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Efficacy of ISR chemicals/elicitors against *Pythium aphanidermatum* causing rhizome rot of turmeric

Chavan PG, Apet KT, Ghante PH, Agale RC and Kadam RV

Abstract
All the ISR chemicals / elicitors tested as rhizome treatment and soil application against turmeric rhizome rot were found effective with reduction in pre and post emergence mortalities of *P. aphanidermatum*, over untreated control. however, Chitosan (RT) + its drenching (97.25 %), followed by Salicylic acid (RT) + its drenching (96.07 %), Chitosan (RT) (94.29 %), β-amino butyric acid (RT) + its drenching (93.56 %), Jasmonic acid (RT) + its drenching (92.27 %), Salicylic acid (RT) + Propiconazole (SA) (91.72 %) and Salicylic acid (RT) (91.61 %). Whereas, Control (Propiconazole (RT)) was recorded comparatively least reduction in average mortality of 77.13.

Keywords: *Curcuma longa*, *Pythium aphanidermatum*, ISR chemicals/ elicitors, management

Introduction
Turmeric (*Curcuma longa* L.) commonly known as 'hidden Lilly' or 'golden spice' or 'turmeric of commerce' or 'Indian saffron' or 'Haldi'. It is one of the major spices belongs to family Zingiberaceae cultivated for its underground rhizome, originated from Tropical South Asia. Turmeric is the third largest spice produced in the country and it accounts for about 14 % of total spices produced in India. India is the world's largest producer of turmeric and apparently accounts for more than 80 per cent of the world's production, followed by China, Indonesia, Bangladesh, and Thailand (Selvan *et al*., 2002) [13]. The area, production and productivity of turmeric in India has been reported to be 175.73 and 185.58 thousand hectares, 959.35 and 943.33 thousand tones and 5459 and 5083 kg/ha, respectively, during year 2014-15 and 2015-16 (Anonymous, 2016) [2]. The total area in Maharashtra under turmeric was 11.0 thousand hectares, with production 11.0 thousand tones and productivity of 1000 kg/ha, respectively (Anonymous, 2015) [1].
Turmeric is affected by many fungal, bacterial, viral and nematode diseases. Among all diseases rhizome rot caused by *P. aphanidermatum* is most destructive and widespread disease causes very high crop loss under favorable conditions (Rathaiah, 1982) [2]. The disease has been reported to causes more than 60 per cent mortality of seedlings both in nursery and field condition and about 50-80 per cent losses during storage (Nirmal, 1992) [4]; rhizome rot resulted in yield loss of 50% (Rajalakshmi *et al.*, 2016) [8].

Material and methods
Evaluation of ISR chemicals/elicitors (Pot culture)
The pot culture experiments were conducted under controlled conditions of screen house at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to evaluate the efficacy of ISR chemicals / elicitors against *P. aphanidermatum* the incitant of turmeric rhizome rot.
A total of 4 ISR chemicals / elicitors (alone and in combination) were evaluated against *P. aphanidermatum* by sick soil method in pot culture under screen house conditions. The earthen pots (30 cm dia.) disinfected with 5 per cent of copper sulphate solution filled with the autoclaved potting mixture of soil: sand: FYM (2:1:1) were inoculated (@ 50 g/kg mixture) with the test pathogens culture mass multiplied on sand: maize medium, watered adequately and incubated in screen house for two weeks to proliferate the test pathogen to make the soil / potting mixture sick. The pot culture experiment comprised of 12 treatments as described under treatment details. The test ISR chemicals / elicitors were applied (alone and in combination) as pre sowing seed treatment to the healthy rhizomes of susceptible turmeric Cv. Selum and sown (1 rhizome / pot) in the earthen pots containing *P. aphanidermatum* sick soil. Six pots / treatment / replication were maintained and all the treatments replicated thrice. The earthen pots containing *P. aphanidermatum* sick soil sown with surface sterilized healthy rhizomes of turmeric Cv. Selum and without application of any ISR chemicals / elicitors and

with application of Propiconazole (fungicide) were maintained as untreated and treated control. A soil drenching of the treatments were undertaken at 60 DAS of the crop.

