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

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CERTIFICATE

This is to certify that thesis entitled, "CONTROL OF RHIZOME ROT OF GINGER THROUGH SELECTED CHEMECALS, BIOAGENT, PLANT EXTRACTS AND SOIL AMENDMENTS" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in PLANT PATHOLOGY, embodies the result of a piece of bonafide research work carried out by Mahmuda Hasnat bearing Registration No. 05-01650 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Date: 14-10-2012
Dhaka, Bangladesh

(Dr. Md. Rafiqul Islam)
Professor
Supervior

Dedicated to

My

Beloved Parents

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ABSTRACT

Experiments were carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March, 2011 to February 2012 to findout the efficacy of selected treatments viz. T_1 (Bavistin 50WP), T_2 (Ridomil Gold), T_3 (Dithane M-45), T_4 (Sulcox), T_5 (Neem leaf extracts), T_6 (Alamonda leaf extracts), T_7 (Poultry waste), T_8 (Saw dust), T_9 (*Trichoderma harzianum*) and untreated control for controlling rhizome rot of ginger caused by *Fusarium oxysporum.* In *in-vitro* assay the highest inhibition (86.33%) of mycelial growth of *Fusarium oxysporum* was observed in case of Bavistin 50 WP followed by Ridomil Gold MZ72 (83.77%), Dithane M-45 (82.66%), *Trichoderma harzianum* (81.11%), alamanda leaf extract (77.7%), Sulcox (76.77%) and neem leaf extract (76.0%). In *in-vivo* assay the lowest disease incidence (27.78%) was recorded in case of T_2 (Ridomil Gold) preceded by T_7 (Poultry waste) (30.55%), T_3 (Dithane M-45) (33.33%), T_1 (Bavistin 50WP) (33.33%) and T_8 (Saw dust) (36.11 %) at 240 DAP (Days After Planting) while the highest disease incidence was recorded in control (63.89%) preceded by T_4 (Sulcox) (38.89%) and T_5 (Neem leaf extracts) (38.89 %). All the treatments effect was found statistically significant in comparison to control. The highest reduction of disease severity (61.25 %) was recorded at 240 DAP in case of T_7 followed by T_2 (58.34 %). The highest percentage of healthy tillers per plot was noted in case of treatment T_7 (81.91%) which was statistically similar with T_1, T_2, T_5 and T_8. The highest plant height (51.11 cm) was recorded in case of treatment T_1 where rhizomes were treated with Bavistin 50 WP followed by foliar spray with the same. The second highest plant height was recorded in (50.89 cm). The highest weight (2520.00 g) of the healthy rhizome was recorded in case of treatment T_7. The highest rhizome yield (14.38 t/ha) was recorded in case of T_7 which was 50.33% increased over control. Poultry waste as soil amendment, neem or alamonda leaves as plant extracts, *Trichoderma harzianum as* bio agent and Bavistin or Ridomil Gold as fungicide could be used to control rhizome rot of ginger.

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Introduction

Chapter I
INTRODUCITION

Indian subcontinent is considered as '*The land of spices*' and enjoys from time immemorial a unique position in the production and export of ginger. The crop are cultivated for their underground rhizomes which are used in many ways.

Ginger is obtained from the underground stems or rhizome of *Zingiber officinale* Rosc. A herbaceous tropical perennial belonging to the family Zingiberaceae. It is usually grown as an annual crop. The whole plant is refreshingly aromatic, but only the underground rhizome (raw or processed) which is valued as spice. Its medicinal value is increasingly being recognized now a days. Ginger originated in South-East Asia, probably in India (Burkill, 1966, Purseglove *et al.*, 1981). The name itself supports this view. The Sanskrit name 'Singabera' has given rise to Greek '*Zingiberi*' and later the generic name *Zingiber.*

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

The refreshing pleasant aroma, biting taste and carminative property of ginger make it an indispensable ingredient of food processing through out the world. Fresh ginger, ginger powder from dry ginger, oleoresin and oil are all used for this purpose. Fresh ginger is unique for its flowery flavor and spicy taste. It is also used in jams and marmalades. The syrup in which ginger is preserved is valued for pickle and sauce making. It is also used in the production of ginger bread (Pruthi, 1993). 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. Moreover, 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. In addition, ginger is used popularly as chewing purpose (Purseglove *et al.,* 1988).

Ginger is cultivated in several parts of the world, and the most important countries *viz.*, India, China, Nigeria, Sierra Leone, Indonesia, Bangladesh, Australia, Fiji, Jamaica and

Nepal. Among them, India and China are the dominant suppliers to the world market (Sagar, 2006). In Bangladesh ginger is cultivated all over the country where Rangpur, Nilpharmari, Tangail, Pabna, Jessore, Khulna, 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 (Ambia, 2006).

The annual production of ginger is 74841 metric tons & the total area of ginger cultivation is about 22403 acres and the yield per acre is about 4541kg (BBS, 2009-2010) in the country which is not sufficient for our National Demand. Thus, the deficit amount has to import from abroad to meet up the national demand.

Disease is a major constraint for the production of healthy rhizome, cause even total failure of crop (Fagaria *et al.* 2006). Ginger is affected by various diseases, such as, rhizome rot, bacterial wilt, soft rot, leaf blight etc. Among all of these, rhizome rot is most damaging one (Chattopadhya, 1997). *Fusarium oxysporum* and *Pythium aphanidermatum* are associated with it causation (Ram *et al.,* 1999).

At first the disease comes slight fading of green color of leaves. The tip of the infected leaves turns yellow and the color proceeds downwards ultimately resulting in withering and death of the leaf. The infection then 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 (Shanna, 1978). The injected rhizomes become rotten and the crop is completely destroyed (Baruah *et al.,* 1998).The disease is important because it causes economic losses to growers resulting in decreased prices of products to the consumers.

Rhizome rot of ginger is a serious constraint for the cultivation of ginger in Bangladesh. Rae (1911) reported that, the reduction in yield by rhizome rot of ginger varied from 10 to 15 percent in low-lying fields and six per cent in upland fields of Bangladesh. Disease in epiphytotic forms causes enormous loss in certain years. Moderate to severe incidence leads to crop loss of more than 50 and 80 per cent have been reported on account of this disease respectively (Butler, 1918).

Rhizome rot of ginger can be controlled by the application of fungicides. Many researchers worked on the chemical control of the disease and they found very promising effect of different chemicals against the disease (Stirling *et al.*, 2006; Usman, 2006; Meena and Mathur, 2005; Singh and Gomez, 2001). Systemic and contact fungicides like Bavistin 50WP, Ridomil Gold MZ-72, Captan, Dithane M-45, Copper Oxychloride and Bordeaux mixture etc. were reported effective against the disease (Sagar, 2006). However, chemicals treatment increase the cost of production and continuous use of the chemicals results in accumulation harmful chemical residues in soil as well as plant products causing serious environmental pollution, deleterious effect to non target beneficial soil microorganism. In search of eco-friendly approach several researchers investigated on organic products. bio-agents, plant extract for the management of the disease (Dohroo *et al.*, 1994; Ram *et al.*, 2002; Anandaraj and Sharma, 2003; Ambia, 2006).

Now a days *Trichoderma* sp is frequently used as a bio-agent against soil borne fungal pathogens (Ahmmed and Hossain. 2006). Soil amendment using poultry wastes and saw dust are now being considered as environment friendly approach that make the soil suppressive improving the antagonistic activities of the soil microorganisms.

Thus, finding out the alternatives of chemical fungicides with eco-friendly components, research need to carry out research with bio-agent, organic soil amendment, plant extracts alone or in combination to formulate the integrated approach for the management of the disease. But no such initiatives have yet been taken in the country for the management of the disease. So, the problem needs to give urgent attention.

Considering the above circumstances, the present investigation has been undertaken to achieve the following objectives.

Objectives:

a. Isolation and identification of causal agent/ agents of rhizome rot of ginger.

b. Evaluation of chemicals, bio-agent, plant extracts, amendments against the diseases.

c. Identification of the suitable management components for controlling rhizome rot of ginger .

Chapter 2
Review of Literature

Chapter II

REVIEW OF LITERATURE

In the cultivation of ginger, a number of diseases for the growers are very crucial. Among the diseases rhizome rot of ginger is a very important one. A few studies 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.

Seed treatment and soil drenches with Bordeaux mixture (2:2:50) and seed treatment with Ceresan (0.25%) for 30 minutes is effectively controlled rhizome rot. (Bhagwat, 1961 and Thomas, 1940).

Pre sowing soil treatment and subsequent treatments every week with Bordeaux mixture (4:4:50) or Perenox (0.35%) were recommended for successful control of rhizome rot caused by *P. myriotylum* and *P. aphanidermatum* (Sahare and Asthana, 1962).

Sharma *et al. (1978)* assessed systemic and contact fungicides in the control of rhizome rot of ginger caused by *Fusarium oxysporuin.* They found that the yield of rhizome was increased when they used fungicides. They reported that Bavistin 50 WP was the best fungicides in controlling rhizome rot of ginger, followed by Captain and Difolatan.

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 *Fusarium oxysporum* was not consistently isolated from rotted ginger tissues and rhizome rot disease did not develop when disease free rhizomes ware 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 *Fusarium equiseti* and *Pythium pleroticum* in storage and obtained good control with Antracol (Propineb,0.25%), cupravit and Blitox-50 (both copper oxchloride. 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 *Fusarium equiseti* (dry rot) and *Pythium pleroticum* (wet rot).

Koshy *et al.* (1984) obtained that, increased germination, reduced incidence of rhizome rot and better yield was obtained with Captafol when used for seed treatment.

Papavizas (1985) reported that, integration of fungicides with bio-control agents is such a step for improving the efficiency of bio-control agents. Integrated management of disease with fungicides and bio-control agents is possible only if they are compatible. Investigation have been carried out to identify organisms resistant or tolerant to fungicides, to manipulate bio-control agents genetically to develop tolerance to fungicides and to evaluate such altered organism in combination with fungicides for disease control under field conditions.

Sadanandan and Iyer (1986) stated that, Neem oilcake @ 2MT/ha gave reduction of rhizome rot and increased yield by 1.78MT/ha.

Bharadwaj and Gupta (1987) observed in *in vitro* tests using *T. viride, T. harzianum* and *T. hamatum* against *P. aphanidermatum, F. equiseti* and *F. solani* showed that these antagonists were inhibitory to the pathogens.

Chet (1987) stated that, the use of biocontrol agents offers an environmentally, economic and safer alternative for fungicides but they really give better control than a good fungicide.

Rathaiah (1987) tested soft rot *(Pythium muriotyhum)* of ginger by Ridomil Gold and in combination with Captafol, Captan or Mancozeb. He stated that dipping of wetting 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.

Thakore (1988) stated that Neem oilcake as well as other oilcakes has also been shown to reduce ginger rhizome rot caused by *P. aphanidermatum* and *F. solani*.

Dataram (1988) observed on farm trials were also conducted with BCAs in India with the results mentioned below. Incidence of rhizome rot was low when *T. viride* was applied to soil along with wood saw dust.

Bharadwaj *et al.* (1988) stated that good control of storage rot caused by *P. aphanidermatum* and *F. equiseti* was obtained when *T. viride* and *T. hamatum* were applied to rhizomes either by dipping them in spore suspension or smearing them with the antagonists.

