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Efficacy of various fungicides against *Macrophomina phaseolina* (Tassi.) Goid causing charcoal rot of soybean

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Abstract

Charcoal rot caused by *Macrophomina phaseolina* (Tassi) Goid., is one of the most widely distributed and destructive disease of soybean, causing accountable quantitative and qualitative losses. The pathogen can induce various diseases *viz*., charcoal / root / stem rots, leaf blight etc. in many crop plants. Therefore, present study entitled "Studies on Chemical Management of Charcoal rot of Soybean caused by *Macrophomina phaseolina* (Tassi.) Goid." were undertaken with the objectives *viz*., efficacy of fungicides (*in vitro*), at the Department of Plant Pathology, College of Agriculture, Parbhani, during *Kharif*, 2024. All of the seven each systemic (each @ 500 and 1000 ppm), non-systemic / contact (each @ 2000, and 2500 ppm) and combi-fungicides (each @ 2000 and 2500) evaluated *in vitro* were found to significantly inhibit mycelial growth of *M. phaseolina*, over untreated control. However, the most effective systemic fungicides were Carbendazim 50% WP, Azoxystrobin 25% EC and Hexaconazole 5% EC, with highest mycelial growth inhibition, respectively of 97.04%, 90.00% and 89.81% @500ppm and 100.00%, 91.30% and 95.00% @1000 ppm. The most effective contact fungicides found were Mancozeb 75% WP with cent per cent average mycelial growth inhibition (100.00%) followed by Chlorothalonil 75% WP (89.44) @2000 ppm. Mancozeb 75% WP and Chlorothalonil 75% WP, with cent per cent average mycelial growth inhibition (each 100.00%) @2500 ppm concentration. The most effective contact fungicides found were, Carbendazim 25% + Mancozeb 63% WP with cent per cent average mycelial growth inhibition (100.00%) followed by Trifloxystrobin 25% + Tebuconazole 50% WG (91.48%) @2000 ppm concentration, Carbendazim 12% + Mancozeb 63% WP and Trifloxystrobin 25% + Tebuconazole 50% WG with cent per cent average mycelial growth inhibition (each 100%) @2500 ppm.

Keywords: Macrophomina phaseolina, charcoal rot, soybean, fungicides

Introduction

Soybean [*Glycine max* (L.) Merrill] is a native of northern China and is the most important legume crop in the world. Soybean is called "Golden bean," "Miracle bean" and "Crop of planet." Soybean plants like many other legumes are capable of fixing and utilizing atmospheric nitrogen through symbiotic relationship with Rhizobium bacterium at the root of the crops. The crop thus, improves soil fertility and economizes crop production not only for themselves but also for the next crop grown in rotation especially, cereal crops (Nassiuma and Wasike, 2002) [12].

It has medicinal importance as soya-based food helps to control diabetics and melts all kinds of stones in the urinary bladder. Seeds were primarily used as pulses by the local population and the green and dried vegetative part were used as foliage for cattle. In addition, 100.00g soybean contains 240.00 mg calcium, 690.00mg phosphorous, 11.50 mg iron, 432.00 calories, 10.50g fats and 426.00 mg vitamins A (carotene), B and D (Nagraj, 1995) [11]. The major soybean growing countries in the world are United States of America, Brazil, Argentina, China, India and European community (Saxena, 1976) [18].

In India, the charcoal rot, which is used to be a minor disease of soybean until 2004, became a serious pest due to altered weather conditions particularly on the account of longer drought spells during crop growth period.

Subsequently, the disease appeared intermittently at high levels in some areas, causing substantial yield losses. The disease can be managed to some extent by cultural, chemical and biological methods (Bristow and Wyllie 1975; Gupta 2004) [2].

