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In-vitro efficacies of different fungicides against stem rot disease of ginger incited by *Sclerotium rolfsii*. sacc.

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Abstract
In vitro evaluation of systemic and non-systemic fungicides indicated that all the test fungicides significantly inhibited mycelial growth of *S. rolfsii* over untreated control. Among the systemic fungicides tested, highest average inhibition recorded by Carboxin and Hexaconazole was found most effective with per cent (100%) inhibition of mycelial growth. This was followed by the fungicides *viz.*, Carbendazim (90.72%), Metalaxyl (80.59%), Tridemefon (78.55%) and Thiophanate methyl (70.02%). Among the non- systemic fungicides tested, highest average inhibition recorded by Cymoxanil + Mancozeb was found most effective with per cent (100%) inhibition of mycelial growth. This was followed by the fungicides *viz.*, Mancozeb (92.07%), Captan (75.12%), Copper oxychloride (60.95%) and Bordeaux mixture (41.18%).

Keywords: Cymoxanil + Mancozeb, *In-vitro*, *S. rolfsii*, efficacy test

Introduction
Ginger (*Zingiber officinale* Rosc.) is an important commercial crop grown for its aromatic rhizomes, which are used as spice and medicine (Sharma *et al.*, 2016) [5]. It is an important crop that earns a sizable amount of foreign exchange for the country (Tarafdar and Saha 2007) [6]. In India, ginger is cultivated in an area of 164.74000 ha with the production of 1084.40 M.T and during 2016-17, in Maharashtra 8.50.000 ha and 125.50 M.T area and production respectively. (Anonymous, 2016-17). Stem rot of ginger causes losses more than 50% in seed crop. The production of ginger, however, it is largely affected by diseases caused by fungi, bacteria, nematodes, phytoplasms. The major constraints involved in cultivation of ginger are the soil borne diseases such as rhizome rot caused by *Pythium aphinidermatum*, Bacterial wilt caused by *Ralstonia solanecarum* and stem rot caused by *Sclerotium rolfsii* (Archana *et al.*, 2013) [2].
Stem rot caused by (*Sclerotium rolfsii* Sacc.) was primarily attacks host stems, although it may infect any part of a plant under favorable environmental conditions. It was first reported in India by Mehrotra (1952) [3].

Material and Methods
Efficacy of 12 fungicides (7 Systemic, 4 non-systemic) was evaluated *in vitro* at different concentrations (@ each 1000, 1500, 2000 and 2500) against *S. rolfsii*, applying Poisoned food technique (Nene and Thapliyal, 1993) [4], using Potato Dextrose Agar (PDA) as basal culture medium. Based on active ingredient, the requisite quantity of each test fungicide was calculated and mixed thoroughly with autoclaved and cooled (40^0c) PDA medium separately in conical flask (250ml/cap) to obtain desired concentrations of 1000, 1500, 2000 and 2500 ppm. Fungicide amended PDA medium poured (20 ml/ plate) aseptically in glass Petri plates (90 mm dia.) and allowed to solidify at room temperature. For each of the test fungicide and its test concentrations, three plates/treatment/replication were maintained and replicate thrice. After solidification of the medium, all the plates were inoculated aseptically with a 5 mm culture disc obtained from a week old actively growing pure culture of *S. rolfsii*. The culture disc was placed on PDA in inverted position in the center of the Petri plate and plates were incubated at 27± 2^0C. Petri plates filled with plain PDA (without any fungicide) and inoculated with the culture disc of *S. rolfsii* were maintained as untreated control.

Result and Discussion
Results indicated that all the systemic fungicides tested significantly inhibited mycelial growth of *S. rolfsii* over untreated control at all the concentration tested and it was found that the radial mycelial growth test pathogen decreased with increase in the concentration of the fungicides tested.

1. Systemic fungicides

Radial mycelial growth

At 1000 ppm, radial mycelial growth of the pathogen was ranged from 00.00 mm (Carboxin and Hexaconazole) to 27.88 mm (Thiophanate methyl) as against 90 mm in untreated control. However, significantly highest, mycelial growth was recorded with the fungicide Thiophanate methyl (27.88 mm). This was followed by the fungicide *viz.,* Triadimefon (22.30 mm), Metalaxyl (17.62 mm). Less mycelial growth found in a Carbendazim (8.44 mm). Whereas, none of the mycelial growth was found with Carboxin and Hexaconazole.

