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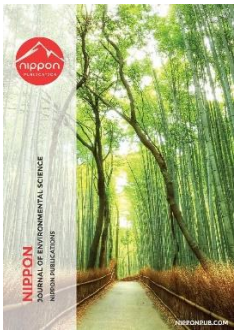

Full Length Research Paper

Integrated Management of Rhizome Rot Disease of Ginger

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Abstract. The experiment was conducted in infected sick plot with rhizome rot disease at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during 2018-19 to find the effective control measures of rhizome rot through an integrated management. Eight integrated treatments including control were used in this experiment. The test variety was used BARI Ada 2. The highest germination (97.83%) was recorded in Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP and the lowest germinaition (90.95%) was recorded from untreated control. Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP resulted the lowest Rhizome rot incidence (15.45%) and control treatment showed the highest Rhizome rot incidence (45.88%). Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP showed the highest yield (28.15 t/ha) and control treatment showed the lowest yield (9.95 t/ha).

Keyword : Ridomil gold, Bordeaux mixture, Management, Rhizome rot, Ginger.

1. INTRODUCTION

Ginger (*Zingiber officinale*) is one of the best cash as well as spice crop of most of the farmers of mid hills of SAARC nations including Bangladesh, Nepal, Bhutan and India. Ginger is popularly used as a spice in cooking and can be used as fresh, dried or powdered. The fresh rhizome can be used to extract ginger essential oil. Ginger may also be used to flavor beverages. More commonly, ginger has been traditionally used in disorders of the gastrointestinal tract, as a stomachic, laxative, sialogogue, gastric emptying enhancer, appetizer, antiemetic, antidyspepsic, antispasmodic, and antiulcer agent with sufficient scientific support. Similarly, ginger has been shown to exhibit anti-inflammatory, hypoglycemic, antimigraine, antioxidant, hepatoprotective, diuretic, hypocholesterolemic, and antihypertensive activities. Recently, ginger has gained wide attention for its therapeutic role as a safe and effective preventive treatment option for nausea and vomiting of pregnancy (Ali and Gilani, 2007)

But, the yield of ginger in Bangladesh is very low compared to other countries. Among several factors affecting ginger production, the rhizome rot or soft rot caused by *Pythium aphanidermatum*, *Fusarium oxysporum* f. sp *zingiberi*, *Fusarium solani*, Bacteria, Rhizome fly etc. are responsible for drastic yield reduction. The pathogens are both seed as well as soil borne in nature. Soft rot is also called rhizome rot or *Pythium* rot. The severity of rhizome rot in Nepal that the losses due to this disease were 25 and 24 percent in the field and storage, respectively (Nepali et al., 2000). *Pythium* sp, the causal pathogen for *Pythium* soft rot in ginger, is spread in soil, water and infected planting material (Smith and Abbas, 2011). The several factors affecting the ginger production, one of the prime factors is the soft root causes by few soil fungi like *Pythium* spp., *P. aphanidermatum*, *Fusarium solani* etc. These fungi attack ginger rhizome separately and sometimes together. The disease reduced 50% rhizome production (Anonymous, 2005). Rai (1995) reported that rhizome rot disease of ginger caused by fungi *Fusarium oxysporium* and *Pythium* sp. *Pythium* sp. usually appeared along with the bacterial wilt causing soft rot. *Fusarium* is invariably associated with nematode *Pratylenchus* and results in storage losses. Among the diseases, rhizome rot of ginger was the most devastating one caused by *Pythium aphanidermatum*, *Fusarium oxysporum*, *Sclerotium rolfsii* and *Ralstonia solanacearum* throughout the world (Chauhan and Patel, 1990). Several species of *Pythium* were reported to cause soft rot disease in different parts of the world. *Pythium* spp. are fungal-like microorganisms

belonging to the family Pythiaceae in the order Peronosporales of the phylum Oomycota, a member of the kingdom Stramenopila (Webster and Weber, 2007). The disease has been found to appear as pre-emergence or post-emergence rotting of rhizomes causing heavy losses even up to 92% in some local cultivars (Daiho and Upadhyay, 2004). There is no resistance source against rhizome rot of ginger and effective control measures in the world. Rhizome rot is difficult to control through single approach. From the above facts, this type of research has so no far been conducted in Bangladesh. So, integrated management with fungicides and bacteriocides may control the disease. Therefore, the present study was undertaken to find out the effective control measures of rhizome rot through an integrated management.

