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RESEARCH ARTICLE

Integrated management of bacterial wilt of ginger incited by *Ralstonia solanacearum*

■ **Roop Singh**

SUMMARY

An experiment was conducted to find out the integrated management of *Ralstonia solanacearum* infecting ginger. Two antibiotics, two biocontrol agents, one phytoextract and one organic amendment and their combination were used. The average reduction in pre emergence seed rot and post emergence seedling mortality recorded with all the treatments tested were ranged from 16.50 to 80.39 per cent over untreated. However, significantly highest reduction in average pre-emergence seed rot and post- emergence seedling mortality was recorded with streptocycline + *P. fluorescens* (80.39%). This was followed by streptocycline + karanj cake (72.31%), streptocycline + *T. viride* (69.55%), streptocycline (58.68%), karanj cake + *A. sativum* (48.49%), *P. fluorescens* (44.94%), karanj cake (36.79%). Whereas, *T. viride*, *A. sativum* and gentamycin were found least effective with comparatively minimum reduction in average mortality, 26.94, 20.94 and 16.50 per cent, respectively. Of the treatments tested, significantly highest root length (8.60 cm), shoot length (18.43 cm) and vigour index (2342.69) were recorded with streptocycline + *P. fluorescens.*

Key Words : Mortality, *Ralstonia solanacearum*, *Zingiber officinale*, Integrated management

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Zingiber officinale Rosc. (Ginger) belonging to the family *Zingiberaceae* is an important commercial crop grown for its aromatic rhizomes which are used as a spice and a medicine (Sharma *et al.,* 2010). The crop suffers from diseases like bacterial wilt caused by *Ralstonia solanacearum*, rhizome rot caused by *Pythium* spp., *Fusarium* spp., *Sclerotium* spp., *Pseudomonas* spp. and others (Dake and Edison, 1989; Senapati and Ghose, 2005; Paret *et al.,* 2010; Sharma *et al.,* 2010 and Kavyashree, 2009). Out of the above mentioned diseases of ginger, Bacterial wilt caused by *R. solanacearum* is deemed to be one of the most important plant diseases in tropical agriculture (Hayward *et al.*, 1990). It has a large host range of more than 200 species in 50 families (Aliye *et al.,* 2008). Bacterial wilt caused by *R. solanacearum* is the major constraints in production of ginger (*Zingiber officinale* Rosc.) (Kumar and Sarma, 2004). Bacterial wilt of ginger is reported from India, China, Japan, Indonesia, Hawaii and many

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other ginger growing countries. In India the disease is found in Kerala, Karnataka, Himachal Pradesh, Sikkim, West Bengal, Assam and other North Eastern States (Kumar *et al*., 2004). The disease is endemic in majority of the ginger growing areas *viz.*, Kerala, Sikkim and many other northeastern regions of the country. Sambasivam and Girija (2005) reported host resistant and loss in ginger cultivation by *R. solanacearum* in Kerala. Many a times this important cash crop is subjected to premature wilting resulting in 100 per cent crop loss. The characteristic symptoms of bacterial wilt of ginger include leaf yellowing and curling followed by necrosis and lethal wilting of the plant (Li *et al.*, 2010; Nelson, 2013; White *et al.*, 2013 and Kai *et al*., 2014). Considering the economic losses incurred by the pathogen, the present investigations were undertaken. The aim of present study was to investigate inhibitory effect of antibiotics, bioagents, organic amendment and phyoextract against *R. solanacearum* isolated from bacterial wilt specimen of ginger.

MATERIAL AND METHODS

This study was conducted at Department of Plant Pathology, College of Agriculture, Vasantarao Naik Marathwada Krishi Vidyapeeth, Parbhani during August 2014 to June 2015. The experiment was laid in Complete Randomized Design (CRD) and imposed following treatments with three replications under each of them. Two antibiotics, two biocontrol agents, one phytoextract and one organic amendment and their combination were used against the test pathogen under glass house conditions for integrated management of wilt of ginger (pot culture).

Soil inoculation of pathogen:

The earthen pots (30 cm dia.) disinfected with 5 per cent of copper sulphate solution were filled with the autoclaved potting mixture of soil: sand: FYM (2:1:1). The virulent isolate of *R. solanacearum* was multiplied on Nutrient broth. The 48 hrs old culture of *R. solanacearum* containing 2×10^8 cfu/ml was inoculated (at 50 ml / kg potting mixture) separately to the potting mixture in pots, mixed thoroughly, watered adequately and incubated for 96 hrs in the glass house, to proliferate the pathogen and make the soil / potting mixture sick.

Seed treatment with antibiotics:

Seed rhizomes were soaked in Streptocycline and Gentamycin (each at 0.05%) for 30 minutes and air dried before sowing.

