CONTROL OF RHIZOME ROT OF GINGER THROUGH SELECTED CHEMICALS, BIOAGENT, PLANT EXTRACTS AND SOIL AMENDMENT

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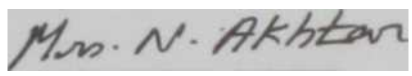

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CERTIFICATE

This is to certify that the thesis entitled **"CONTROL OF RHIZOME ROT OF GINGER THROUGH SELECTED CHEMICALS, BIOAGENT, PLANT EXTRACTS AND SOIL AMENDMENT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in PLANT PATHOLOGY, embodies the result of a piece of bona fide research work carried out by **Noor-E-Ambia, Registration No. 26369/00601** under my supervision and my guidance. No part of the thesis has been submitted for any other degree in any other institutes.

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

Dated:

Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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CONTROL OF RHIZOME ROT OF GINGER THROUGH SELECTED CHEMICALS, BIOAGENT, PLANT EXTRACTS AND SOIL AMENDMENT

ABSTRACT

An experiment was conducted in the field laboratory of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from April 2006 to December 2006. Data on disease incidence and disease severity was recorded at 90, 105, 120, 135, 150 and 165 Days After Sowing (DAS) DAS with 15 days intervals and analyzed. The highest performances were observed in case of application of *Trichoderma harzianum*, garlic extract and neem extract in all recording days in controlling the disease. At 90 DAS, the lowest disease incidence (hill infected) recorded at 90, 105, 120, 135, 150 and 165 DAS respectively were 6.67 %, 33.33%, 33.33%, 20.00%, 13.33% and 13.33% in case of *Trichoderma harzianum* where it was 66.67%, 93.33, 100 %, 100%, 100% and 100%, respectively in control. Similarly the lowest disease severity (0.20, 0.80, 0.28, 0.05, 0.04 and 0.04) was recorded at 90, 105, 120, 135, 150 and 165 DAS in case of *Trichoderma harzianum* where it was 6.82, 20.51, 18.39, 21.97, 30.12 and 28.65, respectively in control. The promising performances were also observed in case of garlic extract and neem extract. The highest yield was recorded in case of *Trichoderma harzianum* (11.67 t /h) followed by garlic extract (6.33 t/h) and neem extract (6.11 t/h). The lowest yield was recorded in control (2.78 t/h) preceded by Folicur (3.65 t/h).

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INTRODUCTION

Ginger (*Zingiber officinale*) is one of the earliest species belongs to the family Zingiberaccae and an important oriental spice crop It has special significance as spice for tropical countries where it is produced and consumed in large quantities (Rahim. 1992). It is an herbaceous plant and has been cultivated and used in Asia from very ancient time and the useful parts of this crop are the rhizomes (Purseglove *et al.,* 1988).

In western countries, ginger is widely used for culinary purpose in ginger-bread, biscuits, cakes, pudding, soups and pickles. It is a frequent constituent of curry powder. It is one of the most widely used spices in Chinese cookery. It is also used in medicine as a carminative and aromatic stimulant to the gastrointestinal tract, externally as an aphrodisiac and internally as a counter irritant. Ginger is used popularly as chewing purpose (Purseglove *et al.,* 1988). In Bangladesh ginger is mainly used as spice. It is cultivated all over the country where Rangpur, Nilphamari, Tangail, Khulna, Pabna, Jessore, Rangamati, Bandharban, Khagachori, Chittagong, and Chittagong Hill tracts are the most suitable places for its commercial cultivation Ginger is grown by the small farmers as their cash crop in different parts of Bangladesh. The annual production of ginger is 47,000 metric tons (BBS, 2004) in the country which is not sufficient for our National Demand, so deficit amount has to import from abroad to meet up the national demand.

Ginger is affected by various diseases, such as, Rhizome rot, Bacterial wilt, Soft rot, blight etc. Among all of these, rhizome rot is most damaging one (Chattopadhya, 1997). *Pythium aphanidermatum* and *Fusarium oxysporum* are associate with it causation(Ram *et al.,* 1999). It came slight fading of green colour of leaves. The tip of the leaves turns yellow and the cholorsis proceeds downwards ultimately resulting in withering and death of the leaf The

y

infection then becomes manifested on the shoot. The foot of the plant and the rhizomes turn pale. The portion just above the ground level becomes watery and soft. The rhizomes gradually decompose turning into a decaying mass of tissues enclosed by the comparatively tough rind (Singh, 1978). The disease is important because it causes economic losses to growers resulting in increased prices of products to the consumers. The infected rhizomes become rotten and the crop is completely destroyed (Baruah *et al.,* 1980).

Rhizome rot of ginger caused by *Fusarium oxysporum* and *Pythium* sp. is a serious constraint for the cultivation of ginger in Bangladesh. The crops are affected in conducive soil for recurrent cultivation and growers are being discouraged for lack of production, the country is depending on the neighboring countries to import of ginger and hence the price is sometimes increased alarmingly.

Rhizome rot of ginger can be control by the application of fungicides. Many workers used of different chemicals against the disease. Though chemical treatment are most effective for controlling the disease, but continuous use of chemicals results in accumulation of harmful chemical residues in soil as well as in the plant products causing serious health hazard. Chemical fungicides also pollute the environment and the develop tolerance of pathogen The chemical fungicide are also costly that is sometimes unbearable for the poor farmers in our country. In addition, their harmful effect is also recorded earlier for air, soil and water pollution. As eco-friendly approach plant extracts could be an alternative option in controlling plant pathogens.

Bioagent like *Trichoderma* sp. are now a days is frequently using against soil borne fungal pathogens as biological controlling tools (Ahmmed, 2006 and Hossain, 2006). Thus use of *Trichoderma* sp. might be another option controlling this disease. Soil amendment using crop wastes or organic maters is now being considered as environment safe approach that make the soil suppressive improving the antagonistic activities of the soil microorganisms Thus soil amendment could be a nice option for the management of the disease (Ahmmed, 2006 and Hossam, 2006).

Rhizome rot of ginger is a prevalent problem to the farmers with the resultant effect of reduce yield much below than the expectation. There are no proper management practices available in the literature to control rhizome rot diseases. In Bangladesh condition, no systematic research work has been done on the control of this disease. But the problem needs to give urgent attention.

Considering the above circumstances, the present investigation has been undertaken to identify the suitable management component(s) for controlling rhizome rot of ginger

Chapter II

Review of literature

Chapter II

REVIEW OF LITERATURE

In the cultivation of ginger, a number of diseases for the growers are a very crucial. Among the diseases rhizome rot of ginger is a very important one. A few studies on the related to control of rhizome rot of ginger have been carried out in the country as well as of the world The works so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings so far been done at home and abroad on this aspect have been reviewed in this chapter.

Sharma *et al* (1978) assessed systemic and contact fungicides in the control of rhizome rot of ginger caused by *Pythium aphanidermatum.* They found that the yield of rhizome was increased when they used fungicides. They reported that the Dithane Z-78 (Zineb) was the best fungicides in controlling rhizome rot of ginger, followed by Captan and Difolatan (Captafol).