At 1500 ppm, systemic trends of mycelial growth was observed with the systemic fungicides tested and it was ranged from 00.00 mm (Carboxin and Hexaconazole) to 21.62 mm (Thiophanate methyl) as against 90 mm in untreated control. However, significantly highest mycelial growth was recorded with the fungicide Thiophanate methyl (21.62 mm), followed by Tridemefon (16.23 mm) and Metalxyl (12.32 mm). While, no mycelial growth was recorded with Carboxin and Hexaconazole (*i.e.* 00.00 mm in both) which is followed by Carbendazim (7.78 mm).

Average mycelial growth recorded with the fungicides was ranged from 00.00 mm (Carboxin and Hexaconazole) to 24.75 mm (Thiophanate methyl) as against 90 mm in untreated control. However, significantly highest mycelial growth was recorded with the fungicides Thiophanate methyl (24.75mm), followed by Tridimefon (19.26 mm), Metalaxyl (14.97 mm). While, no mycelial growth was recorded with Carboxin and Hexaconazole (*i.e.* 00.00 mm in both) which is followed by Carbendazim (8.11 mm).

Mycelial inhibition

Results indicated that all the systemic fungicides tested significantly inhibited mycelial growth of *S. rolfsii* over untreated control at all the concentration tested and was found to increase with increase in concentrations of the fungicides tested. (Table, Fig and PLATE 1) respectively.

At 1000 ppm, per cent mycelial growth inhibition was ranged from 69.02 (Thiophanate methyl) to 100 per cent (Carboxin and Hexaconazole).However, significantly highest mycelial growth inhibition was recorded with the fungicides Carboxin and Hexaconazole (100%) followed by the fungicides, *viz.,* Carbendazim (90.62%), Metalaxyl (79.69%), Triadmefon (76.33%) and Thiophanate methyl (69.02%).

At 1500 ppm, mycelial growth inhibition was ranged from 71.02 per cent (Thiophanate methyl) to 100 per cent (Carboxin and Hexaconazole). However, significantly highest mycelial growth inhibition was recorded with the fungicides Carboxin and Hexaconazole (100%), followed by the fungicides *viz.,* Carbendazim (90.82%), Metalaxyl (81.52%), Triadmefon (80.78%) and Thiophanate methyl (71.02%).

Average mycelial growth inhibition was recorded with the test fungicides was ranged from 70.02 (Thiophanate methyl) to 100 per cent (Carboxin and Hexaconazole). However, Carboxin and Hexaconazole was found most effective with per cent (100%) inhibition of mycelial growth. This was followed by the fungicides *viz.,* Carbendazim (90.72%), Metalaxyl (80.59%), Triadmefon (78.55%) and Thiophanate methyl (70.02%).

2. Non-Systemic fungicides

Results indicated that all of the Non-Systemic fungicides tested significantly inhibited mycelial growth of *S. rolfsii* over untreated control and it was found that radial mycelial growth of the test pathogen was decreased with increased in the concentrations of fungicides tested ((Table, Fig and PLATE 2) respectively.

Radial mycelial growth

At 2000 ppm, radial mycelial growth of test pathogen was ranged from 7.65 mm (Mancozeb) to 00.00 mm (Cymoxanil+Mancozeb), as against 90.00 mm in untreated control. However, significantly highest mycelial growth was recorded with the fungicide Bordeaux mixture (55.27 mm), followed by Copper Oxychloride (38.69 mm) and Captan (23.36 mm). While no mycelial growth was recorded with 00.00 mm (Cymoxanil+ Mancozeb).

All the contact fungicides exhibited similar trend of radial mycelial growth at 2500 ppm as that of 2000 ppm.

At 2500 ppm radial mycelial growth of the test pathogen was ranged from 6.59 mm (Mancozeb) to 50.58 mm (Bordeaux mixture). Maximum radial mycelial growth was recorded with Bordeaux mixture (50.58 mm), followed by Copper oxychloride (31.58 mm) and Captan (21.39 mm), Mancozeb (6.59 mm). While no mycelial growth was recorded with 00.00 mm (Cymoxanil+ Mancozeb).