Macrophomina phaseolina is considered a high-temperature pathogen. Disease severity increases as air and soil temperature increase from 28-35^{0}C and when soil moisture is limited (Gary *et al*., 1991). Charcoal root rot may be a difficult disease to control because of the nature of causal pathogen. *Macrophomina phaseolina* invades the roots of a host at an early stage, 1-2 weeks after planting, but the symptoms appear only in mature plants (Pearson *et al.* 1984) [14]. Collar / root / charcoal rot (*M. phaseolina*) of soybean appeared at various stages of crop growth. The germinating seeds turned brown and rotted. The roots also turned brown, rotted and caused death of young seedlings.

Materials and Methods

During the present studies on “Studies on management of charcoal rot of soybean caused by *Macrophomina phaseolina* (Tassi.) Goid.” various experiments were conducted at the Department of Plant Pathology, College of Agriculture, Parbhani, during 2023-2024, to fulfill the objectives defined. Details of the materials used and methods followed for various experiments attempted are being described herein under following sub-heads.

Experimental materials

The various kinds of materials *i.e*. chemicals, glass wares, culture media and other miscellaneous material required for conducting present studies will be obtained from the Seed Technology Research Unit and Department of Plant Pathology, VNMKV, Parbhani.

In vitro evaluation of Fungicides

Following fungicides (Systemic, Non-systemic and Combi) available at the Department of Plant Pathology, VNMKV, Parbhani were used in various *in vitro* studies. Whereas systemic fungicides were evaluated at 500 and 1000 ppm, Nonsystemic fungicides were evaluated at 1000 and 2000 ppm and Combi fungicides at 2000 and 2500 ppm concentration by Poison food technique to test efficacy of chemicals on mycelial growth of *Macrophomina phaseolina*.

Experimental details

Treatment details

Design: C.R.D (Completely Randomized Design)

Replications: Three

Treatments: Eight

Systemic fungicides (each @ 500 and 1000 ppm)

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Propiconazole 25% EC	T_5	Azoxystrobin 25% EC
T_2	Hexaconazole 5% EC	T_6	Thiophanate methyl 70% WP
T_3	Difenconazole 25% EC	T_7	Carbendazim 50% WP
T_4	Tebuconazole 25.9% EC	T_8	Control (Untreated)

Non-Systemic/Contact fungicides (each @ 2000 and 2500 ppm)

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Copper hydroxide 77%WP	T_5	Chlorothalonil 75% WP
T_2	Copper oxychloride 50% WP	T_6	Zineb 75%WP
T_3	Mancozeb 75% WP	T_7	Propineb 70% WP
T_4	Sulphur 80% WP	T_8	Control (Untreated)

Combi- fungicides (each @ 2000 and 2500 ppm)

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Azoxystrobin 18.2% + Difenconazole 11.4 SC	T_5	Pyraclostrobin 5% + Metiram 55% WG
T_2	Hexaconazole 4% + Zineb 68%WP	T_6	Trifloxystrobin 25% + Tebuconazole 50% WG
T_3	Penflufen13.28% + Trifloxystrobin 13.2% FS	T_7	Thiophanate methyl 45% + Pyraclostrobin 5% FS
T_4	Carbendazim 12% +Mancozeb 63%WP	T_8	Control (Untreated)

Required quantity of each fungicide at each concentration was thoroughly mixed with 150 ml well sterilized potato dextrose agar medium contained in 250 ml capacity flasks. After this, medium was mixed by shaking well to obtain uniform dispersal of the chemical and poured in Petri-plates and allowed to solidify. After solidification, Petri-plates are centrally inoculated with a 5 mm mycelial disc of *M. phaseolina*. One set of controls was also kept in which the medium was not mixed with fungicides. Each treatment was replicated three times. These inoculated Petri-plates were incubated at 27°C. Per cent mycelial growth inhibition of pathogen was calculated by using formula suggested by Vincent (1947) [19].

$$\mathrm{PGI} = \frac{\mathrm{C} - \mathrm{T}}{\mathrm{C}} \times 100$$

Where,

PGI: Per cent growth inhibition, C : Colony diameter (mm) in control, T : Colony diameter (mm) in treatment.

