum*) was prepared before spraying. The name of the fungicides and botanicals and the biological agents with their doses were given below-

Table 2: Spray solutions and their ingredients

Common Name	Active ingredients	Doses used
Autostin 50wp	Carbendazim	0.2% of the commercial formulation
Indofil M-45	Mancozeb	0.4% of the commercial formulation
Allamanda extract	Allamanda leaf (crashed)	100g leaf juice with 400ml water (ratio at 1:4)
Trichoderma solution	*Trichoderma harzianum* fungi	10 days old PDA culture @ 1 plate mixed with 1L water.

3.9. Tagging and data collection

Data collection was done based on counting diseased plants as well as healthy plants and there after measuring the height (cm), pod number etc. After harvesting the dry matter accompanied with yield, based on their treatment identity was recorded.

3.9.1. Isolation and identification of pathogen from leaf

From the experimental plot, the diseased plants are collected after visual surveillance. The plants are uprooted from the field for isolation of the pathogen. The infected samples were washed and dried properly for further work. The root zone of the infected plants was taken for sterilization with surface sterilizing chemical like $HgCl_2$ (1:1000) for 30 seconds. The cut pieces of root then were washed in sterilized water thrice and there after dried. then the cut pieces were placed in a PDA (Potato Dextrose Agar) media for growth of the pathogen. The plates containing the root pieces were placed in an incubator at room temperature for seven days. When the fungus grew well by showing signs of sporulation, then the slide was prepared from the sporulation and was identified under compound microscope.

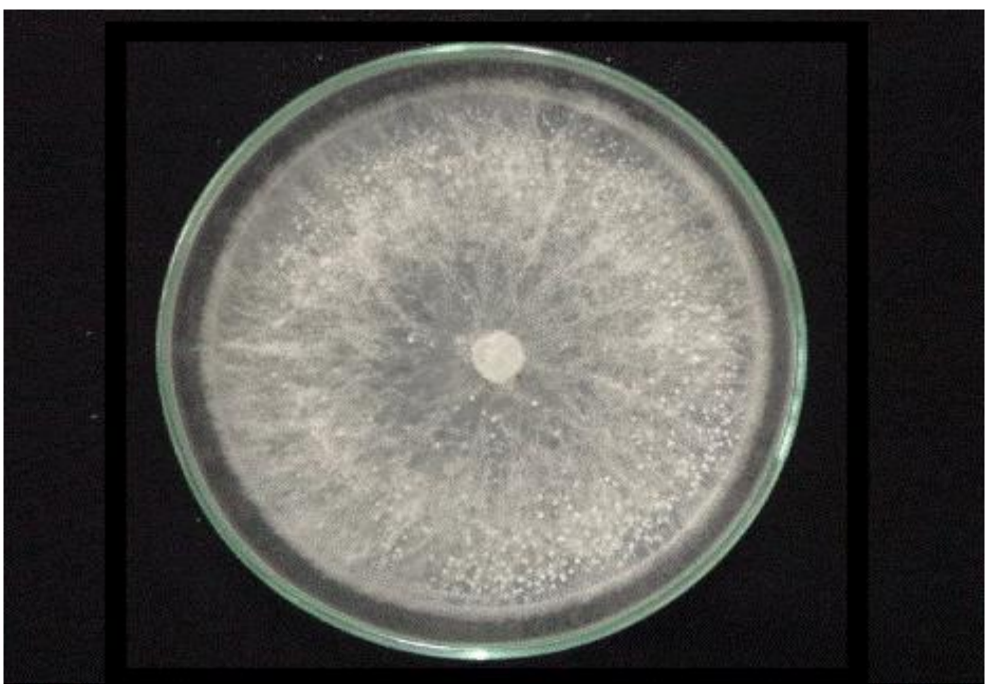


Fig 1: Pure culture of *Sclerotium rolfsii*

3.9.2. Collection of data

The following parameters were measured-

a. Percent plant diseased per plot

Growth parameters

a. Number of branches/ plant

b. Plant height (cm)

Yield and yield contributing characters

a. Number of pod/ plant

b. 1000-seed weight (g)

c. Yield (g/plot)

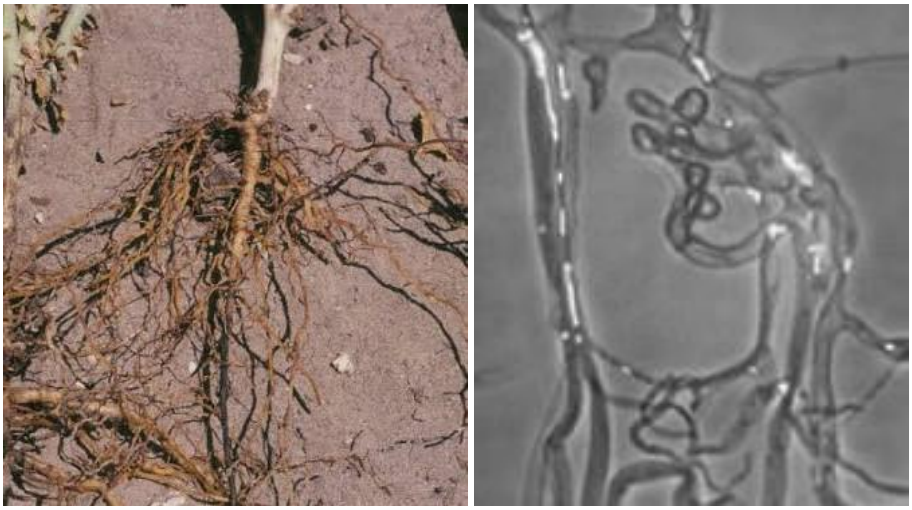
3.9.3. Procedure of data collection

3.9.3.a. Disease incidence

Visual observation was done to count total number of diseased/infected plants at different stages of growth. The data on counting total number of diseased plants per plots were recorded at seedling stage (10 DAS) and consequently at 25 DAS and 40 DAS. Percent plant diseased per plot was calculated by using the following formula-

