

Original Research Article

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Bioefficacy of Various Fungicides against *Rhizoctonia bataticola*, Causing Dry Root Rot of Soybean

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ABSTRACT

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Dry root rot caused by *Rhizoctonia bataticola* (Taub) Butler, is one of the most widely distributed and destructive disease of soybean [*Glycine max* (L.) Merrill], causing accountable quantitative and qualitative losses. All of the 17 fungicides (seven systemic, six contact and four combi- fungicides) evaluated *in vitro* were found effective with significant mycelial growth inhibition of *R. bataticola*, over untreated control. However, carbendazim 50% WP (@ 500, 1000 and 1500 ppm), carboxin 37.5% + thiram 37.5% WP (@ 1500, 2000 and 2500 ppm) and carbendazim 12% WP + Mancozeb 63% WP (@ 2000 and 2500 ppm) resulted with cent per cent (100%) mycelia growth inhibition, followed by Thiophanate methyl 70% WP with average mycelia growth inhibition of 93.57 per cent, Captan 50 % WP (89.48%) and Hexanconazole 5% EC (87.62%), over untreated control.

Introduction

Soybean [*Glycine max* (L.) Merrill] is a major commodity traded in world markets and currently, the world's prime oilseed crop (Sonka *et al.*, 2004). Among various factors contributing to yield losses in Soybean, diseases caused by fungal, bacterial, viral and nematode pathogens are the major constraints. During recent past, the soybean crop has badly been affected by the pathogenic fungus *Rhizoctonia bataticola* (Taub.) Butler, causing dry root rot disease. The disease was previously supposed to be of minor importance in soybean and other crops, but

now has been emerging as a major threat; inflicting potential seed yield losses of 3-36% (Sangeetha and Jahagirdar, 2013) and also reduce plant population per unit area upto 77 per cent (Muthusamy and Mariappan, 1991). In Marathwada region, soybean is being grown on large scale as rainfed crop, due to which the crop is frequently subjected to the attack by dry root rot (*R. bataticola*) and charcoal rot (*M. phaseolina*) diseases. *R. bataticola*, being basically soil borne, with wider adaptability and longer survivability in soil, render difficult to control it with chemicals alone and the use of chemicals is non-feasible, uneconomical and hazardous to

the ecosystem. Hence, it is imperative to exploit alternative and eco-friendly disease management practices for such soil borne diseases.

Materials and Methods

Efficacy of seven systemic (each @ 500, 1000 and 1500 ppm), six contact and four combi-fungicides (each @ 1500, 2000 and 2500 ppm) were evaluated *in vitro* against *R. bataticola* (Rb4 isolate), applying Poisoned food technique (Nene and Thapliyal, 1993) and using Potato dextrose agar (PDA) as basal culture medium. Based on active ingredient, requisite quantity of the test fungicides was separately mixed thoroughly with autoclaved and cooled (45° C) PDA medium in sterile glass conical flasks (250 ml. capacity) to obtain desired concentrations. This PDA medium amended separately with the test fungicides was poured (20 ml / plate) aseptically in sterile glass Petri plates (90 mm dia.) and allowed to solidify at room temperature.

For each of the test fungicide and its desired concentrations, three plates / treatment / replication were maintained. After solidification of the PDA medium, all the plates were inoculated aseptically by placing in the centre a 5 mm pure culture disc, obtained from actively growing 7 days old pure culture of *R. bataticola* and incubated in an inverted position at 28 ± 2 °C. Petri plates filled with plain PDA (without any fungicide) and inoculated with the pure culture disc of *R. bataticola* were maintained as untreated control. Two separate experiments were planned in Completely Randomized Design (CRD) and all the treatments replicated thrice.

