Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 1618-1623

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7692 **Special Issue-6 pp. 1618-1623**
Journal homepage: http://www.ijcmas.com

Original Research Article

Evaluation of Organic Amendments against *R. solanacearum* causing Bacterial wilt of Ginger

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Keywords

Ralstonia solanacearum and organic amendments

A B S T R A C T

All (Ten) the organic amendments applied in sick soil (*R. solanacearum*) were found effective in reducing the pre-emergence rhizome rot as well as post-emergence seedling mortality in ginger. However, highest average reduction in mortality (70.24%) was recorded with Karanj cake. The second best amendment found was Poultry manure (66.64 %) followed by Neem seed cake (63.70 %), Groundnut cake (53.28%), Goat manure (52.71 %), FYM (45.64 %), Vermicompost (37.90 %), Sunflower seed cake (33.79 %), Cotton seed cake (28.90 %) and Safflower seed cake (24.00 %).

Introduction

India is considered as a *"magical land of spices"*. No other country in the world has such a diverse variety of spice crops as India. Indian spices are known for their excellent aroma, flavor and pungency not easily matched by any other country. India has been a leading spice-producing, consuming and exporting country of the world. Ginger is obtained from the underground stems or rhizome of *Zingiber officinale* (Rosc.) a herbaceous tropical perennial belonging to the family Zingiberaceae. It is usually grown as an annual. The whole plant is refreshingly aromatic, but it is the underground rhizome (raw or processed) which is valued as spice. Its medicinal value is increasingly being recognized nowadays. Ginger originated in South-East Asia, probably in India.

The name itself supports this view. The Sanskrit name 'Singabera' has given rise to Greek '*Zingiberi*' and later the generic name *Zingiber*. Ginger grows well in warm and humid climate and is cultivated from sea level to an altitude of 1500 meters above sea level. Ginger can be grown both under rain fed and irrigated conditions. For successful cultivation of the crop, a moderate rainfall at sowing time till the rhizomes sprout, fairly heavy and well distributed showers during the growing period and dry weather for about a month before harvesting are necessary. Ginger thrives best in well drained soils like sandy loam, clay loam, red loam or lateritic loam. A friable loam rich in humus is ideal. However, being an exhausting crop it is not desirable to grow ginger in the same soil year after year.

Ginger crop is affected by several diseases caused by fungi, bacteria, nematodes and abiotic factors. Among the biotic causes bacteria are most important which cause the major diseases *viz.*, Bacterial wilt (*Ralstonia solanacearum*) and Bacterial soft rot (*Erwinia* spp.). The important fungal diseases include, Rhizome rot/Soft rot (*Pythium aphanidermatum*), Pythium soft rot (*Pythium graminicolum*), Yellows disease (*Fusarium oxysporium* f. sp. *zingiberi*), Sclerotium rot (*Sclerotium rolfsii*), nematode diseases like root knot disease caused by *Meloidogyne* spp. and abiotic causes like Sunburn (due to high light intensity), Lime-induced chlorosis (due to excessive liming in soil). Among the bacterial diseases infecting ginger crop, bacterial wilt caused by *Ralstonia solanacearum* (Smith) Yabuuchi, is one of the most destructive disease causing accountable qualitative and quantitative losses.

Materials and Methods

Evaluation of organic amendment

A total of 10 organic amendments were evaluated against *R. solanacearum* by sick soil method in pot culture under screen house conditions. Except vermicompost, all the test amendments were crushed physically to rough powder and used for soil application.

The earthen pots (30 cm dia.) disinfected with 5 per cent solution of Copper sulphate were filled with autoclaved potting mixture of soil: sand: FYM (2:1:1). The mass multiplied (48 hr old nutrient broth culture: 2 $x10^8$ cfu/ml) of *R solanacearum* was drenched (@ 50 ml/ kg potting mixture) evenly to the potting mixture in pots, these pots were incubated for 96 hrs in screen house to proliferate the bacterium and make the soil/potting mixture sick. The coarse ground test amendments were applied (@ 50 g/kg mixture) in the earthen pots containing test bacterium sick soil/ potting mixture, mixed thoroughly, watered regularly and maintained in screen house. After 72 hrs of amendments application, surface sterilized (0.1 % $HgCl_2$) healthy rhizome of ginger were sown (4 rhizomes/pot), watered regularly and maintained in the screen house. Three pots/treatment/replication were maintained. The earthen pots containing *R. solanacearum* sick soil and sown with surface sterilized healthy rhizome of ginger, without amendment were maintained as untreated control.