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

Fig 2: Field view of the experiment at the time of counting disease incidence



(a) **(b)**

Fig 3: Lentil root affected by foot and root rot disease (a) and microscopic view of *Sclerotium rolfsii* (b)

3.9.3.b. Number of branches per plant

Randomly 10 plants were taken from a specific plot and the number of branches per plant were counted. The average of branch number of ten plants was taken for final branch number per plant

3.9.3.c. Plant height

Plant height was measured in centimeter by using a meter scale at both vegetative stage and reproductive stage of plant growth and there after the average of ten plants per plot were selected for final height per plant in centimeter.

3.9.4. Harvesting of crops

When the plants in the experimental field showed 80% to 90% maturity based on straw color, pod filling, pod color, water content per plant etc. indices. At maturity total plants per plot were harvested and tagged based on plot identity. Total 27 plots were separately harvested for data collection.

3.9.5. Data collection on yield and yield contributing characters

3.9.5.a. Number of pods/ plant

After harvesting, plants were collected from different plots to count the number of pods/ plant through visual counting.

3.9.5.b. 1000 seed weight (g)

One thousand grains were collected randomly from different plot and there after the measurement was taken in gram weight.

3.9.5.c. Yield (gm/plot)

Yield was counted by weighing total harvested grains per plot. The yield was measured in gram for final data preparation.

3.10. Statistical analysis

The data collected from different parameters were properly compiled and arranged in excel sheets. Appropriate statistical analysis was done by Statistix-10 -computer package program. The treatment means were compared with LSD (Least Significant Difference) value at 0.05% alpha value.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Effect of different treatments on percent disease incidence of foot and root rot of lentil at different days after sowing (DAS)

Disease incidence at different days after sowing during growth period had been recorded on the basis of visible typical symptoms. Nine treatments were compared with each other for disease incidence recorded at 10 DAS, 25 DAS and 40 DAS. At 10 DAS the highest (30.14%) was recorded disease incidence from treatment T_1 (control), whereas treatment T_2 showed the lowest disease incidence 2.73% Followed by treatment T_4 (2.76%), T_7 (3.21%), T_5 (3.46%), T_9 (3.49%), T_8 (3.52%), T_6 (3.53%) and T_3 (4.01%) as shown in table 3.

At 25 DAS the same trends of results were found where the lowest disease incidence was recorded in T_2 (3.24%) and the highest disease incidence (31.72%) was recorded in control treatment (Table 3).

At 40 DAS, the final disease incidence was counted where the highest incidence of disease was also recorded from T_1 (34.22%) which incurred the highest yield loss and the lowest disease incidence was recorded in T_2 (3.70%) that contributed the highest yield of lentil grain (Figure 4).

Table 3: Effect of different treatments on disease incidence in lentil plant at different days after sowing (DAS)

Treatments	Disease incidence per plot (10 DAS)	(25 DAS)	(40 DAS)	% inhibition over control at 40 DAS
T_1	30.14 a	31.72 a	34.22 a	-
T_2	2.73 e	3.24 g	3.7 g	30.52
T_3	4.01 b	4.53 b	5.03 b	29.19
T_4	2.76 e	3.23 g	3.73 g	30.49
T_5	3.46 c	3.93 e	4.43 e	29.79
T_6	3.53 c	4.05 c	4.54 c	29.68
T_7	3.21 d	3.71 f	4.21 f	30.01
T_8	3.52 c	4.01 cd	4.49 d	29.73
T_9	3.49 c	3.98 d	4.48 de	29.74
LSD	0.123	0.044	0.049	
C.V(%)	1.12	0.37	0.37	

In the column having same letters do not differ significantly at 5% level of significance.

T_1= Control

T_2= Autostin (Seed treatment +Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9=Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