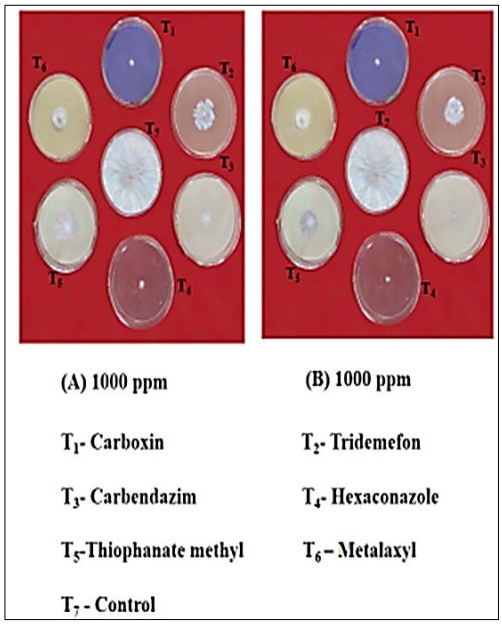

Plate I: *In vitro* effect of systemic fungicides on mycelial growth of *S. rolfsii*

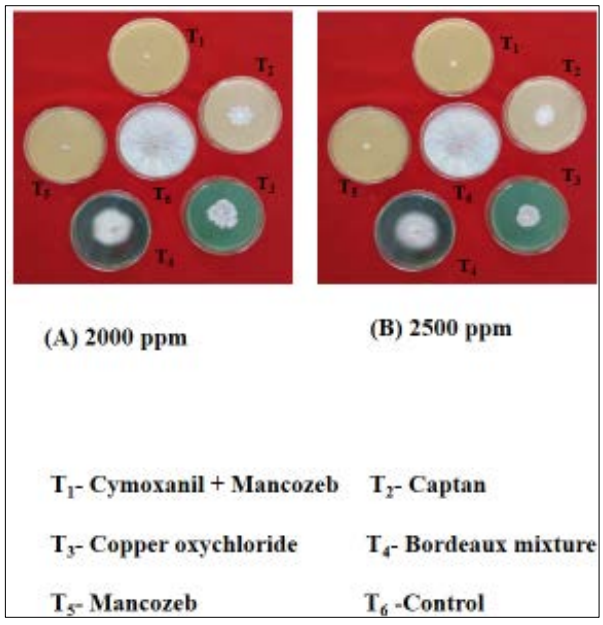

Plate II: *In vitro* effect of non-systemic fungicides on mycelial growth of *S. rolfsii*

Table 1: *In vitro* effect of Systemic fungicides on mycelial growth of *S. rolfsii*

Tr. No	Fungicides	Colony Diameter of pathogen * (mm)		Average (mm)	Inhibition %		Average (mm)
		1000 ppm	1500 ppm		1000 ppm	1500 ppm	
T_1	Carboxin	0.00	0.00	00.00	100 (00.00)	100 (00.00)	100
T_2	Tridemefon	22.30	16.23	19.26	76.33 (60.88)	80.78 (63.99)	78.55
T_3	Carbendazim	8.44	7.78	8.11	90.62 (72.16)	90.82 (72.36)	90.72
T_4	Hexaconazole	0.00	0.00	00.00	100 (90.00)	100 (90.00)	100
T_5	Thiophanate methyl	27.88	21.62	24.75	69.02 (56.17)	71.02 (57.42)	70.02
T_6	Metalaxyl	17.62	12.32	14.97	79.67 (63.19)	81.52 (64.53)	80.59
T_7	Control	90.00	90.00	90.00	00.00 (00.00)	00.00 (00.00)	00.00
	SE +	0.37	0.43		0.44	0.48	
	CD at 1%	1.15	1.33		1.34	1.48	

*****Means of three replications Figures in parenthesis are arcsin values Dia = Diameter (mm), Conc. = Concentration, Av. = Average

Table 2: *In vitro* effect of non-systemic fungicides on mycelial growth of *S. rolfsii.*

