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Management of turmeric rhizome rot using eco-friendly biocontrol consortia

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ABSTRACT: Rhizome rot incited by *Pythium aphanidermatum* is the destructive disease causing considerable damage and reduces yield and quality of rhizomes. Use of antagonistic microbes to manage the diseases replaces the chemicals and protects the environment from toxic hazards. A field trial was conducted to test the efficacy of biocontrol agents against rhizome rot of turmeric during *kharif* 2004-05 to 2006-07. The results revealed that the biocontrol agents application reduced the disease incidence compared to control. The pooled analysis from 2004-05 to 2006-07, indicated that T7 treatment with seed and soil application of consortia of *Trichoderma viride* and *Pseudomonas flourescens* @ 4g kg^{-1} of seed and 2.5kg ha^{-1} as basal and top dressing at 150 days after planting was found to be effective which recorded the least disease incidence of 0.79% with the maximum yield of 60.19 t ha^{-1}. The same treatment also recorded the maximum Cost-benefit ratio of 1: 3.3. The control plots recorded the disease incidence of 27.22% with an yield of 29.57 t ha^{-1}.

KEY WORDS: Biocontrol consortia, management, rhizome rot, turmeric.

INTRODUCTION

Turmeric (*Curcuma longa L.*) is a major spice crop of India and is widely used as food colorant besides as a raw material in pharmaceutical and textile industries. India is the major turmeric producer in the world accounting for about 80 percent of the world production and 60 percent of world in exports. In India, turmeric is raised in an area of 1,34,000 ha with an annual production of 5,34,000 tonnes (RaviKumar, 2002). It is susceptible to many diseases caused by fungal pathogens. Among the various diseases, rhizome rot caused by *Pythium* sp. is a major problem in all turmeric growing areas of India (Rathiah, 1987; Nageshwar Rao, 1994). The symptoms of the disease includes *viz*., toppling down of infected tillers, rotting of roots and the affected rhizome becoming hollow with only fibrous tissues left behind, leading to a loss of up to 95 percent crop yield (Rathiah, 1987). Management of the disease using fungicides has led to the development of resistant strains of pathogens. Hence this study was carried out for the ecofriendly management of rhizome rot of turmeric using antagonistic biocontrol agents.

MATERIALS AND METHODS

A field experiment was conducted at University orchard, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to test the efficacy of biocontrol agents against rhizome rot of turmeric caused by *Pythium aphanidermatum* for three seasons during 2004–2007. The experiment was carried out in RBD with eight treatments and three replications. The variety used for this study was BSR.2.

Treatment Details

T_1 - Recommended NPK (Control)
T_2 - Recommended NPK + FYM
T_3 - Recommended NPK + *Trichoderma viride*+ *Pseudomonas fluorescens* @ 4g kg^{-1} seed as seed treatment.
T_4 - Recommended NPK + *T. viride* + *P. fluorescens* to be applied to soil @ 2.5kg ha^{-1} as basal and top dressing (150 and 180 DAP) respectively.
T_5 - $T_2 + T_3$
T_6 - $T_2 + T_4$
T_7 - $T_2 + T_3 + T_4$
T_8 - T_2 + *Bacillus subtilis* (Biostat) @ 1ml litre^{-1} of water.

The rhizome rot incidence was calculated based on the number of plants infected out of total population and expressed in percentage.

RESULTS AND DISCUSSION

A field trial was conducted to test the bio-efficacy of biocontrol agents against rhizome rot of turmeric caused by *P. aphanidermatum* during *Kharif* 2004-05. The results

Table 1. Management of turmeric rhizome rot using biocontrol agents (2004-2005)