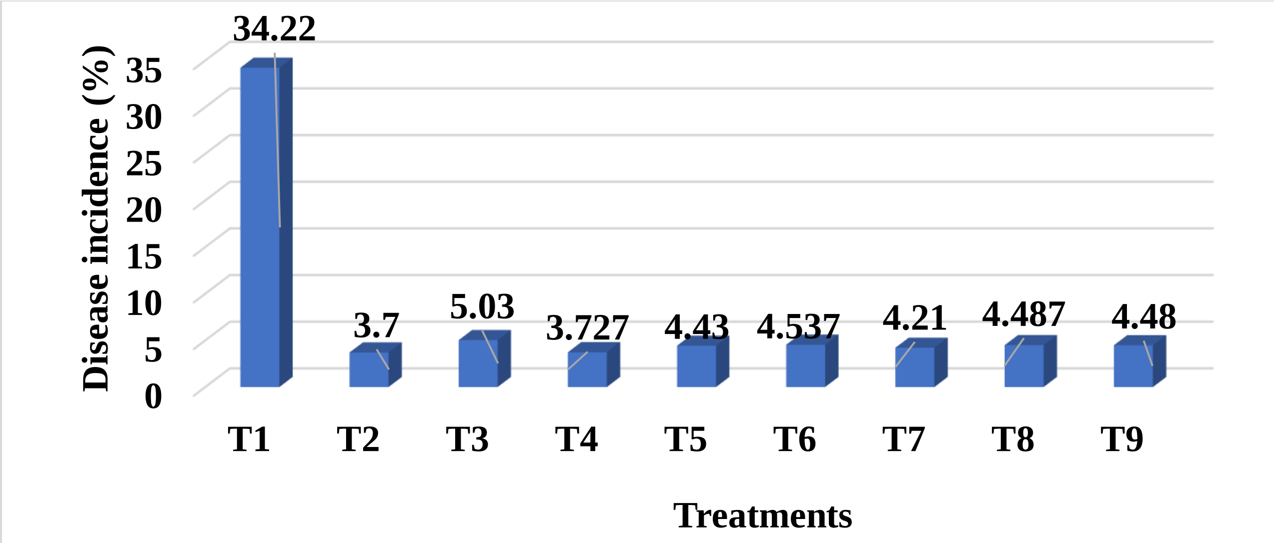


Fig 4: Graph showing Effect of different treatments on disease incidence in lentil plant at 40 DAS.

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.2. Effect of different treatments on different growth parameters

Effects of different treatments have been compared on the basis of different growth parameters like number of branches per plant and plant height.

4.2.1. Effect of different treatments on number of branches per plants

Number of branches per plant differs insignificantly but the highest number of branches was recorded in case of T_2 (10.33) and in case of T_1 the number of branches was recorded as 6.33 which was the lowest among treatments (Figure 5).

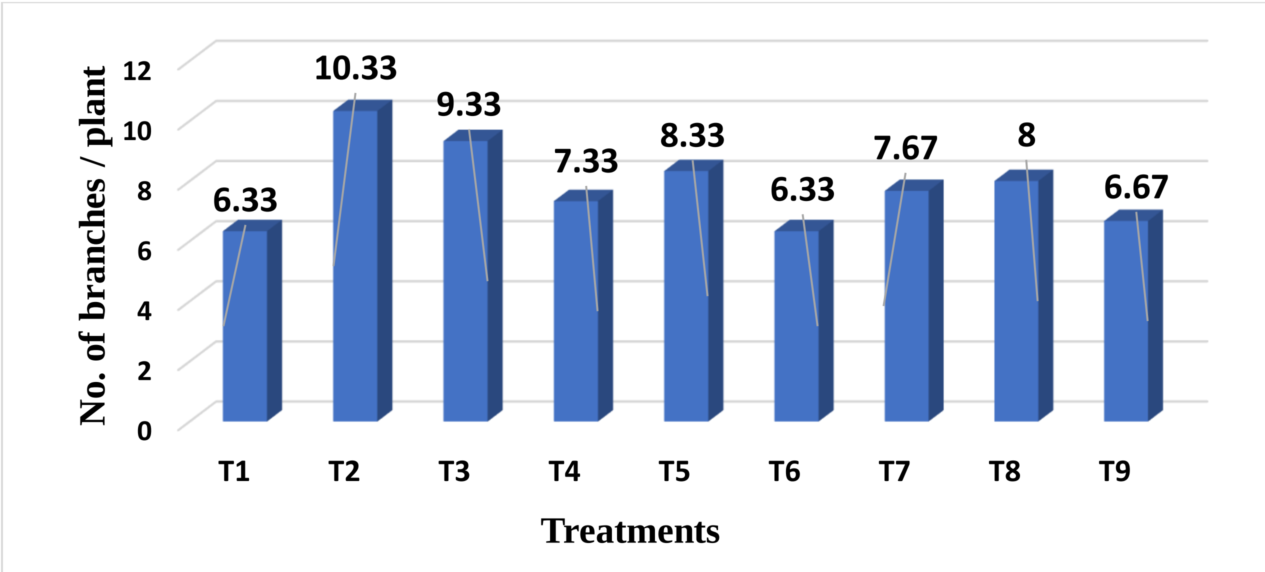


Fig 5: Graph showing Effect of different treatments on number of branches per plant

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.2.2. Effect of different treatments on Plant height

The effect of different treatments on the plant height found to be differed significantly with some extent. The lowest plant height (33.00 cm) was recorded in control treatment which was varied Statistically with treatment T_3 (37.66 cm) and T_9 (37.66 cm). The rest of treatment found statistically insignificant regarding the plant height (Figure 6).