Soil treatment with bioagents:

Test bioagents (*Pseudomonas fluorescens* and *Trichoderma viride*) carrier based preparation was applied in the soil at 10 g/kg soil.

Soil drenching with phytoextract:

Bulb extract at 20 per cent of botanical *Allium sativum* was prepared in equal amount of sterile distilled water (w/v); filtered through double layered muslin cloth and the resultant extract was used (20 ml/kg soil) as soil drench in pots containing sick soil.

Soil application with organic amendment:

Karanj cake were applied at 50 g/kg soil in the earthen pots containing test bacterium sick soil/ potting mixture, mixed thoroughly and watered.

Combinations *viz.*, Streptocycline (ST at 0.05%) + *P. fluorescence* (SA at 10g/kg soil), Streptocycline (ST at 0.05%) + *T. viride* (SA at 10g/kg soil), Streptocycline (ST at 0.05%) + Karanj cake (SA at 50 g/kg soil) and Karanj cake (SA at 50 g/kg soil) + *A. sativum* aq. bulb extract 20% (SD at 20 ml/kg soil) were applied. Pots filled only with steam sterilized potting mixture and inoculated with inoculums were maintained as untreated. Surface sterilized (0.1% $HgCl_2$) healthy rhizome seeds of ginger were sown (10 seeds/pot) in both treated and untreated pots. For each treatment three pots per replication were maintained and all the treatments were replicated thrice. These pots were maintained in screen house and watered regularly.

Pre-emergence mortality and wilt incidence:

Observations on seed germination and pre-emergence mortality were recorded at 15 days after sowing and that of wilting were recorded at 45 and 60 days after sowing. The percentage seed germination, pre emergence seed rot and post emergence seedling mortality and vigour index were calculated by following formulae.

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

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

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

$$\text{Reduction (\%) in PESR and PESM} = \frac{C - T}{C} \times 100$$

where,

C = Per cent rot/mortality in control

T = Per cent rot/mortality in treatment

Vigour index = [Shoot length (cm) + Root length (cm)] x Germination (%)

RESULTS AND DISCUSSION

Bactericides, bioagents, botanical and organic amendment were evaluated (alone and in combination) for the integrated management of bacterial wilt of ginger in pot culture under green house conditions. The results obtained on percentage seed germination, pre-emergence seed rot (PESR), post-emergence seedling mortality (PESM), their reductions are presented in Table 1.

Effect of treatments on seed germination and mortality:

Results (Table 1) revealed that all the treatments exhibited improved seed germination in the range of 43.33 to 86.67 per cent, as compared to the control 33.33 per cent. However, highest seed germination was recorded with streptocycline + *P. fluorescens* (86.67%). This was followed by the streptocycline + karanj cake (80.00%), streptocycline + *T. viride* (78.33%), streptocycline (73.33%), karanj cake + *A. sativum* (66.66%), *P. fluorescens* (64.66%), karanj cake (60.00%). Whereas, *T. viride* (51.67%), *A. sativum* (48.33%) and gentamycin (43.33%) were found least effective with comparatively minimum seed germination.

All the treatments influenced pre-emergence seed rot over untreated. The pre-emergence seed rot (PESR) recorded in all the treatments was ranged from 13.33 to

Table 1: Effect of bactericides, bioagents, botanicals and organic amendments on pre emergence seed rot and post emergence seedling mortality caused by *R. solanacearum* in ginger