Thakore *et al.* (1988) evaluated six non systemic and four systemic fungicides by treating *P. aphanidermatum* inoculated ginger rhizome with respective fungicides before planting. Of these, Dithane M-45, Capatafol, Ziride, Captan and Metalaxyl controlled rhizome rot incidence and increased germination of rhizomes and yield.

Dataram (1988) observed that Soil amendment with wood sawdust reduced disease incidence.

Sadanandan *et al.* (1988) stated that liming along with fertilizer or without it resulted in more disease than untreated plot.

Ramchandran *et al.* (1989) evaluated 5 systematic fungicides for efficacy against rhizome rot of ginger. The fungicides were tested as soil and seed treatments and they fund metalaxyl formulations, namely Ridomil 5G garnules and Apron 35 WS gave the best control of the disease.

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.

A rise in peroxidase activity was recorded by Dohroo (1989) in ginger rhizomes infected by *Pythium pleroticum* and *Fusarum equisti 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.

Dohroo (1989) conducted an another experiment with 10 cultivars tested in the field.Turing 1986 and recorded the lowest incidence of *Fusarium oxysporum f. sp.:ngiberi.* 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.

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 (carbendazom) or 0.3% Dithane M-45 (Mancozeb) in combination with soil treated with the formaldehyde gave satisfactory control of this disease.

In an *in vitro* study with five systemic fungicides against *P. aphanidermatum* viz., Metalaxyl, Oxadixyl 35 WP, Fosetyl aluminium, Promocarb and Ethazole (Etridiazole) as Terrazole 35 WP the last one gave effective control and had the lowest ED 50 and ED 90 values followed by Metalaxyl (Ramachandran *et al.*, 1989). These fungicides were also tested as seed and soil treatments in pre- infested soil in pot culture (Ramachandran *et al.*, 1989) Metalaxyl formulation (Ridomil 5G granules) and Ethazole (Terrazol, 35 WP) gave best control.

Chauhan and patel (1990) reported that rhizome rot disease is associated with a *Pythium spp.* and *Fusarim solani,* either of 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 fomulations tested were effective against *Pythium* spp. and Bordeaux mixture gave the best inhibition of *FF solani.*

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 *Fusarium spp. & 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 (mancozeb) at 0.3% were also effective.

Rana (1991) reported that ginger yellows can be effectively checked by proper seed treatment and may be helpful only if the seed is properly selected.

Sawant and Mukhopadhyay (1991) studied that Some instances of such investigations are briefly described. For example *Trichoderma harzianum* was tolerant to Metalaxyl as exemplified by uninhibited growth, sporulation and spore germination up to 1000ppm level of the fungicides.

Dohroo and Sharma (1983) 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.

Whips and Lumsden(1991) reported that Biological control of *Pythium* species is very difficult because of rapid germinating of sporangia in response to seed or root exudates followed by immediate infection and the ability to cause long term root rots.

Several angatonists 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 subtilis, Cannabis sativa, Lyonia ovalifolia* nd *Aspergillus niger.* The respective percent reductions of infection over controls were *75.9, 69.4. 58.5, 54.7* and 52.0.

Rana and Sharma (1993) reported that seed treatment with fungicides was more effective in reducing ginger yellows compared to soil drenching in the field. Seed treatment with Bavistin (1g/l) was most effective followed by Dithane M-45 (2.5 g/l).

Anon(1994) stated that good control of rhizome rot caused by *P. aphanidermatum* was obtained in Kerala state when *T. harzianum* or *T. hamatum* was applied to soil along with neem oil cake. These BCAs performed better in solarized field .

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

Anon (1994) observed that Effective suppression of rhizome rot under field conditions has been obtained in Rajasthan state when *T. viride*, *T. harzianum* was applied to soil in combination with wood sawdust .

Sharma (1994) Recommended that Dithane, M-45 for seed tratment and soil drenching was made based on its performance in disease control in prolonged on farm evaluations of the fungicides at Indian Institute of Spices Research, Calicut, Kerala.

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)* evaluated the effects of chemicals on the growth of *Fusarium spp. & Pythium zingiberum* causing rhizome rot of ginger and inhabitation of the disease development. They isolated 52 fungal isolates which was obtained form finger rhizomes with rotting symptoms form fields in Wanju (chonhuk) and Seasan (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 (MTI), metalaxyl + copper oxchloride (MC), echlomezol (EM) and propamocarb hydrochloride (pc) varied depending on the isolates tested. They found mycelial growth was almost completely inhibited by MC a MTI at a concentration of 50 mg/litre.

Sharma (1998) stated that *T. harzianum, T. virde, Azadirachta indica* Juss and *Agave americana* L. have been reported to be the most effective in reducing mycelial growth of *Fusarium oxysporum f. sp. zingiberi* and *P. aphanidermatum* causing yellows and rhizome rot of ginger respectively.

Park *et al.* (1998) reported from their experiment conducted in 1996 that *Zingiber ofcinale* plant were infected by rhizome rot in Korea Republic, from September of October. The pathogens associated with rhizome rot were isolated and identified as *Pythium spp., Fusarium spp.,* and bacteria. A total off 8 isolates of *P. zingiberum* were tested for their tolerance to metalaxyl. Nine isolates were tolerant and showed mycelial growth on PDA containing 100 ppm of metalaxyl. At 5001000 ppm, metalaxyl tolerant isolates grew their mycelia while metalaxyl susceptible isolates could not grow at > 10 ppm. Metalaxyl tolerant isolates were completely inhibited by metalaxyl with carbendzim and with copper oxchloride at 1000 ppm. suppression of *Pythium aphanidermatum* and rhizome rot of ginger by *Aspergillus niger, A. tereus, 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 (703%) *Aspergillus cylindraspora* nad *P. aphanidermatum* also exhibited mutual overgrowth in dual culture. *A. niger* showed good protection against rhizome rot. Their severity of rhizome rot infection was low infested soil was treated with *A. terreus, penicillium* species and *A. cylindrospora.* The highest yield was recorded with *A. niger.*

Sharma (1998) stated that *Azadirachta indica* and *Agave americanai* were most effective in reducing mycelial growth of *Fusarium oxysporum* f.sp. *zingiberi* and *P. aphanidermatum*.

Shanmugam *et al.* (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 *Fusarium oxysporum & Pythium aphanidermatum by* dual culture and cell tree culture filtrate studies *Aspergillus niger, A. Fumigatus, A. Flavus* and *Trichoderma viride* were found to be potenial antagonists.

Among the fungicides tested (Copper oxychloride, Mancozeb and Bordeaux mixture). Mancozeb was compatible with all four antagonists.

Ram *et al.* (1999) conducted an experiment to evaluate fungal and bacterial biocontrol agents (BCA) individually in combination and finally both BCA's in integration with fungicidal rhizome treatment. Rhizome treatment with individual BCA resulted in better germination and stand of ginger significant suppression of the disease and increase in yield as compared to the control and these treatments were at par with the fungicides rhizome treatment. Integration of soil application of biocontrol agents with fungicidal rhizome treatment (Bavistin + Ridomil MZ) increased the efficiency of disease control as compared to their individual treatmnents. Soil application of *T. harzianum* and rhizome treatment with *Pseudomonas* sp. and fungicides was the most effective among all the tested treatments.

Dake *et al.* (1999) observed Two fungicides, Bavistin 50 WP (0.3%) and Dithane M-45 (0.3%) and three kinds of lining materials, sand, saw dust, and paddy husk were evaluated in a Factorial Experiment in Randomized Complete Block Design). The highest percentage of healthy rhizomes was recovered with Dithane M-45 (0.3%) as dip treatment for 20 min, and the lowest percentage of infected rhizomes was observed in seed ginger rhizomes stored in pits lined with saw dust.

Ram *et al. (1999)* reported from their experiment that rhizome rot of ginger is caused by either *Fusarium spp. & Pythium* 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, *Pseudomoans* spp. was evaluated alone and in combination with *T. harzianum* and also with fungicidal rhizome treatment. Combination of both resulted in better germination and plant stand, reduced disease and increased yield. Soil Application of BCA was more effective compared with seed treatments. Bavisitin 50 WP + Ridomil MZ increased the efficiency of disease control as compared with their individual treatments. Soil application of *T. harzianum* and rhizome treatment with Pseudomoaas spp. And fungicides was the most effective among all the treatments tested.

Shanmugam *et al.* (1999) conducted experiment on different biocontrol and chemicals as both seed treatment and soil application. The results revealed that *T. harzianium* applied as seed treatment and soil application was equally effective to COC in inducing germination and reducing percent rhizome rot incidence.

Jayasekhar *et al.* (2000) conducted field trials (local ginger variety). Seed was treated with six fungicides and subsequently these fungicides were applied to the soil at 2lit/ plot on 45 and 90 DAP. Seed were treated with three biocontrol agents before planting and these biocontrol agents already multiplied in FYM along with neem cake (200g/plot) were applied to soil prior to planting. Among them, seed treatment and soil application of Metalaxyl MZ @ 0.1% at 45 and 90DAP recorded the lowest disease incidence 4.23 percent followed by Bordeaux mixture.

Ram *et al.* (2000) evaluated resident isolates of biocontrol agents *viz., T. harzianum, T. aureoviride* and *T. virens* for control of ginger rhizome rot. All the four bioagents could establish and reduced the population density of both *F. solani* and *P. aphanidermatum.*

Balakrishnan *et al. (2000)* showed that Rhizome rot caused by *Fusarium oxysporum* is the main production constraint in all ginger growing tracts. As a disease management practice, soil solarization technique was adopted. This was further integrated with seed treatment and soil drenches with Mancozeb, Captafol, Chlorothalonil and Ridomil-Mancozeb. For comparison, the whole experiment was also conducted under non-solarized conditions in *Pvthium-sick soil. Soil* temperature and pathogen population were monitored in solarized and nonsolarized plots. Soil solarisation effectively suppressed *Fusariwn oxysporuin* in soil and as a consequence germination was increased and the incidence of rhizome rot reduced. This in turn reflected in increased yield of rhizomes in solarized plots.

Dohroo (2001) stated that Eighty percent control of diseases caused by *P. pleroticum* and *F. equiseti* was obtained when stored rhizomes were treated with *T. viride.*

Das *et al* (2001) conducted an experiment to find out suitable chemical to control rhizome rot of ginger and variety with higher yield potential. Six varieties were selected with six treatments. Before sowing individual lots of seed rhizome were soaked in each fungicidal solution of 30 min and dried in shade. Maran variety showed highest percent germination and lowest per cent incidence in all the treatment and especially when treated with Ridomil MZ 0.2% which was followed by Rio-de-genario among variety and among chemical COC 0.3% showed good results.

Kusum *et al.* (2002) observrd The effect of soil solarization and fungicidal seed and soil treatments of rhizome rot of ginger cv. Jhadole local was studied in Rajasthan, India field plots inoculated with both pathogens were solarized for 20 days under ambient day temperature of 37.7-45.0 and night temperature of 26.27-27.5°C. Seed were 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 was most effective among the treatments in reducing disease incidence and in increasing the number of sprouts (215) and yield (1.51 kg).