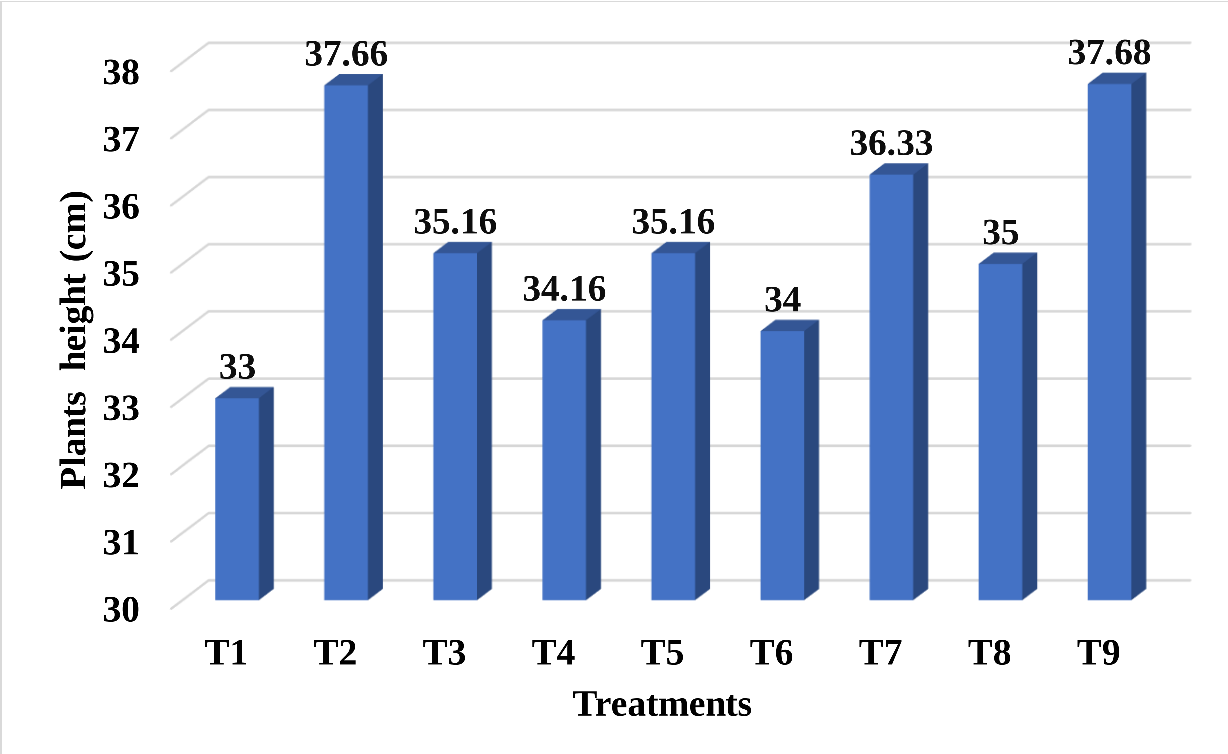


Fig 6: Graph showing effect of different treatments on plant height (cm)

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.3. Effect of different treatments on yield and yield contributing characters

Effects of different treatments have been compared on the basis of yield and yield contributing characters like, Number of pods per plant and 1000 seed weight.

4.3.1. Effect of treatments on number of pods / plant

Number of pod was counted by visual observation after the harvest of the experiment. The highest pod number was counted from T_2 treatment (41.33) and the lowest was counted from T_1 (20.33). The second height number of pods were recorded in case of treatment T_6 (36.33) which was statistically similar to T_5 and T_7. So we can say the treatment T_2 is the best in increasing total number of pods/ plant (Figure 7).

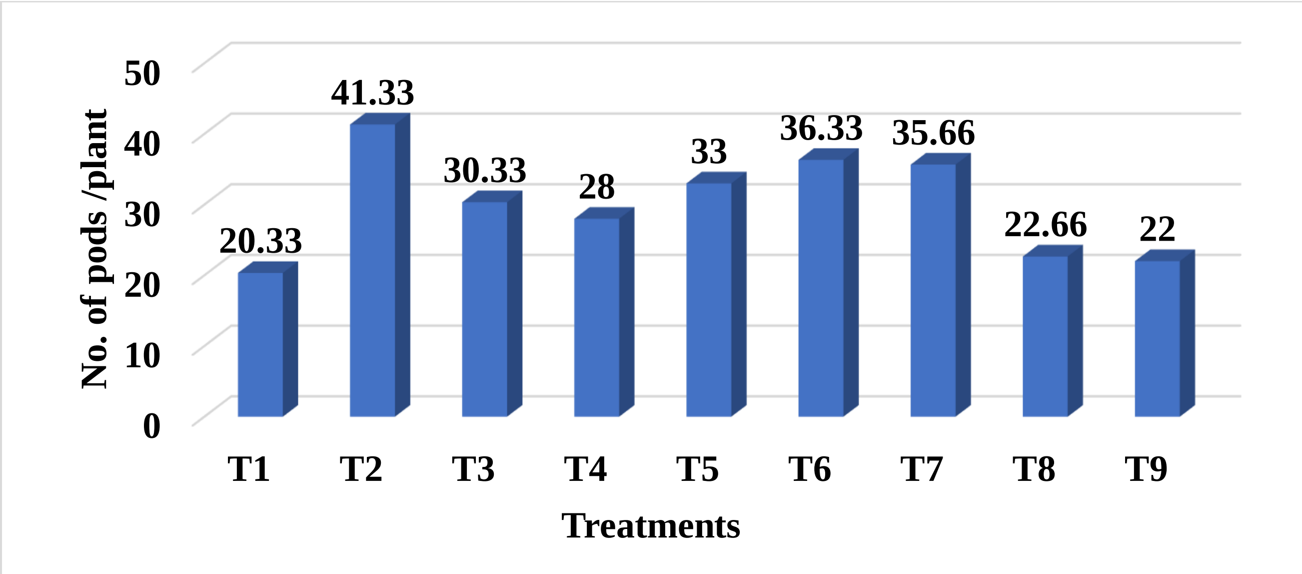


Fig 7: Graph showing Effect of different treatments on number of pods per plant

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.3.2. Effect of treatments on 1000 seed weight (gm)

1000 seeds were taken randomly from each treatment and weighed. The highest weight was recorded in T_2 (125.60 gm) followed by treatment T_4 (115.30 gm), T_9 (115.30 gm) and T_3 (111.00 gm). The lowest 1000 seed weight was recorded in T_1 (101.07 gm) preceded by T_6 (107.00 gm) and T_5 (107.30 gm) (Figure 8). According to the result, the treatment T_2 was the most effective for the highest 1000 seed weight/ plot.