Ichitani (1980) worked on the control of rhizome rot of ginger by cultivating successively and protectively for immature rhizome production in plastic house. He reported that *Pythium zingiberum* was not consistently isolated from rotted ginger tissues and rhizome rot disease did not develop when disease free rhizomes were sown in soil fumigated with methyl bromide. He found that rhizome rot incidence was reduced when seed treated with echlomezol and methyl bromide.

Dohroo and Sharma (1983) evaluated fungicides for the control of rhizome rot of ginger caused by *Pythium pleroticum* and *Fusarium equiseti* in storage and obtained good control with Antracol (propineb. 0.25%), Fycop and Blitox-50 (both copper oxychloride, 0.3%) as 30 min rhizome dips.

Dohroo and Sharma (1984) stated biological control of rhizome rot of ginger in storage with *Trichoderma viride.* They reported that treatment with this antagonist resulted in 80% control of the disease, caused by *Pythium pleroticum* (wet rot) and *Fusarium equiseti* (dry rot).

Rathaiah (1987) tested soft rot (*Pythium muriotylum)* of ginger by Ridomil and in combination with Captafol, Captan or Mancozeb. He stated that dipping or w etting of seed pieces 1 day before planting and soil drenching with a mixture of Ridomil + Captafol 3 months after planting controlled the disease and significantly increased the yield of ginger

Ramchandran *et al.* (1989) evaluated 5 systematic fungicides for efficacy against rhizome rot of ginger. The fungicides w[r]ere tested as soil and seed treatments and they found metalaxyl formulations, namely Ridomil 5G granules and apron 35 WS gave the best control of the disease.

Raj *et al.* (1989) observed the chemical control of rhizome rot of ginger by seed and soil treatments They found that soil treatment with 4% formaldehyde combined with treatment of the rhizome planting material with Toprinm-70 (thiophanate-methyl) at 0.1% gave the best control of this disease caused by *Fusarium oxysporum.* They also noticed that rhizome treated with 0.1% Bavistin (carbendazim) or 0.3% Dithane M-45 (mancozeb) in combination with soil treated with the formaldehyde gave satisfactory control of this disease.

Das *et al.* (1990) stated the efficacy of fungicides for seed treatment against pre-emergence rhizome rot of ginger They reported the lowest incidence of this disease caused by *Pythium* spp. and highest percentage of germination was yielded by seed treatment with Captan

(0.2%) for 30 min, while Captafol (0.2%) and Dithane M-45 (manco/eb) at 0.3% were also effective

Sharma and Dohroo (1991) described the post harvest management of rhizome rot *(Fusarium oxysporum* f sp. *zingiberi trujillo)* of ginger through chemical and antagonist. They also described that *Trichoderma* and *Gliocladium virens* inhibited growth of *Fusarium oxysporum* f sp. *zingiberi in vitro* by 73 and 68 percent, respectively.

Kim *et al.* (1996) reported that average 18.1 % rhizome rot of ginger is recorded in Korea Republic and the disease starts early July, spreads rapidly in rainy season.

Choe *et al.* (1996) evaluate the effects of chemicals on the growth of *Pythium zingiberum* causing rhizome rot of ginger and inhabitation of the disease development. They isolated 52 fungal isolates which was obtained from ginger rhizomes with rotting symptoms from fields in Wanju (chonbuk) and Seosan (chungnam), Korea Republic, in 1993. They identified the pathogen as *Pythium zingiberum.* These appeared pathogenic to the plant in a pot test, although there were some variations in virulence among the isolates Responses of the isolates to fungicides including metalaxyl (MT), metalaxyl + copper oxychloride (me), echlomezol (Em) and propamocarb hydrochloride (Pc) varied depending on the isolates tested. They found mycelial growth was almost completely inhibited by MC and MT at a concentration of 50 mg/litre.

Shanmugam and Varma (1999) conducted an experiment and native microorganisms were isolated from the rhizosphere of healthy ginger plants among rhizome rot affected plants in diseased fields during October 1994 and screened *in virto* for their antagonistic effects against the rhizome rot pathogen *Pythium aphanidermatum* by dual culture and cell free culture filtrate studies. *Aspergillus niger, A. fumigatus, A. flavus* and *Trichoderma vinde* were found to be potential antagonists. Among the fungicides tested (Copper oxychloride, Mancozeb and Bordeaux mixture) . Mancozeb was compatible with all four antagonists.

Ram *et al.* (1999) reported from their experiment that rhizome rot of ginger is caused by either *Pythium* or *Fusarium* spp. or both. The bio-control agent *Trichoderma harzianum*, isolated from rhizome rot suppressive soils, reduced the disease and increased plant stand and yield of ginger. In order to further enhance the efficiency of disease suppression, a bacterial BCA *Pseudomonas* spp. was evaluated alone and in combination with *T. harzianum* and also with fungicidal rhizome treatment Combination of both BCAs resulted in better germination and plant stand, reduced disease and increased yield. Soil application of BCA was more effective compared with seed treatments. Bavistin + Ridomil MZ increased the efficiency of disease control as compared with their individual treatments Soil application of *T. harzianum* and rhizome treatment with *Pseudomonas* spp. and fungicides was the most effective among all the treatments tested

Park *et al.* (1998) reported from their experiment conducted in 1994 that *Zingiber officinale* plant were infected by rhizome rot in seosan, Taean and Iksan, Korea Republic, from September to October. The pathogens associated with rhizome rot were isolated and identified as *Pythium* spp., *Fusarium* spp., and bacteria. A total of 68 isolates of *P. zingiberum* w’ere tested for their tolerance to metalaxvl. Nine isolates were tolerant and showed mycelial growth on PDA containing 100 ppm of metalaxvl. At 500-1000 ppm, metalaxvl tolerant isolates grew their mvcelia and formed oospores, while metalaxvl susceptible isolates could not grow[r] at > 10 ppm. Metalaxvl tolerant isolates w[r]ere completely inhibited by metalaxvl with carbendzim and with copper oxychloride at 1000 ppm.

Suppression of *Pythium aphanidermatum* and rhizome rot of ginger by *Aspergillus niger, A. terreus, Penicillium* spp. and *Absidia cylindrospora* was reported by Balakrishnan *et al.* (1997). The former 3 fungi inhibited *P. aphanidermatum* by up to 100% by producing fungitoxic non-volatile metabolities. *A. cylindrospora* expressed mild inhabitation (7.03%). *A cylindrospora* and *P. aphanidermatum* also exhibited mutual overgrowth in dual culture. *A. niger* showed good protection against rhizome rot. The severity of rhizome rot infection was low when infested soil was treated with *A terreus*, *Penicillium* species and *A. cylindrospora* The highest yield was recorded with A *niger*

The efficacy of 0.2% Dithane M-45, 0.3% Ridomil MZ, 0.1% Bavistan, 0.2% Saaf, 0.2% Shield, 0.3% Blitox-50 and 0.25 % Dithane M-45 + 0.05% Bavistin in controlling rhizome rot of ginger caused by *Pythium aphanidermatum* under storage and field conditions was determined in an experiment carried out in Bihar, India by Singh *et al.* (2004). Application of 0.3% Ridomil MZ resulted in the lowest incidence of the disease. In field conditions, application of Ridomil MZ resulted in the highest seed germination (96.50%) and yield (250.25 q/ha) and lowest disease incidence (5.0%).