Tr. No.	Treatments	Rate of application	Germination (%)	Rot/ mortality (%)		Average mortality (%)	Reduction over control (%)		Average reduction (%)
				PESR	PESM		PESR	PESM	
T_1	Streptocycline	(ST) @ 0.05 %	73.33	26.67	30.00	28.33	59.91	57.45	58.68
			(58.90)	(31.09)	(33.21)	(32.15)	(50.71)	(49.28)	(49.99)
T_2	Gentamycin	(ST) @ 0.05 %	43.33	56.67	57.67	57.16	14.67	18.34	16.50
			(41.16)	(48.83)	(49.41)	(49.11)	(22.52)	(25.35)	(23.96)
T_3	*Pseudomonas*	SA @10g/kg soil	64.66	35.33	40.00	37.66	46.50	43.38	44.94
	fluorescence		(53.52)	(36.46)	(39.23)	(37.85)	(42.99)	(41.19)	(42.09)
T_4	*Trichoderma viride*	SA @ 10g/kg soil	51.67	48.33	51.67	49.99	26.98	26.91	26.94
			(45.95)	(44.04)	(45.95)	(44.99)	(31.29)	(31.24)	(31.26)
T_5	Karanj cake	SA @ 50 g/kg soil	60.00	40.00	46.67	43.33	39.67	33.92	36.79
			(50.76)	(39.23)	(43.09)	(41.16)	(39.03)	(35.62)	(37.34)
T_6	*A. sativum* aq. 20 %	SD 20% @ 20 ml/kg soil	48.33	51.67	57.00	54.33	22.61	19.28	20.94
	Bulb extract		(44.04)	(45.95)	(49.02)	(47.48)	(28.39)	(26.04)	(27.23)
T_7	$T_1 + T_3$	ST @ 0.05 % + SA @10g/kg	86.67	13.33	13.67	13.49	80.15	80.63	80.39
		soil	(68.58)	(21.41)	(21.69)	(21.54)	(63.54)	(63.88)	(63.71)
T_8	$T_1 + T_4$	ST @ 0.05 % + SA @10g/kg	78.33	21.67	20.00	19.99	67.45	71.66	69.55
		soil	(62.25)	(27.74)	(26.56)	(26.55)	(55.21)	(57.83)	(56.50)
T_9	$T_1 + T_5$	ST @ 0.05 % + SA @50g/kg	80.00	20.00	17.83	18.91	69.83	74.79	72.31
		soil	(63.43)	(26.56)	(24.97)	(25.77)	(56.68)	(59.86)	(58.25)
T_{10}	$T_5 + T_6$	SA @ 50g/kg + SD @20	66.66	33.33	37.33	35.33	49.99	46.99	48.49
		ml/kg soil	(54.73)	(35.26)	(37.66)	(36.46)	(44.99)	(43.27)	(44.13)
T_{11}	Control	Untreated	33.33	66.66	70.67	65.16	0.00	0.00	0.00
			(35.26)	(54.73)	(57.20)	(53.82)	(0.00)	(0.00)	(0.00)
S.E.±			2.54	2.39	2.41	2.40	2.59	2.51	2.55
C.D. (P=0.01)			7.45	7.00	7.07	7.03	7.59	7.35	7.47

Figures in parentheses are angular transformed values

56.67 per cent, as against 66.66 per cent in untreated. However, least pre-emergence seed rot was recorded with streptocycline + *P. fluorescens* (13.33%). This was followed by streptocycline + karanj cake (20.00%), streptocycline + *T. viride* (21.67%), streptocycline (26.67%), karanj cake + *A. sativum* (33.33%), *P. fluorescens* (35.33%), karanj cake (40.00%). *T. viride*, *A. sativum*, gentamycin were found comparatively less effective with maximum PESR, 48.33, 51.67 and 56.67 per cent, respectively.

All the treatments tested were found effective against *R. solanacearum* and recorded PESM in the range of 13.67 to 57.67 per cent as compared to control 70.67 per cent. However, least post-emergence seedling mortality was recorded with streptocycline + *P. fluorescens* (13.67%). This was followed by streptocycline + karanj cake (17.83%), streptocycline + *T. viride* (20.00%), streptocycline (30.00%), karanj cake + *A. sativum* (37.33%), *P. fluorescens* (40.00%), karanj cake (46.57%). *T. viride*, *A. sativum*, gentamycin were found comparatively less effective with maximum PESM, 51.67, 57.00 and 57.67 per cent, respectively.

The average mortality (PESR + PESM) recorded with all the treatments were ranged from 13.49 to 57.16 per cent as compared to control the 65.16 per cent. Least average mortality was recorded with streptocycline + *P. fluorescens* (13.49%). This was followed by streptocycline + karanj cake (18.91%), streptocycline + *T. viride* (19.99%), streptocycline (28.33%), karanj cake + *A. sativum* (35.33%), *P. fluorescens* (37.66%), karanj cake (43.33%). *T. viride*, *A. sativum*, gentamycin were found comparatively less effective with maximum PESM, 49.99, 54.33 and 57.16 per cent, respectively.

Reduction in pre-emergence and post-emergence seedling mortality:

The average reduction in pre emergence and post emergence seedling mortality recorded with all the treatments tested were ranged from 16.50 to 80.39 per cent as compared to the control 0.00 per cent. However, highest reduction in average mortality was recorded with *P. fluorescens* (80.39%). This was followed by streptocycline + karanj cake (72.31%), streptocycline + *T. viride* (69.55%), streptocycline (58.68%), karanj cake + *A. sativum* (48.49%), *P. fluorescens* (44.94%), karanj cake (36.79%). Whereas, *T. viride*, *A. sativum* and gentamycin were found least effective with comparatively minimum reduction in average mortality, 26.94, 20.94 and 16.50 per cent.

