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Effect of chemicals, bio-agent plants extract and soil amendments in controlling rhizome rot of ginger

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ABSTRACT

The study was carried out to evaluate the efficacy of Bavistin 50WP (T1), Ridomil gold MZ72 (T2), Dithane M-45 (T3), Sulcox (T4), neem leaf extracts (T5), alamonda leaf extracts (T6), poultry waste (T7), saw dust (T8), *Trichoderma harzianum* (T9) and untreated control for controlling rhizome rot of ginger caused by *Fusarium oxysporum*. 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 (81.91%) 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 performances 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. It can be said that poultry waste as soil amendment, neem or alamonda leaves as plant extracts, *Trichoderma harzianum* as bio agent and Bavistin 50WP or Ridomil gold MZ72 as fungicide could be used for effective control of rhizome rot of ginger.

Key words: rhizome rot, bio-agent, neem, alamonda, fungicide

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INTRODUCTION

Ginger (*Zingiber officinale Rose*.) is an important commercial spices crop in tropical and subtropical

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countries including Bangladesh (Ambia, 2006; Rahim, 1992). The useful parts of this crop are the rhizomes (Purseglove et al., 1988). It is used worldwide as spices for flavouring in a number of foods and food-products and also used in medicines (Lawrence, 1984). 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). The fungus *Fusarium oxysporum* and *Pythium aphanidermatum* are associated with it causation (Ram et al., 1999). The infected rhizomes become rotten and the crop is completely destroyed (Baruah et al., 1998). However, 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 there is 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. Furthermore, the problem has got urgent attention. Considering the above circumstances, present investigation has been undertaken to evaluate the effect of chemicals, bio-agent, plant extracts and soil amendments against the diseases and find out the suitable management components for controlling rhizome rot of ginger in Bangladesh.

MATERIALS AND METHODS

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period of July 2010 to March 2011.

Land preparation

The field plots was prepared and fertilized with urea @ 100kg/ha, Triple super phosphate (TSP) & 170kg/ha, Muriate of potash (MP) @ 160kg/ha, Gypsum ($ZnS0_4$) @ 110 kg/ha,Zno@ 2kg/ha and cowdung @ 5 ton/ha.

Planting material

The seed of rhizome of ginger was collected from spices research center, Bogra, Bangladesh. Randomized Complete Block Design (RCBD) was used for field experiments. Each block was divided into 10 plots. Plot size was 1.2m X 1.5m. Weeding, thinning and irrigation were done as and when necessary. Ektara was applied to control insects.

Collection of plant materials

Fresh and healthy leaves of two plants viz., *Azadirachta indica* (neem) and *Alamonda* were collected from the University campus; leaves were washed thoroughly with detergent to remove any dust. Washed leaves were dried in an electric oven at 30^{o}C for 72 hours and crushed to make powder. For preparation of aqueous extract of each plant 20 grams of dried leaf powder was soaked in 100 ml of sterilized distilled water for 24 hours. Extract was filtered through a double layered muslin cloth followed by Whatman No. 1 filter paper and used in the further experiment immediately. Different concentrations of aquous extract were prepared at the day of experiments.

Seed treatment

Seed treatments were done by dip the rhizomes seeds in different chemicals, plant extracts and in the bio-agent for 30 minutes. Treatments were assessed in the experiment as follows:

T_0 = Untreated (control)
T_1 = Bavistin 50WP
T_2 = Ridomil Gold MZ-72
T_3 = Dithane M-45
T_4 = Sulcox
T_5 = Neem leaf extracts
T_6 = Alamanda leaf extracts
T_7 = Soil application with poultry waste
T_8 = Soil application with saw dust
T_9= *Trichoderma harzianum*

***In vitro* antifungal assay**

Antifungal activity of plant extracts, bio-agent and chemical treatments was carried using cup-plate agar diffusion method (Murray et al. 2009, Igbinosa et al., 2009) and disc diffusion method (Abdel-Wahab et al. 2009, Rios et al., 1988). The *in vitro* test was conducted to determine effectiveness of the treatments on radial mycelial growth of *Fusarium oxysporum*. For the laboratory experiment the plates were arranged on the laboratory desk following Complete Randomized Design (CRD) with 3 replications.

Isolation and identification of pathogen

Ginger rhizome rot was collected for sampling. Diseased rhizome surface was sterilized with $HgCl_2$ (1:1000) for 1 min. Then the samples were washed in sterile water thrice and placed onto acidified PDA in petridish. The plates containing samples were placed at room temperature for seven days. When the fungus grew well, and sporulated, then the slide was prepared from the PDA and was identified under microscope with the help of relevant literature.