Observations on radial mycelial growth / colony diameter were recorded at an interval of 24 hrs, continued till untreated control plates were fully covered with mycelial

growth of the test pathogen and averaged finally. Per cent inhibition of the test pathogen with the test fungicides, over untreated control was calculated by applying following formula (Vincent, 1927).

$$\text{Per cent inhibition} = \frac{C - T}{C} \times 100$$

Where,

C = growth of the test fungus in untreated control plate

T = growth of the test fungus in treated plate

Results and Discussion

In vitro efficacy of systemic fungicides

Mycelial growth

Results (Plate I, Table 1 and Fig. 1) revealed that all of the seven systemic fungicides tested exhibited a wide range of radial mycelial growth of *R. bataticola* and it was decreased drastically with increase in their concentrations.

The systemic fungicides resulted with mycelia growth in the range of 00.00 to 26.95 mm, 00.00 to 22.39 mm and 00.00 to 20.80 mm, respectively @ 500, 1000 and 1500 ppm, as against 90.00 mm in untreated control.

Among the systemic fungicides, Carbendazim 50% WP resulted with none of the mycelial growth at 500, 1000 and 1500 ppm. The next fungicides with significantly least mycelial growth were Thiophanate methyl 70% WP (7.22, 5.08 and 5.06 mm, respectively), followed by Hexaconazole 5% EC (14.92, 11.02 and 7.49 mm, respectively), Tebuconazole 29.9% EC (17.85, 16.80 and 14.90 mm, respectively), Difenconazole 25%

EC (20.95, 12.26 and 7.37 mm, respectively) Benomyl 50% WP (21.19, 20.13 and 18.95 mm, respectively) and Propiconazole 25% EC (26.95, 22.39 and 13.06 mm, respectively), respectively @ 500, 1000 and 1500 ppm.

Average radial mycelial growth of the test pathogen ranged from 00.00 mm (Carbendazim) to 20.80 mm (Propiconazole). However, there was none of the average mycelial growth with Carbendazim.

The fungicides with next lowest average mycelial growth were Thiophanate methyl (5.79 mm), followed by Hexaconazole (11.14 mm), Difenconazole (13.43 mm), Tebuconazole (16.52 mm), Benomyl (20.09 mm) and Propiconazole (20.80).

Mycelial growth inhibition

Results (Table 1, Plate I and Fig. 1) revealed that all of the systemic fungicides tested (each @ 500, 1000 and 1500 ppm) significantly inhibited mycelial growth of *R. bataticola*, over untreated control and it was found to increase with increase in concentrations of the fungicides tested.

The mycelia growth inhibition resulted with the test systemic fungicides ranged from 70.00 to 100.00, 75.12 to 100.00 and 78.94 to 100.00 per cent, respectively @ 500, 1000 and 1500 ppm, over untreated control.

However, Carbendazim 50% WP (@ 500, 1000 and 1500 ppm) resulted with cent per cent (100%) mycelial growth inhibition, followed by Thiophanate methyl 70% WP (91.97, 94.36 and 94.38 %, respectively), Tebuconazole 29.9% EC (90.35, 81.34 and 83.45 %, respectively), Hexaconazole 5% EC (83.42, 87.76 and 91.68 %, respectively), Difenconazole 25% EC (77.03, 86.38 and 91.81%, respectively), Benomyl 50% WP (76.45, 77.64 and 78.94%, respectively) and

Propiconazole 25% EC (70.06, 75.12 and 85.49%, respectively), respectively @ 500, 1000 and 1500 ppm.

Average mycelial growth inhibition recorded with the test systemic fungicides ranged from 76.89 (Propiconazole) to 100 (Carbendazim) per cent. However, it was cent per cent with Carbendazim (100%), followed by Thiophanate methyl (94.57 %), Hexaconazole (87.62%), Difenconazole (85.07%), Tebuconazole (85.05 %), Benomyl (77.68 %) and Propiconazole (76.89%). Thus, all of the systemic fungicides tested were found fungistatic against *R. bataticola* and significantly inhibited its mycelial growth, over untreated control. However, the systemic fungicides found most effective in the order of merit were Carbendazim 50% WP > Thiophanate methyl 70% WP > Hexaconazole 5% EC > Difenconazole 25% EC > Tebuconazole 29.9% EC > Benomyl 50% WP > Propiconazole 25% EC.

