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Effect of Bioagents in Different Formulations towards Rhizome Rot Management of Turmeric in Eastern Ghat High Land Zone of Odisha

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Abstract

A field experiment was conducted at High Altitude Research Station, Pottangi under Odisha University of Agriculture and Technology during the month of May to January 2018–19, 2019–2020 and 2020–21 to find out effect of bioagents in different formulations towards rhizome rot management in turmeric. Seven treatments were tested in the experiments T_1: Tricho capsule (*Trichoderma harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule/120 l. of water. T_2: GRB-35 capsule (*Bacillus amyloliquefaciens* @ 1×10^8 cfu g^{-1}) @ 1 capsule/120 l. of water, T_3: Tricho talc (*T. harzianum* @ 1×10^6 cfu g^{-1}) powder @ 8.5 g l^{-1} of water, T_4: GRB-35 talc powder (*Bacillus amyloliquefaciens* @ 1×10^8 cfu g^{-1}) 8.5 g l^{-1} of water , T_5: Tricho power liquid (*Trichoderma viride* @ 1×10^6 cfu ml^{-1}) @ 5 ml l^{-1} of water, T_6: Monas (*Pseudomonas fluorescens* @ 10^8 cfu ml^{-1}) liquid @ 10 ml l^{-1} of water and T_7: Control without any treatments. In each treatment rhizome treatment for 30 mins and basal applications of bioagents done at 45 and 90 DAS @ 5 l bed^{-1}. Data on percent disease intensity, yield and B:C ratio were recorded at 45, 60 and 90 DAS. The lowest percent disease intensity (8.94%), highest fresh rhizome yield (21.06 t ha^{-1}) and B:C ratio (1.72:1) was found in the treatment T_5 followed by T_1 with (10.33%) disease intensity, (20.57 t ha^{-1}) yield and (1.69:1) B:C ratio.

Keywords: Bio agents, formulations, rhizome rot, turmeric

1. Introduction

Maintaining its identity as 'The land of spices' India is the largest producer, consumer and exporter of turmeric in the World. Turmeric (*Curcuma longa*) which is also known as 'Golden Spice of India' belongs to the family Zingiberaceae, originated from South East Asia (Selvi et al., 2020). Among 18 turmeric growing states Andhra Pradesh, Tamil Nadu, Karnataka, Odisha and West Bengal are the major turmeric producers in India (Selvi et al., 2020). In India cultivated area under Turmeric is 2.38 lakh ha^{-1} with a total production of 11.33 lakh tonn (Anonymous, 2018). Being the major contributor towards their livelihood, turmeric got its importance as cash crop among tribal families of Odisha. Around 21% of India's turmeric cultivated area is contributed by Odisha among which 50% shared by Kandhamal alone. From 27860 ha area Odisha produced 54500 metric tonnes turmeric (Anonymous, 2018). 50-80% loss incurred during storage due to rhizome rot in turmeric (Nirmal et al., 1992). *Pythium aphanidermatum* and *Fusarium solani* found to cause rhizome rot disease (Li et al., 2014) of turmeric in India (Reddy et al., 2003; Anusuya and Sathiyabama, 2014; Anoop et al., 2014, Chenniappan et al., 2020; Gupta and Kaushal, 2017). It is a destructive disease both in turmeric and ginger (Meenu et al., 2019; Prasath et al., 2023). *Pythium aphanidermatum* is a soil borne oomycetous fungus which cause destructive yield loss to turmeric crops in India (Radhakrishnan and Balasubramanian, 2009) by secreting a cell wall degrading enzymes which helps them to colonize around rhizospheric zone for disease initiation (Geethu et al., 2013).

