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Effect of PGPR on Growth and Yield of Ginger through Rhizome Rot Management in Eastern Ghat High Land Zone of Odisha

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Abstract

A field experiment was carried out at High Altitude Research Station, Pottangi, Odisha University of Agriculture and Technology, Koraput, Odisha, India during *kharif* 2018–19 to 2020–21 to study the Effect of Plant Growth Promoting Rhizobacteria in different forms on growth and yield of ginger through soft rot management. The results revealed that % disease intensity has been reduced significantly from 28.10 to 5.9 during the year 2018–2021 in application of Tricho power liquid (*T. viride* @ 1×10^6 cfu ml^{-1}) @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, followed by the application of Tricho capsule (*T.harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 L bed^{-1}, where % disease intensity was 7.1. Similarly fresh rhizome yield increased from 9.6 t ha^{-1} to 17.6 t ha^{-1} during the year 2018–2021 in Tricho power liquid (*T. viride* @ 1×10^6 cfu ml $^{-1}$) @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, followed by Tricho capsule (*T. harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 l bed^{-1}) with 15.8 t ha^{-1} yield.

Keywords: Bio pesticide, disease management, ginger, rhizome rot

1. Introduction

Ginger (*Zingiber officinale* Rosc.) occupy an important position among the cultivated spices in the country which is also known for its culinary and medicinal properties. Being the second largest producer of ginger India accounted for about one fourth of the world's total output (Anonymous, 2012). In India, area under ginger cultivation is 165,000 ha producing about 1081000 Mt (Anonymous, 2017). Area under ginger cultivation in Odisha 14,200 ha with production of 34,200 mt and average productivity of 2.41 mt ha^{-1} (Anonymous, 2017).

Rhizome rot or soft rot is a common disease of ginger caused by fungi such as *Pythium* and *Fusarium* spp. (Savita et al., 2009). It is the most destructive disease of ginger, which can reduce the production by 50 to 90% (Mahendra et al., 2018).

Rhizome rot disease got the capacity to infect almost all parts of ginger crop throughout the growing period (Gupta and Kaushal, 2017). Watery brown lesions first appear at the collar region which subsequently enlarge and coalesce to cause stem rot (Dohroo, 2005). In older leaves foliar symptoms appear as yellowing of leaf margins proceeding towards midrib (Figure 1). Symptoms develop at older leaves first which gradually progress towards the younger leaves and this process continue till the entire plant dies. After infection of collar region, rotting spread to the rhizome causing rhizome rot or soft rot.Infected rhizomes appear as brown, water soaked, soft which helps the diseased stems to be pulled out easily (Figure 2) (Shakywar et al., 2012).

Pythium aphanidermatum, which cause the rhizome rot disease (Stirling et al., 2009) was first reported in China (Li et al., 2014) is a soil as well as seed borne pathogen which is very destructive to ginger crop and its control became a challenge to society (Jayasekhar et al., 2000). Secretion of cell wall degrading enzymes leads for their successful colonization around rhizospheric zone (Geethu et al., 2013). Though chemical fungicides proven to be effective for a specific time period but it's adverse effect also becoming a threat to environment and human health (Hanumantharaju and Awasthi, 2004, Rai et al., 2018). Different alternative management practices like physical, biological has been developed among which biological management practices draw the attention as it comprises of different antagonistic microorganisms which effectively controls the soil borne pathogens without hampering the other beneficial mycoflora in ecosystem. Prasad et al. (2015) narrated that through bio-inputs we can enhance soil health and crop yield (Muthukumar

Figure 1: Symptoms of rhizome rot in ginger plant

et al., 2007). Among different bio control agents *T. viride* and *T. harzianum* has proven it's promising effect towards control of rhizome rot in ginger (Dohroo et al., 2012, Ratanakumar et al., 2018, Tripathy and Singh, 2021, Khatso et al., 2013, Jeyaseelan et al., 2012, Hafiza and Afshan, 2017) through it's different mode of actions like secretion of organic acids (Mishra and Ansari, 2021). But still biopesticides facing a lot of challenges in the form of formulation, registration, commercialization, acceptance and adoption (Geraldin et al., 2018). As per the review done by (Katrijn et al., 2020) commercially non availability of efficient bio control agents is a big hinderance for its mass implementation. Present research has been carried out to know the efficacy of bio control agents in its different forms like liquid, powder and biocapsules against soft rot of ginger.