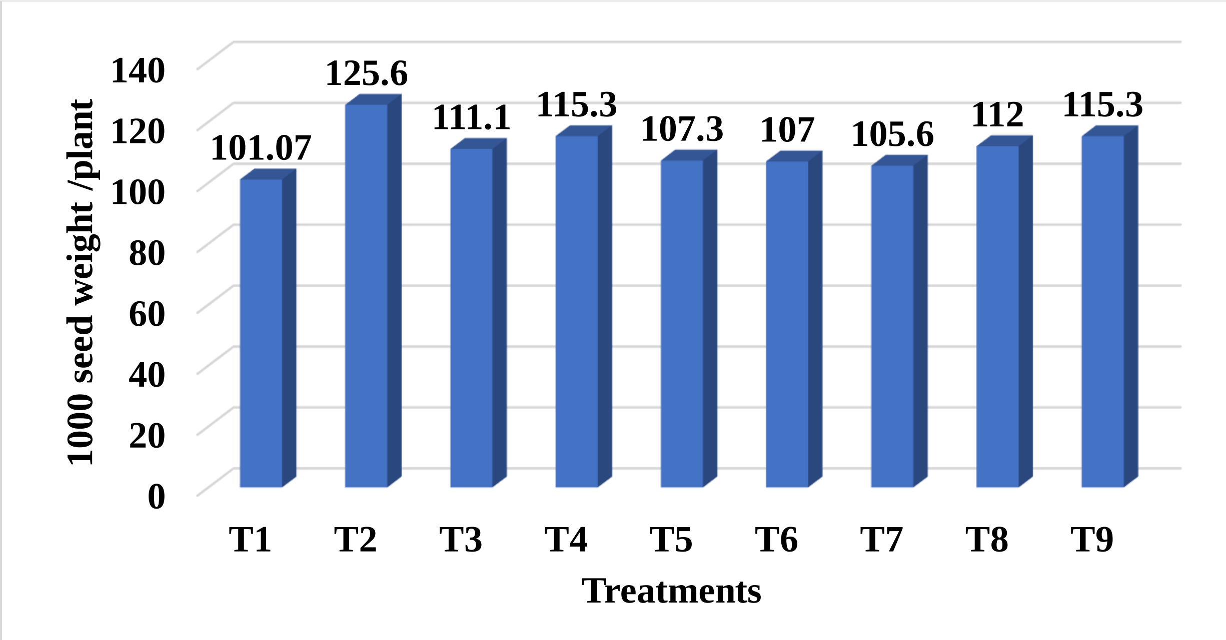


Fig 8: Graph showing effect of different treatments on 1000 seed weight / plant

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.3.3. Effect of different treatments on dry matter weight (gm)

Dry matter weight was taken after harvesting the crop. The dry matter was achieved after sun drying. The highest dry matter weight was recorded from T_2 (498.33 gm) followed by T_7 (473.33 gm) and T_9 (415.00 gm) and the lowest was counted from T_1 (283.33 gm) preceded by T_4 (312.00 gm) and T_5 (335.33 gm) (Figure 9, Table 4).

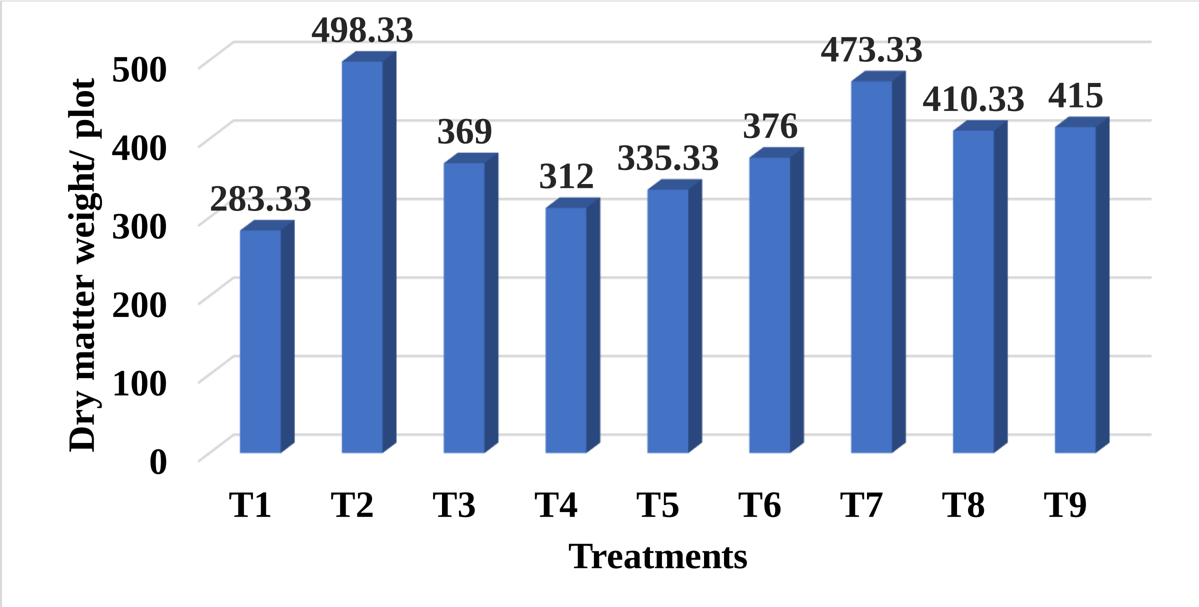


Fig 9: Graph showing effect of different treatments on dry matter weight/ plot

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.3.4. Effect of different treatment on yield (gm)

The effect of different treatments on yield (gm) found to be differed significantly at some extent. The lowest yield (270.33 gm) was recorded in control treatment which was varied statistically with treatment T_2 (422.33 gm) and T_4 (403.33 gm). The rest of treatment found statistically significant at some extent regarding the yield (Table 4).