Collection, isolation and identification of plant pathogen

Isolation

The agar plate method was used for the isolation of microflora associated with seed based on growth and colony characteristics. PDA was used in each sterilized Petri plate for the isolation of pathogenic fungi. Pathogenic fungi were isolated by transferring a bit of actively growing mycelium on PDA.

Identification

A bit of actively growing mycelium from seed was transferred on PDA slants for purification, which was incubated for 48 hrs, the isolate thus obtained were maintained separately. Identification of the fungi was done by examining the culture under the microscope through the characters of mycelium, spore and fruiting bodies with the help of published literature (Barnett and Hunter, 1998) [1].

Results and Discussion

In vitro efficacy of systemic fungicides

Mycelial growth

Results (Table 1) revealed that all of the seven systemic fungicides (Propiconazole 25% EC, Hexaconazole 5% EC, Difenoconazole 25% EC, Tebuconazole 25.9% EC, Azoxystrobin 25% EC, Thiophanate methyl 70% WP, and Carbendazim 50% WP) tested at various concentrations, exhibited a wide range of radial mycelial growth of *M. phaseolina* and it was decreased drastically at higher concentration of 1000 ppm, compared to 500 ppm. At 500 and 1000 ppm it was ranged from 2.67-25.17 mm and 00-17.00 mm, respectively, as against 90.00 mm in untreated control.

However, at 500 ppm, it was significantly least with Carbendazim 50% WP (2.67 mm), followed by Azoxystrobin 25% EC (9.00 mm) and Hexaconazole 5% EC (9.17 mm) which were at par to each other, respectively @ 500 ppm. Whereas rest of the next systemic fungicide with least mycelial growth were Propiconazole 25% EC (11.83 mm) followed by Difenoconazole 25% EC (14.33 mm), Thiophanate methyl 70% WP (20.33). The highest mycelial growth was recorded in fungicide Tebuconazole 25.9% EC (25.17 mm), but it was significantly minimum, compared to untreated control (90.00 mm).

Table 1: *In vitro* efficacy of systemic fungicides against *Macrophomina phaseolina*, causing charcoal rot of soybean.

Tr. No.	Chemical Name	Mycelial growth at ppm*		% Inhibition* at ppm	
		500	1000	500	1000
T_1	Propiconazole 25% EC	11.83	10.67	86.85 (68.74)	88.15 (68.86)
T_2	Hexaconazole 5% EC	09.17	04.50	89.81 (71.38)	95.00 (77.08)
T_3	Difenoconazole 25% EC	14.33	09.33	84.07 (66.48)	89.63 (71.21)
T_4	Tebuconazole 25.9% EC	25.17	17.00	72.04 (58.08)	81.11 (64.24)
T_5	Azoxystrobin 25% EC	09.00	07.83	90.00 (71.57)	91.30 (72.84)
T_6	Thiophanate methyl 70% WP	20.33	15.83	77.41 (61.62)	82.41 (65.20)
T_7	Carbendazim 50% WP	02.67	00.00	97.04 (80.09)	100.00 (90.00)
T_8	Control (Untreated)	90.00	90.00	00.00 (00.00)	00.00 (00.00)
	SE ±	0.44	0.34	0.49	0.38
	CD @ 1%	1.34	1.03	1.49	1.15

*: Mean of three replications, Figures in parenthesis are arcsine transformed values.

At 1000 ppm concentration similar trend as that of 500 ppm was observed. The radial mycelial growth ranged from 00.00 mm to 17.00 mm in different systemic fungicides. The fungicide Carbendazim 50% WP recorded complete inhibition of the mycelial growth and significantly superior over all the treatments. The next fungicide with minimum mycelial growth was Hexaconazole 5% EC (4.50 mm) followed by Azoxystrobin 25% EC (7.83 mm), Difenoconazole 25% EC (9.33 mm) and Propiconazole 25% EC (10.67 mm) which were at par with each other. The least effective systemic fungicide was Thiophanate methyl 70% WP (15.83) and Tebuconazole 25.9% EC with 17.00 mm mycelial growth over the untreated control.