***In vitro* efficacy of contact and combi-fungicides**

Mycelial growth

Results (Table 2, Plate II and Fig. 2) revealed that all of the six contact and four combi-fungicides tested exhibited a wide range of radial mycelial growth of *R. bataticola* and was decreased drastically with increase in concentrations of the test fungicides from 1500 to 2500 ppm.

The test fungicides resulted with mycelia growth in the range of 00.00 to 55.62 mm, 00.00 to 48.94 mm and 00.00 to 43.75 mm, respectively @ 1500, 2000 and 2500 ppm. However, the combi-fungicides Carboxin 37.5% + Thiram 37.5% WP at all three concentrations and Carbendazim 12 % + Mancozeb 63 % WP @ 2000 and 2500 ppm resulted with none of the mycelial growth.

Table.1 *In vitro* efficacy of systemic fungicides against *R. bataticola*

Tr. No.	Treatments	Colony Dia. *(mm) at ppm			Av. (mm)	% Inhibition* at ppm			Av. inhibition (%)
		500	1000	1500		500	1000	1500	
T ₁	Carbendazim 50% WP	0.00	0.00	0.00	0.00	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
T ₂	Thiophanate methyl 70% WP	7.22	5.08	5.06	5.79	91.97 (73.54)	94.36 (76.26)	94.38 (76.29)	93.57 (75.31)
T ₃	Benomyl 50% WP	21.19	20.13	18.95	20.09	76.45 (60.97)	77.64 (61.78)	78.94 (62.68)	77.68 (61.80)
T ₄	Difenconazole 25% EC	20.67	12.26	7.37	13.43	77.03 (61.36)	86.38 (68.34)	91.81 (73.37)	85.07 (67.27)
T ₅	Propiconazole 25% EC	26.95	22.39	13.06	20.80	70.06 (56.83)	75.12 (60.08)	85.49 (67.61)	76.89 (61.27)
T ₆	Tebuconazole 29.9% EC	17.85	16.80	14.90	16.52	90.35 (71.90)	81.34 (64.41)	83.45 (65.99)	85.05 (67.25)
T ₇	Hexaconazole 5% EC	14.92	11.02	7.49	11.14	83.42 (65.97)	87.76 (69.52)	91.68 (73.23)	87.62 (69.40)
T ₈	Control (untreated)	90.00	90.00	90.00	90.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.E.±	0.42	0.20	0.15	0.26	0.31	0.18	0.15	0.21
	C.D.(P=0.01)	1.29	0.60	0.44	0.78	0.92	0.53	0.44	0.63
						Fungicides	Conc.	F X C	-
	S.E.±					2.37	0.10	0.30	-
	C.D.(P=0.01)					7.19	0.30	0.84	-

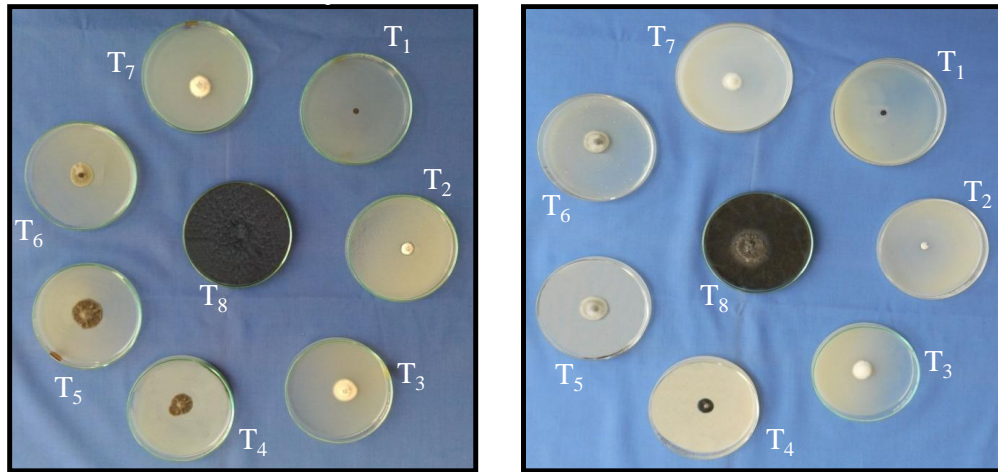
*: Mean of three replications, Dia: Diameter, Av.: Average
Figures in parentheses are arcsine transformed values

