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Invivo Evaluation of Bioagents/Consortia on Turmeric Rhizome Rot caused by *P. aphanidermatum*

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ABSTRACT

Turmeric (*Curcuma longa* L.) is one of the most important spice crop cultivated in India. Field efficacy of bioagents and their consortia was assessed against rhizome rot. Effect of different bioagents/ consortia on *P. aphanidermatum* revealed that, consortial treatment 4 (Biomix) recorded maximum germination (96 %) followed by consortium 1 (92.0 %) whereas minimum germination found in control treatment (42.00 %). Maximum average mortality found in total control treatment (63.00 %) and minimum mortality recorded in consortial treatment 4 (4.00 %) followed by consortial treatment 1 (8.50 %). Maximum average reduction over control found in consortium 4 (93.61%), followed by consortium 1 i.e. 86.49 per cent.

Introduction

Turmeric (*Curcuma longa* L.) is one of the most important spice crop cultivated in India. It is a rhizomates herbaceous perennial plant of the family Zingiberaceae. It has versatile uses in flavoring, dye making, drug preparation, cosmetics and medicine.

Turmeric is officially entered in the Ayurvedic Pharmacopoeia of India, Pharmacopoeia of the People's Republic of China and in Japanese standards of herbal medicines. It also known as 'haridra' meaning yellow colored wood in Sanskrit, is a part of Indian delicacies, health care as well as rites and rituals since time immemorial. 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. Various cultivars / varieties of turmeric are devoid of field resistance or tolerance against rhizome rot and majority of them are more or less prone to *Pythium aphanidermatum*. Though, some of the fungicides have been recommended to manage the disease, but present day farmer perception and environmental hazards are compelling to search for alternative eco-friendly disease management strategies. In the recent days of organic concept, organically grown turmeric has gained lot of demand in both domestic and international market.

Materials and Methods

For studying the effect of different bioagents and its consortium on turmeric different experiments were planned during 2017-18at the farm AICRP (Irrigation Water Management), VNMKV, Parbhani.

Bioprming of turmeric rhizomes was carried out by the soaking of seed rhizomes in bioagent/ consortial solution as per treatment before 24 hrs of planting to evaluate its individual effect on germination, pre emergence rhizome rot incidence, post emergence seedling mortality and its effects on other plant growth parameters. Bioagents was used 250ml/10 litre of water of a 2 x 10^7 CFUs for fungal bioagents and 2 x 10^8 for bacterial bioagents.

A total of three drenching and spraying of all the treatments was undertaken at an interval of 45 days, starting first drenching at 30 DAS of the crop. One treatment was maintained as untreated control, and one standard fungicidal control (Carbendazim @ 0.1 % WP)

Experimental design

Design	: R.B.D.
Variety	:Selum
Replications	: Two
Plot size	: 7.5 x 7.5 m^2
Spacing	: 45 x 15 cm^2
Treatments	: 20

Details of treatment

T_1	:	*Trichoderma viride*
T_2	:	*Trichoderma harzianum*
T_3	:	*Verticillium lecanii*
T_4	:	*P. fluoerescens*
T_5	:	*Beauveria bassiana*
T_6	:	*Metarhizium anisopliae*
T_7	:	*Bacillus subtilis*
T_8	:	*Aspergillus niger*
T_9	:	*Nomuraea rileyi*
T_{10}	:	*Paecilomyces lilacinus*
T_{11}	:	*G. glucani*
T_{12}	:	*Azospirillumbrasilense*
T_{13}	:	*Pseudomonas striata*
T_{14}	:	*Ppfm*
T_{15}	:	Consortium 1
T_{16}	:	Consortium 2
T_{17}	:	Consortium 3
T_{18}	:	Consortium 4
T_{19}	:	Control (Carbendazim @ 0.1 % WP)
T_{20}	:	Control (Untreated)

Observations on rhizome germination and pre-emergence rhizome rot (PERR) were recorded at 20 days after sowing and that of post-emergence seedling mortality (PESM) at 30 days after sowing. The per cent of rhizome germination, pre-emergence rhizome rot (PERR) and post-emergence seedling mortality (PESM) was calculated by following formulae:

Germination (%)
No. of rhizomes germinated
= ----------------------------- x 100
Total no. of rhizomes sown

PERR (%)
No. of rhizomes ungerminated
= -------------------------------------x 100
Total no. of rhizomes sown

PESM (%)
No. Seedling died
= --------------------------x 100
Total no. of seedlings

Results and Discussion

A total 20 treatments, comprising fourteen different bioagents alone, four in combinations (consortia), one standard check and absolute check were evaluated in turmeric (Cv. Selum) during *Kharif* 2017-18 (trail- I and II).

The results obtained on per cent germination, PERR, PESM, average mortality and per cent reduction over control are presented in the Table 1.