Meena and Mathur (2003) conducted an experiment with three biological control agents i.e *Trichoderma viride, Gliocladium virens* and *Pseudomonas fluorescens* and an effective fungicidal mixture of Ridomil MZ and Bavistin 50 WP were used for treating seed rhizome and soil, individually and in combinations, for the suppression of rhizome rot of ginger Crop and disease parameters, such as crop stand, rhizome yield, rotting percentage and pathogen suppression in the rhizosphere, were determined. Pelleting of seed rhizome with biological control agents was not found effective. Pelleting either with the fungicidal mixture or BCAs combined with soil application of BCAs were effective in suppressing the disease and increasing the yield. In the rhizosphere pot study, integrated approach resulted in reduction of inoculum density of *b solani* and increased in the BCAs population. Rhizome seed treatment with fungicidal mixture, followed by soil application of *G. virens* was the most effective treatment and superior to all other treatments.

Jacob *et al.* (2002) earned out a preliminary trail in Kerala, India to manage the rhizome rot of ginger with combined applications of fungicides. The treatments comprised 4 fungicides (triademefon at 1 g/litre, benomyl at 1 g/litre, bitertanol at 1 g/litre and copper oxychloride at 3 g/litre) and an untreated control. Observations on the percentage of infested hills were recorded at 7, 14 and 21 days after treatment (DAT). The infestation was reduced over control in these treatments ranged 25.33 to 31.34.

The effect of soil solarization and fungicidal seed and soil treatments of rhizome rot of ginger cv. Jhadole local was studied in Rajasthan, India by Kusum *et al.* (2002). Field plots inoculated with both pathogens were solarized for 20 day's under ambient day temperature of 37 7-45.0 and night temperature of 26.4-27.5°C. Seed w'ere dipped in 2000 ppm of Captan (2 g/litre), Ridomil MZ (6.25 g/litre), or Chlorothalonil (2 g/litre) for 40 days before sowing. In non-solarized plots, seed treatment increased sprouting. Ridomil MZ seed treatment + Phorate + Ridomil MZ drench w'as most effective among the treatments in reducing disease intensity and in increasing the number of sprouts (215) and yield (1.51 kg). Phorate alone resulted in greater sprouting, low'er disease incidence, and higher yields. In solarized plots, higher number of sprouts (247-275), low'er disease incidence (2.6-4.2%), and higher yields (1.36-1.62 kg) w-ere recorded for Ridomil MZ seed treatment + Ridomil MZ drcnch, Ridomil MZ seed treatment + Phorate + Ridomil MZ drench, Captan seed treatment + Phorate + Captan drench, and Captan seed treatment + captan drench. In the untreated control, disease intensity was lower in solarized plots (16.6%) than in non-solarized plots (20.4%).

Resident isolates of biocontrol agents (BCAs) *Trichoderma harzianum*, *T. aureoviride* and *Gliocladium virens* and a non-resident isolate of *T. viride* were evaluated by Ram *et al.* (2000) for suppression of ginger rhizome rot, a rhizome and seed borne disease caused by *Fusarium solani* or *Pythium myriotylum* or both. Rhizomes pelletted with BCA were planted in two sets of pots, one with sterilized but pathogen infested soil, and another with unsterilized, rhizome rot infested field soil. All the four BCAs could establish in ginger rhizosphere and rhizomeplane and significantly increased in population density and reduced that of *Fusarium* spp., correlated well with reduction of the disease and significant increase in the yield. The trend of efficacy of each BCA observed in the unsterilized rhizome rot infested field soil was confirmed in sterilized, pathogen-infested soil.

Dohroo *et al.* (1994) reported that the incidence of rhizome rot of Z *officinale* was minimum in soil treated with Pmus needle and neem cake pow'der. The *Meloidogyne* population was reduced to 74% but no *Pratylenchus* population w'as recorded in soil following any of the treatments such as neem cake powder, sawdust, Pinus needles or Quercus leaves. *Trichoderma* and *Gliocladium* populations were maximum in neem cake and Pinus needle treatments.

Several antagonists were tested by Pandey *et al.* (1992) for the biological control of rhizome rot of ginger caused by *Fusarium oxysporum* An extract of *Agave americana* was found to be very effective in controlling the disease under laboratory and field conditions, followed closely by culture filtrates/extracts of *Bacillus suhtilis, Cannabis sati\»a, Lyonia ovalifolia* and *Aspergillus niger.* The respective percent reductions of infection over controls were 75.9, 54.7 and 52.0.

Raj *et al.* (1989) conducted an experiment in consideration of soil treatment with 4% formaldehyde combined with treatment of the rhizome planting material with Topsin M-70 at 0.1% gave the best control of this disease, caused by *Fusarium oxysporum.* Ginger rhizome treatment with 0.1% Bavistin or 0.3% Dithane M-45, with the formaldehyde soil treatment, was also satisfactory, through less effective.

Ramachandran *et al.* (1989) carried out an experiment with Metalaxyl, Oxadixyl 25 WP, Fosetyl aluminum, Propamocarb and Etridiazole to test *P aphanidermatum* isolated from infected ginger. Etridiazole gave the most effective control and had the lowest ED50 and ED90 values followed by metalaxyl.

A rise in peroxidase activity was recorded by Dohroo (1989) in ginger rhizomes infected by *Pythium pleroticum* and *Fusarium equiseti* 3 days after infection followed by a sharp decline. The decline was nearly double in rhizomes infected by *F. equiseti* compared with that in rhizomes infected by *P. pleroticum.* Polyphenol oxidase activity could not be detected in healthy or inoculated rhizomes.

Chauhan and Patel (1990) reported that rhizome rot disease is associated with a *Pythium* spp and *Fusarium solani,* either together or separately. Pathogenicity of both organisms was confirmed experimentally. This is the first report of *F. solani* causing soft rot of ginger and also of combined infection with *Pythium,* resulting in rapid drying of the shoot, followed by rhizome rot. All the metalaxyl formulations tested were effective against *Pythium* spp. and Bordeaux mixture gave the best inhibition of *F solani.*

Das *et al.* (1990) conducted an experiment to estimate the efficacy of fungicides for seed treatment against pre-emergence rhizome rot of ginger and found the low est incidence of this disease, caused by *Pythium* spp and highest percentage germination was given by seed piece treated with Captan (0.2% ai.) for 30 min, Captafol (0.2% ai.) and Dithane M-45 (0.3%).