The percentage seed germination, pre-emergence seed rot and post-emergence seedling mortality were calculated by following formulae.

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

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

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

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

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 (%)

Experimental details

Design: CRD
Replications: Three
Treatments: Eleven

Treatment details

T_1: FYM
T_2: Poultry manure
T_3: Neem seed cake
T_4: Sunflower seed cake
T_5: Vermicompost
T_6: Cotton seed cake
T_7: Karanj cake
T_8: Goat manure
T_9: Groundnut cake
T_{10}: Safflower seed cake
T_{11}: Control (Untreated)

Results and Discussion

Evaluation of organic amendments against *R. solanacearum* (RsSn isolate) (Pot culture)

A total of 10 amendments were evaluated as pre-sowing soil application to assess their efficacy against *R. solanacearum* (RsSn isolate), employing sick soil technique and sowing susceptible ginger local variety in pot culture under screen house conditions. The results obtained on rhizome germination, pre-emergence rhizome wilt (PERW) and post-emergence seedling mortality (PESM) are presented in the Table 1 and that of on growth parameters in Table 2.

Effect on rhizome germination

Results presented in Table 1, revealed that all the test amendments recorded significantly improved rhizome germination, over untreated control and it was ranged from 46.67 to 80.00 per cent, as against 33.33 per cent in untreated control. However, significantly highest rhizome germination was recorded with Karanj cake (80.00). This was followed by Poultry manure (76.67%), Neem seed cake (73.33%), Groundnut cake (66.67%), Goat manure (66.67%), FYM (63.33%), Vermicompost (56.67%), Sunflower seed cake (53.33 %) and Cotton seed cake (50.00 %). Whereas, Safflower cake (46.67) was found least effective with comparatively minimum rhizome germination.

Pre-emergence rhizome rot (PERR)

Results (Table 1), revealed that PESR with all the organic amendments and oil cakes recorded in the range of 20.00 to 53.33 per cent as against 66.67 per cent in untreated control. However, Karanj cake was found most effective and recorded significantly least (20.00 %) PESR. The second best amendment found was Poultry manure (23.33 %) followed by Neem seed cake (26.67 %), Goat manure and Groundnut cake (33.33 %), FYM (36.67 %), Vermicompost (43.33 %), Sunflower seed cake (46.67 %), Cotton seed cake (50.00 %) and Safflower seed cake (53.33 %).

Post emergence seedling mortality (PESM)

The results (Table 1), revealed that PESM with all the organic amendments and oil cakes recorded in the range of 20.50 to 50.00 per cent as against 69.45 per cent in untreated control.

However, significantly least PESM (20.50 %) was recorded with Karanj cake. The second best amendment found was Poultry manure (22.02 %) followed by Neem seed cake (22.62 %), Groundnut cake (30.16 %), Goat manure (30.95 %), FYM (37.30 %), Vermicompost (41.11 %), Sunflower seed cake (43.33 %), Cotton seed cake (46.67 %) and Safflower seed cake (50.00 %).

Table.1 Efficacy of organic amendments against *R. solanacearum* (RsSn isolate)