Table 4: Effect of different treatments on yield and yield contributing characters as well as growth parameters of lentil

Treatments	Yield and yield contributing characters				Growth parameters		% yield increased over control
	Dry matter weight (gm)	Number of pod /plant	1000 seed weight (gm)	Yield (gm/plot)	Number of branches /plant	Plant height (cm)	
T_1	283.33 f	20.33 e	101.07 f	270.33 e	6.33 a	33.00 ab	0
T_2	498.33 a	41.33 a	125.67 a	422.33 a	10.33 a	37.67 a	56.23
T_3	369.00 cde	30.33 cd	111.00 cd	273.33 de	9.33 a	35.17 ab	1.11
T_4	312.00 ef	28.00 d	115.33 b	403.33 ab	7.33 a	34.17 ab	49.25
T_5	335.33 def	33.00 bc	107.33 de	350.33 bc	8.33 a	35.16 b	29.62
T_6	376.00 cde	36.33 b	107.00 e	321.33 cde	6.33 a	34.00 ab	18.88
T_7	473.33 ab	35.67 b	105.67 e	355.00 abc	7.67 a	36.33 ab	31.48
T_8	410.33 bcd	22.67 e	112.00 bc	343.33 bcd	8.00 a	35.00 ab	27.03
T_9	415.00 bc	22.00 e	115.33 b	348.33 bc	6.67 a	37.67 a	28.88
LSD	75.56	4.21	3.83	70.05	2.73	3.81	
C.V(%)	11.31	8.11	19.9	11.80	42.73	6.24	

Columns having same letters don't differ significantly at 5% level of significance

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

T_8=Poultry waste (Soil amendment) + Allamanda extract (Field spray at 7 DAS)

T_9= Poultry waste (Soil amendment) +Allamanda extract (Field spray at 15 DAS)

4.3.5. Percent yield increase over control

Based on the experimental findings, it was noticed that treatment T_3 where both seed treatment and field spray were done by Autostin 50 WP increased seed grain yield by 56.23% followed by T_4 (seed treatment with Indofil M-45 and field spray with Autostin 50 WP at 7 DAS) and T_7 (seed treatment with *Trichoderma harzianum* spore solution and field spray with Autostin 50 WP at 15 DAS) (Table 4).

4.4. Relation of disease incidence with yield regarding different treatments

Disease incidence shows proper relation with yield in respect of different treatments. T_1 with higher disease incidence (5.22%) shows higher yield loss with no chemical spray, whereas T_3 and T_4 show lower disease incidence as 3.7% and 3.73% respectively which shows lower yield losses (Figure 10).

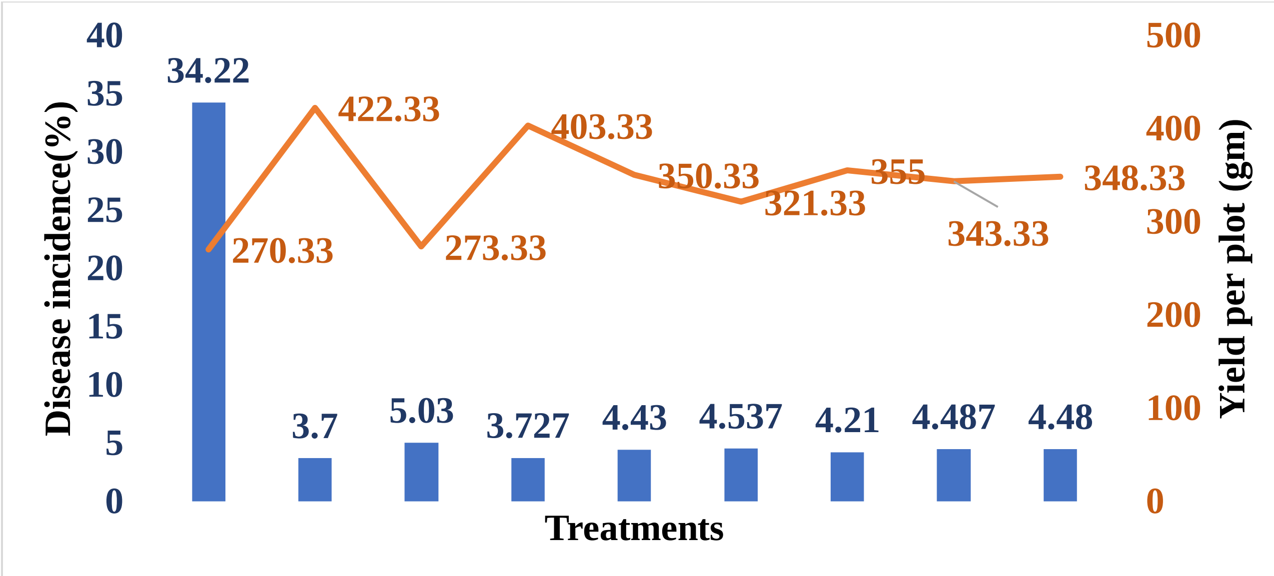


Fig 10: Graph showing Relation of disease incidence with yield regarding different treatments