Dohroo (1989) conducted an experiment with 10 cultivars tested in the field during 1986 and recorded the lowest incidence of *Fusarium oxysporum* f sp. *zingiberi.* Disease in the field was positively correlated with its occurrence in storage and 87% of the pre-emergence rot and yellows was transmitted from infected rhizomes. The importance of pre-planting chemical treatments for control of this disease was confirmed

Chapter III

Materials and Methods

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MATERIALS AND METHODS

A field experiment was conducted in the Farm of Sher-e Bangla Agricultural University, Dhaka. Bangladesh during the period from April to December 2006 to study the control of rhizome rot of ginger through selected chemicals, bioagent, plant extracts and soil amendment. The details materials and methods of this experiment are presented in this chapter -

3.1 Experimental site

The present piece of research work was conducted in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. Bangladesh. The site of the experimental plot is in 23°74'N latitude and 90°35'E longitude with an elevation of 8.2 meter from sea level (Anon. **1989).**

3.2 Characteristics of soil

The soil of the experimental area was non-calcarious dark grey and belongs to the Modhupur Tract (UNDP. 1988) under AEZ 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The pH of the soil was 5.6. The characteristics of the soil under the experimental plot were analyzed in the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and details of the soil characteristics are presented in Appendix I.

3.3 Weather condition of the experimental site

The geographical situation of the experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or rainy season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*, 1979). The total annual rainfall of the experimental site was 218 **mm** and average monthly maximum and minimum temperature were 29 45°C and y

13 86°C, respectively. Details of the metrological data of air temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division) and presented in Appendix II

3.4 Planting materials

In this research work, the rhizomes of gingers were used as planting materials. The seeds of the rhizome were collected from Spices Research Center, Bogra. The rhizomes of ginger w^{r}ere broken into small pieces bearing 1-2 buds The average weight of individual pieces was 40-50 gm

3.5 Treatment of the experiment

The experiment was designed to control of rhizome rot of ginger taking chemicals, biological, botanical agents and soil amendment against the pathogen. Details are presented below:

Treatment

T_1 : Bavistin 50 WP

T_2 : Furadan 5 G

T_3 : Tilt 250 SE

T_4 : Cupravit 50 WP

T_5: Folicur

T_6 : Ridomil

T_7 : *Trichoderma harzianum*

T_8 : Neem Extract

T_9 : Garlic Extract

T_{10} : Soil amendment with Khudepana *(Lemna polyrrhiza)*

T_{11} : Control

3.6 Layout of the experiment

The experiment was laid out in the single factors RCBD (Randomized Complete Block Design) with three replications. The layout of the experiment was prepared for distributing the treatment into every plot of each block. Each block was divided into 11 plots where 11 treatments were allotted at random. There were 33 unit plots altogether in the experiment. The size ot the plot was 3.0 m * 1.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. Layout of the experimental field was presented in Appendix III).

3.7 Preparation of the main field

The plot selected for the experiment was opened in the second week of April 2006 with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of ginger rhizomes. The experimental plot was partitioned into the unit plots in accordance with the experimental design Recommended doses of well-rotten cowdung manure and chemical fertilizers (Table 1) were applied in the soil of each unit plot.

3.8 Application of manure and fertilizers

Well decomposed cowdung manure 5 t/ha was applied al the time of final land preparation. The sources of fertilizers used for N, P and K were urea, TSP and MP were applied respectively. The entire amount of TSP, MP applied during the final preparation of land. Urea was applied in three equal installments at 30, 45 and 60 Days after planting The doses and installment of application of fertilizer are shown in Table 1

Table 1. Dose and installments of application of fertilizers in ginger field

Fertilizers	Dose (Kg/ha)	Application (%)			
		Basal	15 DAT	30 DAT	45 DAT
Urea	100	–	33.33	33.33	33.33
TSP	170	100	—	–	—
MP	160	100	—	–	—
Gypsum	110	100	–	–	—
ZnO	2	100	–	—	—

Source. Krishi Prqjukti Hatboi, BARI, Joydebpur, Gazipur, Bangladesh (2006)

3.9 Application of treatments

3.9.1 Collection and preparation of plant extracts

For extraction of juice, required amount of respective parts of each plant was taken, washed in tap water, crushed in a mortar and pestle. The crushed materials were blended in an electric blender adding equal amount of sterile water for 1:1 solution The blend was filtered through sterile cheesecloth. The supernatant was diluted in equal amount of sterile water for 1:2 solutions.

3.9.2 Preparation of spore suspension of *Trichoderma harzianum*

Trichoderma harzianum was grown on PDA (Potato Dextrose Agar) medium in petridish at 25°C temperature After formation of conidia (in about 7-10 days), added 5 ml/plate sterile water and the spore masses was scraped away with sterile needle/scalpel. The conidial suspension thus made with additional water adjusted 3 liter volume.

3.9.*3* Collection and preparation of chemicals solution

All of the chemical fungicides were collected from local market. Fungicide solutions were prepared diluted required amount of fungicide in water for each concentration in hand sprayer. The hand sprayer was shaken thoroughly before use.

3.9.4 Seed treatment

Seed treatments were done by dipping rhizomes seeds in different chemicals, plant extracts and in the bio-agent for 30 minutes. Then the rhizome seeds kept open to remove excess moisture for the w^hole night.

3.9.5. Sowing of rhizome seed

Rhizomes seeds were sown at 19th April, 2006 just next day of seed treatment. In this experiment plant to plant distance was maintained 20 cm and row to row distance was 45 cm. Seeds were sown at a depth of 5 to 7 cm.

3.9.6 Application of treatment in the field

First treatment of spraying solutions with respective components was applied when the rhizomes sprouted. The treatment was applied five times with fifteen days interval starting from 26th April, 2006 treatments were applied in soils at the base of the plants and on leaves by using hand sprayer

3.10 lntercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of the ginger as and when necessary.

3.10.1 Irrigation

Light over-head irrigation was provided with a watering can to the plots immediately after sowing of rhizome seeds. Surface irrigation was given time to time as needed.

3.10.2 Weeding

Weeding is carefully done for proper growth and development of rhizomes wilt required intervals.

3.10.3 Plant protection

The crop was protected from the attack of insect-pest by spra>'ing insecticide Ektara. Insecticide was used as required according to the recommended doses.

3.11 Isolation and identification of pathogen

The diseased rhizome were collected by using polythene bag and taken to the laboratory of Department of Plant Pathology. Sher-e-Bangla Agricultural University, Dhaka. Then the diseased rhizomes were surface sterilized with Chlorox (1:1000) for one minute Then the rhizomes were washed into sterilized water thrice and placed in a petridish. The petndish containing rhizomes were incubated at 25±1°C for seven days. Then the organism grew fircshlv on to the rhizome and isolated and cultured again on another PDA plate to have pure culture. Finally the pure culture of the pathogen *(Fusarium oxysporum)* was obtained and identified

3.12 Harvesting

Harvesting was done when rhizomes were properly matured In this experiment rhizomes of ginger was harvested on 22th December, 2006.

3.13 Data recording

The data were collected from the inner rows of plants of each treatment to avoid the border effect. In each unit plot, 5 plants were selected at random for data collection. Data were collected in respect of the plant growth characters and yield of ginger. Data on germination of rhizome, number of rhizome rot infected plant and leaves, plant height; disease severity, weight of rhizomes were collected. The following parameters were set up for recording data and for the interpretation of the results-

3.13.1 % Infected hill

Percent of infected hill was estimated with counting 5 hill from each plot.