Figure 2: Symptoms of rhizome rot in ginger rhizome

2. Materials and Methods

The experiment was conducted at HARS, Pottangi under Odisha University of Agriculture and Technology during *kharif* (May to January) 2018–19, 2019–2020 and 2020–21. Seven treatments were tested in the experiments. T_1 Tricho capsule (*Trichoderma harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 l bed^{-1}, T_2 GRB - 35 capsule (*Bacillus amyloliquefaciens* @ 1×10^8 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m basal application at 45 and 90 DAS @ 5 l bed^{-1}, T_3 Tricho talc (*Trichoderma harzianum* @ 1×10^6 cfu g^{-1}) powder@ 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_4 GRB35 talc powder (*Bacillus amyloliquefaciens* @ 1×10^8 cfu g^{-1}) 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_5 Tricho power liquid (*T. viride* @ 1×10^6 cfu ml^{-1}) @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_6 Monas (*Pseudomonas fluorescens* @ 10^8 cfu ml^{-1}) liquid @ 10 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_7 Control .

The experiments were laid out in a Randomized Block Design with three replications. Ginger variety Suprabha sown in the 3×1 m^2 plot size with row to row distance 30 cm and rhizome to rhizome distance was 25 cm. Each plot was 10 rows and in each row four seed rhizomes of about 20–25 gms were sown. Healthy rhizomes were treated with bio agents before sowing. Rhizomes were dipped in solution of different bio agents for 30 m and dried under shade before sowing in the field. Non treated seeds sown in control plots. Same treatments which has been applied as basal again repeated at 45 and 90 days after sowing. Planting was done in the last week of April in all the three years with recommended dose of fertilizer, N: P: K @ 125:100:100 with three split doses 1st as basal dose, 2nd at 45 days after sowing and 3rd at 90 days after sowing.

Data on % disease intensity,% disease control, yield, yield advantage over control and B:C ratio were recorded. Cumulative data of three years are presented. The weight of rhizome per plot was recorded and converted into per hectare yield.

The % disease intensity was calculated by following formula.

% Disease Intensity=(Number of infected plants/Total number of plants)×100………(1)

The % disease control was calculated by following formula.

% Disease Control=(% disease intensity in control-% disease intensity in treatment)/% disease intensity in control)×100………(2)

The yield advantage over control was calculated by following formula.

Yield advantage over control (%)=(Yield in control-yield in treatment/yield in control)×100………(3)

3. Results and Discussion

Pooled data of the year 2018–19, 2019–2020 and 2020–21 presented in table 1 revealed that after third spray (90 days after sowing) the best treatment in reducing the rhizome rot disease was seed treatment with Tricho power liquid (*T. viride* @ 1×10^6 cfu ml^{-1}) @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 days after sowing followed by seed

Sl. No.	Treatment Details	Percent Disease Intensity	Percent Disease Control (%)	Yield (t ha^{-1})	Yield Advantage over control (%)	B:C ratio
T_1	Tricho capsule @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 l bed^{-1}	7.1	74.73	15.8	64.58	2.5:1
T_2	GRB - 35 capsule @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m basal application at 45 and 90 DAS @ 5 l bed^{-1}	10.0	64.41	13.2	37.5	2.1:1
T_3	Tricho talc powder@ 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS	9.8	65.12	13.7	42.70	2.2:1
T_4	GRB35 talc powder @ 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS	8.1	71.17	15.3	59.37	2.5:1
T_5	Tricho power liquid @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS	5.9	79.00	17.6	83.33	2.8:1
T_6	Monas liquid @ 10 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS	12.4	55.87	11.8	22.91	1.9:1
T_7	Control	28.1	-	9.6	-	1.5:1
	SEm±	0.69		0.33		
	CD (p=0.05)	2.07		1.03		

Table 1: Effect of PGPR on % disease Intensity, yield and B:C ratio towards effective management of rhizome rot of ginger

treatment with Tricho capsule (*T. harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 l bed^{-1} which reduced the % disease intensity 5.9 and 7.1 respectively with percent disease control 79 and 74.73 respectively. Maximum disease intensity was observed in control 28.1%.