Jacob *et al.* (2002) carried out a preliminary trail in Kerala, India to mange 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, bitertanlo at 1 g/litre and copper oxchloride at 3 g/litre) and 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.

Ram *et al. (2002)* were evaluated that Resident isolates of biocontrol agents (BCAs) *Trichoderina harzianumm, T. aureoviride* and *Gliocladium vixens* and a non-resident isolate of *T. viride* for suppression of ginger rhizome rot, a rhizome and seed borne disease caused by *Fusarium solani* or *Pythium inyriotylum* or both. Rhizomes related with BCA were planed in two set of pots, one with sterilized but pathogen ingested 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* pp., correlated well with reduction of the disease and significant increase in the field. The trend of efficacy of each BCA observed in the unsterilozed rhizome rot infested field soil was confirmed in sterilozed, pathogen-ingested soil.

Kusum *et al.* (2002) conducted soil solarization using thin transparent polythene film. They attempted in integration with fungicidal seed treatment and Phorate as soil application in the field experiment for management of rhizome rot of ginger. All the treatments in the solarized fields had significantly less disease as compared to the untreated control and least disease was observed in Captan seed dressing+ Phorate soil application + Metalaxyl MZ drench.

Anandaraj and Sarma (2003) for controlling rhizome rot and yellows diseases, an integrated disease management module has been developed by selecting disease free rhizomes, dip treatment with a mixture of Dithane M-45 (0.25%) + Bavistin
0.1 %) + Durmet (0.1 %) for 60 minutes, applying Thimet I OG (12 kg/ha) at field preparation, and using *Trichoderma harizianum* (lkg in 25 kg FYM/ha) as soil treatment in furrows.

Bhat and Srivastava (2003) tested fourteen fungicides (250-1000 ppm; Emisan. Blitox 50 Captaf , Indofil M-45, Bavistin, Benlate, Roko, Saar, Calixin, Tilt. Contaf , Topas, RIL F004 and Contaf 5% SC) and four neem formulations against *F. oxysporum, Pythium aphanidermatum, Fusarium solani, F. moni/itof iie.* Sclerotium rolfsii and Fusarium sp.for inhibition and three *Trichoderma spp.* for compatibility in vitro. Emisan and Saaf (250 ppm) and triazoles (250-1000 ppm) were highly inhibitory against both pathogens and *Trichoderma sp.* . Bavistin and Benlate completely inhibited *Fusarium* and *Trichoderma* even at 250 ppm. Similarly, Captaf, Calixin, RIL F004, Tilt, and Indofil M-45 completely inhibited *P. aphanidermatum* and *S. rolfsii* at the same concentration. Indofl M-45 was fungistatic against *T. viride,* while showing complete inhibition of F. *solanni. F. oxysporum, P. aphanidermatum* and *S. rolfsii* at 500 ppm.

Reddy *et al.* (2003) stated that *Trichoderma harzianum* when applied in the field against rhizome rot of turmeric (*F. solani*), resulted in reduced disease incidence and increased yield.

Singh and Awasthi *(2004)* carried out an experiment in Bihar, India in controlling rhizome rot of finger caused by *Pythium aphanidermatum* under storage and field conditions. 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% Dithanc M-45 + 0.25% Bavistin.

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 (250.25q/ha) and lowest disease incidence (5.0%).G

Meena and Mathur (2005) conducted an experiment with three biological control agents i.e. *Trichoderma virde, Gliocladium virens* and *Pseudomonasfluorescens* 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. Pelletion of seed rhizome with biological control agents was not found effective. Pelletion either with the fungicidal mixture or BCAs combined with soil application of BCAs was effective in suppressing, the disease and increasing the yield. In the rhizosphere pot study, integrated approach resulted in reduction inoculums density of *F. 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.

Anon (2005) observed in integrated management of ginger against *Pythium, Fusarium* and *Ralstonia*, the results indicated that Mancozeb, seed solarization and hot water treatments of ginger rhizomes were effective in increasing the emergence and yield of ginger.

Anon (2005) showed that the trials conducted at Kumarganj for management of rhizome rot of ginger,minimum incidence and maximum yield was observed in the treatment seed treatment with hot waster at 51OC for 10 minutes and *Trichoderma harzianum* for 30 minutes with neem cake .

Anon (2005) studied to find out the effect of seed treatment with five fungicides on soft rot disease of ginger was conducted at Dholi. The pooled data of three years (1997-2000) showed that, minimum disease incidence (16.40%) was recorded by one hour seed treatment with Ridomil MZ (3g/l of water) followed by Indofil M-45 seed treatment (25.30%).

Anon (2005) conducted a trials for the management of rhizome rot of ginger, showed that seed treatment+ soil application of *Trichoderma viride* and *Pseudomonas fluorescens* + application of recommended N,P,K and FYM were found effective.

Ambia (2006) reported that lowest disease incidence and disease severity of rhizome rot of ginger was found in case of application of *Trichoderma harzianum* garlic extract, neem leaf extract at different days after planting and those treatments resulted maximum yield of rhizome.

Usman (2006) conducted an experiment in controlling rhizome rot disease of ginger caused by *Fusarium oxysporum is* a serious problem in ginger. As a part of disease management, field evaluation of bio-control agents was carried out in *Fusarium-sick* soil. Further, the efficacy of these bio-control agents in combination with soil solarisation was evaluated as a measure of integration. *Trichoderma viride, T. harzianum I & 11, T. hamatum* and *Gliocladium vixens* were the bio-control agents used and compared with fungicide mancozeb. Two years of field trials showed that the isolate *T. harzianum* was efficient in controlling the disease both in solarized and non-solarized plots. The disease incidence was less and the yield was high in both the years. *T hamatum* was the second best in both the years. In general, the yield was higher in solarized plots in both the years but significant increase in yield was obtained in the second year only. The weed growth was also suppressed in the solarized plot to an extent of 40%.

Stirling *et al. (2006)* added *2* qtls of neem cake per ha before planting. Treated seedling materials with3 gm Metalaxyl -MZ per litre solution before planting after the notice of drying leaf /initial symptoms Spray Metalaxyl MZ 3 gm/liter of water and also drench the same to affected areas.

Karuppiyan *et al.*(2007) treated rhizome with bio-inoculant Pseudomonas fluorescens and Trichoderma harzianum followed by soil application 60 days after planting to reduce rhizome rot. Soil application of Bio-control agents like T. *harzianum* and *P. fluorescence* during planting time a 2-5% gives effective control of the diseases.

Pandey *et al. (2010)* observed Rhizome rot of ginger, caused by *Pythium aphanidermatum* (Edson) Fitz, is a major constraint for the production of healthy rhizome, sometimes causing total failure of crop. Chemical control of this pathogen is not economical because of high cost of chemicals, breake down of resistance, environmental pollution, deleterious effect to non target beneficial soil micro-organism and ultimately the choice of the consumer for a organic product. Thus the treatment with plant products (*Boerhaavia diffusa* root extract) may offer a practical and economical alternative for eco-friendly management of this disease. Rhizomes dipped overnight in the suspension of 10.00 per cent crude root extract followed by 3 foliar sprays of the same proved quite effective in the management of the disease. Results indicated a gradual decrease in disease incidence with the corresponding increase in number of sprays and rhizome treatment with *B. diffusa* root extract.

Bhuyan (2010) studies on the integrated management rhizome rot of ginger and reported that Poultry waste , Bavistin 50 WP, Ridomil Gold MZ-72, alamonda or neem leaf extracts and saw dust alone or combination may be used as eco friendly approach.

Chapter 3

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

A field experiment was conducted in the farm of Sher-c-Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2011 to February 2012 to study the management of rhizome rot of ginger. The details materials and methods of this experiment are presented in this chapter

3.1 Experimental site

The present piece of research work conducted in the Farm of sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. Bangladesh. The site of the experimental plot is in $23^{\circ}74$ N latitude and $90^{\circ}35$ E longitudes with an elevation of 8.2 meter from sea level (Anon, 1994).

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 P^H 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-1.

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 of hot season from March to April and monsoon period from May to October (Edris et al., 1997). The total annual rainfall of the experimental site was 218 mm and average monthly maximum and minimum temperature were 29.45 $^{\circ}$C and 13.86 $^{\circ}$C, respectively (BBS, 2009-2010)

Details of the metrological data of air temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Bangladesh Metrological 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 (rhizome) of the ginger were collected from Spices Research Center, Bogra, The rhizomes of ginger were broken into small pieces bearing 1-2 buds. The average weight of individual pieces was 45-50 gm.

3.5 Treatment of the experiment

The experiment was designed for the management of rhizome rot of ginger using chemicals, biological agent, plant extracts and soil amendments. Details are presented below:

Treatments will be assessed in the experiment as follows:

T_0 = Untreated (Control)

T_1 = Rhizome treatment and spraying in the root zone with Bavistin 50WP

T_2 = Rhizome treatment and spraying in the root zone with Ridomil Gold MZ-72

T_3 = Rhizome treatment and spraying in the root zone with Dithane M-45

T_4 = Rhizome treatment and spraying in the root zone with Sulcox

T_5 = Rhizome treatment and spraying in the root zone with neem leaf extracts

T_6 = Rhizome treatment and spraying in the root zone with alamanda leaf extracts

T_7 = Soil application with Poultry waste

T_8= Soil application with Saw dust

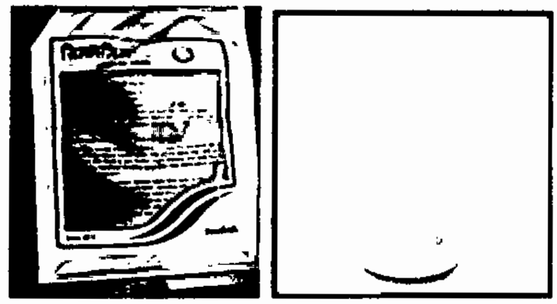
T_9= Rhizome treatment and soil application with spore suspention of *Trichoderma harzianum*

3.6 Layout of the experiment

The experiment was laid out in the single factor 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 10 plots where 10 treatments were allotted at random. There were 30 unit plots altogether in the experiment. The size of the plot was 1.2 m X 1.5 m. The distance maintained between two blocks and two plots were 1.0 and 0.5 m respectively. Layout of the experimental field was presented in Appendix I.