3.13.2 % Infected leaves

Percent of infected leaves was estimated from each plot.

3.133 Disease severity scale

Disease severity was measured by using the following '0 - 5' scale (Islam *et al*, 2001)

% LAD	Scale / grade
0	0
0.1-5	1
5.1-12	2
12.1-25	3
25.1-50	4
>50	5

3.13.4 Yield of rhizome

The weight of rhizome per selected hill was recorded at the time of harvest The weight of rhizome per plot was recorded and was converted into per hectare yield

3.13.5 Assessment of reaction of different treatments on rhizome rot of ginger

After appearance of disease symptom records on expression of symptom of leaf was taken at the interval of 15 days starting from 19th July, 2006. Infection was expressed in percentage. Percent disease index (PDI) was measured by using the following formula (Islam *et al*, 2001).

$$\textbf{PDI} = \frac{\textbf{Sum of total ratings/ grading}}{\textbf{Total number of observation x Highest grade in the scale}} \times 100$$

3.14 Statistical analysis

The data obtained for different characters were statistically anah'zed to find out the significance of the difference of treatment on yield and yield contributing characters of ginger. The mean values of all the characters were evaluated and analysis of variance was performing by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations means 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 present experiment was conducted to study the control of Rhizome rot of ginger. The analysis of variance (ANOVA) of the data on total number, % infestation of hill and leaves, again disease severity of disease at 0-5 scale and yield are given in Appendix IV-IX. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Data recorded after 90 days of seed planting

4.1.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control (table 2). The highest potential performance was recorded in case of *Trichoderma harzianum* (6.6%) and the lowest performance was noticed in case of Folicur (53.33%) application. Rest of the treatment like Bavistin 50 WP, Tilt 250 EC, Neem extract and garlic extract also showed remarkable performance (26.67%) in comparison to control.

4.1.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observed in case of most of the treatment in comparison to control (table 2). The lowest leaf infection was recorded in case of *Trichoderma harzianum* (0.56%) followed by garlic extract (3.3%), Neem extract **(4 4%)** and the highest leaf infection was observed in case of untreated control (12.78%) which is followed by Furadan (8.33%), Ridomil (8.33%), Folicur (7 78) and Khudepana (6.67%). Rest of the treatments showed medium performances against disease in controlling leaf infection.

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 2). Very promising performances in reducing disease severity

4.1.3 Disease severity

was recorded in case *of Trichoderma harzianum* (0.20 PD1) which was statistically identical with the performances of garlic extract (0.26 PD1) and neem extract (0.29 PDI) Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease seventy in comparison to control. Very negligible reduction of disease severity was observed in case of Furadan and Folicur.

4.2 Data recorded after 105 days of seed planting

4.2.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control (table 3). The highest potential performance was recorded in case *of Trichoderma harzianum* (33.33%) and the lowest performance was noticed in case of Bavistin (93.33%) application. Rest of the treatment like Folicur, Cupravit 50 WP, Tilt 250 EC, Furadan MZ 68 WP, Neem extract and garlic extract also showed remarkable performance in comparison to control.

4.2.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observed in case of most of the treatment in comparison to control (table 3). The lowest leaf infection was recorded in case of *Trichoderma harzianum* (6.11%) followed by Neem extract (7.22%), Garlic extract (10.56%) and the lowest performance in reducing leaf infection was observed in case of Ba\istin 50 WP (40.56%), Folicur (28.89%). Rest of the treatments showed medium performances against disease in controlling leaf infection.

4.2 .3 Disease severity

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 3). Very promising performances in reducing disease severity was recorded in case of *Trichoderma harzianum* (0.80 PDI) which was statistically identical with the performances of garlic extract (0.91 PDI) and neem extract. Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease severity' in comparison to control. Very negligible reduction of disease severity was observed in case of Furadan and Folicur.

4.3 Data recorded after 120 days of seed planting

4.3.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control (table 4). The highest potential performance was recorded in case of *Trichoderma harzianum* (33.33%) and the lowest performance was noticed in case of Folicur (73 .33%) application. Rest of the treatment like Bavistin 50 WP, Tilt 250 EC, Neem extract and garlic extract also showed remarkable performance in comparison to control.

4.3.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observed in case of most of the treatment in comparison to control (table 4). The lowest leaf infection was recorded in case of *Trichoderma harzianum* and garlic extract (5.56%) followed by Neem extract (6.11%) and the highest leaf infection was observ ed in case of control (41.67%). Rest of the treatments showed medium performances against disease in controlling leaf infection.

4.3.3 Disease severity

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 4). Very promising performances in reducing disease severity was recorded in case of *Trichoderma harzianum* (0.28 PDI) which was statistically identical with the performances of garlic extract (0.35 PDI) and Neem extract (0.51 PDI). Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease severity in comparison to control. Very negligible reduction of disease severity was observed in case of Furadan and Folicur

4.4 Data recorded after 135 days of seed planting

4.4.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control (table 5). The highest potential performance was recorded in case *of Trichoderma harzianum* (20.00%) and the lowest performance was noticed in case of Folicur (46.67%) application. Rest of the treatment like Bavistin 50 WP. Tilt 250 EC, Neem extract and garlic extract also showed remarkable performance in comparison to control.

4.4.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observed in case of most of the treatment in comparison to control (table 5). The lowest leaf infection was recorded in case of *Trichoderma harzianum* and Neem extract (3.33%) followed by garlic extract (6.67%), and the highest performance in reducing leaf infection was observed in case of control (52.22%) followed by Folicur (10.56%). Rest of the treatments showed medium performances against disease in controlling leaf infection

4.4.3 Disease severity

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 5). Very promising performances in reducing disease severity- was recorded in case of *Trichoderma harzianum* (0.05 PDI) which was statistically identical with the performances of other treatments. Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease severity in comparison to control. Very negligible reduction of disease severity' was observ ed in case of Furadan and Folicur.

4.5 Data recorded after 150 days of seed planting

4.5.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observ ed in reducing the disease incidence in terms of hill infection in comparison to control (table 6). The highest potential performance was recorded in case of *Trichoderma harzianum* (13.33%) and the lowest performance was noticed in case of Khudepana (53.333%) application. Rest of the treatment like Bavistin 50 WP, Tilt 250 EC, Neem extract and garlic extract also showed remarkable performance in comparison to control.

4.5.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observ ed in case of most of the treatment in comparison to control (table 6). The lowest leaf infection was recorded in case of *Trichoderma harzianum (2.22%)* followed by Garlic and Neem extract (2 78%) and the lowest performance in reducing leaf infection was observed in case of Furadan MZ 68 WP and Ridomil which is closely followed by Folicur and Khudepana. Rest of the treatments showed medium performances against disease in controlling leaf infection.

4.5.3 Disease severity

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 6). Very promising performances in reducing disease severity was recorded in case of *Trichoderma harzianum* and garlic extract (0.0.04 PDI) which was statistically identical with the performances of Neem extract (0.26 PDI) and neem extract (0.29 PDI). Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease severity in comparison to control Very negligible reduction of disease severity was observed in case of Furadan and Folicur.