Tr. No.	*Treatments*	*Germination (%)*	*Rot/ mortality (%)**		*Average mortality (%)*	*Reduction over control (%)*		*Average reduction (%)*
			PERR	PESM		PESR	PESM	
T_1	FYM	63.33 (52.73)	36.67 (37.27)	37.30 (37.64)	36.98 (37.45)	44.99 (42.12)	46.29 (42.87)	45.64 (42.50)
T_2	Poultry manure	76.67 (61.12)	23.33 (28.88)	22.02 (27.99)	22.67 (28.43)	65.00 (53.73)	68.29 (55.73)	66.64 (54.72)
T_3	Neem seed cake	73.33 (58.91)	26.67 (31.09)	22.62 (28.40)	24.64 (29.76)	59.99 (50.76)	67.42 (55.19)	63.70 (52.95)
T_4	Sunflower seed cake	53.33 (46.91)	46.67 (43.09)	43.33 (41.17)	45.00 (42.13)	29.99 (33.20)	37.60 (37.82)	33.79 (35.54)
T_5	Vermicompost	56.67 (48.83)	43.33 (41.17)	41.11 (39.88)	42.22 (40.52)	35.00 (36.27)	40.80 (39.70)	37.90 (37.99)
T_6	Cotton seed cake	50.00 (45.00)	50.00 (45.00)	46.67 (43.09)	48.33 (44.04)	25.00 (30.00)	32.80 (34.94)	28.90 (32.52)
T_7	Karanj cake	80.00 (63.43)	20.00 (26.57)	20.50 (26.92)	20.25 (26.74)	70.00 (56.79)	70.48 (57.09)	70.24 (56.94)
T_8	Goat manure	66.67 (54.74)	33.33 (35.26)	30.95 (33.80)	32.14 (34.54)	50.00 (45.00)	55.43 (48.12)	52.71 (46.55)
T_9	Groundnut cake	66.67 (54.74)	33.33 (35.26)	30.16 (33.31)	31.74 (34.29)	50.00 (45.00)	56.57 (48.78)	53.28 (46.88)
T_{10}	Safflower seed cake	46.67 (43.09)	53.33 (46.91)	50.00 (45.00)	51.66 (45.95)	20.00 (26.57)	28.00 (31.95)	24.00 (29.33)
T_{11}	Control (Untreated)	33.33 (35.26)	66.67 (54.74)	69.45 (56.45)	68.06 (55.59)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
SE ±		**2.56**	**1.30**	**2.64**	-	**2.90**	**1.48**	-
CD (P=0.01)		**7.88**	**3.89**	**8.14**	-	**8.10**	**4.37**	-
C.V. %		**1.57**	**3.94**	**1.59**	-	**11.80**	**6.43**	-

*: Mean of three replications; Figures in parentheses are arcsine transformed values

Table.2 Effect of organic amendments on the growth parameters in ginger against *R. solanacearum* (RsSn isolate)

Tr. No.	**Treatments**	**Germination (%)***	**Root Length (cm)***	**Shoot Length (cm)***	**Vigour Index***
T_1	FYM	63.33 (52.73)	6.32	16.10	1419.85
T_2	Poultry manure	76.67 (61.12)	7.00	17.30	1863.08
T_3	Neem seed cake	73.33 (58.91)	6.88	17.15	1762.11
T_4	Sunflower cake	53.33 (46.91)	6.10	15.60	1157.26
T_5	Vermicompost	56.67 (48.83)	6.18	15.88	1250.14
T_6	Cotton seed cake	50.00 (45.00)	6.00	15.54	1077.00
T_7	Karanj cake	80.00 (63.43)	7.23	19.50	2138.40
T_8	Goat manure	66.67 (54.74)	6.40	16.50	1526.74
T_9	Groundnut cake	66.67 (54.74)	6.50	16.65	1543.41
T_{10}	Safflower cake	46.67 (43.09)	5.60	15.18	969.80
T_{11}	Control (Untreated)	33.33 (35.26)	5.12	14.67	659.60
SE +		**2.56**	**0.25**	**0.57**	-
CD (P=0.01)		**7.88**	**0.76**	**1.72**	-
C.V. %		**1.57**	**11.89**	**5.39**	-

* Mean of three replications; Figures in parentheses are angular transformed values

The average mortality (PERR + PESM) recorded with all the treatments ranged from 20.25 to 51.66 per cent as against 68.06 per cent in untreated control. However, Karanj cake was found most effective which recorded significant least average mortality of (20.25 %). The second best amendment was Poultry manure (22.67 %) followed by Neem seed cake (24.64 %), Groundnut cake (31.74 %), Goat manure (32.14 %), FYM (36.98 %), Vermicompost (42.22 %), Sunflower seed cake (45.00 %), Cotton seed cake (48.33 %) and Safflower seed cake (51.66 %).