Percent mycelial growth inhibition

At 500 ppm, mycelial growth inhibition ranged from 72.04-97.04 per cent in different systemic fungicides tested. Among these Carbendazim 50% WP was found most effective with cent per cent (97.04%) mycelial inhibition which were significantly superior over all the treatments followed by Azoxystrobin 25% EC (90.00%) and Hexaconazole 5% EC (89.81%) which were at par to each other, Propiconazole 25% EC (86.85%), Difenoconazole 25% EC (84.07%) and Thiophanate methyl 70% WP (77.41%). Among the fungicides least per cent inhibition was recorded by Tebuconazole 25.9% EC (72.04%) over the untreated control.

At 1000 ppm concentration also similar trend of mycelial inhibition was observed as at 500 ppm concentration. The mycelial growth inhibition was observed in the range the 81.11 to 100 per cent. Among these Carbendazim 50% WP was inhibited cent per cent (100.00%) mycelial growth followed by Hexaconazole 5% EC (95.00%), Azoxystrobin 25% EC (91.30%), Difenoconazole 25% EC (89.63%), Propiconazole 25% EC (88.15%) Thiophanate methyl 70% WP (82.41%) and Tebuconazole 29.9% EC (81.11%) over the untreated control.

In vitro efficacy of non-systemic/ contact fungicides

Radial mycelial growth

Results (Table. 2) revealed that all of the seven non-systemic/contact fungicides (Copper hydroxide 77% WP, Copper oxychloride 50% WP, Mancozeb 75% WP, Sulphur 80% WP, Chlorothalonil 75% WP, Zineb 75% WP, Propineb 70% WP) tested at various concentrations, exhibited a wide range of radial mycelial growth of *M. phaseolina* and it was decreased drastically at higher, concentration of 2500 ppm, compared to 2000 ppm. At 2000, and 2500 ppm it ranged from 00-87.33 mm and 00-84.33 mm, respectively, as against 90.00 mm in untreated control.

However, at 2000 ppm, it was significantly least with Mancozeb 75% WP was found most effective with no mycelial growth followed by Chlorothalonil 75% WP (09.50 mm), Propineb 70% WP (25.83 mm), Whereas rest of the next non-systemic/contact fungicides with least mycelial growth was Zineb 75%WP (40.67 mm) followed by Sulphur 80% WP (67.83 mm), Copper oxychloride 50% WP (80.00 mm). The highest mycelial growth was recorded in fungicide Copper

Table 2: *In vitro* efficacy of non-systemic / contact fungicides against *Macrophomina phaseolina,* causing charcoal rot of soybean.

Tr. No.	Chemical Name	Mycelial growth* at ppm		% Inhibition* at ppm	
		2000	2500	2000	2500
T_1	Copper hydroxide 77%WP	87.33	84.33	02.96 (09.91)	06.30 (14.53)
T_2	Copper oxychloride 50% WP	80.00	77.67	11.11 (19.47)	13.70 (21.63)
T_3	Mancozeb 75% WP	00.00	00.00	100.00 (90.00)	100.00 (90.00)
T_4	Sulphur 80% WP	67.83	53.33	24.63 (29.75)	40.74 (39.66)
T_5	Chlorothalonil 75% WP	09.50	00.00	89.44 (71.04)	100.00 (90.00)
T6	Zineb 75%WP	40.67	31.67	54.81 (47.46)	64.81 (53.62)
T_7	Propineb 70% WP	25.83	17.33	71.30 (57.60)	80.74 (63.97)
T_8	Control (Untreated)	90.00	90.00	00.00 (00.00)	00.00 (00.00)
	SE ±	0.73	0.59	0.82	0.66
	CD @ 1%	2.23	1.79	2.48	1.99

*: Mean of three replications, Figures in parenthesis are arcsine transformed values.

hydroxide 77% WP (87.33 mm), but it was significantly minimum, compared to untreated control (90.00 mm).