At the collar region of turmeric watery brown lesions appear as the first symptom of rhizome rot which subsequently enlarge and coalesce to cause stem rot (Dohroo, 2005). Foliar

symptoms appear first in older leaves as yellowing of leaf proceeding from margin towards midrib. Symptoms progress from older leaves to younger leaves and continue till entire plant dies. From collar region the infection spread to upward and downward direction infecting rhizome to cause rhizome rot or soft rot (Figure 1 and 2). Due to rottening of rhizome the stem attached to it comes out easily by gentle pulling,

Figure 1: a: Rhizome rot infected field; b: Initial symptoms of the disease; c: Advanced stage of the disease; d-f: Infected rhizomes; g: Infected young sprout with healthy mother rhizome; h-i: Advanced stage of infected rhizome colonized by maggots

Figure 2: Symptoms of rhizome rot in turmeric plant

Due to its ability to colonize both in soil and seed, *Pythium aphanidermatum* is very destructive in nature and difficult to control, which is a big challenge to the society (Jayasekhar et al., 2000). Due to its adverse effect on ecology and human health, use of chemical fungicides become a threat to society (Hanumantharaju and Awasthi, 2004, Rai et al., 2018). Management of fungal and bacterial diseases through bio agents proven to be effective one as it enhances soil health and crop yield (Muthukumar and Bhaskaran, 2007, Bastakoti et al., 2017, Hedge et al., 2017, Singh et al., 2018, Prabhukarthikeyan et al., 2017, Elshahawy et al., 2019;). *T. viride* and *T. harzianum* both got efficacy to control rhizome rot diseases (Dohroo et al., 2012, Vinale et al., 2013, Singh et al., 2018, Tripathy and Singh, 2021, Khatso and Tiameren, 2013, Jeyaseelan et al., 2012, Hafiza and Rahman, 2017, Hirpara et al., 2017, Mishra et al., 2021, Yassin et al., 2021, Yassin et al., 2022). Commercial availability of efficient bio control agents is a challenge (Katrijn et al., 2020) due to its formulation, registration, commercialization, acceptance and adaptation (Geraldin and Muthomi, 2018). More research needed to make effective availability of bio control agents to society for sustaining effort towards ecofriendly approach. Keeping all these matters into consideration research has been conducted to find out the effect of different bio agents in it's different formulations to control rhizome rot in turmeric.

2. Materials and Methods

Experiment on "effect of bioagents in different formulations towards rhizome rot management of turmeric in Eastern Ghat High Land Zone of Odisha" has been conducted at HARS, Pottangi under Odisha University of Agriculture and Technology during the months May to January, 2018–19, 2019–2020 and 2020–21. 7 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 powder (*Trichoderma harzianum* @ 1×10^6 cfu g^{-1}) @ 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_4 GRB - 35 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 liquid (*Pseudomonas fluorescens* @ 10^8 cfu ml^{-1}) @ 10 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS, T_7 Control .

Turmeric variety Surama was taken for this experiment. The experimental design was laid out in randomized block with three replications. 20–25 gms of rhizome seeds were sown in a plot of 3×1 m^2 size with 30 cm distance within rows. Accordingly, one plot divided into 10 rows and each row planted with 4 rhizome seeds at 25 cm distance between rhizomes. Shade dried rhizomes were sown in field after treating with different formulations of bio agents for 30 minutes along with a control plot without any seed treatments. All the treatments were applied three times in plots as basal, 45 and 90 days after sowing. Planting was done consecutively for three years in the last week of April with recommended dose of N:P:K fertilizer @ 125:100:100 with three split applications as basal, 45 and 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 plot^{-1} was recorded and converted into hectare^{-1} 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 treatment - yield in control/yield in control)×100…… (3)

3. Results and Discussion

After statistical analysis for consecutively three years 2018 to 2021 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 found to be best in reduction of rhizome rot disease followed by seed treatment with Tricho capsule (*T. harzianum* @ 1×10^6 cfu g^{-1}) @ 1 capsule 120 l^{-1}. of water for 30 m, basal application at 45 and 90 DAS @ 5 l bed^{-1} which reduced the % disease intensity 8.94 and 10.33 respectively. Maximum disease intensity was observed in control 35.46%. All the bio agents shown their efficacy in different formulations towards the management of rhizome rot as compared to control.

Minimum percent disease intensity with highest yield 21.06 t ha^{-1} and B:C ratio 1.72:1 observed with the treatment Tricho power liquid (*T. viride* @ 1×10^6 cfu ml^{-1}) followed by seed treatment with Tricho capsule (*T. harzianum* @ 1×10^6 cfu g^{-1}) with 20.57 t ha^{-1} yield and 1.69:1 B:C ratio. Minimum yield 16.29 t ha^{-1} with lowest B:C ratio 1.33:1 found in untreated control. Effect of different bio agents on percent disease intensity, yield and B:C ratio towards effective management of rhizome rot of turmeric has been shown in Table 1 and represented in graphical form in Figure 3.