Effect on rhizome germination

Results (Table 1) revealed that all treatment dosages recorded improved significant rhizome germination, over untreated control. Maximum per cent germination was recorded in treatment consortium of 4 (96.0) followed by consortium of 1 (92.0) and consortium 2 and consortium 3 (90.0). Whereas minimum per cent germination was recorded 42.0 (control) followed by 75.0 (*Verticillium lecanii*) and 76.0 (*Beauveria bassiana* and *Aspergillus niger*). Rest of treatments recorded per cent germination 77.0 (*Bacillus subtilis*) to 85.0 (*Trichoderma viride*). Results indicated the treatment consortium 1 found at par with consortium 4.

Effect on pre and post emergence mortalities

Results (Table 1) revealed that treatment dosages significantly influenced both pre emergence rhizome rot (PERR) and post emergence seedling mortality (PESM), caused by *P. aphanidermatum* in turmeric Cv. Selum.

Maximum per cent pre emergence rhizome rot was recorded in treatment of untreated control (58.0) followed by *Verticillium lecanii* (25.0) and *Beauveria bassiana* and *Aspergillus niger* (24.0). Minimum pre emergence rhizome rot per cent was observed 4.0 (consortium 4) followed by 8.0 (consortium 1) and 10.0 (consortium 2 and consortium 3).

Rest of treatments recorded 15.0 (*Trichoderma viride* and Carbendezim @ 0.1%) to 23.0 (*Bacillus subtilis*) per cent pre emergence rhizome rot incidence. Results indicated that treatments consortium 1, consortium 2 and consortium 3 found at par with consortium 4.

Similar trend with increased post emergence seedling mortality (PESM) also observed and it was maximum in untreated control (68.0) followed by *Verticillium lecanii* (32.0) and *Beauveria bassiana* (31.0). Minimum post emergence seedling mortality per cent was observed 4.0 (consortium 4) followed by 9.0 (consortium 1) and 12.0 (consortium 2 and consortium 1). Rest of treatments recorded 18.0 (*Trichoderma viride*) to 29.0 (*Aspergillus niger*) post emergence seedling mortality. Results indicated that treatment consortium 1 found at par with consortium 4.

Table.1 Field efficacy of different bioagents alone/ consortia on rhizome rot incidence of turmeric

Treatment No.	Treatment/ Dose	% Germination*	% Increase over control	% Incidence*		Av. Mortality	% Reduction over control		Av. Reduction
				PERR	PESM		PERR	PESM	
T_1	*Trichoderma viride*	85.00 (67.21)	50.59 (45.34)	15.00 (22.79)	18.00 (25.10)	16.50 (23.97)	74.14 (59.43)	73.53 (59.04)	73.83 (59.23)
T_2	*Trichoderma harzianum*	82.00 (64.90)	48.78 (44.30)	18.00 (25.10)	23.00 (28.66)	20.50 (26.92)	68.97 (56.15)	66.18 (54.44)	67.57 (55.29)
T_3	*Verticillium lecanii*	75.00 (60.00)	44.00 (41.55)	25.00 (30.00)	32.00 (34.45)	28.50 (32.27)	56.90 (48.97)	52.94 (46.69)	54.92 (47.82)
T_4	*Pseudomonas fluorescens*	80.00 (63.43)	47.50 (43.57)	20.00 (26.57)	25.00 (30.00)	22.50 (28.32)	65.52 (54.04)	63.24 (52.68)	64.38 (53.36)
T_5	*Beauveria bassiana*	76.00 (60.67)	44.74 (41.98)	24.00 (29.33)	31.00 (33.83)	27.50 (31.63)	58.62 (49.96)	54.41 (47.53)	56.52 (48.75)
T_6	*Metarhizum anisopliae*	78.00 (62.03)	46.15 (42.79)	22.00 (27.97)	27.00 (31.31)	24.50 (29.67)	62.07 (51.98)	60.29 (50.94)	61.18 (51.46)
T_7	*Bacillus subtilis*	77.00 (61.34)	45.45 (42.39)	23.00 (28.66)	27.00 (31.31)	25.00 (30.00)	60.34 (50.97)	60.29 (50.94)	60.32 (50.96)
T_8	*Aspergillus niger*	76.00 (60.67)	44.74 (41.98)	24.00 (29.33)	29.00 (32.58)	26.50 (30.98)	58.62 (49.96)	57.94 (49.57)	58.28 (49.77)
T_9	*Nomuraea rileyi*	79.00 (62.73)	46.84 (43.19)	21.00 (27.27)	26.00 (30.66)	23.50 (29.00)	63.79 (53.00)	62.70 (52.36)	63.25 (52.68)
T_{10}	*Paecilomyces lilacinus*	78.00 (62.03)	46.15 (42.79)	22.00 (27.97)	27.00 (31.31)	24.50 (29.67)	62.07 (51.98)	61.11 (51.42)	61.59 (51.70)
T_{11}	*Gluconacetobacter glucani*	82.00 (64.90)	48.78 (44.30)	18.00 (25.10)	23.00 (28.66)	20.50 (26.92)	68.97 (56.15)	67.46 (55.22)	68.21 (55.68)