Table.2 *In vitro* efficacy of contact fungicides against *R. bataticola*

Tr. No.	Treatments	Colony Dia. *(mm) at ppm			Av. (mm)	% Inhibition* at ppm			Av. Inhibition (%)
		1500	2000	2500		1500	2000	2500	
T ₁	Captan 50% WP	11.83	9.65	6.93	9.47	86.86 (68.74)	89.28 (70.89)	92.30 (73.89)	89.48 (71.07)
T ₂	Thiram 75% WP	15.19	14.17	14.12	14.49	83.13 (65.75)	84.26 (66.62)	84.31 (66.67)	83.90 (66.34)
T ₃	Mancozeb 75% WP	17.07	15.12	10.94	14.38	81.03 (64.18)	83.20 (65.80)	87.84 (69.60)	84.03 (66.44)
T ₄	Chlorothalonil 75% WP	28.36	21.55	18.64	22.85	68.49 (55.85)	76.06 (60.70)	79.29 (62.93)	74.61 (59.74)
T ₅	Propineb 70% WP	49.86	40.97	37.92	42.92	44.60 (41.90)	54.47 (47.57)	57.86 (49.52)	52.31 (46.32)
T ₆	Copperoxy chloride 50% WP	30.80	25.90	20.55	25.75	65.77 (54.19)	71.22 (57.56)	77.17 (61.46)	71.39 (57.66)
T ₇	Carbendazim 12 % + Mancozeb 63 % WP	8.19	0.00	0.00	2.73	90.90 (72.44)	100.00 (90.00)	100.00 (90.00)	96.97 (79.97)
T ₈	Carbendazim 25 % + Mancozeb 50 % WS	19.50	16.44	12.30	16.08	78.33 (62.26)	81.73 (64.69)	86.34 (68.31)	82.13 (65.00)
T ₉	Carboxin 37.5 % + Thiram 37.5 % WP	0.00	0.00	0.00	0.00	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
T ₁₀	Metalaxyl 8 % + Mancozeb 64 % WP	55.62	48.94	43.75	49.43	38.20 (38.18)	45.63 (42.49)	51.39 (45.80)	45.07 (42.17)
T ₁₁	Control (untreated)	90.00	90.00	90.00	90.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.E.±	0.34	0.20	0.17	0.24	0.27	0.15	0.14	0.19
	C.D.(P=0.01)	1.00	0.58	0.50	0.69	0.80	0.46	0.41	0.56
						Fungicides	Conc.	F X C	
	S.E.±					1.56	0.06	0.18	
	C.D.(P=0.01)					4.61	0.16	0.52	

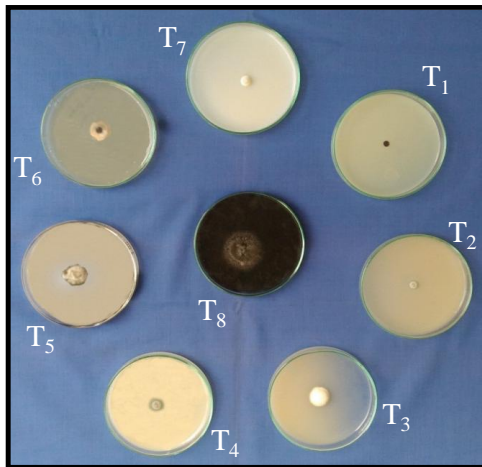
*: Mean of three replications, Dia: Diameter, Av.: Average
Figures in parentheses are arcsine transformed values