2. MATERIALS AND METHODS

The experiment was conducted in infected sick plot with rhizome rot disease at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh during 2018-19 to find the effective control measures of rhizome rot through an integrated management. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering to break the clods as well as level the soil. The weeds and stubbles of previous crops were collected and removed from the soil. Cowdung 5 t/ha, N @ 140 kg/ha, P @ 54 kg/ha, K @ 117 kg/ha, S @ 20 kg/ha and Zn 3 kg/ha were applied. The entire quantity of cowdung, P, S, Zn and half of K were applied during final land preparation. The rest K and N were applied with two equal splits at 80 and 110 DAP, respectively. The experiment was carried out following Randomized Complete Block Design with three replications. Size of the unit plots was 3.0 m × 1.5 m and plant spacing was 50 cm × 25 cm. BARI Ada-2 was used in the experiment. The integrated treatments were T_1 = Rhizome treatment and soil drenching with Ridomil gold (Metalaxyl + Mancozeb) @0.25%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP, T_2= T_1 + Apparently healthy looking fresh rhizome, T_3 = T_1 + Soil application with Stable bleaching powder (25 kg/ha) before 2 weeks of planting, T_4 = T_1 + Soil ammendment with Poultry refuse (3.5 t/ha), T_5= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Timsen TM (Analkalile dimithyle benzayil ammonium chloride) @0.1%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP, T_6= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP, T_7= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (Streptomycin Sulphate 9% + Tetracycline hydrochloride 1%) @0.1%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP and T_8 = untreated control.

Furadan 5G was applied in all treatment as recommended dose for rhizome fly control. Rhizomes of ginger were planted on April 25, 2018. Four weedings were done at 50, 95, 140 and 185 days after planting. Other intercultural operations were done to maintain the normal hygienic condition of crop in the field. The crop was harvest on February 14, 2019. Data was recorded on germination, rhizome rot, number of primary rhizomes/plant, weight of primary rhizomes/plant, number of secondary rhizomes/plant, weight of secondary rhizomes/ plant, plant height and yield. The recorded data were analyzed statistically to find out the level of significance and the variations among the respective data were compared following Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1. Effect of treatments on germination and rhizome rot of ginger

Results on the effect of treatments on germination and rhizome rot of ginger are presented in Table 1. The treatments showed significant effect on germination and rhizome rot incidence. The highest germination (97.83%) was recorded in T_6 (Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP) and the lowest germination (90.95%) was recorded in untreated control. T_6 also showed the the lowest Rhizome rot incidence (15.45%) which was statistically similar to T_7 (Rhizome treatment with Ridomil gold @0.25% + Soil drenching with Crossin AG 10 SP @0.1%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP), and control treatment showed the highest Rhizome rot incidence (45.88%). The highest plant survival (84.55%) and disease reduction over control (66.33%) were obtained from T_6, and the lowest plant survival (54.12%) and lowest disease reduction over control (32.76%) were obtained from untreated control, and T_1 (Rhizome treatment and soil drenching with Ridomil gold (Metalaxyl + Mancozeb) @0.25%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP), respectively.