T. No.	Treatments	Rhizome rot incidence (%)	Yield t ha^{-1}	Cost-benefit ratio
T_1	Recommended NPK (Control)	64.00^{e}	14.75^{a}	1: 1.18
T_2	Recommended NPK + FYM	19.00^{d}	23.46^{bc}	1: 1.87
T_3	T_{3-} Recommended NPK + *T. viride* + *Pseudomonas fluorescens* @ 4g kg^{-1} of seed as seed treatment	10.10^{c}	31.86^{de}	1: 2.54
T_4	Recommended NPK + *T. viride* + *Pseudomonas fluorescens* to be applied to soil @ 2.5kg ha^{-1} as basal and top dressing respectively.	10.66^{c}	34.00^{e}	1: 2.78
T_5	T_2+T_3	9.33^{c}	20.56^{b}	1: 1.60
T_6	T_2 + T_4	6.00^{b}	27.03^{cd}	1: 2.16
T_7	T_2 + T_3 + T_4	2.36^{a}	54.55^{f}	1: 4.44
T_8	T_2 + *Bacillus subtilis* (Biostat) @ 1ml $litre^{-1}$ of water	6.00^{b}	53.41^{f}	1: 4.18

Means followed by common letters are not significantly different at 5 per cent probability by DMRT.

Table 2. Management of turmeric rhizome rot using biocontrol agents (2005-2006)

T. No.	Treatments	Rhizome rot incidence (%)	Yield t ha^{-1}	Cost-benefit ratio
T_1	Recommended NPK (Control)	9.66^{a}	38.63^{c}	1: 1.8
T_2	Recommended NPK + FYM	8.00^{b}	44.07^{c}	1: 2.0
T_3	Recommended NPK + *T. viride* + *P. fluorescens* @ 4g kg^{-1} of seed as seed treatment	5.66^{c}	40.01^{c}	1: 1.9
T_4	Recommended NPK + *T. viride* + *P. fluorescens* to be applied to soil @ 2.5 kg ha^{-1} as basal and top dressing respectively.	0.00^{d}	58.63^{b}	1: 2.9
T_5	T_2+T_3	0.00^{d}	40.63^{c}	1: 1.9
T_6	T_2 + T_4	0.00^{d}	57.33^{d}	1: 2.7
T_7	T_2 + T_3 + T_4	0.00^{d}	69.36^{a}	1: 3.3
T_8	T_2 + *B. subtilis* (Biostat) @ 1 ml lit^{-1} of water	0.00^{d}	62.64^{b}	1: 3.0
	CD (5%)	0.526	3.36	-

Means followed by common letter are not significantly different at 5 per cent probability by DMRT.

revealed that the biocontrol agents applied plots recorded significant reduction of the disease incidence when compared to the control (Table 1).

The same experiment was repeated during the period 2005-06 *kharif* with same treatment combination. The results revealed that the biocontrol agents applied plots recorded significant reduction of the disease incidence when compared to the plot treated with biocontrol agents by soil application. Among the treatments, seed and soil application of *T. viride* and *P. fluorescens* (T_7) recorded the maximum yield of 69.36 and free from rhizome rot symptom. The control plot recorded the disease incidence of 9.66 percent with an yield of 38.63t ha^{-1} (Table 2). The cost benefit ratio revealed that the seed and soil application of biocontrol agents recorded maximum ratio of 1: 3.3 followed by 1: 1.30 in *B. subtilis* sprayed plot. Seed and soil application of consortia of *T. viride* and *P. fluorescens* @ 4g kg^{-1} and 2.5kg ha^{-1} was found to be effective for the control of turmeric rhizome rot.

The highest yield (54.55t ha^{-1}) was recorded in the seed and soil application of *Trichoderma viride* and *Pseudomonas fluorescens* with cost-benefit ratio of 1: 4.44 against control 14.75 t ha^{-1} and 1: 1.8 respectively. The treatment (T_7) was on par with *B. subtilis* sprayed plot (T_8) which recorded 53.41t ha^{-1} of yield and 1: 4.18 CB ratio.

This trial was repeated during *kharif* 2006-07 with same treatment combinations and the results are presented in Table 3. The results revealed that the plots treated with biocontrol agent recorded significant reduction of disease incidence when compared to control. There was no disease incidence in the plots treated with biocontrol agents by soil application. Among the treatments, treatment T_7 with recommended NPK+ FYM 12.5t ha^{-1} + seed and soil application of *T. viride* and *Pseudomonas fluorescens* recorded the maximum yield of 54.80t ha^{-1} and free from rhizome rot symptom. The control plots recorded the disease incidence of 8.00 percent (Table. 3).