All the fungicidal treatments reduced the disease as compared to control. Seed treatment with Tricho power liquid (*T. viride* @ 1×10^6 cfu ml^{-1}) @ 5 ml l^{-1} along with basal application @5 l bed^{-1} at 45 and 90 days after sowing recorded maximum yield 17.6 t ha^{-1} followed by seed treatment with Tricho capsule (*T.harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water rhizome treatment for 30 m, basal application at 45 and 90 DAS @ 5 L bed^{-1} with 15.8 t ha^{-1} with 83.33% and 64.58% yield advantage over control. Minimum yield 9.6 t ha^{-1} obtained from control.

Considering Benefit:Cost (B:C) ratio, the most economical treatment which recorded highest B:C ratio 2.8:1 was Tricho power liquid both seed treatment and soil drenching with the same at 45 and 90 DAS followed by seed treatment with Tricho capsule along with soil drenching at 45 and 90 DAS recorded B:C ratio of 2.5:1.

Effect of different PGPR on % Disease Intensity, yield and B:C ratio towards effective management of rhizome rot of ginger has been shown in Table 1.

Similar results were reported by various researchers such as Seethe et al. (2010) observed that the application of *T. viride* and *P. fluorescens* could inhibit the mycelia growth of *Fusarium solani* by 80–88%. Through in vitro evaluation, Anita et al. (2012) found that isolates of *T. viride* through dual culture methods inhibits 83.33% of *Pythium*. Maurya et al. (2014) found *P. fluorescens* having highest antagonistic activity against *Fusarium moniliforme, Rhizoctonia solani* and *Alternaria alternate*. Ajilogba et al. (2013) found that *B. amyloliquefaciens* can inhibit the growth of *F. solani* up to 95.2% and with 75% disease control.

Trichoderma strains are naturally resistant to the toxic compounds present in herbicides, fungicides and pesticides therefore after inoculating in the soil it grows rapidly without any hinderance (Chet et al., 1997). Francesco et al. (2013) observed the production of natural products in *Trichoderma harzianum* which got antifungal ability and enhance the defence mechanism in host plant against the pathogens. Antagonistic micro-organisms colonizes around root tips due to which secretion of root exudates,the major source of nutrients for pathogens is reduced (Cook and Baker, 1983). Different antagonistic effect like antibiosis, parasitism, induced systemic resistance in host cells etc. enable bio control agents to fight more effectively against pathogens (Alabouvette et al., 1992). Chet and Inbar (1994) studied the bio chemical and molecular biology effect of *Trichoderma sps*. towards control of different diseases. Talla et al. (2015) proven the antagonistic effect of *Trichoderma viride* against *F. oxysporium*. Inhibitory effects of different isolates of *Trichoderma spp.* against *Fusarium* spp. has been studied by

Ghanbarzadeh et al. (2014). As per the study carried out by Al-Saeedi et al. (2014) *T. harzianum* has proven its potential as bio control agent against various fungal pathogens. Singh (2011) in his findings proven that *Trichoderma harzianum* can effectively control rhizome rot in ginger.

4. Conclusion

Tricho power liquid @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} gave minimum per cent disease intensity (5.90%) and maximum yield (17.60 t ha^{-1}). The next best treatment was Tricho capsule @ 1 capsule 120 l^{-1} of water @ 5 l bed^{-1} with (7.10%) disease intensity and (15.80 t ha^{-1}) yield. Both treatments were found to be statistically at par with respect to reduction of disease intensity and increase in the yield.

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