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Exploring efficacy of organic amendments against *Rhizoctonia solani* f. sp. *sasakii*, causing banded leaf and sheath blight in maize (*Zea mays* L.)

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ABSTRACT: Maize (*Zea mays* L.) is an important crop widely cultivated as for food, feed and fodder purposes. Among fungal diseases, banded leaf and sheath blight (BLSB) disease caused by *Rhizoctonia solani* f. sp. *sasakii* is a major problem in maize cultivation, all over the world. Recently, use of organic amendments to control soil borne diseases is emerging as one of the promising practises as its cost effective, avoids health hazards eco-friendly and an efficient non-chemical method approach to control the pathogens. Therefore, the polybag culture (screen house) studies were undertaken to manage maize BLSB (*Rhizoctonia solani* f. sp. *sasakii*) disease, applying soil organic amendments. Of the 12 soil amendments tested, neem seed cake soil application @ 50g/kg potting mixture was found most effective with significantly highest seed germination (87.57 %), least pre-emergence (12.43 %), post-emergence (15.22 %) and average mortality (13.82 %) and thereby resulted significantly with highest reduction in pre-emergence (81.63 %), post-emergence (83.18 %) and average mortality (82.40 %), followed by the soil amendments *viz.*, Castor seed cake, Karanj cake and Groundnut cake.

Keywords: Soil amendments, *Rhizoctonia solani*, Banded leaf and sheath blight, Polybags culture, Mortality.

INTRODUCTION

Maize (*Zea mays* L.), the world's leading crop is widely cultivated as for food, feed and fodder which originated from Mexico and Central America and is versatile emerging crops with wider adaptability. Globally, maize is known as "Queen of cereals" because of its highest genetic yield potential and is the Third most important cereal crop after rice and wheat. Maize ranks fourth in production and fifth in the area, among major cereals in India (Kaur *et al*., 2020).

In India, maize is cultivated on an area of 10.10 million hectares with 34.61 million tonnes of production and productivity of 3.40 tonnes during 2022-2023 (Anonymous, 2022). The predominant maize growing states contributing more than 85 per cent of the total maize production in India are: Karnataka, Madhya Pradesh, Bihar, Tamil Nadu, Telangana, Maharashtra, Andhra Pradesh, Rajasthan, Himachal Pradesh and Gujarat (Anonymous, 2021). In Maharashtra, the area under maize crop was 0.93 million hectares with 1.77 million tonnes of production and productivity of 1.90 tonnes, during 2020-2021 (Anonymous, 2021).

Among a number of fungal, bacterial and viral diseases, banded leaf and sheath blight caused by *Rhizoctonia solani* f. sp. *sasakii* Exner (*Thanatephorus cucumeris*), is one of the most destructive disease, of common prevalence in almost all maize growing pockets of India. Whatever, maize varieties, cultivars, hybrids and composites under cultivation have been found to be prone to BLSB. Organic amendments applied to the soil improves soil conditions and crop productivity, increase water holding capacity and support other beneficial microorganisms, suppressing soilborne pathogens. Due to polyphagous nature maize BLSB disease difficult to manage with chemicals alone and it is also uneconomical. Therefore, present study was undertaken to explore the possibility of soil application of various organic soil amendments on management of maize BLSB disease.

MATERIALS AND METHODS

A total of 12 organic amendments were evaluated against *R. solani* f. sp. *sasakii*, by sick soil method in black polybags (size: 20 x 30 cm.), under screen house conditions. Black coloured polybags filled with autoclaved potting mixture of Soil: Sand (3:1) were inoculated (@ 50 g / kg mixture) with the test pathogen (Rs-3 isolate) mass multiplied (sand: maize medium) culture, watered lightly and incubated in screen house for two weeks, so as to proliferate the pathogen and made the potting mixture sick. After two weeks of incubation, these bags were amended separately with the coarse powdered test amendments (each @ 50 g/kg potting mixture), mixed thoroughly, watered lightly and maintained in screen house. After 72 hrs. of amendments application, surface sterilized (Sodium hypochlorite (NaOCl) solution for 1-2 minutes) healthy

seeds of maize Hy. Kanchan were sown (10 seeds / bag), watered lightly and maintained in the screen house. The black coloured nursery polybags containing sick soil (without any amendment) and sown with surface sterilized healthy seeds of maize Hy. Kanchan were maintained as untreated control.