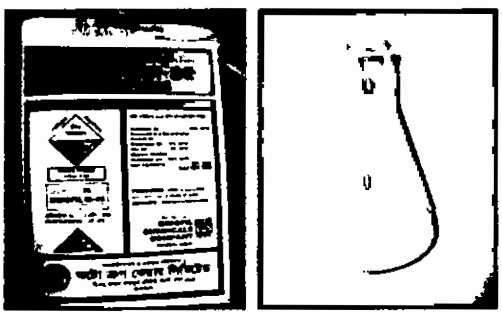
Bavistin

A



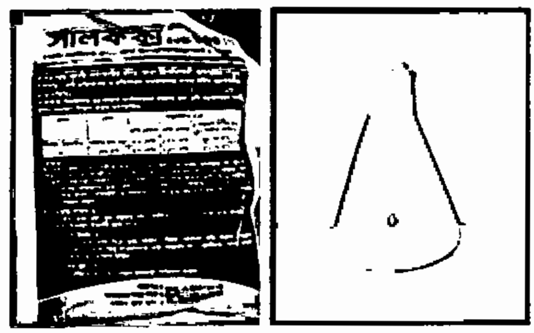
Ridomil Gold

B



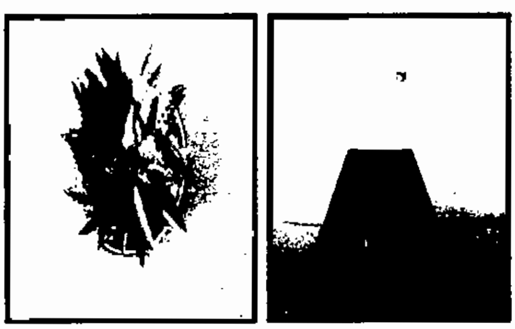
Dithane M-45

C



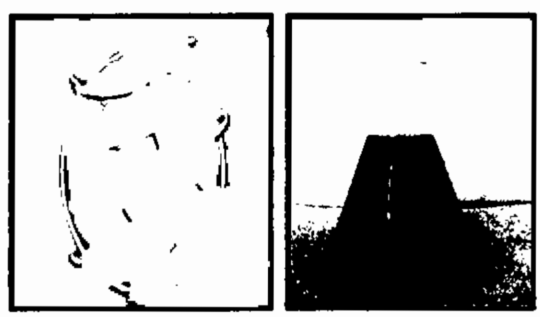
Sulcox

D



Neem leaves and it's extract

E

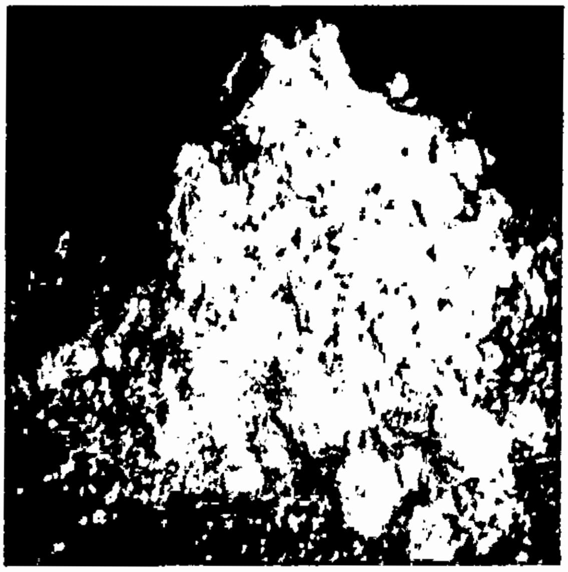


Alamanda leaves and it's extract

F

Plate 1. a. Different treatment materials applied in the experiment

Continued

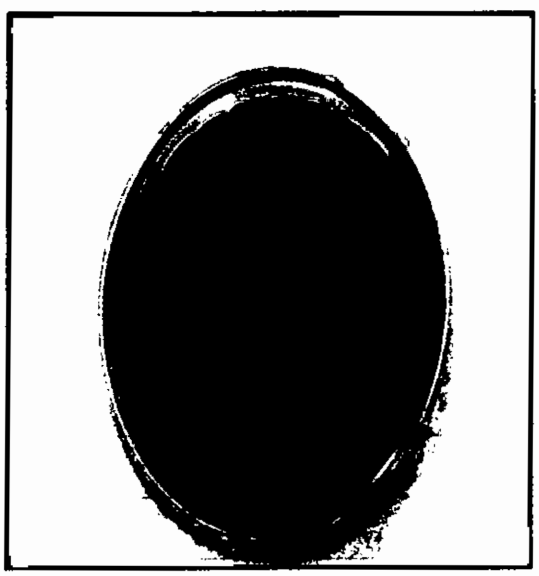


Saw dust

G

Poultry waste

H



Trichoderma harzianum

I

Plate 1. b. Different treatment materials applied in the experiment

3.7 Preparation of the main field

The selected plot of the experiment was opened in the 15 March'2011 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 experiment design. Recommended doses of well-rotten cow-dung manure and chemical fertilizers (Table 1.) were applied in the soil of each unit plot.

3.8. Application of manure and fertilizers

Well decomposed cow-dung manure 5 t/ha was applied at 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 were applied during the final land preparation of land. Urea was applied in three equal installments at 30, 45 and 60 Days after planting.

Table 1. The 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 Projukti Hatboi, BARI, Joydebpur, Gazipur, Bangladesh (2009).

3.9 Application of treatments

3.9.1 Collection and preparation of plant extracts

For extraction of juice, required amount of neem leaves & alamanda leaves were 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. Their supernatant was diluted in equal amount of sterile water for 1:1 solutions.

3.9.2 Preparation of spore suspension of *Trichoderma harzianum*

Trichoderma harzianum was grown on PDA (Potato Dextrose Agar) medium in Petridish at room temperature. After formation of conidia (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 by required amount of fungicide in water for each concentration in hand sprayer. The hand sprayer was shaken thoroughly before use.

3.9.4 Rhizomes treatments

Rhizomes treatment were done by dipping rhizomes in different fungicides, plant extracts and in the bio-agent for 30 minutes. Then the treated rhizomes kept overnight to remove excess moisture.

3.9.5 Planting of rhizomes

After the seed treatment the rhizomes were planted in the field. In this experiment plant to plant distance was maintained 20 cm and row to row distance was 45 cm. Rhizomes were planted 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 were sprouted. The treatment was applied five times with fifteen days interval starting from 30 June, 2011.Moreover,the treatments were applied in soils at the base of the plants and on leaves by using hand sprayer.

3.10 Intercultural 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 cane 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 with required intervals.

3.10.3 Plant protection

The crop was protected from the attack of insect-pest by spraying insecticide Ektara. The insecticide was used as required according to the recommended doses.

3.11 Isolation and identification of pathogen

The causal pathogen was isolated by 2-methods.

A. Soil dilution technique

Soil from the rhizosphere zone of infected rhizome was collected. 5-different test tubes each of which contains 9 ml sterile water. From the collected soil sample 5 gm soil taken & diluted it into a test tube containing 9 ml sterile water & from the prepared solution (1:10) 1 ml suspension was transfered to the next test tube (1: 100) and likewise soil suspension was transferred to the rest of the test tubes will contain concentration 1:1000, 1:10000 & 1:100000 respectively.

Plate 2. Plantation of rhizome in the experimental field

Plate 3. Foliar application of fungicide in the experimental field

B. Tissue Planting technique

The diseased rhizomes were collected by using polythene bag and were 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 Petri dish. The Petri dish containing rhizomes were incubated at 25°C for seven days. Then the organism grew freshly on 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 rhizome of ginger was harvested on February, 2012.

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, all plants from each row 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 height, disease severity, weight of rhizomes was collected. The following parameters were set up for recording data and for the interpretation of the results.

3.13 Estimation of disease incidence and disease severity :

$$\% \text{ Plant/hill infection} = \frac{\text{No. of infected hill}}{\text{No. of inspected hill}} \times 100.$$

$$\% \text{ Disease Severity} = \frac{\text{Total no. of dead tillers / plot}}{\text{Total no.of tiller / plot}} \times 100.$$

3.14 Yield of Rhizome

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

3.15 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of difference among the treatments. The mean values of all characters were evaluated and analysis of variance was performed by `F' value test. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 0.01% level of probability for lab experiment and 0.05% level of probability for field experiment. (Singh and Gomez, 2001).

Chapter 4
Results

CHAPTER IV
RESULTS

***In-vitro* assay of selected fungicides, plant extracts and bio-agent *(Trichoderma harzianum)* against *Fusarium oxysporum* (causing pathogen of rhizome rot of ginger).**

The *in-vitro* assay of selected fungicides, plant extracts and bio-agent *(Trichoderma harzianum)* against *Fusarium oxysporum* has been conducted in cup method and disc method. The effect of selected fungicides, plant extracts and bioagent *(Trichoderma harzianum)* against *Fusarium oxysporum* has been presented in Table 2. All the selected treatments showed significant inhibition of mycelial growth and spore germination in comparison to control. The inhibitory effect of the selected treatments against *Fusarium oxysporum* differred significantly among themselves both in cup and disc method. In cup method, the highest (86.33%) inhibition of mycelial growth of *Fusarium oxysporum* was observed in case of Bavistin 50 WP. The second highest (83.77%) inhibition of mycelia growth was recorded in case of Ridomil gold MZ-72 which is significantly indifferent with Dithane M-45 (82.66%). The *Trichoderma harzianum* also showed promising effect (81.11%) against *Fusarium oxysporum* followed by alamanda leaf extract (77.77%) and neem leaf extract (76.0%). The effect of neem leaf extract and alamanda leaf extract also found significantly similar in inhibition of radial growth of *Fusarium oxysporum.* The highest mycelial growth was recorded in control. In Disc method, the performance of selected treatments against the mycelial growth and spore germination of *Fusarium oxysporum* were more or less similar with the result of the cup method. The highest inhibition zone (5.53 cm) was recorded in case of Bavistin 50WP followed by Ridomil gold MZ-72 (4.90 cm). The effect of Ridomil gold MZ72 and Dithane M-45 also found statistically similar in making inhibition zone. Among the botanicals, the effect of neem leaf extract (4.10cm) was found better than the alamanda leaf extract (3.36 cm) which was statistically identical with the inhibitory effect of *Trichoderma harziamwm* (3.36cm). No inhibition zone was made in case of control treatment.

Table 2. *In-vitro* assay of selected fungicides, plant extracts and bio-agent *(Trichoderma harzianum)* against *Fusarium oxysporum* causing rhizome rot of ginger

Treatments	Radial Growth (Diameter) (cm)		Inhibition Zone (Diameter) (cm)	
	Cup Method		**Disc Method**	
T_1= Bavistin50 WP	1.23 (-86.33)	c	5.53	a
T_2= Ridomil Gold	1.46 (-83.77)	d	4.90	b
T_3= Dithane M-45	1.56 (-82.66)	d	4.73	b
T_4=Sulcox (Cu fungicide)	2.18 (-76.77)	b	3.30	d
T_5= Neem leaf extract	2.16 (-76.0)	b	4.10	c
T_6= Alamonda leaf extract	2.03 (-77.77)	b	3.36	d
T_9= Trichoderma harzianum	1.73 (81.11)	c	3.26	d
T_0=Control	9.00	a	0.0	c
$LSD_{(0.01)}$	**0.136**		**0.305**	
Level of Significance	**		**	
CV(%)	**1.87**		**3.29**	

In a column means having similar letter(s) is identical and those having dissimilar letter(s) differ significantly as per 0.01% level of probability.