The seed and soil application of biocontrol agents (T_7) recorded the maximum C: B ratio of 1: 2.8 followed by T_8 treatment (1: 2.6). The pooled analysis for this trial was worked out from 2004-05 to 2006-07 and the results are presented in Table 4. The results revealed that T_7 treatment with seed and soil application of consortia of *T. viride* and

Table 3. Effect of biocontrol agents in the management of turmeric rhizome rot (2006-07)

T. No.	Treatment details	Disease incidence (%)	Yield t ha^{-1}	Cost benefit ratio
T_1	Recommended NPK (control)	8.00	35.33	1: 1.7
T_2	Recommended NPK + FYM 12.5t ha^{-1}	6.00	40.00	1: 1.9
T_3	Recommended NPK + *T. viride* + *P. fluorescens* seed treatment @ 4g kg^{-1} of seed	4.00	44.07	1: 2.1
T_4	Recommended NPK + *T. viride* + *P. fluorescens* to be applied to soil @ 2.5kg ha^{-1} as basal and top dressing respectively.	0.0	46.07	1: 2.0
T_5	$T_2 + T_3$	0.0	48.00	1: 2.2
T_6	$T_3 + T_4$	0.0	52.00	1: 2.4
T_7	$T_2 + T_3 + T_4$	0.0	54.80	1: 2.8
T_8	T_2 + *B. subtilis* @ 1ml lit^{-1} of water (500 lit ha^{-1})	0.0	46.90	1: 2.8
	CD (0.05%)	1.94	3.64	
	CV	19.76	15.39	

Table 4. Effect of biocontrol agents in the management of turmeric rhizome rot (Pooled mean of 3 years)

T. No.	Treatment details	Disease incidence (%)	Yield t ha^{-1}	C: B ratio
T_1	Recommended NPK (control)	27.22	29.57	1: 1.56
T_2	Recommended NPK + FYM 12.5t ha^{-1}	11.00	35.84	1: 1.66
T_3	Recommended NPK + *T. viride* + *P. fluorescens* seed treatment @ 4g kg^{-1} of seed	3.00	38.65	1: 2.18
T_4	Recommended NPK + *T. viride* + *P. fluorescens* as soil application	3.55	46.23	1: 2.56
T_5	$T_2 + T_3$	3.11	38.40	1: 2.07
T_6	$T_3 + T_4$	2.00	46.90	1: 2.45
T_7	$T_2 + T_3 + T_4$	0.79	60.19	1: 3.58
T_8	T_2 + *B. subtilis* @ 1ml lit^{-1} of water (500 lit ha^{-1})	2.00	54.70	1: 3.12
	CD (0.05%)	3.94	13.13	
	SEd	1.52	6.12	
	CV	13.59	17.11	

P. *fluorescens* recorded the least disease incidence of 0.79% with maximum yield of 60.19t ha^{-1} as compared to control and the highest cost-benefit ratio of 1: 3.3. The control plots recorded the disease incidence of 27.22 % with the yield of 29.57t ha^{-1} (Table 4).

The present study revealed that seed and soil application of consortia of *T. viride* and *P. fluorescens* recorded the least disease incidence of 0.79% with maximum yield of 60.19t ha^{-1} as compared to control and the highest cost-benefit ratio of 1: 3.3. Similar results were reported by several workers. Better and effective biological control results can be expected from mixtures of antagonists rather than from high populations of a single antagonist since more the antagonists more will be the stability (Baker and Cook 1974). Suppression of rhizome rot of turmeric was achieved through soil application of *T. viride* at the rate of 1kg ha^{-1} (Ramarethinam and Rajagopal, 1999). Similarly application of a mixture of introduced biocontrol agents would more closely mimic the natural dynamics and might broaden the spectrum of biocontrol activity and enhance the efficacy and reliability of control (Duffy and Weller, 1998). Application of consortia formulation *of P. chlororaphis* isolate PA 23 and *B. subtilis* isolate CBE 4 as rhizome dip and soil application (third and fifth months after planting) recorded the least rhizome rot incidence with higher yield (Kavitha, 2004).

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