4.6 Data recorded after 165 days of seed planting

4.6.1 Percentage of hill infection

A remarkable performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control (table 7). The highest potential performance was recorded in case *of Trichoderma harzianum* (13.33%) and the lowest performance was noticed in case of Folicur (26.67%) application. Rest of the treatment like Bavistin 50 WP, Tilt 250 EC, Neem extract and garlic extract also showed remarkable performance in comparison to control.

4.6.2 Percentage of leaf infection

A remarkable control of disease in terms reducing leaf infection was observed in case of most of the treatment in comparison to control (table 7). The lowest leaf infection was recorded in case of *Trichoderma harzianum* and garlic extract (2.22%) followed by Neem extract. Cupravit 50 WP (2.78%) and the low'est performance in reducing leaf infection w as observ ed in case of Furadan MZ 68 WP and Ridomil which is closely followed by Folicur and

Khudepana Rest of the treatments showed medium performances against disease in controlling leaf infection.

4.6.3 Disease severity

A considerable reduction of disease severity was achieved by using the treatment used in the experiment compared to control (table 7) Very promising performances in reducing disease severity was recorded in case of *Trichoderma harzianum* (0.04 PDI) which was statistically identical with the performances of other treatments. Application of Bavistin 50WP and Cupravit 50 WP also scored better performance in reducing the disease severity in comparison to control. Very negligible reduction of disease severity was observed in case of Furadan and Folicur

4.7 Rhizome yield

In respect of rhizome yield the performances of the treatment used in the experiment significantly varied with control (table 8). Weight of rhizome ranged from 73.33 g to 216.70 g. The highest w'eight/rhizome was recorded in case of *Trichoderma harzianum* followed by garlic extract (210.15 g) and neem extract (193.3 g). More or less similar weight/rhizome was noticed in case of rest of the treatment except control (73.33 g).

The average yield of rhizome maintained similar trend to weight/rhizome in case of replication of different treatments in comparison to control (table 8). The average yield due to application of different treatment varied from 2.78 t/ha to 11.67 t/ha The highest rhizome yield was achieved by using *Trichoderma harzianum* (11.67) follow-ed by garlic extract (6.33 t/ha) and neem extract (6.11 t/ha). More or less similar average yield was recorded in case of rest of the treatments except control (2.78 t/ha) that were ranged from 3.56 t/ha to 4.94 t/ha.

The result of the present findings are supported by the previous workers (Ram *et al* (1999), Ram *et al* (2000). Meena and Mathur (2003). Dohroo *et al* (1994) Sharma and Dahroo (1991) reported that *Trichoderma* sp and *Gliocladium virens* inhibited the growth of *Fusarium oxysporum* f sp *zingiberi in vitro* bv 73 and 68 percent respective!v that were suggested to control rhizome rot as post harv est management Ram *et. al* (1999) reported that soil application of *Trichcxierma harzianum* increase the suppressive nature of soil that control the rhizome rot disease of ginger as bio control agent Meena and Mathur (2003) reported that palliating of seed rhizome with biological control agent *Thichoderma viride. Gliocladium virens* and *Pseudomonas flourescens* could effectively control rhizome rot disease of ginger Dharoo *et al* (1994) reported that application of neem cake in the soil maximized the population of *Trichoderma* and *Gliocladium* that reduced the incidence of rhizome rot of ginger

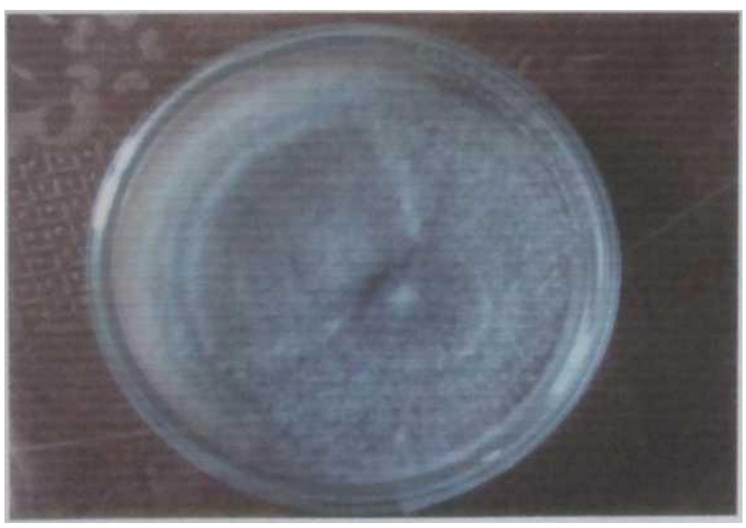

Figure 1 Pure culture (*Fusarium oxysporum). the* causal organism of Rhizome rot of ginger

Figure 2 Affected rhizome caused by Rhizome rot disease

Figure.3 Rhizome rot infected experimental plot

Table 2. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 90 DAS (days after sowing)

Treatment	% Hill infected	% Leaf infected	Disease severity (PDI)
Bavistin 50 WP	26.67	5.56 be	1.07 f
Furadan 5 G	46.67	8.33 ab	5.61 b
Tilt 250 EC	26.67	6.11 be	1.89 e
Cupravit 50 WP	33.33	5.56 be	1.02 f
Folicur	53.33	7.78 be	5.24 b
Ridomil	33.33	8.33 ab	3.46 d
Trichoderma harzianum	6.67	0.56 c	0.20 g
Neem Extract	26.67	4.44 be	0.29 g
Garlic Extract	26.67	3.33 be	0.26 g
Khudepana	26.67	6.67 be	4.14 c
Control	66.67	12.78 a	6.82 a
LSD(0.05)	–	5.522	0.457
Level of significance	*	*	**
CV (%)	5.57	11.36	6.69

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

***• Significant at 0.01 level of probability**
*** Significant at 0.05 level of probability**

Table 3. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 105 DAS (days after sowing)

Treatment	% Hill infected	% Leaf infected	Disease seventy (PDI)
Bavistin 50 WP	93.33	40.56 ab	6.63 d
Furadan 5 G	53.33	21.67 abc	18.34 b
Tilt 250 EC	60.00	20.00 be	12.28 c
Cupravit 50 WP	73.33	15.00 c	4.59 e
Folicur	86.67	28.89 abc	17.44 b
Ridomil	66.67	21.11 abc	6.78 d
Trichoderma harzianum	33.33	6.11 c	0.80 g
Neem Extract	40.00	7.22 c	3.05 f
Garlic Extract	40.00	10.56 c	0.91 g
Khudepana	60.00	16.11 be	12.92 c
Control	93.33	45.00 a	20.51 a
LSD($_0$.O5)	38.11	21.88	1.021
Level of significance	*	*	**
CV (%)	8 16	6.85	4.06

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

***• : Significant at 0.01 level of probability**
*** : Significant at 0.05 level of probability**

Table 4. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 120 DAS (days after sowing)