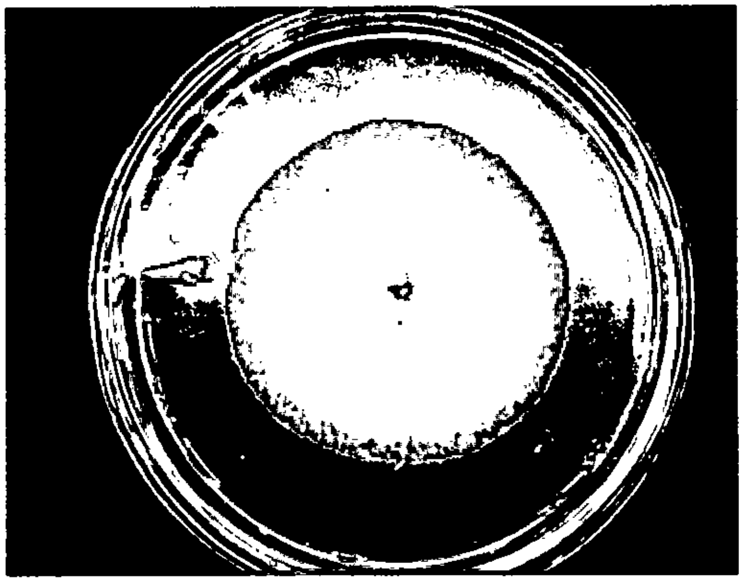


Plate 4. Pure culture of *Fusarium oxysporum*

Plate 5. Macro and micro conidia of *Fusarium oxysporum*

Incidence of rhizome rot of ginger in response to different treatments against *Fusarium oxysporum* recorded at different Days After Planting (DAP).

Incidence of rhizome rot of ginger in response to different treatment against *Fusarium oxysporum* recorded at different DAP is presented in Table 3. Different treatment showed remarkable effect on the incidence of rhizome rot of ginger. The performance of the selected treatments in reducing the incidence of rhizome rot were found always higher in comparison the untreated control irrespective of DAP. The incidence of rhizome rot of ginger in response to different treatments were recorded at different days after planting starting from 30DAP to 240 DAP with 30 days interval. At the beginning (at 30 DAP) the treatment effects were significantly differed with untreated control but among the treatments, the effect on disease incidence were significantly indifferent. The differences of treatment effect become sharpen with the age of the crop and distinct difference were found at 240 DAP among the treatments (Table 3.).

At 30 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table 3). The potential performances were recorded in case of T_7 (Poultry waste), T_1 (Bavistin 50WP), T_2 (Ridomil Gold), T_3 (Dithane M-45), T_5 (Neem leaf extracts), T_9 (*Trichoderma harzianum*) where the incidence was 2.777 %. The second highest potential performance was recorded in case of T_4 (Sulcox) and T_6 (Alamonda leaf extracts) where the incidence was 5.553 %. The lowest performance was noticed in case of T_8 (Saw dust) where the incidence was 8.33%.

At 60 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (16.67 %) (Table3). The highest performance was recorded in case of T_7 , T_1 , T_2, T_3, T_9 where the incidence was (5.553 %) and the lowest performance was noticed in case of rest of the treatment T_6 and T_8 where the incidence was (8.330 %) followed by T_4. The treatment T_6, T_8 and T_4 did not show any performances in reducing disease incidence in comparison to untreated control.

At 90 DAP, a marked differences of the effect of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table3). The highest performance was recorded in case of T_7 and T_2 where the disease incidence was 8.330 %. The second highest performance was recorded in case of T_1, T_3, T_5, T_6, T_9 where the incidence was 11.11 %, which was statistically similar with T_8 (Saw dust). The lowest performance was noticed in case of T_4 and that was statistically similar with the untreated control.

At 120 DAP, a sharp differences of the effect of the of treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table3). The highest performance was recorded in case of T_7 (Poultry waste) where the incidence was 11.11 %. The second highest performance was recorded in case of T_1, T_2, T_3 where the incidence was 13.89 %. The third highest performance was recorded in case of T_5, T_6, T_9, T_8 where the disease incidence was 16.67 %. The lowest performance was noticed in case of T_4 where the incidence was 22.22 % which was statistically indifferent with untreated control (33.33 %).

At 150 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table 3). The highest potential performance was recorded in case of T_7 and T_2 where the incidence was 13.89 %. The second highest performance was recorded in case of T_1 where the incidence was 16.67 %. The third highest performance was recorded in case of T_3, T_5, T_6, T_9, T_8 which was 19.45 %. The lowest performance was noticed in case of T_4 (22.22 %).All the treatments were statistically similar except untreated control.

At 180 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table 3). The highest performance was recorded in case of T_7, T_1 and T_2 where the disease incidence was 19.45 %. The second highest performance was recorded in case of T_3, T_5, T_6, T_9 and T_8 where the incidence was 22.22 %. The lowest performance was noticed in case of T_4 (27.78 %). All treatments effect were statistically significant in comparison to untreated control.

At 210 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to untreated control (Table 3). The highest potential performance was recorded in case of T_7, T_1, T_2, T_3, T_6, T_8 where the incidence was 27.78 % and followed by T_5 where the incidence was 30.55 %, T_9 (33.33 %) and T_4 (38.89 %). All treatments effect were statistically significant in comparison to untreated control.

The performance of the treatments at 240 DAP against rhizome rot of ginger were found significant in comparison to untreated control (Table 3). The lowest disease incidence (27.78 %) was recorded in case of T_2 preceded by T_7 (30.55%), T_3 (33.33%), T_1 (33.33%) and T_8 (36.11 %).On the other hand the highest disease incidence (63.89 %) was recorded in untreated control. All the treatments effect were found statistically significant in comparison to untreated control.

Table 3. Disease Incidence of rhizome rot of ginger at different DAP

Treatment	Disease Incidence (%)							
	30DAP	60DAP	90DAP	120DAP	150DAP	180DAP	210DAP	240DAP
T_0	16.67 a	16.67 a	25.00 a	33.33 a	38.89 a	47.22 a	55.55 a	63.89 a
T_1	2.777 b	5.553 b	11.11 bc	13.89 b	16.67 b	19.45 b	27.78 b	33.33 b
T_2	2.777 b	5.553 b	11.11 bc	13.89 b	13.89 b	19.45 b	27.78 b	27.78 b
T_3	2.777 b	5.553 b	8.333 c	13.89 b	19.45 b	22.22 b	27.78 b	33.33 b
T_4	5.553 b	13.89a b	19.45ab	22.22 ab	25.00 b	27.78 b	38.89 b	41.67 b
T_5	2.777 b	5.553 b	11.11bc	16.67 b	19.45 b	22.22 b	30.55 b	38.89 b
T_6	5.553 b	8.330 ab	13.89 bc	16.67 b	19.45 b	22.22 b	27.78 b	41.67 b
T_7	2.777 b	5.553 b	8.330 c	11.11 b	13.89 b	19.45 b	27.78 b	30.55 b
T_8	8.330 b	8.330 ab	13.89 bc	16.67 b	19.45 b	22.22 b	27.78 b	36.11 b
T_9	2.777 b	5.553 b	11.11 bc	16.67 b	19.45 b	22.22 b	33.33 b	38.89 b
$LSD(\%)_{(0.05)}$	9.164	8.656	9.691	11.74	10.80	9.163	10.76	12.93
CV(%)	96.87	62.65	42.37	39.10	30.62	21.85	19.30	19.53
Level of Significance	*	*	*	*	*	*	*	*

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

Legend:

T_0 = Untreated (Control)

T_1 = Rhizome treatment and spraying in the root zone with Bavistin 50WP

T_2 = Rhizome treatment and spraying in the root zone with Ridomil Gold MZ-72

T_3 = Rhizome treatment and spraying in the root zone with Dithane M-45

T_4 = Rhizome treatment and spraying in the root zone with Sulcox

T_5 = Rhizome treatment and spraying in the root zone with neem leaf extracts

T_6 = Rhizome treatment and spraying in the root zone with alamanda leaf extracts

T_7 = Soil application with Poultry waste

T_8= Soil application with Saw dust

T_9= Rhizome treatment and soil application with spore suspention of *Trichoderma harzianum*

Effect of different treatments on the severity of rhizome rot of ginger at different DAP.

The severity of rhizome rot of ginger in response to different treatments were recorded at 80 DAP, 160 DAP, 240 DAP and presented in Table 4.

In case of 80 DAP, the lowest severity (19.44 %) was recorded in case of T_7 where soil was amended with poultry waste which was statistically similar with T_1. The effect of treatment T_2 where rhizomes were treated with Ridomil Gold followed by spray in the root zone with the same fungicide was also statistically similar with T_1 .The second lowest severity (22.33 %) was recorded in case of T_3 where rhizomes were treated with Dithane M-45 followed by spray in the root zone with the same fungicide. The third lowest severity (25.54 %) was recorded in case of T_9 and T_5. The highest disease severity(44.33 %) was recorded in controlled treatment. The performance of T_4, T_8 and T_6 were lower but much better in comparison to untreated control.

In case of 160 DAP, the lowest severity (19.79 %) was recorded in case of T_7 which was statistically similar with T_1. The effect of treatment T_2 was also statistically similar with T_1 .The second lowest severity (23.19 %) was recorded in case of T_3. The third lowest severity (25.86 %) was recorded in case of T_9 and T_5. The highest disease severity (47.67 %) was recorded in controlled treatment. The performance of T_4, T_8 and T_6 were lower but much better in comparison to untreated control.

In case of 240 DAP, the lowest severity (20.28 %) was recorded in case of T_7.The second lowest (21.80 %) severity was recorded in case of T_2. The third lowest severity (23.51 %) was recorded in case of T_1 which was also statistically similar with T_3. The highest disease severity was recorded in untreated controlled treatment (52.33 %). The performance of rest of the treatments were lower but much better in comparison to untreated control.

Based on disease severity data recorded on 240 DAP,the highest reduction (61.25 %) of disease severity of rhizome rot was measured in case of treatment T_7 followed by treatment T_2 (58.34.The third highest reduction (54.56 %) of disease severity was caused by treatment T_1. Performance of treatment T_1 in reduction of rhizome rot severity was closely followed by treatment T_3 (54.35 %). The lowest performance in reduction of disease severity (44.01 %) was measured in case of treatment T_8 that was closely followed by T_6 and T_4.

Table 4. Disease Severity of rhizome rot of ginger at different DAP

Treatment	% Disease Severity			
	80DAP	160DAP	240DAP	Reduction of diseases severity as on 240 DAP (%)
T_0	44.33 a	47.67 a	52.33 a	-
T_1	20.53 d	22.22 de	23.51 d	54.56
T_2	20.68 d	21.29 de	21.80 e	58.34
T_3	22.33 cd	23.19 cd	23.89 d	54.35
T_4	27.43 b	28.19 b	28.99 b	44.60
T_5	25.54 bc	25.75 bc	26.07 c	50.18
T_6	28.27 b	28.43 b	29.11 b	44.37
T_7	19.44 d	19.79 e	20.28 f	61.25
T_8	28.17 b	28.47 b	29.30 b	44.01
T_9	25.28 bc	25.86 bc	26.32 c	49.70
$LSD(\%)_{(0.01)}$	3.196	3.054	1.334	1.850
Level of Significance	**	**	**	
CV(%)	7.11	6.57	2.76	

In a column means having similar letter(s) is identical and those having dissimilar letter(s) differ significantly as per 0.01% level of probability.