Plate - I



500 ppm

1000 ppm



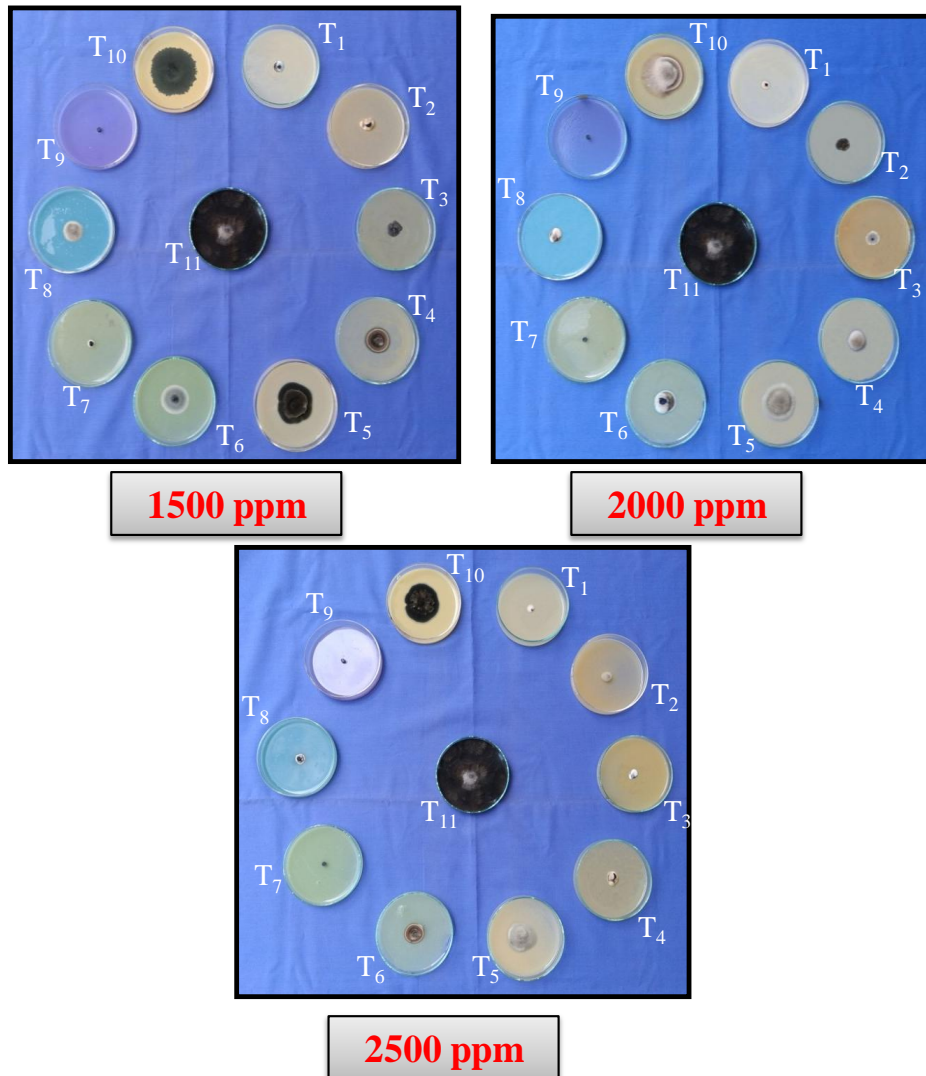
1500 ppm

Tr. No.	Treatments
T ₁	Carbendazim 50 % WP
T ₂	Thiophanate methyl 70% WP
T ₃	Benomyl 50% WP
T ₄	Difenconazole 25% EC

Tr. No.	Treatments
T ₅	Propaconazole 25% EC
T ₆	Tebuconazole 29.9% EC
T ₇	Hexaconazole 5% EC
T ₈	Control (untreated)