T_1= Control

T_2= Autostin (Seed treatment + Field spray at 7 DAS)

T_3= Autostin (Seed treatment + Field spray at 15 DAS)

T_4= Indofil (Seed treatment) + Autostin (Field spray at 7 DAS)

T_5= Indofil (Seed treatment) + Autostin (Field spray at 15 DAS)

T_6=*Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 7 DAS)

T_7= *Trichoderma harzianum* (Seed treatment) + Autostin (Field spray at 15 DAS)

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

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

CHAPTER 5

SUMMARY AND CONCLUSION

Experiments were conducted at the central farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during the month of December 2017 to April 2018. Lentil variety BARI MASUR -5 was used in this experiment. The experiment was done with RCBD design with nine treatments alone and in combination of two chemical fungicides (Autostin 50WP, Indofil M-45), one bio-fungicide (*Trichoderma harzianum*), one botanical fungicide (Allamanda extract) and soil amendment with poultry waste. Investigation was carried out to find out the effect of these treatments on the post emergence mortality, percent disease incidence of foot and root rot and yield contributing characters of lentil and yield of the crop.

The effects of most of the nine different treatments were significant in controlling disease of foot and root rot of lentil. Seed treatment Autostin 50 WP (Carbendazim) followed by field spray with Autostin 50 WP was found to be the best in controlling disease incidence of foot and root rot of lentil as well as decreasing post emergence mortality, where other treatments showed lower performance.

Number of pods/ plant, yield / plot, plant height were significantly influenced by different treatments at some extent. Among them, the treatment T_2 comprising seed treatment with Autostin 50 WP and field spray at 7 DAS followed by another treatment comprising two fungicide (one for seed treatment as Indofil M-45 and another as field spray at 7 DAS) were found to be effective in increasing number of pods/ plant, yield / plot, plant height of lentil plant.

At 10 DAS the lowest disease incidence (2.73%) was recorded from T_2 whereas the highest disease incidence (30.14%) was observed from T_1 Treatment. At 25 DAS the lowest disease incidence (3.24%) was recorded from T_2 whereas the highest disease incidence (31.72%) was observed from T_1 Treatment. After 40 days of sowing the lowest disease incidence (3.70%) was recorded from T_2 whereas the highest disease incidence (34.22%) was observed from T_1 Treatment.

The highest plant height (37.66 cm) was recorded from T_2 treatment and the lowest plant height (33.00%) was observed from T_1 treatment. The highest number of branches/ plant (10.33) was recorded from T_2 treatment whereas lowest number of branches/ plant (6.33) was recorded from T_1 and T_6 treatment.

The highest number of pods/ plant (41.33) was recorded from T_2 treatment and the lowest number of pods/ plant (20.33) was recorded from T_1 treatment. The highest 1000 seed weight/ plot (125.67 gm) was recorded from T_2 and the lowest 1000 seed weight (101.07 gm) was recorded from T_1 treatment. The highest yield/ plot (422.33 gm) was recorded from T_2 with 56% increase in yield over control (T_1), where the lowest yield/ plot (270.33 gm) was recorded from control (T_1).

The findings of the present study have clearly pointed out that among the fungicides used, Autostin 50 WP, appeared to be the best in controlling the disease of foot and root rot as well as yield of lentil plant. So the lentil grower can be recommended to use Autostin 50 WP at 0.2 to 0.4% as seed treatment and field spraying of the seeding against foot and root rot of lentil caused by *Sclerotium rolfsii*, However, further investigations may be carried out to clarify and justify the results.

CHAPTER 6

RECOMMENDATIONS

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

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

CHAPTER 7

REFERENCES

Agarwal, S. C., Khare, M. V. and Jain, A. C. (1979). Diseases of lentil and their control. Technical bulletin. Jawaharlal Nehru Krishi viswa Vidyalaya, Jabalpur, Madhya Pradesh, India.

Anonymous. (1986). Annual report 1985-86. Plant Path. Div. BARI, Gazipur.P. 19.

Asghari, M. R. and Mayee, C. D. (1991). Comparative efficiency of management practices on stem and pod rots of groundnut. Indian Phytopathol. **44**(3): 328-332.

BARI Hand Book, (2005), Dal fasol utpadon podoti. P.101-104.

BBS. (2011). Bangladesh Bureau of Statistics. Ministry of Planning. Dhaka, Bangladesh. 126.

Begum, F. (2003). Integrated control of seedling mortality of lentil caused by *Sclerotium rolfsii*. MS thesis submitted to the Department of Plant pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

Benitez, T., Rincon, A.M., Limon, M.C., Codon, A.C. (2004). Biological mechanisms of *Trichoderma* strains. Intl. Microbiol. **7**: 249-260.

Dey, T. K., Ayub, A., Ahmed, H. U. and Rahman, M. H. (1993). Screening of chickpea germplasm against *Fusarium* wilt. Bangladesh J. Plant pathol. **9**(1&2):29-30.

Fakir, G. A. (1983). Pulse disease and its control. Dept. of Plant Pathol., Bangladesh Agril. Univ., Mymensingh. P.17

Faruk, M. I. and Rahman, M. L. (2016). Management of stem and root rot disease of lentil through soil amendment with tricho-compost. BARI, Dhaka, Bangladesh. Int. J. Sci. Res. Sci. Tech. **2**(3):301-308.