Legend:

T_0 = Untreated (Control)

T_1 = Rhizome treatment and spraying in the root zone with Bavistin 50WP

T_2 = Rhizome treatment and spraying in the root zone with Ridomil Gold MZ-72

T_3 = Rhizome treatment and spraying in the root zone with Dithane M-45

T_4 = Rhizome treatment and spraying in the root zone with Sulcox

T_5 = Rhizome treatment and spraying in the root zone with neem leaf extracts

T_6 = Rhizome treatment and spraying in the root zone with alamanda leaf extracts

T_7 = Soil application with Poultry waste

T_8= Soil application with Saw dust

T_9= Rhizome treatment and soil application with spore suspention of *Trichoderma harziamum*

Plate 6. Control plot showing severely affected by rhizome rot of ginger

Plate 7. A ginger plant hill showing infection in the root zone

Plate 8. A severely infected ginger plant showing below ground rotten ginger

Plate 9. Healthy ginger plot where soil was amended with poultry waste

Effect of different treatments on yield and yield contributing characters

Different yield contributing characters like percentage of healthy tillers per plot, percentage of diseased tillers per plot, average plant height per plot, weight of healthy rhizome per plot, weight of infected rhizome per plot and yield of rhizome were recorded against rhizome rot of ginger in responseto different treatments (Table 5). The performance of the treatments against rhizome rot of ginger in respect of different parameters varied significantly. The highest percentage of healthy tillers per plot (81.91%) was noted in case of treatment T_7 and that was statistically similar with T_8, T_5, T_2 and T_1 . The performance of T_9, T_3, T_6, T_4 were statistically similar and significantly indifferent with T_0 (untreated control).

The lowest percentage of diseased tillers per plot was noted in case of reatment T_7 (18.09 .which is statistically similar with T_8 (24.20 %), T_5 (24.22 %) T_1(25.16 %) and T_2(26.66 %). The effect of treatment T_9 (28.45%), T_3 (29.21 %), T_6 (30.11 %) T_4 (30.41 %) were statistically similar and their performance were significantly indifferent with T_0 (53.48%).

In case of average height of the plant, significantly the highest height (51.11 cm) was recorded in T_1 which was statistically identical with T_7 (50.89cm) and T_9 (50.85 cm). The second highest height(50.45 cm) was recorded in case of treatment T_5 which was statistically identical with T_2 (50.38 cm) followed by T_3 (49.18 cm). The lowest average plant height (29.36cm) was recorded in untreated control treatment preceded by T_8 (47.79 cm), T_6 (47.77 cm), T_4 (47.39 cm) but their performances regarding plant height were significantly indifferent among themselves.

In case of healthy rhizome, significantly the highest weight (2520.00 g) of the healthy rhizome was recorded in T_7. The second highest weight (1672.50g) of rhizome was recorded T_9 which was statistically identical with T_2 (1529.25 g), T_1 (1491.43 g), T_5 (1375.79 g), T_8 (1346.80 g) ,T_6 (1325.73 g) and T_3 (1325.67g). The lowest weight (491.9g) of the healthy rhizome was recorded in untreated control treatment preceded by T_4 (1167.00 g).

In case of infected rhizome, significantly the highest weight (608.8 g) was recorded in untreated control treatment preceded by T_9 (601.0 g) T_5 (563.5 g), T_6 (555.9 g), T_1 (540.0 g) and T_3 (518.2 g). These treatments were statistically identical to T_4. The lowest weight (307.3g) of infected rhizome was recorded in T_8 (465.8 g) followed by T_2 (481.3 g) and T_7 (484.6g).

The highest yield (14.38 t/ha) was recorded in T_7 and that was 50.33% increased over untreated control. The second highest yield (11.96 t/ha) was noted in T_9 and that was 40.28% increased over the untreated control. Among the fungicides, the highest yield was recorded in Bavistin 50WP (11.28 t/ha) followed by Ridomil Gold (11.17 t/ha),Dithane M-45 (10.24 t/ha) and Sulcox (9.227 t/ha). Among the plant extracts, the highest yield was recorded in case of neem leaf extract (10.77 t/ha) followed by alamanda leaf extract (10.45 t/ha). Among the soil amendment Poultry waste showed remarkable performance then Saw dust. The lowest yield (7.143 t/ha) was recorded in case of untreated control.

Table 5. Effect of different treatment on yield and yield contributing character of ginger

Treatmant	% healthy tiller/plot	% Diseased tiller/plot	Plant height (cm)	Weight of healthy Rhizome/ plot (gm)	Weight of infected Rhizome/plot (gm)	Yield (t/ha)
T_0	46.52 c	53.48 a	29.36 d	491.9 d	608.8 a	7.143 e
T_1	74.84 ab	25.16 bc	51.11 a	1529.25 bc	481.3 c	11.17 bc (+36.05%)
T_2	73.34 ab	26.66 bc	50.38 ab	1491.43 bc	540.0 abc	11.28 bc (+36.68%)
T_3	70.79 b	29.21 b	49.18 b	1325.67 bc	518.2 abc	10.24 cd (+30.24%)
T_4	69.59 b	30.41 b	47.39 c	1167.00 c	494.3 bc	9.227 d (+22.59%)
T_5	75.78 ab	24.22 bc	50.45 ab	1375.79 bc	563.5 abc	10.77 c (+33.68%)
T_6	69.89 b	30.11 b	47.77 c	1325.73 bc	555.9 abc	10.45 c (+31.65%)
T_7	81.91 a	18.09 c	50.89 a	2520.00 a	484.6 c	14.38 a (+50.33%)
T_8	75.80 ab	24.20 bc	47.79 c	1346.80 bc	465.8 c	10.07 cd (+29.07%)
T_9	71.55 b	28.45 b	50.85 a	1672.50 b	601.0 ab	11.96 b (+40.28%)
LSD(%)$_{(0.01)}$	8.630	8.630	1.340	333.9	98.69	1.086
Level of Significance	**	**	**	**	**	**
CV(%)	7.09	17.35	1.64	13.66	10.83	5.94

In a column means having similar letter(s) is identical and those having dissimilar letter(s) differ significantly as per 0.01% level of probability.

Legend:

T_0 = Untreated (Control)

T_1 = Rhizome treatment and spraying in the root zone with Bavistin 50WP

T_2 = Rhizome treatment and spraying in the root zone with Ridomil Gold MZ-72

T_3 = Rhizome treatment and spraying in the root zone with Dithane M-45

T_4 = Rhizome treatment and spraying in the root zone with Sulcox

T_5 = Rhizome treatment and spraying in the root zone with neem leaf extracts

T_6 = Rhizome treatment and spraying in the root zone with alamanda leaf extracts

T_7 = Soil application with Poultry waste

T_8= Soil application with Saw dust

T_9= Rhizome treatment and soil application with spore suspention of *Trichoderma harzianum*

Chapter 5
Discussion

CHAPTER V
DISCUSSION

The *in-vitro* assay of selected fungicides, plant extract and bio-agent *(Trichoderma harzianum)* against *Fusarium oxysporum* has been conducted in cup method and disc method. In cup method, Bavistin 50 WP resulted the highest inhibition of *Fusarium oxysporum* mycelia growth. Another two fungicides viz. Ridomil Gold MZ-72 and Dithane M-45 was performed statistically similar inhibitory action against *Fusarium oxysporum.* The another treatments used in the experiment showed higher inhibitory effect against *Fusarium oxysporum* than untreated control. In disc method, Bavistin 50WP showed the highest inhibition zone followed by Ridomil Gold MZ-72. Among the botanicals, the effect of neem leaf extract was found better than the alamanda leaf extract. Alamanda leaf extract was made statistically similar inhibition zone with Sulcox fungicide and *Trichoderma harzianum.* The findings of the present study corroborates with the findings of Choe *et al.* (1996). In a similar type of study they reported that Metalaxyl (Ridomil Gold) completely inhibited the mycelial growth of *Fusarium oxysporuin* in *in-vitro* condition. The result also closely matched with the report of the Ramachandran *et al.* (1989) whose were found that Ridomil Gold gave best control against *Fusarium solani* and *Pythium sp.* Ridomil Gold (Metalxyl formulation) was found effective in inhibition of *Fusarium solani* and *Pythium sp.* (Chauhan *et. al.,* 1990). Bharadwaj and Gupta (1987) observed in *in-vitro* tests using *T. viride, T. harzianum* and *T. hamatum* against *P. aphanidermatum, F. equiseti* and *F. solani* and found that these antagonists were inhibitory to the pathogens. Dohroo and Sharma (1983) described that *Trichoderma* inhibited growth of *Fusarium oxysporum f. sp. zingiberi* in-vitro by 73 percent. In Bangladesh many researchers worked with Bavistin 50 WP, Ridomil Gold MZ-72, Dithane M-45, neem leaf extracts and alamanda leaf extract to inhibit the mycelial growth of *Fusarium oxysporum* in *in-vitro* condition and found promising result (Bhuyan, 2010).

The incidence of rhizome rot of ginger in response to different treatments were recorded at different days after planting starting from 30 DAP to 240 DAP with 30 days interval. At 30 DAP, the lowest disease incidence (2.77 %) was recorded in case of poultry waste which was statistically indifferent with Bavistin 50 WP, Ridomil Gold

MZ-72, Dithane M-45, neem leaf extracts and alamanda leaf extracts except control. The similar result was found at 60 DAP. At 90 DAP, a remarkable performance of the treatments was observed in reducing the disease incidence in comparison to untreated control. The potential performance was recorded in case of Poultry waste and Ridomil Gold which was statistically similar with Dithane M-45. At 120 DAP, a remarkable performance of the treatments used in the experiment was observed in reducing the disease incidence in comparison to control (Table 3). At 150 DAP and 180 DAP the lowest disease incidence was recorded in case of Poultry waste which was statistically similar with rest of the treatments except control. At 210 DAP, the lowest disease incidence recorded from all treatments except untreated control was statistically similar. On the other hand the highest. disease incidence was recorded in untreated control treatment. At 240 DAP, when crop was in mature stage, the disease incidence of rhizome rot of ginger reached to the highest level in each case of the treatments applied. The highest disease incidence(63.89 %) was recorded in case of control treatment while the lowest disease incidence (30.55 %) was recorded in case poultry waste which was statistically similar with rest of the treatments except control. The findings of the present study corroborates with the findings of Bhuyan (2010) and Dataram (1988). Bhuyan (2010) reported that poultry waste was found potential for controlling rhizome rot of ginger. Dataram (1988) reported that the incidence of rhizome rot was low when *T. viride* was applied to soil along with wood saw dust. . The result also closely matched with the report of the Thakore (1988) who found that Neem oilcake as well as other oilcakes has also been shown to reduce ginger rhizome rot caused by *P. aphanidermatum* and *F. solani.* A similar type of study was found by Shanmugam *et al.* (1999).They conducted experiment on different biocontrol and chemicals as both seed treatment and soil application. The results revealed that *T. harzianium* applied as seed treatment and soil application was equally effective to COC in inducing germination and reducing percent rhizome rot incidence. The findings of the present study are supported by Thakore *et al.* (1988) who found that Bavistin 50 WP, Dithane M-45, Capatafol, Ziride, Captan and Metalaxyl reduced the disease incidence of rhizome rot of ginger. These findings also corroborates with the findings of Jayasekhar *et al.* (2000), Balakrishnan *et al.* (2000), Kusum *et al.* (2002), Singh and Awasthi *(2004),* Meena and Mathur (2005) and Anon (2005).