Table 1. Effect of treatments on germination and rhizome rot of ginger

Treatments	Germination (%)	Rhizome rot (%)	Plant survival (%)	Disease reduction over control (%)
T_1 = Rhizome treatment and soil drenching with Ridomil gold (Metalaxyl + Mancozeb) @0.25%	94.09 ab	30.85 b	69.15	32.76
T_2= T_1 + Apparently healthy looking fresh rhizome	94.88 a	27.69 bc	72.31	39.65
T_3 = T_1 + Soil application with Stable bleaching powder (25 kg/ha)	96.56 a	20.33 ef	79.67	55.69
T_4 = T_1 + Soil ammendment with Poultry refuse (3.5 t/ha)	95.78 a	25.62 cd	74.38	44,16
T_5= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Timsen TM (0.1%)	95.87 a	22.49 de	77,51	50.98
T_6= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture	97.83 a	15.45 g	84.55	66.33
T_7= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (0.1%)	97.05 a	17.63 fg	82,37	61.57
T_8 = Untreated Control	90.95 b	45.88 a	54.12	-
CV (%)	8.29	7.81	-	-

In a column, similar letter(s) do not differ significantly at 5% level of probability.

3.2. Effect of treatments on primary and secondary rhizomes of ginger

Results on the effect of treatments on number and weight of primary and secondary rhizomes of ginger are presented in Table 2. The treatments showed significant effect on the number of secondary rhizomes per plant but not on the number of primary rhizomes per plant of ginger. The highest number (4.96) and weight (113.33 g) of primary branches was obtained from T_6 which was followed by T_7 and T_3 (T_1 + Soil application with Stable bleaching powder @25 kg/ha before two weeks of planting), and the lowest number (3.86) and weight (80.11 g) of primary rhizomes per plant was recorded in untreated control. T_6 showed the highest number (37.58) and weight (498.35 g) of secondary rhizomes per plant which was also followed by T_7 and T_3, and control treatment showed the lowest number (16.88) and weight (205.75 g) of secondary rhizomes per plant.

Table 2. Effect of treatments on primary and secondary rhizomes of ginger

Treatments	No. of primary rhizomes/plant	Wt. of primary rhizomes/plant (g)	No. of secondary rhizomes/ plant	Wt. of secondary rhizomes/ plant (g)
T_1 = Rhizome treatment and soil drenching with Ridomil gold (Metalaxyl + Mancozeb) @0.25%	4.20	87.45 f	23.05 e	301.36 f
T_2= T_1 + Apparently healthy looking fresh rhizome	4.33	90.86 ef	25.75 de	330.95 e
T_3 = T_1 + Soil application with Stable bleaching powder (25 kg/ha)	4.27	100.66 bc	32.49 b	405.85 c
T_4 = T_1 + Soil ammendment with Poultry refuse (3.5 t/ha)	4.07	94.17 de	28.11 cd	360.49 d
T_5= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Timsen TM (0.1%)	4.25	97.33 cd	30.67 bc	385.11 c
T_6= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture	4.96	113.33 a	37.58 a	498.35 a
T_7= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (0.1%)	4.50	104.2 b	34.33 ab	449.69 b
T_8 = Untreated Control	3.86	80.11 g	16.88 f	205.75 g
CV (%)	5.64	8.99	7.57	8.43

In a column, similar letter(s) do not differ significantly at 5% level of probability.

3.2. Effect of treatments on plant height and yield of ginger

Plant height and yield was significantly differed by the treatments (Table 3). The highest plant height (82.26 cm) was recorded in T_6 and the lowest plant height (68.65 cm) was recorded in untreated control. Yield was varied from 9.95 to 28.15 t/ha, while T_6 showed the highest yield which was statistically at par with T_7, and control treatment showed the lowest yield which was statistically dissimilar to other treatments. The highest yield increased over control (182.92%) was recorded in T_6 which was followed by T_7, and the lowest yield increased over control (89.39%) was recorded in T_1.