Ganeshan, G. (1997). Fungicidal control of *Sclerotium* basal rot of cluster bean cv. *Pusa Naubahar*. Indian Phytopathol. **50**(4): 508-512.

Hoque, M. A., Hamim, I., Haque, M. R., Ali, M. A. and Ashrafuzzaman, M. (2014). Effect of some fungicides on foot and root rot of lentil. Univ. J. Plant Sci. **2**(2): 52-56.

Hossain, M. D., Meah, M. B. and Siddiqua, M. K. (1999). Effect of seed treatment with Bavistin and *Rhizoctonia* on foot and root rot of lentil. Bangladesh J. Plant Pathol. **15**(1&2):1-4.

Islam, M. T. (2004). Integrated management of *Fusarium* wilt of chickpea. M. S. Thesis, Department of Plant Pathology, Bangladesh Agricultural university, Mymensingh.

Khalequzzaman, K. M. (2016). Control of foot root rot of lentil by using different management tools. ABC j. Adv. Res. **5**(1): 35-42.

Khatun, M. P.(2005). Efficacy of chemicals for the management of foot and root rot of lentil. M. S. Thesis submitted to the dept. of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka

Parvin, R. (2013). Management of foot and root rot disease of betel vine caused by *Sclerotium rolfsii*. M.S. Thesis Submitted to the dept. of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka

Patil, M. R., Waghe, S. V., Wangikar, P. D. and Khune, N. N. (1986). Chemical control of wilt of betel vine. Pesticides. **20**(90):28-31.

Prasad, R. and Basuchudhary, K.C. (1987). Seed treatment to control root rot of lentil. Farm Sci. J. **2**(2):112-115.

Rahman, M. L., Haque, M. S., Mukit, A., Alam, K. B. and Ali, S. (1994). Response of *Sclerotium rolfsii* to different fungicides. Bangladesh J. Plant Pathol. **10**(1&2): 35-36.

Reddy, M. R. S., Mann, G. and Reddy, B. C. (1988). Management of twig blight in Kagzi lime. Indian Phytopathol. **41**(3): 499-500.

Sattar, M.A., Podder, A.R., Chandra, M.C., and Rahman, M. (1996). The most promising BNF technology for green legume production. BNF Association, Dhaka, Bangladesh. pp. 15-20.

Saxena, D. R. and Saxena, M. (1993). Evaluation of chemicals against biological drying of lentil. Bhartiya Krishi Anushandhan Patrika. **8**(1): 25-29.

Singh, D. (1990). Chemical management of *Sclerotinia* rot of pea. Indian Phytopathol. Supplementary issue of vol. **44**.

Singh, J. and Tripathy, S. C. (1999). Mycoflora association with stored seeds of *lens esculenta.* Herbal Pesticide Lab., Dept. of Botany, Gorakhpur Univ. Gorakhpur, India.

Srivastava, S. N. and Tripathi, R. C. (1998). Management of sugarbeet seedling disease complex by combination of fungicides. Indian Phytopathol. **51**(1): 75-77.

Sultana, N., Hoque, S., Faruq, A.N., Bhuiyan, M.Z.R. and Islam, N. (2015). *In-vitro* evaluation of selected bio-control agents against foot and root rot pathogens of lentil. Scholarly J. Agric. Sci. **5**(1):8-15.

CHAPTER 8

APPENDICES

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

Agro-ecological region	: Madhupur Tract (AEZ- 28)
Land Type	: Medium high land
General soil type	: Non- calcareous dark gray floodplain soil
Topography	: Up land
Soil series	: Tejgaon
Drainage	: Fairly good
Field level	: Above flood level
Firmness (consistency)	: Compact to friable when dry
Soil p^H	: 4.47-5.55
Organic matter content	: 0.82

Appendix II: Agro-ecological zones of Bangladesh

ID	Zones/Regions
1.	Old Himalayan Piedmont Plain
2.	Active Tista Floodplain
3.	Tista Meander Floodplain
4.	Karatoya-Bangali Floodplain
5.	Lower Atrai Basin
6.	Lower Punarbhaba Floodplain
7.	Active Brahmaputra-Jamuna Floodplain
8.	Young Brahmaputra and Jamuna Floodplain
9.	Old Brahmaputra Floodplain
10.	Active Ganges Floodplain
11.	High Ganges River Floodplain
12.	Low Ganges River Floodplain
13.	Ganges Tidal Floodplain
14.	Gopalganj-Khulna Beels
15.	Arial Beel
16.	Middle Meghna River Floodplain
17.	Lower Meghna River Floodplain
18.	Young Meghna Estuarine Floodplain
19.	Old Meghna Estuarine Floodplain
20.	Eastern Surma-Kushiyara Floodplain
21.	Sylhet Basin a)
22.	Northern and Eastern Piedmont Plain
23.	Chittagong Coastal Plain
24.	St Martin’s Coral Island
25.	Level Barind Tract
26.	High Barind Tract
27.	North-eastern Barind Tract
28.	Madhupur Tract
29.	Northern and Eastern Hills
30.	Akhaura Terrace

Appendix III: Monthly mean weather of the experimental site

Monthly mean of average temperature (°c), average Relative humidity (%) and Pressure (mbar) from December/2017 to February/2018 are given bellow-

Year	Month	Average air temperature(°c)	RH (%)	Pressure (mbar)
2017	December	22	79	1014
2018	January February	19 25	75 66	1012 1013

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