Experimental details:

Design : Completely Randomised Design (CRD)
Replications : Three
Treatments : Thirteen

Treatment details:

Tr. No	Treatments	Tr. No	Treatments
T_1	Compost	T_8	Castor seed cake
T_2	Vermicompost	T_9	Cotton seed cake
T_3	Poultry manure	T_{10}	Karanj cake
T_4	Goat manure	T_{11}	Neem seed cake
T_5	Sunflower seed cake	T_{12}	Groundnut cake
T_6	Safflower seed cake	T_{13}	Control (untreated)
T_7	Soybean seed cake	-	-

Observations on pre-emergence seed rot (PRESR), post-emergence seedling mortality (POESM) were recorded at seven and 30 days after sowing, respectively. Per cent PRESR, POESM and total mortality was calculated by applying the formulae (Kashyap *et al.*, 2019). The data was statistically analysed at 1 per cent C.D.

$$\text{PRESR (\%)} = \frac{\text{No. of Seeds un-germinated}}{\text{Total no. of Seeds sown}} \times 100$$

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

Total mortality (%) = PRESR + POESM

Further, per cent reduction in total mortality with the treatments, over untreated control (sick soil alone) was calculated by formula

$$\text{Disease control} = \frac{C - T}{C} \times 100$$

Where,

C= per cent average mortality (pre- and post-emergence) in treatment polybags.

T = per cent average mortality (pre- and post-emergence) in untreated control polybags.

RESULTS AND DISCUSSION

***In vitro* efficacy of organic amendments against *R. solani* f. sp. *sasakii* (Polybag culture)**

A total of 12 organic amendments were evaluated as pre-sowing soil application to assess their efficacy against *R. solani* f. sp. *sasakii*, by sick soil method, in polybags under screen house conditions. The results obtained on per cent mortality (pre-, post-emergence and average) and reductions, over untreated control are presented in Table 1 and depicted in PLATE I and Fig. 1.

Seed germination. The results (Table 1) revealed that all the test amendments recorded significantly improved seed germination over untreated control and it was ranged from 46.46 to 87.57 per cent, as against 32.30 per cent in untreated control. However, significantly highest seed germination was recorded in Neem cake (87.57 %). These were followed by the amendments *viz*., Castor seed cake (77.37 %), Karanj cake (74.33 %), Groundnut cake (70.40 %), Safflower seed cake (68.23 %), Sunflower seed cake (67.53 %), both were on par to each other, Cotton seed cake (64.75 %), Soybean seed cake (59.54 %), Vermicompost (55.91 %), Poultry manure (52.77 %) and Compost (48.83 %) whereas, Goat manure was found least effective with comparatively minimum seed germination of 46.46 per cent.