Cup method for the bioassay of different treatments against *Fusarium oxysporum*

From a PDA plate three 5.0 mm discs of the medium were scooped from three places maintaining an equal distance from the centre by a sterilized disc cutter. One milliliter of treatment solution was put into each hole and the plates were stored overnight in refrigerator for diffusion of the input in the medium around the hole before resumption of fungal growth. The next day, one 5 mm culture block of *Fusarium oxysporum* was cut and placed at the centre of the treated PDA plate. Each treatment was replicated 3 times. For control treatment, only sterile water was used instead of any treatment. The plates were then placed at 25±1°C for 15 days. The linear growth (cm) of mycelium of *Fusarium oxysporum* was recorded at 3 days interval until the control plates were filled.

Disc method for evaluation of treatment efficacy on mycelial growth of *Fusarium oxysporum*

In filter paper disc method we used 15 mm diameter filter paper discs and soaked them in methanol extract of plants then put disc at the centre of 9 cm diameter petri dishes which had PDA medium culture and then 5 mm diameter mycelial disc of the pathogen was placed at the centre of filter paper disc and put petri dishes in incubator with 25 C. The PDA medium with filter paper soaked in distilled water served as control. Three replications were maintained. The colony diameter of pathogen was measured after 72h of incubation.

Collection of data

Data was collected as % of hill infection, % of leaf infection, disease severity and yield of rhizome. The % leaf infection and PDI were calculated as follows-

$$\%\text{ leaf infection} = \frac{\text{No of infected leaf}}{\text{No of total infected leaf}} X\, 100$$

$$\%\text{ PDI} = \frac{\text{Sum of total ratting/grading}}{\text{Total no of observation} \times \text{Highest grade in scale}}$$

RESULTS AND DISCUSSION

In vitro assay

The effect of selected fungicides, plant extracts and bio-agent *(Trichoderma harzianum)* against *Fusarium oxysporum* has been presented in table 1. 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* differed 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 followed by Ridomil gold MZ-72 (83.77%). The effect of neem leaf extract and alamanda leaf extract also found significantly similar in inhibition of radial growth of *Fusarium oxysporum.* 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). 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).

Incidence of rhizome rots of ginger in response to different treatment against *Fusarium oxysporum* recorded at different days after planting (DAP) is presented in table 2. 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 30 DAP 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 2.). The performance of the treatments at 240 DAP against rhizome rot of ginger were found significant in comparison to untreated control (table 2). 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 effects were found statistically significant in comparison to untreated control.

Effect of different treatments on the severity of rhizome rot of ginger

The severity of rhizome rot of ginger in response to different treatments was presented in table 3. At the end of the experiment (240 DAP), the lowest severity (20.28 %) was recorded in T_7 followed by T_2 (21.80 %). 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 1
In vitro effect of different treatments against *Fusarium oxysporum*

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 (-77.7) b	3.36 d
T_9= *Trichoderma harzianum*	1.73 (81.11) c	3.26 d
T_0= Control	9.00 a	0.00 c

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.

Table 2
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	13.89 ab	19.45 ab	22.22 ab	25.00 b	27.78 b	38.89 b	41.67 b
T_5	2.777 b	5.553 b	11.11 bc	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

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.

Table 3
Disease severity of rhizome rot of ginger at different DAP

Treatment	% Disease Severity			Reduction of diseases severity as on 240 DAP (%)
	80DAP	160DAP	240DAP	
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

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.

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 4). 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 treatment 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%).

The highest average height (51.11 cm) of the plant was found 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.

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 (1529.25g), T_1 (1491.43g), T_5 (1375.79g), T_8 (1346.80g), T_6 (1325.73g) 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).

Among the treatment group the highest weight (601.0 g) was recorded in T_9 followed by T_5 (563.5 g), T_6 (555.9 g), T_1 (540.0g) and T_3 (518.2g). The lowest weight (307.3g) of infected rhizome was recorded in T_8 (465.8g) followed by T_2 (481.3g) 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.

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.* 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 whose effect is almost similar with Sulcox fungicide and *Trichoderma harzianum.*

Table 4
Effect of different treatment on yield and yield contributing character of ginger

Treatment	% 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%)

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.

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) where 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 *Trichoderma viride, Trichoderma harzianum* and *Trichoderma harzianum* against *Pythium aphanidermatum, Fusarium equiseti* and *Fusarium 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).

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 *Trichoderma 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 *Pythium aphanidermatum* and *Fusarium solani*. A similar type of study was found by Shanmugam *et al.* (1999). They conducted experiment on different bio-control 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 we*re 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 *Trichoderma harzianum* and *Pseudomonas fluorescens* 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).

Considering 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.

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