***In vitro* efficacy of systemic fungicides against *R. bataticola* (Rb-4 isolate)**

Plate - II



Tr. No.	Treatments	Tr. No.	Treatments
T ₁	Captan 50% WP	T ₇	Carbendazim 12 % + Mancozeb 63 % WP
T ₂	Thiram 75% WP	T ₈	Carbendazim 25 % + Mancozeb 50 % WS
T ₃	Mancozeb 75% WP	T ₉	Corboxin 37.5 % + Thiram 37.5 % WP
T ₄	Chlorothalonil 75% WP	T ₁₀	Metalaxyl 8 % + Mancozeb 64 % WP
T ₅	Propineb 70% WP	T ₁₁	Control (untreated)
T ₆	Copperoxy chloride 50% WP		

In vitro* efficacy of contact and combi-fungicides against *R. bataticola

Fig.1 *In vitro* bio-efficacy of systemic fungicides against *R. bataticola*

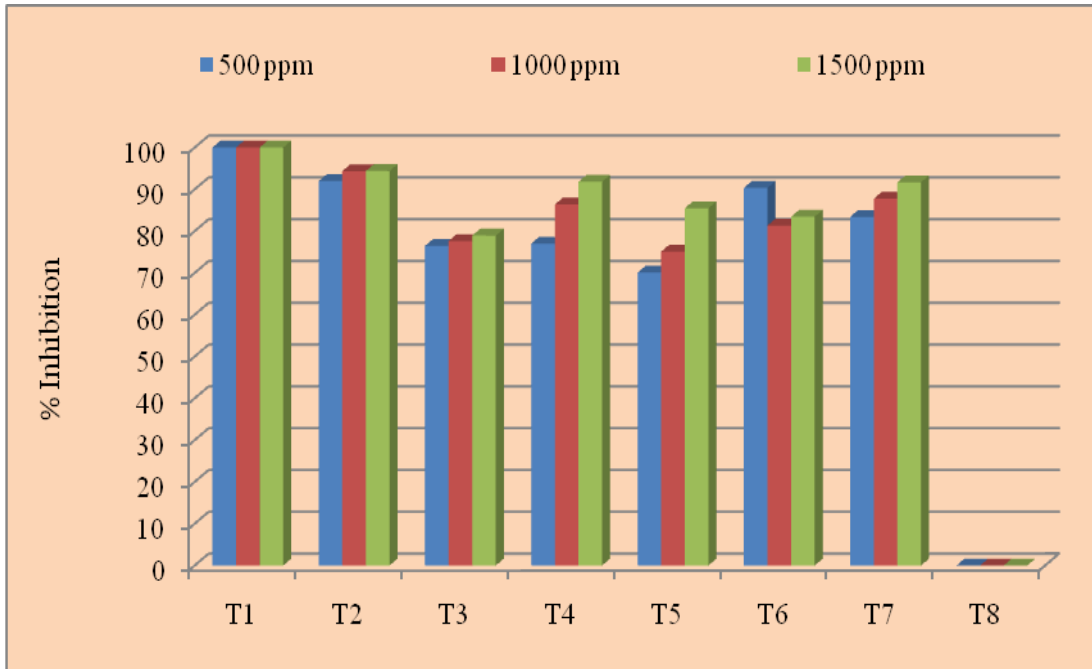
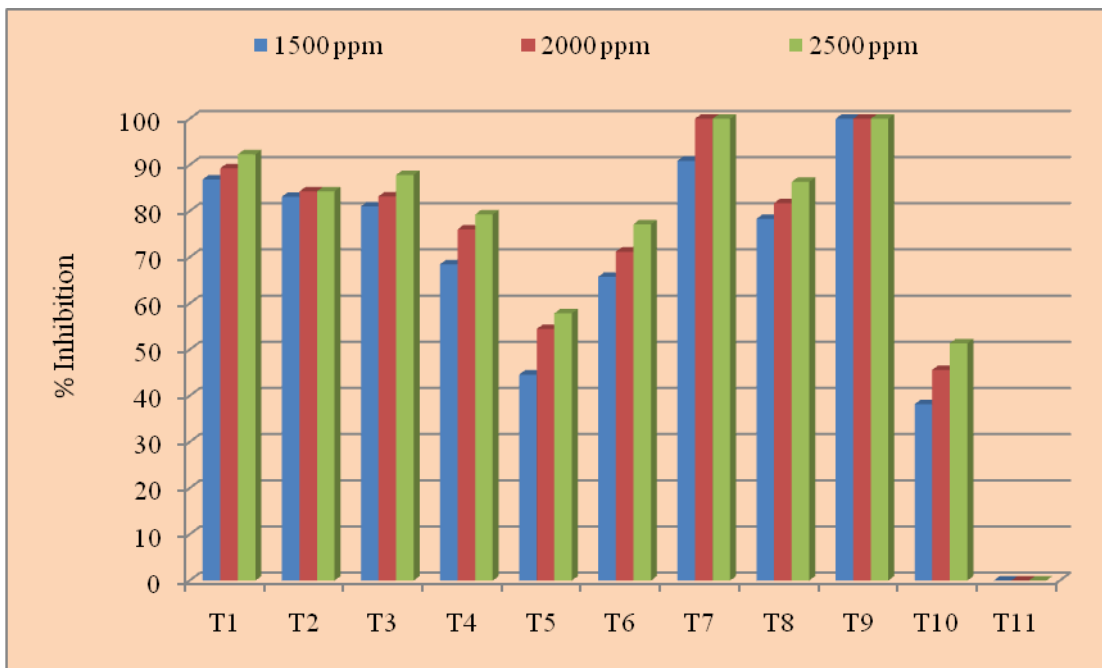