Observations on rhizome germination and pre emergence rhizome rot (PERR) will be recorded at 30 days after sowing and that of post emergence seedling mortality (PESM) at 60, 90, 120 and 150 days after sowing. The per cent of rhizome germination, pre emergence rhizome rot (PERR) and post emergence seedling mortality (PESM) will be calculated by following formulae:

$$\text{Germination (\%)} = \frac{\text{No. of rhizomes germinated}}{\text{Total no. of rhizomes sown}} \times 100$$

$$\text{PERR (\%)} = \frac{\text{No. of rhizomes ungerminated}}{\text{Total no. of rhizomes sown}} \times 100$$

$$\text{PESM (\%)} = \frac{\text{No. of seedlings died}}{\text{Total no. of seedlings}} \times 100$$

Result and discussion

Effect on rhizome germination

Results revealed that all the test treatments recorded significantly increase in rhizome germination, over untreated control and it was ranged from 45.92 (Propiconazole (RT)) to 51.00 (Chitosan (RT)) per cent. However, highest increase in rhizome germination was recorded with Chitosan (RT) (51.00 %), followed by Chitosan (RT) + its drenching (50.67 %), Salicylic acid (RT) + its drenching and Salicylic acid (RT) (each 50.44 %), β-amino butyric acid (RT) (49.98 %), Salicylic acid (RT) + Propiconazole (SA) (49.82 %), β-amino butyric acid (RT) + its drenching (49.63 %), Jasmonic acid (RT) (48.94 %), and Jasmonic acid (RT) + its drenching (48.82 %). Whereas, Control (Propiconazole (RT)) and Jasmonic acid + Propiconazole (SA) were found less effective with 45.92 and 48.56 per cent increase in rhizome germination, respectively.

Reduction in mortality

All the test treatments were found to reduce both (pre and post) emergence mortalities over untreated control.

The reduction in pre emergence rhizome rot (PERR) was ranged from 77.62 (Propiconazole (RT)) to 95.16 (Chitosan (RT)) per cent. However, it was significantly highest with Chitosan (RT) (95.16 %), followed by Chitosan (RT) + its drenching 93.91 %), Salicylic acid (RT) + its drenching (93.05 %), Salicylic acid (RT) (93.03 %), β-amino butyric acid (RT) (91.35 %), Salicylic acid (RT) + Propiconazole (SA) (90.77 %), β-amino butyric acid (RT) + its drenching (90.08 %), Jasmonic acid (RT) (87.61 %), and Jasmonic acid (RT) + its drenching (87.19 %). Whereas, Control (Propiconazole (RT)) and Jasmonic acid (RT) + Propiconazole (SA) were recorded comparatively least reduction in pre emergence rhizome rot of 77.62 and 86.29 per cent, respectively.

The reduction in post emergence seedling mortality (PESM) was ranged from 99.00 (Chitosan (RT) + its drenching) to 76.87 (Control (Propiconazole RT)) per cent. However, it was significantly highest with Chitosan (RT) + its drenching (99.00 %), followed by Salicylic acid (RT) + its drenching (97.65 %), β-amino butyric acid (RT) + its drenching (95.37 %), Jasmonic acid (RT) + its drenching (94.92 %), Chitosan (RT) (93.84 %), Salicylic acid (RT) + Propiconazole (SA) (92.22 %), Salicylic acid (RT) (90.86 %), Jasmonic acid (RT) + Propiconazole (SA) (90.44 %) and β-amino butyric acid (RT) (89.25 %). Whereas, (Propiconazole (RT)) and Jasmonic acid (RT) were recorded comparatively least reduction in post emergence seedling mortality of 76.87 and 87.44 per cent, respectively.