Similar trend as that of 2000 ppm was observed at the concentration of 2500 ppm. The radial mycelial growth ranged from 00.00 to 84.33 mm in different non-systemic/contact fungicides. The fungicide Mancozeb 75% WP and Chlorothalonil 75% WP recorded complete inhibition of the cent mycelial growth and significantly superior over all the treatments. The next fungicide with minimum mycelial growth was Propineb 70% WP (17.33 mm) followed by Zineb 75% WP (31.67 mm), Sulphur 80% WP (53.33 mm) and Copper oxychloride 50% WP (77.67 mm). The least effective non-systemic/contact fungicide was Copper hydroxide 77% WP with 84.33 mm mycelial growth.

Percent mycelial growth inhibition

Results (Table 2) revealed that all of the non-systemic/contact fungicides (Copper hydroxide 77% WP, Copper oxychloride 50% WP, Mancozeb 75% WP, Sulphur 80% WP, Chlorothalonil 75% WP, Zineb 75%WP, Propineb 70% WP) tested (each @ 2000 and 2500 ppm) significantly inhibited mycelial growth of *M. phaseolina*, over untreated control and it was directly proportional to concentrations of the fungicides tested. With the test fungicides, mycelial growth inhibition ranged from, 2.96-100 and 6.30-100 per cent, @ 2000 and 2500 ppm respectively, over untreated control.

At 2000 ppm, mycelial growth inhibition ranged from 02.96-100.00 per cent in different non-systemic/contact fungicides tested. Among these Mancozeb 75% WP was found most effective with cent per cent (100.00%) mycelial inhibition which were significantly superior over all the treatments followed by Chlorothalonil 75% WP (89.44%), Propineb 70% WP (71.30%) and Zineb 75% WP (54.81%). The least mycelial inhibition was recorded with fungicides Sulphur 80% WP (24.63%) and Copper oxychloride 50% WP (11.11%). Among the fungicides least per cent inhibition was recorded by Copper hydroxide 77% WP (2.96%) over untreated control.

At 2500 ppm concentration also similar trend of mycelial inhibition was observed as at 2000 ppm concentration. The mycelial growth inhibition was observed in the range the 6.30-100 per cent. Among these Mancozeb 75% WP and Chlorothalonil 75% WP was inhibited cent per cent (100%) mycelial growth followed by Propineb 70% WP (80.74%), Zineb 75%WP (64.81%) Sulphur 80% WP (40.74%), Copper oxychloride 50% WP (13.70%) and Copper hydroxide 77% WP (6.30%) over untreated control.

***In vitro* efficacy of combi fungicides**

Radial mycelial growth

Results (Table 3) revealed that all of the seven combi fungicides (Azoxystrobin 18.2% + Difenoconazole 11.4 SC, Hexaconazole 4% + Zineb 68% WP, Penflufen13.28% + Trifloxystrobin 13.2% FS, Carbendazim 12% +Mancozeb 63% WP, Pyraclostrobin 5% + Metiram 55% WG, Trifloxystrobin 25% + Tebuconazole 50% WG, Thiophanate methyl 45% + Pyraclostrobin 5% FS) tested at various concentrations, exhibited a wide range of radial mycelial growth of *M. phaseolina* and it was decreased drastically at higher, concentration of 2500 ppm, compared to 2000 ppm. At 2000, and 2500 ppm it ranged from 00.00-27.33 mm and 00.00-22.83 mm, respectively, as against 90.00 mm in untreated control.