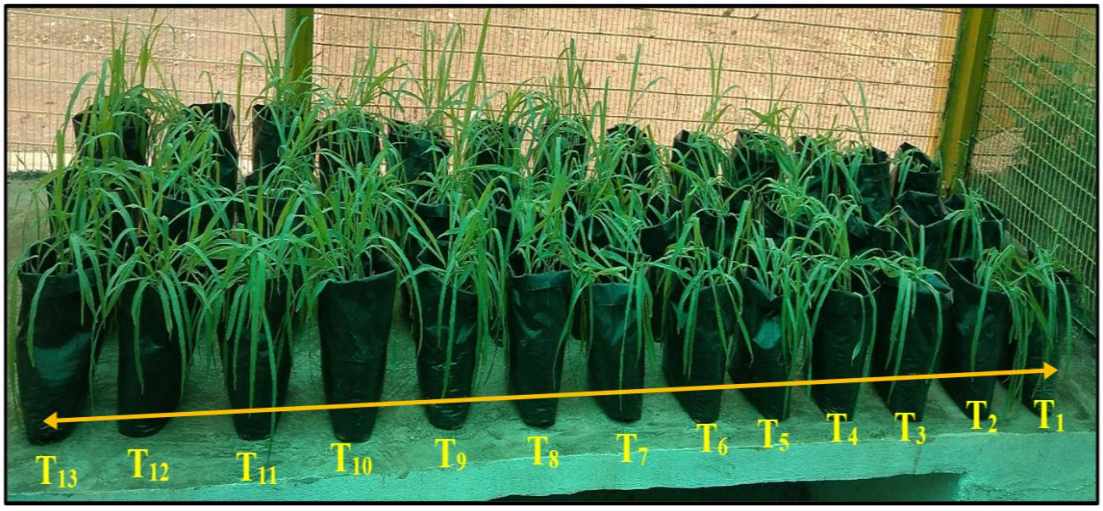

PLATE I. *In vitro* efficacy of soil organic amendments against *R. solani* f. sp. *sasakii*, causing BLSB of maize (Hy. Kanchan).

Pre-emergence seed rot (PRESR). The results (PLATE I, Table 1 & Fig. 1) revealed that the test organic amendments significantly influenced pre-emergence seed rot (PRESR) which ranged from 12.43 to 50.54 per cent, as against 67.70 per cent in untreated control. However, it was significantly least with Neem seed cake (12.43 %), followed by Castor seed cake (22.63 %), Karanj cake (25.67 %), Groundnut cake (29.60 %), Safflower seed cake (31.77 %), Sunflower seed cake (32.47 %), both were on par to each other and Cotton seed cake (35.25 %). Rest of the amendments caused comparatively maximum PRESR in the range of 40.46 to 50.54 per cent, but it was significantly highest in untreated control (67.70 %).

Table 1: Efficacy of organic amendments against *R. solani* f. sp. *sasakii*, causing maize banded leaf and sheath blight (Polybag culture).

Tr. no.	Treatments	Germi-nation (%)	Incidence (%) *		Av. Mor. (%)	Red. (%) over control		Av. Red. (%)
			PRESR	POESM		PRESR	POESM	
T_1	Compost	48.83 **(44.32)**	51.17 **(45.67)**	55.35 **(48.07)**	53.26 **(46.86)**	24.41 **(29.60)**	38.85 **(38.55)**	31.63 **(34.22)**
T_2	Vermicompost	55.91 **(48.39)**	44.09 **(41.60)**	47.78 **(43.72)**	45.93 **(42.66)**	34.87 **(36.19)**	47.21 **(43.40)**	41.04 **(39.83)**
T_3	Poultry manure	52.77 **(46.58)**	47.23 **(43.41)**	50.18 **(45.10)**	48.70 **(44.25)**	30.23 **(33.35)**	44.56 **(41.87)**	37.39 **(37.69)**
T_4	Goat manure	46.46 **(42.97)**	50.54 **(45.30)**	54.12 **(47.36)**	52.33 **(46.33)**	25.34 **(30.22)**	40.21 **(39.35)**	32.77 **(34.92)**
T_5	Sunflower seed cake	67.53 **(55.26)**	32.47 **(34.73)**	35.23 **(36.40)**	33.85 **(35.57)**	52.03 **(46.16)**	61.08 **(51.40)**	56.55 **(48.76)**
T_6	Safflower seed cake	68.23 **(55.69)**	31.77 **(34.30)**	34.75 **(36.12)**	33.26 **(35.21)**	53.07 **(46.76)**	61.61 **(51.71)**	57.34 **(49.22)**
T_7	Soybean seed cake	59.54 **(50.49)**	40.46 **(39.50)**	44.33 **(41.74)**	42.39 **(40.62)**	40.23 **(39.36)**	51.02 **(45.58)**	45.62 **(42.48)**
T_8	Castor seed cake	77.37 **(61.59)**	22.63 **(28.40)**	25.36 **(30.23)**	23.99 **(29.32)**	66.57 **(54.67)**	71.98 **(58.03)**	69.27 **(56.33)**
T_9	Cotton seed cake	64.75 **(53.57)**	35.25 **(36.42)**	37.12 **(37.53)**	36.18 **(36.97)**	47.93 **(43.81)**	58.99 **(50.17)**	53.46 **(46.98)**
T_{10}	Karanj cake	74.33 **(59.55)**	25.67 **(30.44)**	28.77 **(32.43)**	27.22 **(31.44)**	62.08 **(51.99)**	68.21 **(55.67)**	65.14 **(53.81)**
T_{11}	Neem seed cake	87.57 **(69.35)**	12.43 **(20.64)**	15.22 **(22.96)**	13.82 **(21.82)**	81.63 **(64.62)**	83.18 **(65.78)**	82.40 **(65.19)**
T_{12}	Groundnut cake	70.40 **(57.03)**	29.60 **(32.96)**	32.34 **(34.65)**	30.97 **(33.81)**	56.27 **(48.60)**	64.27 **(53.29)**	60.27 **(50.92)**
T_{13}	Control (untreated)	32.30 **(34.63)**	67.70 **(55.36)**	90.52 **(72.06)**	79.11 **(62.80)**	00.00 **(00.00)**	00.00 **(00.00)**	00.00 **(00.00)**
	S.E. +	**0.64**	**0.66**	**0.64**	--	**0.61**	**0.74**	--
	C.D. (P = 0.01)	**1.88**	**1.95**	**1.88**	--	**1.79**	**2.19**	--