The reduction in average mortality (PESM) was ranged from 77.13 (Control (Propiconazole RT)) to 97.25 (Chitosan (RT) + its drenching) per cent. However, it was significantly highest with Chitosan (RT) + its drenching (97.25 %), followed by Salicylic acid (RT) + its drenching (96.07 %), Chitosan (RT) (94.29 %), β-amino butyric acid (RT) + its drenching (93.56 %), Jasmonic acid (RT) + its drenching (92.27 %), Salicylic acid (RT) + Propiconazole (SA) (91.72 %), Salicylic acid (RT) (91.61 %), β-amino butyric acid (RT) (89.97 %) and Jasmonic acid (RT) + Propiconazole (SA) (89.02 %). Whereas, Control (Propiconazole (RT)) and Jasmonic acid (RT) were recorded comparatively least reduction in average mortality of 77.13 and 87.50 per cent, respectively.

These results are in conformity with the findings of those reported earlier by several workers against, *Pythium aphanidermatum* infecting turmeric. Radhakrishnan and Balasubramanian (2009) [6] reported induced resistance response by salicylic acid in turmeric against *Pythium aphanidermatum*. They reported increase in enzymatic activities, PR proteins, protease, trypsin and chymotrypsin inhibitors, soluble and ionically bound peroxidase activity due to SA. Increased activities of peroxidases and protease inhibitors played major role in restricting (*P. aphanidermatum*) development of disease by reduction in cell death. So that SA is an effective resistance activator in turmeric and a potentially useful agent for the control of rhizome rot disease. Sathiyanarayanan and Muthukrishnan (2014a) [10] reported chitosan for its potential to induce resistance in turmeric against *Pythium aphanidermatum*. Its application to turmeric induces defense enzymes such as chitinases and chitosanases which played a role in restricting the development of disease symptoms. The eliciting properties of chitosan make chitosan as potential antifungal agent against turmeric rhizome rot. Similar results are reported earlier by several workers against, *Pythium aphanidermatum* infecting turmeric (Ushamalini *et al*., 2008; Radhakrishnan *et al*., 2011; Sathiyanarayanan and Muthukrishnan, 2014b; Boominathan and Sivakumaar, 2015; Radhakrishnan and Balasubramanian, 2015a; Sathiyanarayanan and Muthukrishnan, 2015b) [14, 7, 11, 3, 12].

Table 1: Bioefficacy of ISR chemicals against *P. aphanidermatum* causing turmeric rhizome rot (Pot Culture)

T. No.	Treatments	Dose (g/kg of rhizome or t/ha of soil)	Germination * (%)	% Incr. over control	Incidence (%) *		Av. Mor. (%)	Red. (%) over control		Av. Red. (%)
					PERR	PESM		PERR	PESM	
T_1	Salicylic acid (RT)	50 mg/kg	96.36 (79.00)	50.44 (45.25)	3.64 (11.00)	9.14 (17.60)	6.39 (14.64)	93.03 (74.69)	90.86 (72.40)	91.61 (73.16)
T_2	Salicylic acid (RT) + its drenching	50 mg/kg + 50 mg/lit	96.37 (79.02)	50.44 (45.25)	3.63 (10.98)	2.35 (8.82)	2.99 (9.96)	93.05 (74.72)	97.65 (81.18)	96.07 (78.57)
T_3	β-amino butyric acid (RT)	50 mg/kg	95.48 (77.73)	49.98 (44.99)	4.52 (12.27)	10.75 (19.14)	7.64 (16.04)	91.35 (72.89)	89.25 (70.86)	89.97 (71.54)