However, at 2000 ppm, it was significantly least with Carbendazim 12% + Mancozeb 63% WP (00.00 mm), followed by Trifloxystrobin 25% + Tebuconazole 50% WG (07.67 mm) and Pyraclostrobin 5% + Metiram 55% WG (08.33) which were at par to each other, @ 2000 ppm. Whereas, rest of the next combi fungicide with least mycelial growth was Hexaconazole 4% + Zineb 68% WP (12.33 mm) followed by Azoxystrobin 18.2% + Difenoconazole 11.4 SC (22.83 mm), Penflufen13.28% + Trifloxystrobin 13.2% FS (23.16 mm). The highest mycelial growth was recorded in fungicide Thiophanate methyl 45% + Pyraclostrobin 5% FS (27.33 mm), but it was significantly minimum, compared to untreated control (90.00 mm).

Similar trend as that of 2500 ppm was observed at the concentration of 2000 ppm. The radial mycelial growth ranged from 00.00-22.83 mm in different combi fungicides. The fungicide Carbendazim 12% + Mancozeb 63% WP and Trifloxystrobin 25% + Tebuconazole 50% WG recorded complete inhibition of the mycelial growth and significantly superior over all the treatments. The next fungicide with minimum mycelial growth was Pyraclostrobin 5% + Metiram 55% WG (6.67 mm), Hexaconazole 4% + Zineb 68% WP (9.67 mm) followed by Azoxystrobin 18.2% + Difenoconazole 11.4% SC (14.33 mm) and Penflufen13.28% + Trifloxystrobin 13.2% FS (18.83 mm). The least effective combi fungicide was Thiophanate methyl 45% + Pyraclostrobin 5% FS with 22.83 mm mycelial growth.

Percent mycelial growth inhibition

Results (Table 3) revealed that all of the combi fungicides (Azoxystrobin 18.2% + Difenoconazole 11.4% SC, Hexaconazole 4% + Zineb 68% WP, Penflufen 13.28% + Trifloxystrobin 13.2% FS, Carbendazim 12% +Mancozeb 63% WP, Pyraclostrobin 5% + Metiram 55% WG, Trifloxystrobin 25% + Tebuconazole 50% WG, Thiophanate methyl 45% + Pyraclostrobin 5% FS) tested (each @ 2000 and 2500 ppm) significantly inhibited mycelial growth of *M. phaseolina*, over untreated control and it was directly proportional to concentrations of the fungicides tested. With the test fungicides, mycelial growth inhibition ranged from, 69.62-100 and 74.63-100 per cent, @ 2000 and 2500 ppm respectively, over untreated control.

Table 3: *In vitro* efficacy of combi-fungicides against *Macrophomina phaseolina*, causing charcoal rot of soybean.

Tr. No.	Chemical Name	Mycelial Growth* at ppm		% Inhibition* at ppm	
		2000	2500	2000	2500
T_1	Azoxystrobin 18.2% + Difenoconazole 11.4 SC	22.83	14.33	74.63 (59.76)	84.07 (66.48)
T_2	Hexaconazole 4% + Zineb 68%WP	12.33	09.67	86.29 (68.27)	89.26 (70.87)
T_3	Penflufen13.28% + Trifloxystrobin 13.2% FS	23.16	18.83	74.26 (59.51)	79.07 (62.78)
T_4	Carbendazim 12% +Mancozeb 63%WP	00.00	00.00	100.00 (90.00)	100.00 (90.00)
T_5	Pyraclostrobin 5% + Metiram 55% WG	08.33	06.67	90.74 (72.28)	92.59 (74.2)
T_6	Trifloxystrobin 25% + Tebuconazole 50% WG	07.67	00.00	91.48 (73.03)	100.00 (90.00)
T_7	Thiophanate methyl 45% + Pyraclostrobin 5% FS	27.33	22.83	69.62 (56.56)	74.63 (59.76)
T_8	Control (Untreated)	90.00	90.00	00.00 (71.57)	00.00 (00.00)
	SE ±	0.66	0.90	0.735	1.01
	CD @ 1%	2.00	2.72	2.22	3.02

*: Mean of three replications, Figures in parenthesis are arcsine transformed values.