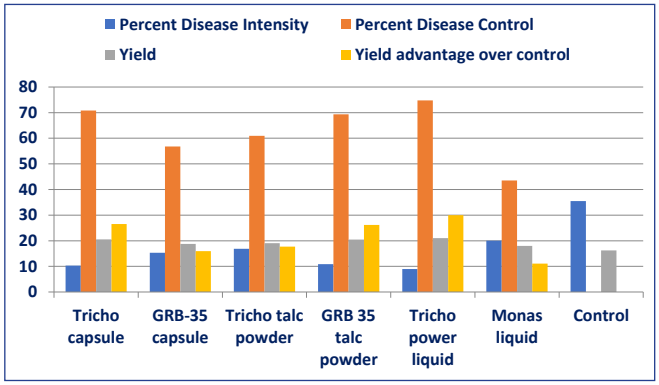

Figure 3 : Effect of bioagents in different formulations towards rhizome rot management of turmeric

Table 1: Effect of bioagents in different formulations towards rhizome rot management of turmeric

Treat-ments	Percent disease intensity	Percent disease control	Yield (t ha^{-1})	Yield advantage over control (%)	B:C ratio
T_1	10.33	70.86	20.57	26.54	1.69:1
T_2	15.31	56.82	18.79	15.98	1.52:1
T_3	13.85	60.94	19.07	17.71	1.58:1
T_4	10.88	69.31	20.44	26.17	1.67:1
T_5	8.94	74.78	21.06	30.00	1.72:1
T_6	20.03	43.51	18.00	11.11	1.47:1
T_7	35.46	-	16.20	-	1.33:1
CD (p=0.05)	5.02		1.20		0.07
SEm±	1.66		0.40		0.02

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}; T_2: GRB-35 @ 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 powder @ 8.5 g l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS; T_4: GRB-35 talc powder @ 8.5 g l^{-1} along with ba-sal application @ 5 l bed^{-1} at 45 and 90 DAS; T_5: Tricho power liquid @ 5 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS; T_6: Monas liquid @ 10 ml l^{-1} along with basal application @ 5 l bed^{-1} at 45 and 90 DAS; T_7: Control

Research results found similarity with the work of other researchers. It is observed by Ramulu et al. (2010) that mycelia growth of Fusarium solani inhibited by 80–88% when treated with *T. viride* and *P. fluorescence*. Through dual culture technique it is found by Patil et al. (2012) that *T. viride* inhibited *Pythium* by 83.33%. Due to its resistance power towards toxic compounds present in herbicides, fungicides and pesticides, *Trichoderma* grows very fast in soil (Chet et al., 1997). Enhancement of the defence mechanism in host plants observed by Vinale et al. (2013) due to production of natural products by *Trichoderma harzianum*. Due to the colonization of antagonistic micro-organisms around root tips the root exudates secretion ceases which ultimately reduce the pathogen population by obstructing their source of nutrients (Cook and Baker, 1983). Antibiosis, parasitism, induced systemic resistance in host cells etc. are some antagonistic characters which increase the efficacy of bio control agents against pathogens. *T. harzianum* effectively controls various fungal pathogens along with rhizome rot in Ginger (Singh, 2011, Ghimire et al., 2023). *Trichoderma* strains are available commercially in different formulations for crop production (Herman, 2000). Vinale et al. (2012) observed that the secondary metabolites produced from *Trichoderma* affect

plant metabolism and enhance growth. It has been reported by Prabhu Karthikeyan (2018) that the combined application of rhizome dip+soil drench of *Pseudomonas fluorescens* increase plant growth. Behera and Sial (2023) through their research observed the efficacy of different formulations of bio pesticides towards the management of 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 (8.94%) and maximum yield (21.06 t ha^{-1}). The next best treatment was Tricho capsule @ 1 capsule 120 l^{-1} of water @ 5 l bed^{-1} with (10.33%) disease intensity and (20.5 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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