Reduction in mortality

Result (Table 1), revealed that both PESR and PESM were significantly reduced with the application of all the oil seed cakes tested. The percentage reductions in PERR recorded ranged from 20.00 to 70.00 per cent. However, significantly highest reduction in PERR was recorded with Karanj cake (70.00 %). The second best amendment was Poultry manure (65.00 %) followed by Neem seed cake (59.99 %), Groundnut cake and Goat manure (50.00 %), FYM (44.99 %), Vermicompost (35.00 %), Sunflower seed cake (29.99 %), Cotton seed cake (25.00 %) and Safflower seed cake (20.00 %).

Percentage reduction in PESM recorded with the oilseed cakes and organic amendments tested, ranged from 28.00 to 70.48 per cent. However, significantly highest reduction PESM was recorded with Karanj cake (70.48 %). The second best amendment found was Poultry manure (68.29 %) followed by Neem seed cake (67.42 %), Groundnut cake (56.57 %), Goat manure (55.43 %), FYM (46.29 %), Vermicompost (40.80 %), Sunflower seed cake (37.60 %), Cotton seed cake (32.80 %) and Safflower seed cake (28.00 %).

The average (PERR+PESM) reduction in mortality recorded with all the oilseed cakes and amendments tested were ranged from 24.00 to 70.24 per cent. However, highest average reduction in mortality (70.24 %) was recorded with Karanj cake. The second best amendment found was Poultry manure (66.64 %) followed by Neem seed cake (63.70 %), Groundnut cake (53.28 %), Goat manure (52.71 %), FYM (45.64 %), Vermicompost (37.90 %), Sunflower seed cake (33.79 %), Cotton seed cake (28.90 %) and Safflower seed cake (24.00 %).

Thus, all the organic amendments applied in sick soil (*R. solanacearum*) were found effective in reducing the pre-emergence rhizome rot as well as post-emergence seedling mortality in ginger. However, Karanj cake was found most effective with highest average reduction in mortality. In the order of merit of effectiveness in reducing mortality, the other organic amendments found effective were Poultry manure, Neem seed cake, Groundnut cake, Goat manure, FYM, Vermicompost, Sunflower seed cake, Cotton seed cake and Safflower seed cake.

Effect of organic amendments on the growth parameters in ginger against *R. solanacearum* (RsSn isolate)

Results (Table 2) revealed that all the amendments tested for management of *R. solanacearum* (RsSn isolate) (pot culture) also influenced the growth characteristics in ginger.

All the test amendments improved root length, shoot length and vigour index in ginger. Among the amendments tested, significantly highest root length (7.23 cm), shoot length (19.50 cm) and vigour index (2138.40) were recorded with Karanj cake against significantly least root length (5.12

cm), shoot length (14.67cm) and vigour index (659.60) in untreated control. The second best amendment found was Poultry manure (7.00 cm, 17.30 cm and 1863.08) respectively. This was followed by Neem seed cake (6.88 cm, 17.15 cm and 1762.11), Groundnut cake (6.50 cm, 16.65 cm and 1543.41), Goat manure (6.40 cm, 16.50 cm and 1526.74), FYM (6.32 cm, 16.10 cm and 1419.85), Vermicompost (6.18 cm, 15.88 cm and 1250.14), Sunflower seed cake (6.10 cm, 15.60 cm and 1157.26), Cotton seed cake (6.00 cm, 15.54 cm and 1077.00) and Safflower seed cake (5.60 cm, 15.18 cm and 969.80) of root length, shoot length and vigour index respectively.

Results of the present study obtained for the organic amendments *viz.*, karanj cake, Poultry manure, Neem seed cake, Groundnut cake, Goat manure, FYM, Vermicompost, Sunflower seed cake, Cotton seed cake and Safflower seed cake against *R. solanacearum* (RsSn isolate). The results are in agreement with the findings of earlier workers (Sharma and Kumar, 2000; Lemaga *et al.*, 2001; Schonfeld *et al.*, 2003; Sharma and Kumar, 2004; Islam and Toyota, 2004; Sharma and Kumar, 2009; Yadessa *et al.*, 2010; Reddy *et al.*, 2012).

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