Fig.2 *In vitro* bio-efficacy of contact and combi-fungicides against *R. bataticola*



The next best fungicides with significantly least mycelia growth were Captan 50% WP (11.83, 9.65 and 6.93 mm, respectively), followed by Thiram 75% WP (15.19, 14.17 and 14.12 mm,

respectively), Mancozeb 75% WP (17.07, 15.12 and 10.94 mm, respectively) and Carbendazim 25% + Mancozeb 50% WS (19.50, 16.44 and 12.30 mm, respectively), each @ 1500, 2000

and 2500 ppm, respectively. Rest of the fungicides tested also resulted with minimum mycelia growth, compare to untreated control (90.00 mm).

Average mycelial growth of the test pathogen ranged from 00.00 to 49.43 mm. However, it was nil with Carboxin 37.5 % + Thiram 37.5 % WP (0.00 mm), followed by Carbendazim 12 % WP + Mancozeb 63 % WP (2.73 mm), Captan 50 % WP (9.47 mm), followed by Mancozeb 75 % WP (14.38 mm), Thiram 75 % WP (14.49 mm), Carbendazim 25 % + Mancozeb 50 % WS (16.08 mm), Chlorothalonil 75 % WP (22.85 mm), Copperoxy chloride 50 % WP (25.75 mm), Propineb 70 % WP (42.92 mm) and Metalaxyl 8 % + Mancozeb 64 % WP (49.43 mm).

Mycelial growth inhibition

Results (Table 2, Fig. 2) revealed that all of the contact and combi- fungicides tested (each @ 1500, 2000 and 2500 ppm) significantly inhibited mycelial growth of *R. bataticola*, over untreated control and it was found to be increased with increase in concentrations of the fungicides tested.

With the contact and combi-fungicides tested, mycelia growth inhibition ranged from 38.20 to 100 per cent, 45.63 to 100 per cent and 51.39 to 100 per cent, respectively @ 1500, 2000 and 2500 ppm. However, Carboxin 37.5% + Thiram 37.5% WP (@ 1500, 2000 and 2500 ppm) and Carbendazim 12 % WP + Mancozeb 63 % WP (@ 2000 and 2500 ppm), resulted with cent per cent (100%) mycelial growth inhibition. These were followed by Captan 50% WP (86.86, 89.28 and 92.30 %, respectively), Thiram 75% WP (83.13, 84.26 and 84.31%, respectively), Mancozeb 70% WP (81.03, 83.20 and 87.84%, respectively), Carbendazim 25 % + Mancozeb 50 % WS (78.33, 81.73 and 86.34%, respectively) and Chlorothalonil 75% WP (68.49, 76.06 and 79.29%, respectively), @ 1500, 2000 and 2500 ppm, respectively). Rest of the fungicides also resulted with significant mycelia growth inhibition, over untreated