T_{12}	*Azospirillum brasilense*	81.00 (64.16)	48.15 (43.94)	19.00 (25.84)	23.00 (28.66)	21.00 (27.27)	67.24 (55.08)	66.18 (54.44)	66.71 (54.76)
T_{13}	*Pseudomonas striata*	82.00 (64.90)	48.78 (44.30)	18.00 (25.10)	22.00 (27.97)	20.00 (26.57)	68.97 (56.15)	67.65 (55.34)	68.31 (55.74)
T_{14}	*Pink pigmented facultative methylobacterium*	80.00 (63.43)	47.50 (43.57)	20.00 (26.57)	26.00 (30.66)	23.00 (28.66)	65.52 (54.04)	61.76 (51.80)	63.64 (52.92)
T_{15}	Consortium 1	92.00 (73.57)	54.35 (47.50)	8.00 (16.43)	9.00 (17.46)	8.50 (16.95)	86.21 (68.20)	86.76 (68.66)	86.49 (68.43)
T_{16}	Consortium 2	90.00 (71.57)	53.33 (46.91)	10.00 (18.43)	12.00 (20.27)	11.00 (19.37)	82.76 (65.47)	82.35 (65.16)	82.56 (65.32)
T_{17}	Consortium 3	90.00 (71.57)	53.33 (46.91)	10.00 (18.43)	12.00 (20.27)	11.00 (19.37)	82.76 (65.47)	82.35 (65.16)	82.56 (65.32)
T_{18}	Consortium 4	96.00 (78.46)	56.25 (48.59)	4.00 (11.54)	4.00 (11.54)	4.00 (11.54)	93.10 (74.77)	94.12 (75.97)	93.61 (75.36)
T_{19}	Carbendezim @ 0.1%	85.00 (67.21)	50.59 (45.34)	15.00 (22.79)	21.00 (27.27)	18.00 (25.10)	74.14 (59.43)	69.12 (56.24)	71.63 (57.82)
T_{20}	Control	42.00 (40.40)	0.00 (0.00)	58.00 (49.60)	68.00 (55.55)	63.00 (52.53)	0.00 (.000)	0.00 (.000)	0.00 (0.00)
SE(m) ±		**2.03**	**1.14**	**2.38**	**2.23**	**2.23**	**2.06**	**2.04**	**2.79**
CD (P=0.05)		**6.05**	**3.40**	**7.09**	**6.65**	**6.67**	**6.15**	**6.08**	**8.33**

*-Mean of three replications, Av.: Average, PERR: Pre emergence rhizome rot, PESM: Post Emergence Seedling Mortality, Figures in parentheses are angular transformed values

The average mortality recorded with all the treatments and it was maximum in untreated control (63.0) followed by *Verticillium lecanii* (28.50) and *Beauveria bassiana* (27.50). Minimum per cent average mortality was observed 4.0 (consortium 4) followed by 8.50 (consortium of 1) and 11.0 (consortium 2 and consortium 3). Rest of treatments recorded 16.50 (*Trichoderma viride*) to 26.50 (*Aspergillus niger*) average mortality. Results indicated that treatment consortium 1 found at par with consortium 4.

Reduction in mortality

All the test treatment dosages were found to reduce both PERR and PESM over untreated control. Highest per cent reduction in pre emergence rhizome rot was recorded in treatment consortium of T_1 to T_{14} (93.10) followed by consortium 1 (86.21) and consortium 2 and consortium 3 (82.76). Whereas lowest per cent reduction in pre emergence rhizome rot was recorded by *Verticillium lecanii* (56.90) followed by *Beauveria bassiana* and *Aspergillus niger* (58.62) and *Bacillus subtilis* (60.34). Rest of treatments recorded 62.07 (*Metarhizum anisopliae* and *Paecilomyces lilacinus*) to 74.14 (*Trichoderma viride* and Carbendezim @ 0.1%) per cent reduction in pre emergence rhizome rot.

The reduction in post emergence seedling mortality was highest in treatment consortium 4 (94.12) followed by consortium 1 (86.76) and consortium 2 and consortium 3 (82.35). Whereas lowest per cent reduction in post emergence seedling mortality was recorded by *Verticillium lecanii* (52.94) followed by *Beauveria bassiana* (54.41) and *Aspergillus niger* (57.94). Rest of treatments recorded 60.29 (*Metarhizum anisopliae* and *Bacillus subtilis*) to 73.53 (*Trichoderma viride*) per cent reduction in post emergence seedling mortality.

The reduction in average mortalities (pre and post) was highest in treatment consortium 4 (93.61) followed by consortium 1 (86.49) and consortium 2 and consortium 3 (82.56). Whereas lowest per cent reduction in post emergence seedling mortality was recorded by *Verticillium lecanii* (54.92) followed by *Beauveria bassiana* (56.52) and *Aspergillus niger* (58.28). Rest of treatments recorded 60.29 (*Metarhizum anisopliae*) to 73.83 (*Trichoderma viride*) per cent reduction in average mortality. Results indicated that treatment consortium 1 found at par with consortium 4 in average mortality reduction.

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