The severity of rhizome rot of ginger in response to different treatments were recorded at 80 DAP, 160 DAP, 240 DAP. All treatments reduced the disease severity of rhizome rot of ginger over untreated control. The lowest disease severity was recorded in case of Poultry waste. Based on disease severity data recorded on 240 DAP, the highest reduction was 61.25 % . The another three fungicides viz. Bavistin 50 WP, Ridomil Gold MZ-72 and Dithane M-45 were statistically similar to reduce the disease severity of rhizome rot of ginger. Neem leaf extract showed statistically similar result with alamanda leaf extracts, *Trichoderma harzianum*, saw dust and Sulcox. These findings corroborates with the findings of Dohroo and Sharma (1984) who stated that rhizome rot of ginger caused by *Fusarium* were control by *Trichoderma viride* and reduced by 80%. The result also closely matched with the report of the Ambia (2006) where the lowest disease incidence and disease severity of rhizome rot of ginger was found in case of application of *Trichoderma harzianum* and neem leaf extract at different days after planting and those treatments resulted maximum yield of rhizome. The result also closely matched with the report of the Karuppiyan *et al.*(2007) where soil application of bio-control agents like T. *harzianum* and *P. fluorescence* during planting time a 2-5% gave effective control of the diseases. The findings of the present study also supported by Sadanandan and Iyer (1986) who stated that, Neem oilcake @ 2MT/ha gave reduction of rhizome rot. These findings also corroborates with the findings of Rana and Sharma (1993) who were reported that, Seed treatment with Bavistin, Ridomil was most effective followed by Dithane M-45. Bhuyan (2010), reported that severity of rhizome rot of ginger was potentially controlled by poultry waste.

The performance of the treatments in respect of yield and yield contributing characters against rhizome rot of ginger varied significantly. In this study, application of poultry waste was effectively suppressed the incidence and severity rhizome rot disease. The plants produced highest number of tillers on poultry waste applied plot. Moreover, statistically similar result was also found on Bavistin 50 WP, Ridomil Gold MZ-72, neem leaf extracts and saw dust applied plot. The similar result was also found in term of other yield contributing characters viz. plant height and weight of healthy rhizome per plot. Alternatively, the lowest diseased tillers/plot and weight of infected rhizome/plot was observed from poultry waste applied plot which was closely followed by Bavistin 50 WP, Ridomil Gold MZ-72 and neem leaf extracts. In case of yield of rhizome, the yield performance of the plants on different treatments were differed remarkably. The plants generated highest rhizome yield in plot where soil was amended with poultry waste. Moreover, the yield recorded in poultry waste applied plot was 50.33% increased over untreated control. The other treatments also showed statistically higher yield compared to untreated control. Among the treatments Bavistin 50 WP and Ridomil Gold MZ-72 was efficiently suppress the pathogen and increased the yield of ginger. The present findings of the experiment regarding the reduction of disease severity of rhizome rot of ginger and improving the yield attributing characters and yield were supported by the previous reports. . Sharma *et. al.* (1978) while working with the systemic and contact fungicides against rhizome rot of ginger reported that Bavistin 50 WP was the best fungicide in controlling rhizome rot of ginger. Rathaiah (1987) showed that Ridomil resulted better in controlling disease and significantly increase the yield of rhizome. Rhizome treated with Bavistin 50 WP or Dithane M-45 with formaldehyde gave satisfactory control of the rhizome rot disease of ginger (Raj *et.al.,* 1989). Anon (2005) observed in integrated management of ginger against *Pythium, Fusarium* and *Ralstonia,* the results indicated that Mancozeb, seed solarization and hot water treatments of ginger rhizomes were effective in increasing the emergence and yield of ginger Kusum *et. al.* (2002) carried out an experiment by using Ridomil MZ resulted most effective treatment in reducing the disease severity and increased the number of tillering. Anandaraj and Sharma, (2003) developed an integrated disease management approach by using selective mixture of fungicides with *Trichoderma harzianum* for soil treatment. In field condition, application of Ridomil MZ resulted in the highest seed germination and yield (Singh and Awasthi,2004). Sadanandan and Iyer (1986) stated that, Neem oilcake @ 2MT/ha increased yield by 1.78MT/ha. Meena and Mathur, (2005) worked on both bio-control agent and fungicides and showed that rhizomes were treated with fungicides followed by the soil application of bio-agents resulted suppression of the disease and increasing the yield. Usman *et. al.* (2006) reported that *Trichoderma harzianum* was very effective in controlling the disease. . These findings also supported by Ram *et al.* (1999) , Thakore *et al.* (1988), Balakrishnan *et al.* (2000), Ambia (2006) and Bhuyan (2010).

Chapter 6

Summary and Conclusion

CHAPTER VI

SUMMARY AND CONCLUSION

In-vitro and *In vivo* experiment were conducted in the Plant Pathology laboratory and farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2011 to February 2012 to determine the effective management component of rhizome rot of ginger using selected fungicides, bio-agent, organic soil amendment and plant extracts against the pathogen. The experiment was laid out in the single factors RCBD (Randomized Complete Block Design) with three replications. In lab experiment, cup method and disc method were used. In cup method, the highest inhibition (86.33%) was found in case of Bavistin 50 WP followed by Ridomil Gold MZ72, Dithane M-45, *Trichoderma harzianum* , alamanda leaf extracts, neem leaf extracts and sulcox. In disc method, Bavistin 50WP showed highest inhibition zone (5.53cm) followed by Ridomil Gold MZ-72. Among the botanicals, the effect of neem leaf extract was found better than the alamanda leaf extract. Alamanda leaf extract was made statistically similar inhibition zone with sulcox fungicide and *Trichoderma harzianum* In *in-vivo* assay the lowest disease incidence (27.78%) was recorded in case of Ridomil Gold applied plot which was statistically similar with the plots which were applied with poultry waste, Bavistin 50WP, Dithane M- and saw dust at 240 DAP while the highest disease incidence (63.89%)was recorded in untreated control plot. All the treatments effect was found statistically significant in comparison to untreated control plot. The lowest severity (20.28 %) at 240 DAP was recorded in case of Poultry waste followed by Bavistin 50 WP, Ridomil Gold and Dithane M-45 The highest severity (52.33 %) was recorded in untreated control plot. Saw dust, sulcox fungicide, *Trichoderma harzianum* and neem leaf extracts showed lower performance but they were statistically higher than the untreated control. The plants produced highest number of tillers(75.80%) on poultry waste applied plot. Moreover, statistically similar result was also found on Bavistin 50 WP, Ridomil Gold MZ-72, neem leaf extracts and saw dust applied plot. The similar result was also found in term of other yield contributing characters viz. plant height and weight of healthy rhizome per plot. Alternatively, the lowest diseased tillers/plot(18.09%) and weight of infected rhizome/plot(484.6 g) was observed from poultry waste applied plot which was closely followed by Bavistin 50 WP, Ridomil

Gold MZ-72 and neem leaf extracts. In case of yield of rhizome, the yield performance of the plants on different treatments were differed remarkably. The plants generated highest rhizome yield in plot (14.38 t/ha) where soil was amended with poultry waste. Moreover, the yield recorded in poultry waste applied plot was 50.33% increased over untreated control. The other treatments also showed statistically higher yield compared to untreated control. Among the treatments Bavistin 50 WP and Ridomil Gold MZ-72 was efficiently suppress the pathogen and increased the yield of ginger. Condidering the overall results, use of Poultry waste, *Trichoderma harzianum* , Neem leaf extract , Alamanda leaf extract or saw dust might be recommended as eco-friendly approach for the management of rhizome rot of ginger. Among the fungicides Bavistin 50WP and Ridomil Gold MZ-72 are promising fungicide. However, further investigation is needed to justify the present findings in different Agro Ecological Zone (AEZ) in the country for consecutive year.

Chapter 7

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CHAPTER VII

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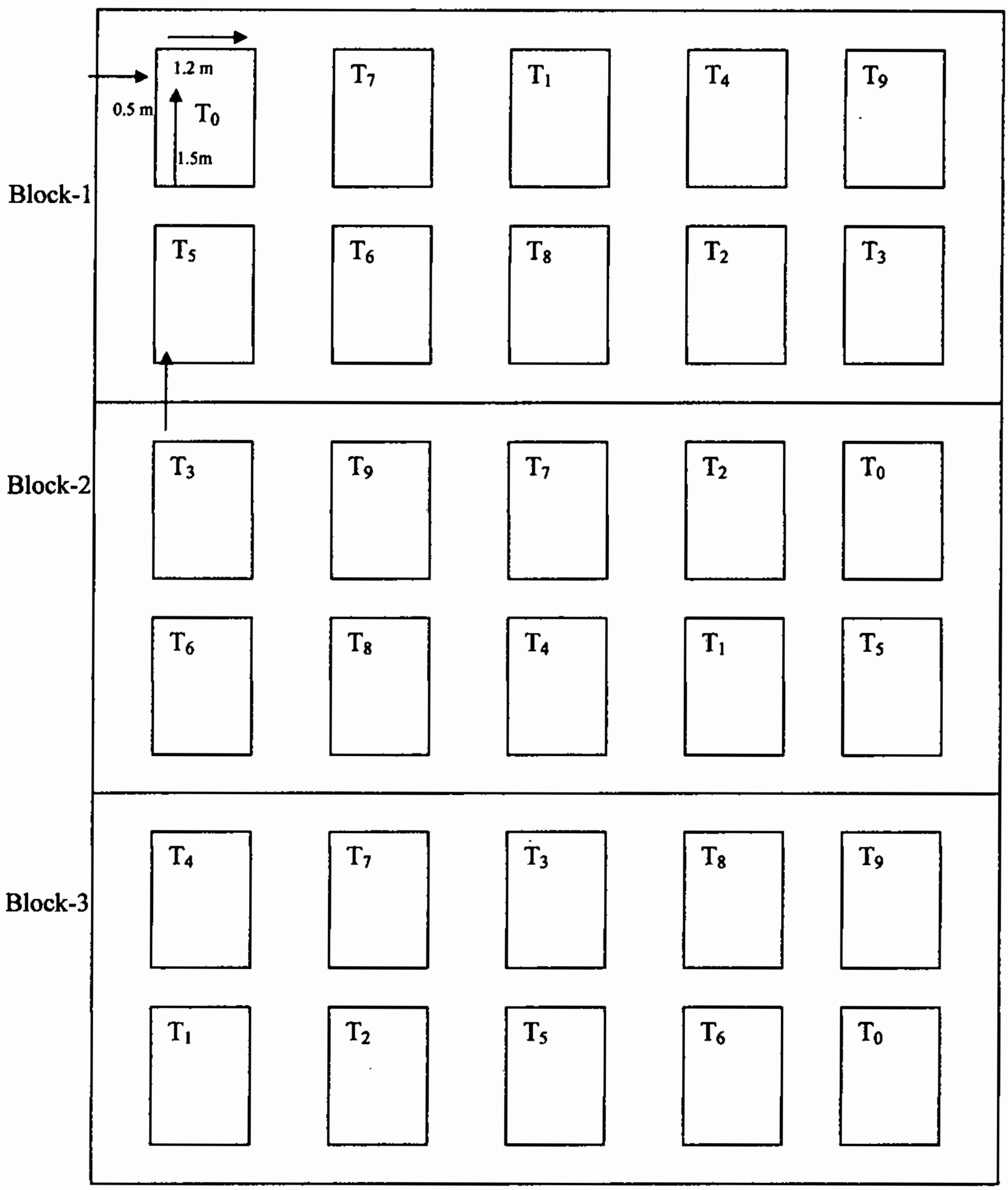
Appendices

Appendix I. Layout of the experimental field .