control. Average mycelial growth inhibition recorded with the test contact and combi-fungicides ranged from 45.07 to 100 per cent. However, it was cent per cent (100 %) with Carboxin 37.5 % + Thiram 37.5 % WP followed by Carbendazim 12 % WP + Mancozeb 63 % WP (96.97 %), Captan 50 % WP (89.48 %), Mancozeb 75 % WP (84.03 %), Thiram 75 % WP (83.90 %), Carbendazim 25 % + Mancozeb 50 % WS (82.13 %), Chlorothalonil 75 % WP (74.61 %), Copperoxy chloride 50 % WP (71.39 %), Propineb 70 % WP (52.31 %) and Metalaxyl 8 % + Mancozeb 64 % WP (45.07 %). Thus, all of the contact and combi-fungicides tested were found fungistatic against *R. bataticola* and significantly inhibited its mycelial growth, over untreated control. However, on the basis of order of merit the contact and combi-fungicides found most effective were Carboxin 37.5 % + Thiram 37.5 % WP > Carbendazim 12 % WP + Mancozeb 63 % WP > Captan 50 % WP > Mancozeb 75 % WP > Thiram 75 % WP > Carbendazim 25 % + Mancozeb 50 % WS.

These results of the present study on *in vitro* bioefficacy of seven systemic, six contact and four combi-fungicides against *R. bataticola* are in conformity with the earlier findings of several workers, who also reported these fungicides as most effective in inhibiting mycelial growth of *R. bataticola* / *M. phaseolina*, causing dry root rot / charcoal rot of soybean as well as many other crops. Khonde *et al.*, (2008) reported Carbendazim 50 % WP (0.1%), Thiram 75 % WP (0.3%), Mancozeb 75 % WP (0.25%), Thiophanate methyl 70 % WP (0.1%) and Penconazole 50 % EC (0.1%) as most effective in inhibiting mycelial growth of *R. bataticola*, causing root rot of soybean. Magar *et al.*, (2011) reported that Carbendazim 50% WP @ 0.1% and Mancozeb 75 % WP @ 0.25% caused 100 per cent mycelial growth inhibition of *M. Phaseolina*. Khan *et al.*, (2012) reported Mancozeb 75 % WP, Carbendazim 50 % WP, Benomyl 50 % WP, Copperoxy chloride 50 % WP (each @ 0.2 %) as effective against *R. bataticola*, causing dry root rot of chickpea. Sangeetha and Jahagirdar (2013) reported

Carbendazim 50 % WP and Thiophanate methyl 70 % WP caused 100 per cent mycelial growth inhibition of *R. Bataticola*, causing root rot of soybean; whereas, Hexaconazole 5% EC, Propiconazole 25 % EC, Carbendazim 25 % + Mancozeb 50 % WP, Carboxin 37.5 % + Thiram 37.5 % WP and Mancozeb 75 % WP caused 91.60 to 96.41 per cent mycelial growth inhibition, respectively. Maruti *et al.*, (2017) reported that, Tebuconazole 25.9 % EC (@ 500 ppm), Propiconazole 25 % EC, Hexaconazole 5 % EC, Difenconazole 25 % EC, Carbendazim 50 % WP and Thiophanate methyl 70 % WP (each @ 500, 1000 and 1500 ppm) resulted with 100 per cent mean mycelial growth inhibition of *R. bataticola*, causing dry root rot of chickpea. The contact fungicides *viz.*, Mancozeb 75 % WP, Thiram 80 % WP, Chlorothalonil 75 % WP and Captan 70 % WP (each @ 1000, 2000 and 3000 ppm) and combi-fungicides *viz.*, Carbendazim 12% + Mancozeb 63% WP, and Carboxin 37.5% + Thiram 37.5% WP (each @ 1000, 2000 and 3000 ppm) were also effective against *R. bataticola*.

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