Treatment	% Hill infected	% Leaf infected	Disease severity (PDI)
Bavistin 50 WP	53.33	18.89 b	1.18 b
Furadan 5 G	40.00	11.11 b	1.31 b
Tilt 250 EC	46.67	10.00 b	0.72 b
Cupravit 50 WP	40.00	10.00 b	3.43 b
Folicur	73.33	18.89 b	2.88 b
Ridomil	60.00	10.00 b	0.87 b
Trichoderma harzianum	33.33	5.56 b	0.28 b
Neem Extract	40.00	6.11 b	0.51 b
Garlic Extract	33.33	5.56 b	0.35 b
Khudepana	40.00	10.00 b	1.25 b
Control	100.00	41.67 a	18.39 a
LSD(O.O5)	37.78	13.49	6.582
Level of significance	*	**	**
CV (%)	4.58	8.96	13.46

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

**** Significant at 0.01 level of probability**

***   : Significant at 0.05 level of probability**

Table 5. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 135 DAS (days after sowing)

Treatment	% Hill infected	% Leaf infected	Disease seventy (PDI)
Bavistin 50 WP	33.33	3.89 b	0.56 b
Furadan 5 G	33.33	6.67 b	1.02 b
Tilt 250 EC	33.33	5.56 b	0.42 b
Cupravit 50 WP	40.00	5.56 b	1.12b
Folicur	46.67	10.56 b	1.03 b
Ridomil	33.33	7.22 b	0.36 b
Trichoderma harzianum	20.00	3.33 b	0.05 b
Neem Extract	33.33	3.33 b	0.32 b
Garlic Extract	26.67	6.67 b	0.05 b
Khudepana	60.00	5.00 b	0.34 b
Control	100.00	52.22 a	21.97 a
$LSD_{(0.05)}$	32.26	10.52	5.880
Level of significance	**	**	**
CV (%)	5.30	6.77	9.40

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

***• : Significant at 0.01 level of probability**

Table 6. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 150 DAS (days after sowing)

T realment	% Hill infected	% Leaf infected	Disease severity (PDI)
Bavistin 50 WP	33.33	5.56 b	0.45 b
Furadan 5 G	26.67	4.44 b	0.58 b
TUt 250 EC	20.00	3.89 b	0.40 b
Cupravit 50 WP	33.33	3.89 b	0.75 b
Folicur	33.33	7.78 b	0.89 b
Ridomil	26.67	4.44 b	0.28 b
Trichoderma harzianum	13.33	2.22 b	0.04 b
Neem Extract	20.00	2.78 b	0.22 b
Garlic Extract	33.33	2.78 b	0.04 b
Khudepana	53.33	3.33 b	0.23 b
Control	100.00	62.22 a	30.12 a
LSD$_{(0.05)}$	29.59	7.749	7.332
Level of significance	+ *	**	**
cv (%)	8.59	8.43	13.28

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

**** Significant at 0.01 level of probability**

Table 7. Effect of different treatments on the incidence and disease severity of rhizome rot of ginger after 165 DAS (days after sowing)

Treatment	% Hill infected	% Leaf infected	Disease seventy (PDI)
Bavistin 50 WP	33.33	4.44 b	0.56 b
Furadan 5 G	20.00	3.33 b	0.61 b
Tilt 250 EC	26.67	3.33 b	0.32 b
Cupravit 50 WP	26.67	2.78 b	0.69 b
Folicur	26.67	5.56 b	0.82 b
Ridomil	26.67	3.89 b	0.28 b
Trichoderma harzianum	13.33	2.22 b	0 .04 b
Neem Extract	20.00	2.78 b	0.16 b
Garlic Extract	13.33	2.22 b	0.04 b
Khudepana	26.67	3.33 b	0.30 b
Control	100.00	64.44 a	28.65 a
$LSD_{(0.05)}$	19.49	4.582	5.801
Level of significance	**	+*	**
CV (%)	4.44	4 44	15.40

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

**** : Significant at 0.01 level of probability**

Table 8. Effect of different treatments on rhizome weight and yield of rhizome due to application of treatments against rhizome rot of ginger

Treatment	Weight/rhizome (g)	Yield (kg/plot)	Yield (t/ha)
Bavistin 50 WP	166.70	1.10 ab	3.67 ab
Furadan 5 G	153.33	1.17 b	3.89 ab
Tilt 250 EC	153.3	1.17 ab	3.89 ab
Cupravit 50 WP	156.67	1.13 ab	3.78 ab
Folicur	125.00	1.07 ab	3.56 ab
Ridorrul	166.7	1.48 ab	4.94 ab
Trichodcrma harzianum	216.70	3.50 a	11.67 a
Neem Extract	193.3	1.83 ab	6.11 ab
Garlic Extract	210.15	1.90 ab	6.33 ab
Khudepana	143.3	1.30 ab	4.33 ab
Control	73.33	0.83 ab	2.78 b
$LSD_{(OO5)}$	95.84	2.378	7.926
Level of significance	**	**	**
CV(%)	3.55	9.68	9.68

In a column means having similar letter (s) or without letter is identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

•• : Significant at 0.01 level of probability

Chapter V

Summary and Conclusion

Chapter V

SUMMARY AND CONCLUSION

A field experiment was conducted in the field laboratory of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from April 2006 to December 2006 to control rhizome rot of ginger through selected chemicals, bioagent, plant extracts and soil amendment. The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with three replications. After emergence of seedlings, various intercultura J operations were accomplished for better growth and development of the ginger Data were collected in respect of percentage of infected hill and leaves, disease severity and yield of ginger. The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments.

A encouraging performances of the treatments used in the experiment was observed in reducing the disease incidence in terms of hill infection in comparison to control at 90 DAS. The highest potential performance was recorded in case of *Trichoderma harzianum* (6.6%) and the lowest performance was noticed in case of Folicur (53.33%) applicatioa The lowest leaf infection was recorded in case of *Trichoderma harzianum* (0.56%) and the highest leaf infection was observed in case of Furadan MZ 68 WP and Ridomil which was closely followed by Folicur (7.78) and Khudepana (6.67%). Very promising performance in reducing disease severity (PDI) was recorded in case of *Trichoderma harzianum* (0.20) which was statistically identical with the performance of garlic extract (0.26) and neem extract (0.29). At 105 DAS the highest potential performance was recorded in case of *Trichoderma harzianum* (33.33%) and the lowest performance was observed in case of Bavistin (93.33%) application. The lowest leaf infection was recorded in case of *Trichoderma harzianum* (6.11%) and the highest leaf infection was observed in case of Bavistin 50 WP (40.56%).

