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Beneficial microbial application for the management of ginger rhizome rot

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Abstract
Rhizome rot caused by *Pythium aphanidermatum*, is one of the major constraints in the production of ginger. Management of plant diseases by chemical fungicides has lead to the development of fungicide resistant strains of plant pathogens. Hence, biological control of disease using bio control organisms is the distinct possibility and can be exploited within the framework of integrated disease management system. The pooled data of trials conducted at two different locations in Gudalur region indicated that, treatment of rhizomes with *P. fluorescens* @ 10g kg^{-1} of rhizomes at the time of planting along with soil application on 3, 5 and 7 months after planting reduced the incidence of rhizome rot (11.37 %) in ginger with an average rhizome yield of 37.04 t ha^{-1}, while in control the incidence was 22.47 % with an average rhizome yield of 19.87 t ha^{-1}.

Keywords: Ginger, rhizome rot, biocontrol

Introduction
Ginger (*Zingiber officinale* rose L.), is an important spice crop belonging to the family zingiberaceae. India's production of ginger constitutes about 50% of the total world's production of ginger. Rhizome rot of ginger caused by *Pythium aphanidermatum* is a major constraint for the production of healthy rhizome, sometimes causes total failure of the crop (Fagaria *et al*., 2006) [2]. The rhizome rot was seen in isolated patches or sometimes it might involve several adjacent clumps resulting in diseased patches. This disease is seed and soil borne in nature (Kumar *et al*., 1989) [5]. P*ythium aphanidermatum* (Dake and Edison, 1989) [1], *P. myriotylum*, *P. vexans* (Ramakrishnan, 1949) [8], *F. oxysporum* f sp. *zingiberi* from Madya Pradesh (Haware *et al*., 1973) [4] and *Pseudomonas solanacearum* from Kerala (Sarma and Anandaraj, 2000) [10] were reported to cause the disease.
Management of plant diseases by chemical fungicides has lead to the development of fungicide resistant strains of plant pathogens. Hence, biological control of disease is the distinct possibility and can be exploited within the framework of integrated disease management system. Bio control of soil borne plant pathogens using PGPR has gained practical importance in several crops. The application of biological controls using antagonistic microorganisms has proved to be successful for controlling various plant diseases in many countries.
Rhizome rot management using biocontrol agents was reported by several workers. Management of rhizome rot by *T. harzianum* was reported by Rajan *et al*., 2002 [6] and Rathore *et al*., 1992 [9]. Management of ginger rhizome rot by seed treatment with *Trichoderma* spp. and *Gliocladium* spp. was reported by Ram *et al*. (2000) [7].
Keeping in view of these points, a study was conducted for the management of rhizome rot using bio control agents.

Materials and Methods
Two experimental trials were conducted during 2016-17 at farmer's field in Gudalur, Nilgiri distict (Latitude- 11.152829° N: Longitude 76.92° E) in Kharif season. The Rhizomes of ginger variety, Rio-de-janeiro was planted at a spacing of 30 x 20 cm in a plot size of 3 x1m^2. The plots were laid out in Randomised Block Design (RBD) with three replications.
The rhizomes were treated with biocontrol agent's *viz*., *Trichoderma viride* (@ 4g kg^{-1}) and *Pseudomonas fluorescens* (@ 10g kg^{-1}) for 30 minutes before planting. The biocontrol agents were also applied in soil @ 2.5 kg ha^{-1} along with FYM on 3rd, 5th and 7th months after planting.

The rhizome rot incidence was calculated using the following formula

$$\text{Per cent disease incidence} = \frac{\text{Infected plants}}{\text{Healthy plants}} \times 100$$

Observations were also recorded on germination percentage, plant height and rhizome yield.

Results and discussion

The trial conducted at Puduvayal in Gudalur during 2017-18 indicated that, all the treatments recorded germination ranged from 75 to 77 percent. The plant height varies from 51 to 55 cm, maximum plant height was recorded in plants applied with rhizome treatment and soil application of *P. fluorescens* (55.10cm), followed by *T. viride* (52.93 cm), while in control, it was 41.77cm. The plants applied with *P. fluorescens* (@ 10g kg^{-1}) along with soil application @ 2.5 kg ha^{-1} on 3, 5 and 7months after planting recorded minimum incidence of 13.67 % with an average plot yield of 57.4 kg, while in control the incidence was 25.03 % with an average plot yield of 25 kg (Table 1).

Table 1: Effect of biocontrol agents on the incidence of ginger rhizome rot 2017-18 (Field trial 1- Puduvayal)

S. No	Treatments	Germination (%)	Plant height (cm)	Rhizome rot incidence (%)	Rhizome yield/ plot (kg 15m^{-2})	Yield (t ha^{-1})
1	RD in *T. viride* @ 4 g kg^{-1} of rhizomes	76.57(61.06)	51.43	19.03(25.86)	36.3	24.20
2	RD in *P. fluorescens* @ 10 g kg^{-1} of rhizomes	76.80(61.21)	52.23	18.33(25.84)	40.3	26.87
3	T1+ SA of *T. viride* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	75.53(60.35)	52.93	15.03(22.80)	45.5	30.33
4	T2+ SA of *P. fluorescens* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	78.23(62.19)	55.10	13.63(21.66)	57.4	38.27
5	RD in metalaxyl 0.1% and SD on 3, 5, 7 MAP	75.20(60.14)	52.07	11.70(20.00)	50.1	33.40
6	RD with COC 0.25% and SD on 3, 5, 7 MAP	75.77(60.81)	51.37	12.33(20.56)	51.9	34.60
7	Control	69.80(56.67)	41.77	25.03(30.02)	25.0	16.67
	S.Ed	1.0526	0.6888	0.5947	1.2140	
	CD(0.05)	2.2892	1.3919	1.2957	3.0028	