*-Mean of three replications, Figures in parentheses are arcsine transformed values,
Av.: Average, Mor.: Concentration, Red.: Reduction, PRESR: Pre emergence seed rot,
POESM: Post Emergence Seedling Mortality.

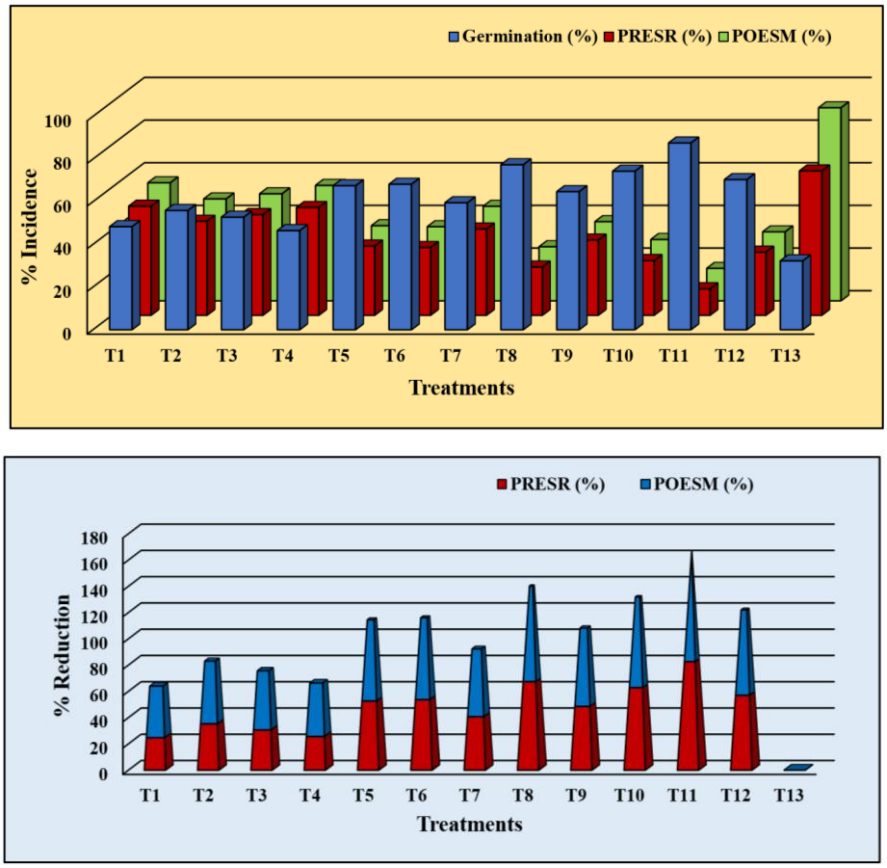

Fig. 1. *In vitro* bioefficacy of organic amendments against *R. solani* f. sp. *sasakii* (Rs-3 isolate), causing maize banded leaf and sheath blight (Polybag culture).