Very promising performances in reducing disease severity (PDI) was recorded in case of *Trichoderma harzianum* (0.80) which was statistically identical with the performance of garlic extract (0.91) and neem extract (3.05). The performance of the treatments recorded in 120 DAS. 135 DAS, 150 DAS were found in similar trend as that of 90 DAS and 105 DAS in controlling the disease with little extent where the highest performances in terms of reducing disease incidence, leaf infection and disease severity (PDI) was observed in case of *Trichoderma harzianum*, garlic extract and neem extract. At 165 DAS the disease incidence was recorded 33.33 *%* in case of *Trichoderma harzianum* and it was noticed 26.67 % in case of Folicur application. The lowest leaf infection was recorded in case of *Trichoderma harzianum* and garlic extract (2.22%) followed by Neem extract, Cupravit 50 WP (2.78%) and the lowest performance in reducing leaf infection was observed in case of Furadan 5 G and Ridomil. Very promising performance in reducing disease severity was recorded in case of *Trichoderma harzianum* (0.04 PDI). Application of Bavistin 50 WP and Cupravit 50 WP also scored better performance in reducing the disease severity in comparison to control. Weight of*)* rhizome ranged from 73.33 g to 216.70 g. The highest weight/rhizome was recorded in case of *Trichoderma harzianum* (216.70 g) followed by garlic extract (210.15 g) and neem extract (193.3 g). The average yield of rhizome maintained similar trend to weight/rhizome in case of replication of different treatments in comparison to control. The average yield due to application of different treatments varied from 2.78 t/ha to 11.67 t/ha. The highest rhizome yield was achieved by using *Trichoderma harzianum* (11.67) and the lowest yield was achieved in case of Folicur (3.56 t/ha). Considering the overall result, application of *Trichoderma harzianum,* garlic extracts and neem extract might be recommended as ecofriendly approach for controlling rhizome rot of ginger. However, further investigation is needed to justify the present findings in different Agro Ecological Zones (AEZ) in the country for consecutive years

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Appendices

APPENDICES

Appendix I. Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	33.45
Silt	60.25
Clay	6.20
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.12
Organic carbon (%)	1.32
Total nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K. (%)	0.2

Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from April to December 2006

Month	Air temperature (°C)		RH (%)	Total rainfall (mm)
	Maximum	Minimum		
April 06	33.74	23.87	85	69
May 06	34.20	24.20	77	173
June 06	33.40	26.80	91	279
July 06	31.52	25.35	88	233
August 06	28.25	24.55	82	165
September 06	26.20	24.15	73	117
October 06	26.70	21.13	89	41
November 06	22.00	20.15	87	00
December 06	20.00	20.90	64	00

Source : Dhaka metrological center

Appendix III. Layout of the field experiment.

Block 1 Block 2 Block 3

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease severity' (PDI)
Replication	2	521.212	12.458	9.959
T reatment	10	785.46*	29.680*	117.613**
Error	20	294.55	10.513	19.711

** **Significant at 0.01 level of probability * Significant at 0.05 level of probability**

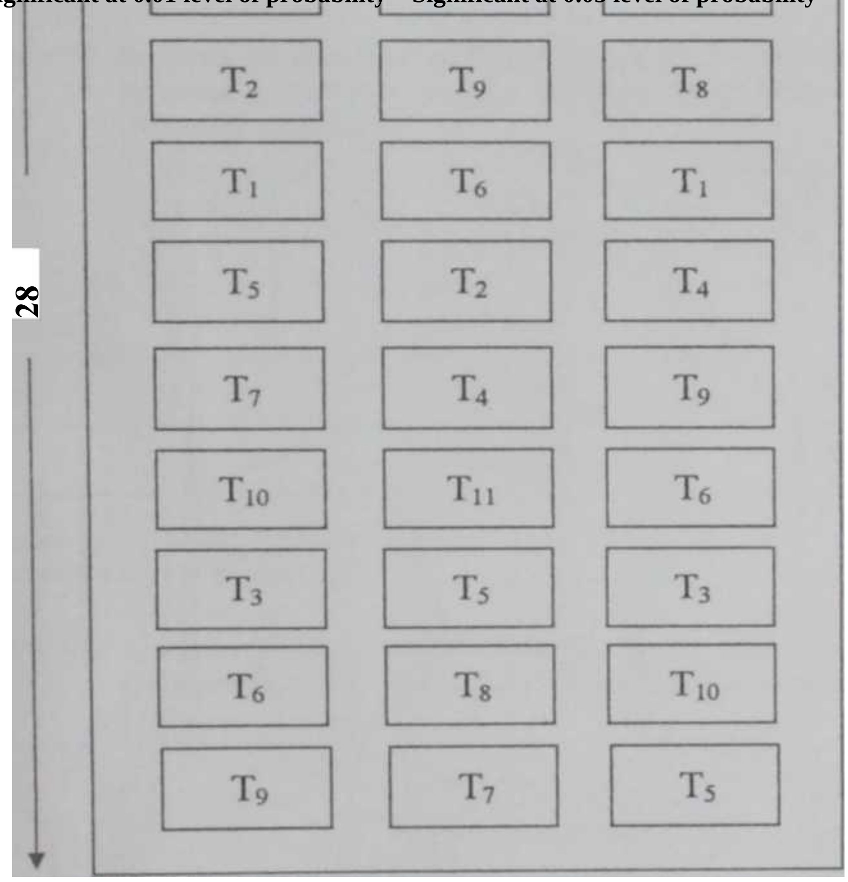

Figure 1. Layout of the experiment

Appendix IV. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 90 DAS (days after sowing) as influenced by different treatment

Appendix V. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 105 DAS (days after sowing) as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease severity (PDI)
Replication	2	1127.27	1170.286	187.432
Treatment	10	1369.70*	480.741*	853.766**
Error	20	500.606	165.008	149.600

**** Significant at 0.01 level of probability • Significant at 0.05 level of probability**

Appendix VI. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 120 DAS (days after sowing) as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease sev enty (PDI)
Replication	2	145.455	22.559	15.692
T reatment	10	1233.94*	326.08**	82.879**
Error	20	492.121	62.744	14.933

**** Significant at 0.01 level of probability**
• Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 135 DAS (days after sowing) as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease severity (PDI)
Replication	2	145.455	18.434	11.953
Treatment	10	*1442.42***	601.111**	125.780**
Error	20	358.788	38.157	11.919

***• Significant at 0.01 level of probability**

Appendix VIII. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 150 DAS (days after sowing) as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease seventy (PDI)
Replication	2	48.485	7.828	19.343
T real men t	10	1687.27**	928.05**	241.370**
Error	20	301.818	20.699	18.532

***• Significant at 0.01 level of probability**

Appendix IX. Analysis of variance of the data on the incidence and disease severity of rhizome rot of ginger after 165 DAS (days after sowing) as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		% Hill infected	% Leaf infected	Disease severity (PDI)
Replication	2	157.576	9.848	13.903
Treatment	10	1716.36**	1019.53**	218.081**
Enor	20	130.909	9.478	11.602

**** Significant at 0.01 level of probability**

Appendix X. Analysis of variance of the data on rhizome weight and yield of rhizome due to rhizome rot of ginger as influenced by different treatment

Source of variation	Degrees of freedom	Mean square		
		Weight/rhizome (g)	Yield (Kg/plot)	Yield (t/ha)
Replication	2	14743.182	9.791	108.789
Treatment	10	10583.788**	29.856**	358.452**
Error	20	3166.515	1.949	21.655

***• Significant at 0.01 level of probability'**

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