The trial conducted at Vadavayal indicated that, all the treatments recorded germination percentage more than 75 percent. The plant height was maximum in plants applied with *P. fluorescens* (52.07 cm), while in control it was 38.20 cm. The plants applied with *P. fluorescens* (@ 10g kg^{-1}) along with soil application @ 2.5 kg ha^{-1} on 3, 5 and 7months after planting recorded 9.10 % diseases incidence with an average plot yield of 53.7 kg in, while in control the incidence was 34.6 % with an average plot yield of 34.6 kg (Table 2).

Table 2: Effect of biocontrol agents on the incidence of ginger rhizome rot (2017-18) (Field trial I1- Vadavayal)

S. No	Treatments	Germination (%)	Plant height (cm)	Rhizome rot incidence (%)	Rhizome Plot yield (kg 15m^{-2})	Yield (t ha^{-1})
1	RD in *T. viride* @ 4 g kg^{-1} of rhizomes	75.23(60.17)	47.23	13.80(21.78)	40.7	27.13
2	RD in *P. fluorescens* @ 10 g kg^{-1} of rhizomes	76.20(60.81)	48.3	12.78(20.88)	41.1	27.40
3	T1+ SA of *T. viride* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	76.87(60.92)	48.4	10.37(18.77)	45.1	30.07
4	T2+ SA of *P. fluorescens* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	77.60(61.77)	52.07	9.10(17.54)	53.7	35.80
5	RD in metalaxyl 0.1% and SD on 3, 5, 7 MAP	75.23(60.15)	46.67	8.83(17.27)	43.5	29.00
6	RD with COC 0.25% and SD on 3, 5, 7 MAP	75.68(60.42)	48.33	9.83(18.06)	43.2	28.80
7	Control	65.33(53.94)	38.20	19.90(25.01)	34.6	23.07
	S.Ed	1.3242	1.7513	0.7842	1.7335	
	CD(0.05)	2.8852	3.8158	1.7086	3.7815	

The pooled data of the two trials indicated that, treatment of rhizomes with *P. fluorescens* @ 10g kg^{-1} of rhizomes at the time of planting along with soil application on 3, 5 and 7 months after planting reduced the incidence of rhizome rot (11.37 %) in ginger with an average rhizome yield of 37.04 t/ha, while in control the incidence was 22.47 % with an average rhizome yield of 19.87 t ha^{-1} (Table 3). The supplementary soil application on 3rd, 5th and 7th months after planting enhances the beneficial microbial population load in the rhizosphere, thereby it reduced the pathogen activity in the soil. Rhizome treatment with metalaxyl 0.1 % was significantly reduced the rhizome rot (10.27 %) and it was followed by *P. fluorescens* treatment. Similar results were reported by Rajan, 2003 [6] and Ghorpade and Ajri (1982) [3]. Seed treatment with Ridomil MZ 72% WP was found to be effective followed by *Trichoderma harzianum* in the management of ginger rhizome rot (Singh *et al.*, 2011) [12]. Application of the neem cake along with *T. harzianum* reduced the incidence of rhizome rot in ginger (Singh and Tomar, 2009) [11].

Table 3: Testing the efficacy of biocontrol agents on the rhizome rot incidence in ginger (2017-18) (Pooled data of two field trials)

S. No	Treatments	Germination %	Plant height (cm)	Rhizome rot incidence (%)	Rhizome Plot yield (kg 15m^{-2})	Yield (t ha^{-1})
1	RD in *T. viride* @ 4 g kg^{-1} of rhizomes	75.90 (60.62)	49.33	16.42(23.82)	38.50	25.67
2	RD in *P. fluorescens* @ 10 g kg^{-1} of rhizomes	76.50 (61.01)	50.27	15.56(23.36)	40.70	27.14
3	T1+ SA of *T. viride* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	76.20(60.64)	50.67	12.70(20.79)	45.30	30.20
4	T2+ SA of *P. fluorescens* @ 2.5 kg ha^{-1} on 3.5 and 7 MAP	77.92 (61.98)	53.59	11.37(19.60)	55.55	37.04
5	RD in metalaxyl 0.1% and SD on 3, 5, 7 MAP	75.22 (60.15)	49.37	10.27(18.64)	46.80	31.20

6	RD with COC 0.25% and SD on 3, 5, 7 MAP	75.73(60.62)	49.85	11.08(19.31)	47.55	31.70
7	Control	67.57(55.31)	39.99	22.47(27.52)	29.80	19.87
	S.Ed	1.19	1.22	0.69	1.47	
	CD(0.05)	2.59	2.60	1.50	3.39	

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