Table 3: Effect of treatments on plant height and yield of ginger

Treatments	**Plant height (cm)**	**Yield (t/ha)**	**Yield increased over control (%)**
T_1 = Rhizome treatment and soil drenching with Ridomil gold (0.25%)	70.45 cd	17.95 e	89.39
T_2= T_1 + Apparently healthy looking fresh rhizome	72.95 c	18.85 de	89.44
T_3 = T_1 + Soil application with Stable bleaching powder (25 kg/ha)	77.9 b	24.69 b	148.14
T_4 = T_1 + Soil ammendment with Poultry refuse (3.5 t/ha)	76.76 b	20.74 cd	108.44
T_5= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Timsen TM (0.1%)	77.13 b	22.45 c	125.63
T_6= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture	82.26 a	28.15 a	182.92
T_7= Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (0.1%)	78.53 b	26.55 ab	166.83
T_8 = Untreated Control	68.65 d	9.95 f	-
CV (%)	8.09	6.49	-

In a column, similar letter(s) do not differ significantly at 5% level of probability.

It was observed from the above study that treatments showed significant effect on germination and rhizome rot incidence. The highest germination was recorded in T_6 (Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP) and the lowest germination was recorded in untreated control. T_6 also showed the the lowest Rhizome rot incidence which was statistically similar to T_7 (Rhizome treatment with Ridomil gold @0.25% + Soil drenching with Crossin AG 10 SP @0.1%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP), and control treatment showed the highest Rhizome rot incidence. The highest plant survival and disease reduction over control were obtained from T_6, and the lowest plant survival and lowest disease reduction over control were obtained from untreated control and T_1 (Rhizome treatment and soil drenching with Ridomil gold @0.25%, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP), respectively. In India, Beena (2006) stated and recommended for the management of soft rot and a number of fungicide formulations were evaluated or recommended for the management of soft rot of ginger. Many organomercurials, copper fungicides, dithiocarbamates and a number of systemics were effective in improved sprouting, reduced disease incidence of rhizome rot and increased yield. Some of the results obtained for the various tests conducted could be summarized as follows. Seed treatment and soil drenching with Bordeaux mixture-BM (2:2:50) was found to effectively control rhizome rot. Pre-sowing soil drenching and subsequent treatments every week with Bordeaux Mixture (4:4:50) reduced rhizome rot caused by *P. aphanidermatum* and *P. myriotylum*. Metalaxyl was recommended for the seed treatment 12 and soil drenching based on its performance in disease control after prolonged on farm evaluations of the fungicides at the Indian Institute of Spices Research, Calicut. Five systemic fungicides i.e. Fosetyl aluminium, Metalaxyl, Oxadixyl, Propamocarb and Ethazole were evaluated against rhizome rot caused by *P. aphanidermatum*, both as seed treatment and soil drench, Metalaxyl formulations viz Ridomil 5-G granules and Apron 35 WS gave the best control. Beena (2006) also tested six non systemic fungicides and four systemic fungicides against *P. aphanidermatum*, Metalaxyl, Captafol, Ziride and Captan and Metalaxyl formulations reduced rhizome rot incidence and increased germination. Several agronomical practices and chemicals like proper drainage, use of healthy and vigorous rhizomes, seed rhizome treatment with Ridomil MZ