At 2000 ppm, mycelial growth inhibition ranged from 69.62-100 per cent in different combi fungicides tested. Among these Carbendazim 12% +Mancozeb 63% WP was found most effective with cent per cent (100.00%) mycelial inhibition which were significantly superior over all the treatments. Whereas it was followed by Trifloxystrobin 25% + Tebuconazole 50% WG (91.48%) and Pyraclostrobin 5% + Metiram 55% WG (90.74%) which were at par to each other, followed by Hexaconazole 4% + Zineb 68%WP (86.29%), Azoxystrobin 18.2% + Difenoconazole 11.4 SC (74.62%) and Penflufen13.28% + Trifloxystrobin 13.2% FS (74.25) which are statistically at par with each other. Among the fungicides least per cent inhibition was recorded by Thiophanate methyl 45% + Pyraclostrobin 5% FS (69.62%) over untreated control.

At 2500 ppm concentration also similar trend of mycelial inhibition was observed as at 2000 ppm concentration. The mycelial growth inhibition was observed in the range the 74.63 to 100 per cent. Among these Carbendazim 12% +Mancozeb 63% WP and Trifloxystrobin 25% + Tebuconazole 50% WG was inhibited cent per cent (100.00%) mycelial growth followed by Pyraclostrobin 5% + Metiram 55% WG (92.59%), Hexaconazole 4% + Zineb 68% WP (89.25%), Azoxystrobin 18.2% + Difenoconazole 11.4% SC (84.07%), Penflufen13.28% + Trifloxystrobin 13.2% FS (79.07%) and Thiophanate methyl 45% + Pyraclostrobin 5% FS (74.63%) over untreated control.

These findings correspond with those of previous studies who reported various systemic, non-systemic/contact, and combination fungicides as fungistatic against *M. phaseolina* (= *R. bataticola*), causing charcoal / root / stem rots in many agronomical and horticultural crops, including soybean.

The fungicides, Carbendazim 50% WP, Azoxystrobin 25% EC, , Hexaconazole 5% EC, Mancozeb 75% WP, Chlorothalonil 75% WP, Propineb 70% WP, Carbendazim 12% + Mancozeb 63% WP and Trifloxystrobin 25% + Tebuconazole 50% WG, tested *in vitro* at various concentrations were reported to inhibit significantly mycelial growth of *M. phaseolina* (= *R. bataticola*), earlier by several workers (Tandel *et al*. 2010; Khalikar *et al*. 2011; Moradia 2011; Magar *et al*. 2011; Chaity *et al*. 2012; Sangeetha and Jahagirdar 2013; Singh *et al*. 2014; Ingole and Zade 2020; Iqbal and Mukhtar 2020; Lokesh *et al.* 2020; Kumar 2020; Hingole and Kendre 2021; Yadav *et al*. 2022; Lakhran *et al*. 2022.) [18, 10, 9, 3, 15, 17, 4, 8, 6, 20, 7].

Conclusion

Systemic fungicides demonstrated significant inhibition of *M. phaseolina*. Carbendazim 50% WP was the most effective, achieving 97.04 and 100% inhibition at 500 and 1000 ppm. Among non-systemic fungicides, Mancozeb 75% WP achieved complete inhibition at 2000 ppm. Whereas at 2500 ppm Mancozeb 75% WP and Chlorothalonil 75% WP cent percent inhibition. Combi-fungicides such as Carbendazim 12% + Mancozeb 63% WP showed complete inhibition at 2000ppm. Similar trade was followed at 2500 Carbendazim 12% + Mancozeb 63% WP and Trifloxystrobin 25% + Tebuconazole 50% WG were highly effective, with 100% inhibition observed.

Statistical analysis

The one-way analysis of variance (ANOVA) was used for all statistical analysis if the probability level was significant. OPSTAT software, was used to compare the means of the treatments. (http://14.139.232 166/opstat.).

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