Tr. No.	Fungicides	Colony Diameter of pathogen * (mm)		Average (mm)	Inhibition %		Average (mm)
		2000 ppm	2500 ppm		2000 ppm	2500 ppm	
T_1	Cymoxanil+ Mancozeb	00.00	00.00	00.00	100 (90.00)	100 (90.00)	100
T_2	Captan	23.36	21.39	22.37	74.03 (56.36)	76.22 (60.81)	75.12
T_3	Copper oxychloride	38.69	31.58	35.13	57.00 (49.02)	64.90 (53.66)	60.95
T_4	Bordeaux mixture	55.27	50.58	52.92	38.58 (38.39)	43.78 (41.42)	41.18
T_5	Mancozeb	7.65	6.59	7.12	91.48 (73.02)	92.67 (74.29)	92.07
T_6	Control	90.00	90.00	90	00.00 (00.00)	00.00 (00.00)	00.00
	SE +	0.39	0.44		0.43	0.49	
	CD at 1%	1.22	1.38		1.36	1.53	

* Means of four replications, Figures in parenthesis are arcsin values Dia.= Diameter (mm), Conc.= Concentration (%), Av.=Average

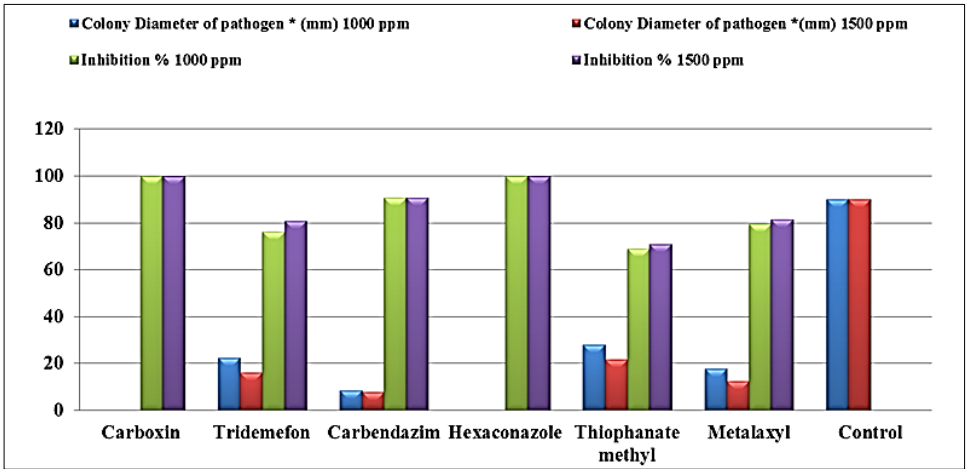

Fig 1: *In vitro* effect of systemic fungicides on mycelial growth and inhibition of *S.rolfsii*

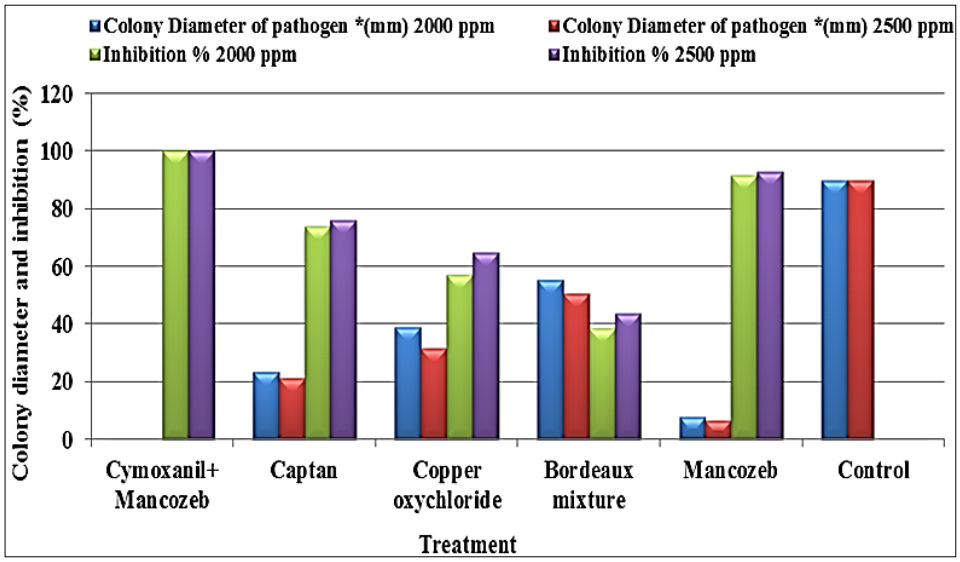

Fig 2: *In vitro* effect of non-systemic fungicides on mycelial growth of *S. rolfsii*

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