T_4	β-amino butyric acid (RT) + its drenching	50 mg/kg + 50 mg/lit	94.82 (76.84)	49.63 (44.79)	5.18 (13.16)	4.63 (12.43)	4.91 (12.80)	90.08 (71.65)	95.37 (77.57)	93.56 (75.29)
T_5	Jasmonic acid (RT)	50 mg/kg	93.53 (75.26)	48.94 (44.39)	6.47 (14.74)	12.56 (20.76)	9.51 (17.97)	87.61 (69.39)	87.44 (69.24)	87.50 (69.30)
T_6	Jasmonic acid (RT) + its drenching	50 mg/kg + 50 mg/lit	93.31 (75.01)	48.82 (44.32)	6.69 (14.99)	5.08 (13.03)	5.89 (14.04)	87.19 (69.03)	94.92 (76.97)	92.27 (73.86)
T_7	Chitosan (RT)	50 mg/kg	97.47 (80.85)	51.00 (45.57)	2.53 (9.15)	6.16 (14.37)	4.35 (12.03)	95.16 (77.29)	93.84 (75.63)	94.29 (76.18)
T_8	Chitosan (RT) + its drenching	50 mg/kg + 50 mg/lit	96.82 (79.73)	50.67 (45.38)	3.18 (10.27)	1.00 (5.74)	2.09 (8.31)	93.91 (75.72)	99.00 (84.26)	97.25 (80.48)
T_9	Salicylic acid (RT) + Propiconazole (SA)	50 mg/kg + 1 g/lit	95.18 (77.32)	49.82 (44.90)	4.82 (12.68)	7.78 (16.20)	6.30 (14.54)	90.77 (72.32)	92.22 (73.80)	91.72 (73.28)
T_{10}	Jasmonic acid + Propiconazole (SA)	50 mg/kg + 1 g/lit	92.84 (74.48)	48.56 (44.17)	7.16 (15.52)	9.56 (18.01)	8.36 (16.81)	86.29 (68.27)	90.44 (71.99)	89.02 (70.65)
T_{11}	Control (Propiconazole RT)	1 g/kg	88.31 (70.01)	45.92 (42.66)	11.69 (19.99)	23.13 (28.75)	17.41 (24.66)	77.62 (61.77)	76.87 (61.25)	77.13 (61.43)
T_{12}	Control (Untreated)	---	47.76 (43.72)	0.00 (0.00)	52.24 (46.28)	100.00 (90.00)	76.12 (60.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	SE ±		0.33	0.52	0.39	0.37	0.30	0.39	0.40	0.30
	CD (P=0.01)		0.98	1.51	1.14	1.12	0.94	1.17	1.18	0.92

*-Mean of three replications, Av.: Average, Mor.: Concentration, Incr.: Increase Red.: Reduction, PERR: Pre emergence rhizome rot, PESM: Post Emergence Seedling Mortality, RT: Rhizome Treatment, SA: Soil Application, Figures in parentheses are angular transformed values

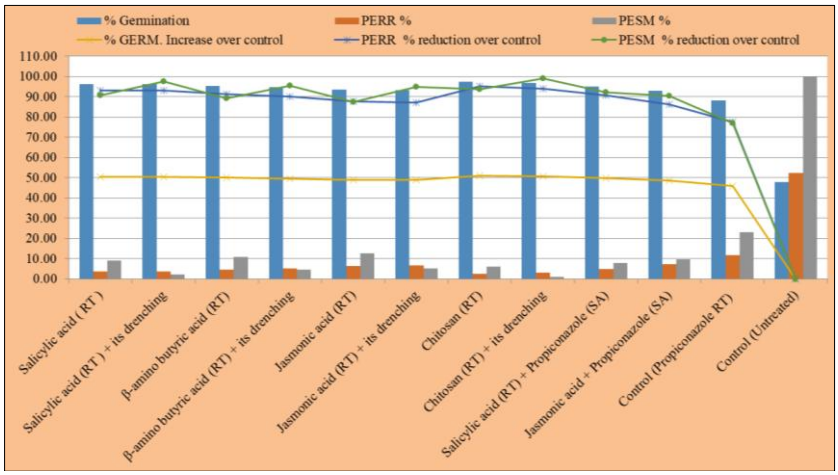

Fig 1: Bioefficacy of ISR chemicals against *P. aphanidermatum* causing turmeric rhizome rot

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