(0.2%) before storage and during plantation, 3 or 4 years crop rotation, (Anonymous, 2005; Anonymous, 2011; Poudyal, 2011) was recommended to control soft rot disease. Lalfakawma (2014) found that Copper oxychloride rhizome treatment effectively suppressed the rhizome rot disease development (5.16%) at 150th day after planting in the field. Elliott (2003) dipped seed pieces in Ridomil MZ (0.2%) for 20 minutes and allow to air dry prior to planting which controlled rhizome rot of ginger. Acharya and Regmi (2015) found that seed treatment with Ridomil MZ 0.2% + Bavistin 0.1% combination was the most effective for disease management, lowest rhizome rot severity and least diseased rhizome production. Jayasekhar *et al*. (2000) dipped seeds of ginger in 0.2% copper oxychloride, 1% Bordeaux mixture, 0.1% chlorothalonil, 0.01% Metalaxyl MZ and sowed in a field of Tamil Nadu, India during 1994-97. The fungicides which were incorporated in farmyard manure, were applied to the soil prior to sowing. They found that all tested fungicides exhibited effectiveness in the reduction of ginger rhizome rot caused by *P. aphanidermatum*. Metalaxyl MZ at 1% recorded the lowest disease incidence (4.23%) and consequently the highest disease reduction (88.85%). Gade *et al.* (2016) tested Ridomil fungicide against *Fusarium solani* and found effective against *Fusarium solani* causing rhizome rot of Ginger. The fungicide Ridomil was tested at five concentrations i.e., 0.025, 0.05, 0.1, 0.15 and 0.2% in vitro against *Fusarium solani*. The result showed that 0.2% concentration of Ridomil was most effective in controlling the growth of *Fusarium solani* causing rhizome rot of ginger. Ridomil gold and Secure were found to increase the germination of rhizome and plant growth by reducing the incidence and disease severity of rhizome rot of ginger (Hossain *et al*., 2015). Ayub *et al*. (2009) found that the most effective treatment against rhizome rot of ginger was seed treatment (0.2%) and soil drenching (0.2%) with Ridomil gold. Ridomil gold significantly decreased the incidence and severity of the diseases and increased germination, tiller number and rhizome yield. Seed rhizomes treated with fungicides azoxystrobin 25%, tebuconazole 25.9%, copper oxychloride 50%, carbendazim 50%, propiconazole 25%, metalaxyl-M 4% + mancozeb 64%, metiram 55% + pyraclostrobin 5%, carbendazim 12% + mancozeb 63%, tebuconazole 25% + trifloxystrobin 25% and metalaxyl 8% + mancozeb 64% resulted in effective management of rhizome rot of ginger (Behera *et al*., 2020). Among the different treatments, Bavistin 50 WP and Ridomil Gold MZ-72 was efficiently suppress the pathogen and increased the yield of ginger (Hasnat *et al*., 2014).

The highest number and weight of primary branches were obtained from T_6 which was followed by T_7 and T_3 (T_1 + Soil application with Stable bleaching powder @25 kg/ha before two weeks of planting), and the lowest number and weight of primary rhizomes per plant was recorded in untreated control. T_6 showed the highest number and weight of secondary rhizomes per plant which was also followed by T_7 and T_3, and control treatment showed the lowest number and weight of secondary rhizomes per plant. The highest plant height was recorded in T_6 and the lowest plant height was recorded in untreated control. Lalfakawma (2014) reported that maximum plant height was recorded in plots with *Trichoderma* spp. + neem extract rhizome seed treatment, followed by copper oxychloride rhizome seed treatment.

T_6 showed the highest yield which was statistically at par with T_7, and control treatment showed the lowest yield which was statistically dissimilar to other treatments. The highest yield increased over control was recorded in T_6 which was followed by T_7, and the lowest yield increased over control was recorded in T_1. Beena (2006) tested six non systemic fungicides and four systemic fungicides against *P. aphanidermatum*, Metalaxyl, Captafol, Ziride and Captan and Metalaxyl formulations increased and yield. Lalfakawma (2014) recorded that per hectare highest yield (59.14 qts/ha) in plots with copper oxychloride rhizome seed treatment followed by copper oxychloride + neem extract (49.30 qts/ha). Acharya and Regmi (2015) found that seed treatment with Ridomil MZ 0.2% + Bavistin 0.1% combination was the most effective for disease management with highest fresh rhizome production. Jayasekhar *et al*. (2000) dipped seeds of ginger in 0.2% copper oxychloride, 1% Bordeaux mixture, 0.1% chlorothalonil, 0.01% Metalaxyl MZ and sowed in a field of Tamil Nadu, India during 1994-97. The fungicides which were incorporated in farmyard manure, were applied to the soil prior to sowing. They found that all tested fungicides increased crop yield.

4. CONCLUSION

From the above study, it may be concluded that Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Bordeaux mixture, first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP followed by Rhizome treatment with Ridomil gold (0.25%) + Soil drenching with Crossin AG 10 SP (0.1%), first drenching was done during planting, thereafter, drenching was continued at 20 days interval starting from 40 DAP upto November significantly reduced rhizome rot incidence and increased yield of Ginger.

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