Post-emergence seedling mortality (POESM). Similar trend as that of pre-emergence mortality was observed in respect of post-emergence seedling mortality (POESM), which ranged from 15.22 to 55.35 per cent, as against 90.52 per cent in untreated control. However, it was significantly least with Neem seed cake (15.22 %), followed by Castor seed cake (25.36 %), Karanj cake (28.77 %), Groundnut cake (32.34 %), Safflower seed cake (34.75 %), Sunflower seed cake (35.23 %), both were on par to each other and Cotton seed cake (37.12 %) Rest of the amendments caused comparatively maximum POESM in the range of 44.33 to 55.35 per cent, but it was significantly highest in untreated control (90.52 %).

Average mortality influenced by the test organic amendments was ranged from 13.82 to 53.26 per cent. However, it was significantly least with Neem seed cake (13.82 %), followed by Castor seed cake (23.99 %), Karanj cake (27.22 %), Groundnut cake (30.97 %), Safflower seed cake (33.26 %), Sunflower seed cake (33.85 %), both were on par with each other and Cotton seed cake (36.18 %). Rest of the test amendments recorded average mortality in the range of 42.39 to 53.26 per cent, but it was significantly highest in untreated control (79.11 %).

Reduction in mortality. All of the organic amendments tested (Table 1 and Fig. 1) were found effective in reducing pre-emergence, post-emergence and total mortality, over untreated control.

The most effective organic amendment found was Neem seed cake, with significantly highest reduction in PRESR (81.63 %), POESM (83.18 %) and their average reduction (82.40 %). This was followed by Castor seed cake (66.57 %, 71.98 % and 69.27 %), Karanj cake (62.08 %, 68.21 % and 65.14 %), Groundnut cake (56.27 %, 64.27 % and 60.27 %), Safflower seed cake (53.07 %, 61.61 % and 57.34 %), Sunflower seed cake (52.03 %, 61.08 % and 56.55 %), both were on par. Rest of the test amendment recorded reductions in PRESR (range: 24.41 to 47.93 %), POESM (range: 38.85 to 58.99 %) and average mortality reduction in the range of 31.63 to 53.46 per cent.

The use of organic amendments is one of the indirect potential approaches of non-chemical means to control soil borne plant pathogens / diseases, which not only reduces the disease incidence, but also increase soil fertility and microbial activity in general and particularly the antagonist's activity.

In the present study organic amendments *viz.*, Neem seed cake, Castor seed cake and Karanj cake resulted with significantly highest per cent reduction in pre-, post-emergence and total mortality induced by *R. solani* in maize. These findings are in conformity with those reported earlier by several workers (Meena and Muthusamy, 1999; Kumar *et al*., 2006; Aiyanathan and Salalrajan, 2008; Senapoty, 2010; Yadav *et al*., 2013; Deshmukh *et al*. 2016; Lal *et al*., 2017; Agale, 2018; Kumar and Kumar, 2018 and Gaikwad, 2020, Navale, 2021).

CONCLUSIONS

Organic amendments *viz*., Neem seed cake and Castor seed cake were found most effective *in vitro* against *R. solani* f. sp. *sasakii*, with significant mycelial growth inhibition as well as significant reduction in mortality (pre- and post-emergence and average), over untreated control, respectively.

FUTURE SCOPE

Application of organic amendments can be gainfully employed in soil fertility restoration by small-scale farmers, especially neem seed cake. Neem seed cake can reduce the mining of soil nutrients and improve overall crop productivity. Neem seed cake, has a long-term effect of building the organic matter content of soil which helps in improving the soil physical properties and hence the increase in the nutrient status of soils.

Author Contribution. S. N. Banne, carried out research work, recorded, analysed observations and wrote the manuscript. A. P. Suryawanshi, conceived and designed the research and guided during period of study. S. S. Kadam and J. B. Bhalerao, recorded and analysed observations during period of study.

Conflict of Interest. There is no conflict of interest regarding the manuscript among the authors.

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