Unit Plot : (1.2m × 1.5m) , Distance :Plot to Plot : 0.5 m, Block to Block : 1.0 m



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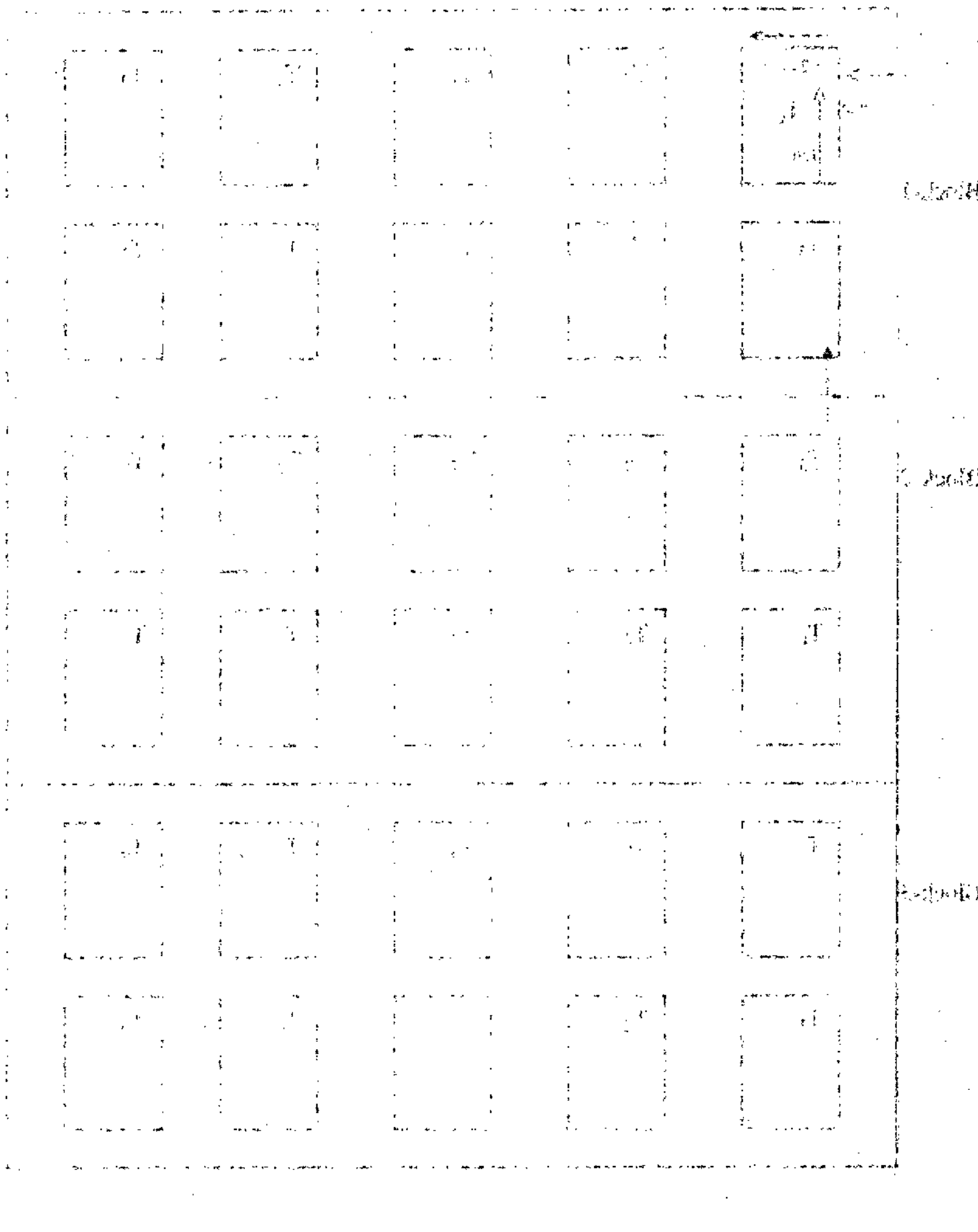

Appendix II. Results of mechanical and chemical analysis of soil of the experimental Field.

A. Mechanical analysis

Constituents	Percent (%)
Sand	33.45
Silt	60.25
Clay	6.25
Textural class	Sill clay

B. Chemical analysis

Soil properties	Amount
Soil $_pH$	6.12
Organic Carbon	1.32
Toyal nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (&)	0.2

Appendix III. Analysis of variance of the data on in -vitro assay of radial growth of mycelium and % inhibition of mycelial growth in cup and disc method.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	0.01	0.004	1.64	0.2353
Treatment	6	138.89	23.149	8838.55	0.0000
Error	12	0.03	0.003		

Coefficient of Variation= 1.87%

Significant at 0.0 1% level of probability

Appendix IV. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 30 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	0.01	0.004	1.64	0.2353
Treatment	9	138.89	23.149	8838.55	0.0000
Error	18	0.03	0.003		
Total	29	1194.356			

Coefficient of Variation= 96.87%
Significant at 0.0 5% level of probability

Appendix V. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 60 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	282.404	141.202	5.5458	0.0133
Treatment	9	437.617	48.624	1.9097	0.1160
Error	18	458.300	25.461		
Total	29	1178.320			

Coefficient of Variation= 62.65%
Significant at 0.0 5% level of probability

Appendix VI. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 90 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	166.667	83.333	2.6113	0.1010
Treatment	9	731.719	81.302	2.5477	0.0436
Error	18	574.426	31.913		
Total	29	1472.811			

Coefficient of Variation= 42.37%
Significant at 0.0 5% level of probability

Appendix VII. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 120 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	222.311	111.156	2.3738	0.1216
Treatment	9	1067.187	118.576	2.5323	0.0446
Error	18	842.874	46.826		
Total	29	2132.373			

Coefficient of Variation= 39.10%
Significant at 0.0 5% level of probability

Appendix VIII. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 150 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	351.726	175.863	4.4396	0.0271
Treatment	9	1398.241	155.360	3.9221	0.0066
Error	18	713.015	39.612		
Total	29				

Coefficient of Variation= 30.62%
Significant at 0.0 5% level of probability

Appendix IX. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 180 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	365.520	182.760	6.4048	0.0079
Treatment	9	1888.844	209.872	7.3549	0.0002
Error	18	513.628	28.535		
Total	29	2767.993			

Coefficient of Variation= 21.85%
Significant at 0.0 5% level of probability

Appendix X. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 210 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	541.467	270.733	6.8806	0.0060
Treatment	9	2131.800	236.867	6.0199	0.0006
Error	18	708.256	39.348		
Total	29				

Coefficient of Variation= 19.30%
Significant at 0.0 5% level of probability

Appendix XI. Analysis of variance of the data on the disease incidence of rhizome rot of ginger at 240 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	782.520	391.260	6.8822	0.0060
Treatment	9	2706.337	300.704	5.2894	0.0013
Error	18	1023.313	56.851		
Total	29	4512.170			

Coefficient of Variation= 19.53%
Significant at 0.0 5% level of probability

Appendix XII. Analysis of variance of the data on the disease severity of rhizome rot of ginger at 80 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	7.540	3.770	1.0860	0.3587
Treatment	9	1389.233	154.359	44.4635	0.0000
Error	18	62.489	3.472		
Total	29				

Coefficient of Variation= 7.11%
Significant at 0.0 5% level of probability

Appendix XIII. Analysis of variance of the data on the disease severity of rhizome rot of ginger at 160 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	14.610	7.305	2.3048	0.1285
Treatment	9	1672.266	185.807	58.6241	0.0000
Error	18	57.050	3.169		
Total	29	1743.926			

Coefficient of Variation= 6.57%
Significant at 0.0 5% level of probability

Appendix XIV. A nalysis of variance of the data on the disease severity of rhizome ror of ginger at 240 DAP (Days After Planting) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	4.420	2.210	3.6539	0.0466
Treatment	9	2212.475	245.831	406.4352	0.0000
Error	18	10.887	0.605		
Total	29				

Coefficient of Variation= 2.76%
Significant at 0.0 5% level of probability

Appendix XV. A nalysis of variance of the data on percentage healthy tillers per plot of ginger at in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	56.487	28.243	1.1160	0.3492
Treatment	9	2363.482	262.609	10.3764	0.0000
Error	18	455.549	25.308		
Total	29	2875.518			

Coefficient of Variation= 17.35%
Significant at 0.0 5% level of probability

Appendix XVI. Analysis of variance of the data on number of average height of ginger plant in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	0.061	0.030	0.0497	0.0000
Treatment	9	1154.476	128.275	210.4495	0.0000
Error	18	10.972	0.610		
Total	29	1165.508			

Coefficient of Variation= 1.64%
Significant at 0.0 5% level of probability

Appendix XVII. Analysis of variance of the data on weight of healthy rhizome per plot in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	164165.06	82082.532	2.1663	0.1436
Treatment	9	6723177.9	747019.77	19.7150	0.0000
Error	18	682038.07	37891.004		
Total	29	7569381.07			

Coefficient of Variation= 13.66%
Significant at 0.0 5% level of probability

Appendix XVIII. Analysis of variance of the data on weight of diseased rhizome per plot in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	751.432	375.71	0.1135	
Treatment	9	69261.5	7695.7	2.3251	0.0610
Error	18	59577.8	3309.8		
Total	29	129590.878			

Coefficient of Variation= 10.83%
Significant at 0.0 5% level of probability

Appendix XIX. Analyses of variance of the data on percentage rhizome rot per plot of ginger at in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	4.036	2.018	0.5176	0.0000
Treatment	9	3659.360	406.596	104.298	
Error	18	70.171	3.898		
Total	29				

Coefficient of Variation= 6.53%
Significant at 0.0 5% level of probability

Appendix XX. Analysis of variance of the data on yield of rhizome (t/ha) in response to different treatments.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Replication	2	1.935	0.968	2.4105	0.1181
Treatment	9	93.624	10.403	25.9115	0.0000
Error	18	7.226	0.401		
Total	29	102.786			

Coefficient of Variation= 5.94%
Significant at 0.0 5% level of probability

Appendix XXI. List of symbol and abbreviations

%	=	Percentage
et. al.	=	and others
Spp.	=	Species
No.	=	Number
viz.	=	Namely
df.	=	Degrees of freedom
@	=	At the rate of
etc	=	Etcetera
PDA	=	Potato Dextrose Agar media
°C	=	Degree Celsius
Cm	=	Centimeter
J.	=	Journal
BBS	=	Bangladesh Bureau of Statistics
RH	=	Relative Humidity
ANOVA	=	Analysis of variances
CV%	=	Percentages of Co-efficient of Variance
LSD	=	Least Significant Difference
Sci.	=	Science
BBS	=	Bangladesh Bureau of Statistics
DI	=	Disease Incidence
DS	=	Disease Severity
DAP	=	Days After Planting