Effect of treatments on growth parameters:

The effect of all the treatments imposed for management of *R. solanacearum* and their influence on plant growth parameters *viz.*, root length, shoot length and vigour index in ginger were recorded and the results are presented in Table 2.

The average root length, shoot length and vigour index recorded with all the treatments were ranged from 5.26 to 8.60 cm, 10.03 to 18.43 cm and 662.51 to 2342.69, respectively while 4.49, 6.56 cm and 381.96, respectively in untreated. Of the treatments tested, highest root length (8.60 cm), shoot length (18.43 cm) and vigour index

Table 2 : Effect of bactericides, bioagents, botanicals and organic amendments on growth parameters in ginger against *R. solanacearum*

Tr. No.	Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
T_1	Streptocycline (ST) @ 0.05 %	73.33 (58.90)	7.70	15.20	1679.25
T_2	Gentamycin (ST) @ 0.05 %	43.33 (41.16)	5.26	10.03	662.51
T_3	*Pseudomonas fluorescence* (SA) @ 10g/kg soil	64.66 (53.52)	6.63	13.36	1292.55
T_4	*Trichoderma viride* (SA) @ 10g/kg soil	51.67 (45.95)	6.38	12.65	983.28
T_5	Karanj cake (SA) @ 50 g/kg soil	60.00 (50.76)	6.50	12.80	1158.00
T_6	*A. sativum* aq.ex. 20% (SD) @ 20 ml/kg soil	48.33 (44.04)	5.46	12.16	851.57
T_7	T_1 (ST) + T_3 (SA)	86.67 (68.58)	8.60	18.43	2342.69
T_8	T_1 (ST) + T_4 (SA)	78.33 (62.25)	7.93	15.90	1866.60
T_9	T_1 (ST) + T_5 (SA)	80.00 (63.43)	8.20	17.80	2080.00
T_{10}	T_5 (SA) + T_6 (SD)	66.66 (54.73)	7.13	14.70	1455.18
T_{11}	Control (Untreated)	33.33 (35.26)	4.90	6.56	381.96
	SE ±	2.54	0.18	0.32	-
	C.D. (P=0.01)	7.45	0.53	0.94	-

Figures in parentheses are angular transformed value

(2342.69) were recorded with streptocycline + *P. fluorescens*. The second best treatment found was streptocycline + karanj cake (8.20 cm, 17.80 cm and 2080.00), respectively. This was followed by streptocycline + *T. viride* (7.93 cm, 15.90 cm and 1866.60), streptocycline (7.70 cm, 15.20 cm and 1679.25), karanj cake + *A. sativum* (7.13 cm, 14.70 cm and 1455.18), *P. fluorescens* (6.63 cm, 13.36 cm and 1292.55) and karanj cake (6.50 cm, 12.80 cm and 1158.00), respectively. Rest of the treatments except gentamycin were found at par to each other and recorded average root length of 5.26 cm, shoot length of 10.03 cm and vigour index 662.51, respectively.

Bactericide, Streptomycine in combination of bioagents *P. fluorescens* and *T. viride*, organic amendment karanj cake and aq. bulb extract of *A. sativum* were effective earlier by several workers (Ojha *et al*., 1986; Anith *et al*., 2000; Dubey, 2005; Bora and Deka, 2007; Biswas and Singh, 2008 and Hussain and Bora, 2008). Sharma and Kumar (2009) reported that in soil application of karanj cake, bleaching powder, lime and seedling dip and spray of streptocycline reduced the initial population of *R. solanacearum* in soil. Ravi and Suryanarayana (2011) reported that pre-sowing rhizome treated with combinations of 0.05 per cent streptocycline + 0.2 per cent copper oxycloride for 20 min and post-sowing soil drench with 0.2 per cent bleaching powder and 0.1 per cent Metalaxyl MZ thrice at 20 days intervals from disease inception found very effective in reducing the Per cent Disease Index (PDI) (2.79). Sawant *et al.* (2014) reported that the highest reduction mortality was recorded with Recommended Dose of Fertilizers (RDF) + 66g Gypsum /kg soil + Copper oxychloride 2500 ppm +Streptocycline 300 ppm (75.23%), followed by *Neem* seed kernel extract 20% + Copper oxychloride + Streptocycline (73.84) and Noni fruit extract 20% +Copper hydroxide + Streptocycline (72.68%).

Conclusion:

Bacterial wilt is one of the major constraints in the production of ginger, causing heavy quantitative as well as qualitative losses. The studies on integrated management of bacterial wilt (*R. solanacearum*) disease under pot culture conditions indicated that the antibiotic streptocycline combination with bioagent *P. fluorescens*, *T. viride*, organic amendment, karanj cake and botanical *A. sativum* were most effective and economical for the management of bacterial wilt of ginger.

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