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Original article

Evaluation of natural plant extracts, antagonists and fungicides in controlling root rot, collar rot, fruit (brown) rot and gummosis of citrus caused by *Phytophthora* spp. *in vitro*

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ABSTRACT

The results revealed that all the six bioagents tested *in vitro* applying dual culture technique against *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora* significantly inhibited the mycelial growth of the test pathogen over untreated control. However, bioagent, *Trichoderma harzianum* recorded minimum mean colony diameter (7.73 cm^2) and highest inhibition (87.85%) of mycelial growth of *P. nicotianae* over untreated control followed by the bioagent *T. viride*, *T. koningii* which recorded mean colony diameter of 9.95 cm^2, 14.15 cm^2 and mean mycelial inhibition of 84.36 %, 77.76%, respectively. Evaluation of different botanicals by Poisoned Food Technique showed that all plant extracts tested *in vitro* were found significantly effective in reducing the percentage mycelial growth of *P. nicotianae*, *P. citrophthora* and *P. palmivora* over untreated control. However, plant extract (@ 5, 10 and 15%) of Garlic, recorded lowest mean colony diameter (47.45 mm) and highest mean mycelial growth inhibition (47.26%) followed by Neem, Onion which recorded the mycelial growth of 55.20 mm, 60.85 mm, and the mean mycelial growth inhibition of 38.65%, 32.38%, respectively. Results revealed that all the nine fungicides tested *in vitro* applying Poisoned Food Technique against *P. nicotianae*, *P. citrophthora* and *P. palmivora* significantly inhibited the mycelial growth of the test pathogen over untreated control. However, fungicide, Cymoxynil 8% + Mancozeb 64% (Curzate M-8) recorded minimum mean colony diameter (16.12 mm) and maximum mean inhibition (82.09%) of mycelial growth of the test pathogen over untreated control (mean colony diameter 90.00 mm and mean

inhibition 0.00) followed by the fungicide Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), Metyram (Polyram), which recorded mean colony diameter of 20.16 mm, 24.16 mm and mean mycelial inhibition of 77.59%, 73.14%, respectively.

1. Introduction

Citrus is one of the most important tropical fruit crops of the world. Citrus is considered to be native of Himalayan foot hills of North-Eastern India, North Central China and its adjoining area from where a number of citrus species/varieties have their origin and later taken to different parts of the world. The most important commercial fruits in India the sweet orange (*Citrus sinensis* Osbeck), Mandarin orange (*Citrus reticulata*), Sour orange (*Citrus aurantium*), Lemon (*Citrus lemon* B.) and Sour lime (*Citrus aurantifolia*). On commercial basis, they are grown in Assam, Maharashtra, Andhra Pradesh, Punjab, Kerala, Karnataka, Uttar Pradesh and Meghalaya.

India ranks sixth among top citrus producing countries of the world. Globally citrus is grown in 114 countries out of these 53 countries grow citrus commercially on production basis, Brazil tops the list amongst citrus producing countries with 19.9 million tonnes followed by USA (14.1 MT), China (12.1MT) Mexico (6.4 MT), Spain (5.7 MT), India (4.4.MT) and Italy (3.54 MT). Thus, these top citrus producing countries contribute more than 70% to the world citrus production (FAO, 2003). The area under citrus in India is 7.89 lakh hectares with annual production 6825.7 thousand tonnes and productivity 25.5 tonnes per hectare (Anonymous, 2009). The Maharashtra state considered as the second most citrus growing state in terms of area (2.7 lakh ha), production (1627.7 thousand tonnes) and nineth in terms of productivity (6.2 t/ha) (Anonymous, 2009). Although, large number of diseases due to fungi and virus have been reported on citrus. The root rot, collar rot, fruit (brown) rot and gummosis caused by *Phytophthora* spp. are most important. *Phytophthora* infects roots, leaves and fruit, Fruit rot caused by *Phytophthora citrophthora* (Smith and Smith). Leonian, *P. nicotianae* (Breda de Haan) (=*parasitica*) and *P. plmivora* (*E.J. Butler*) is an endemic disease in India and is reported to pose a serious problem grown on large scale. In Maharashtra, citrus suffers from severe infection of this disease. The weather condition appears to be favourable during monsoon months from July to August. More than 20 per cent plants die due to this pathogen in citrus nurseries of central India where 7-8 million citrus plants are being propagated every year (Das, 2009). In order to know the cause of the severe brown rot and gummosis of sweet orange and to develop suitable control measures the present research project was undertaken.

2. Materials and methods

2.1. *In vitro* inhibition of pathogen by bioagents using dual culture technique

The antagonistic potential of *T. viride, T. hamatum, T. harzianum, Gliocladium virens, T. koningi* and *Pseudomonas fluorescens* was assessed against *Phytophthora* spp. by dual culture technique on PDA medium. For this 20 ml of sterilized and cooled medium (PDA) was poured in each petriplates (90 mm diameter) and was allowed to solidify. A 5 mm disc of *Phytophthora* spp. was plated at one end of the medium with the help of sterilized cork borer. Just opposite to it 5 mm disc of the *Trichoderma* spp. (bioagent) was placed at another end 0.5 to 1.0 cm away from edge of petriplates. For this a week old culture of *Phytophthora* spp. and *Trichoderma* spp. in petriplates on sterilized PDA medium were used. Four replications for *Phytophthora* spp. and control i.e. without incubation of the *Trichoderma* spp. were maintained. Petriplates were incubated at 28 $\pm$ 2^{o}C temperature in inverted position.

2.2. *In vitro* evaluation of botanicals against *Phytophthora* spp. by poisoned food technique (PFT)

For evaluation of different botanicals by poisoned food technique, leaves of neem, tulasi and rhizome of turmeric, ginger and garlic and red onion bulbs were collected from the field of College of Agriculture, MKV, Parbhani. These botanicals were crushed with mortal and pistal. Extract of 5 ml, 10 ml and 15 ml of neem, tulasi, onion, garlic, ginger and turmeric was taken from each botanical and was poured in 95, 90 and 85 ml luke warm

PDA in 250 ml conical flask. These flasks were plugged with non absorbent cotton and sterilized in autoclave at 15 lbs pressure psi for 15 min. After sterilization, PDA of each botanical was poured in sterilized petriplates. For each botanical 4 replicates of petriplates were poured. After cooling, 5 mm disc of *Phytophthora* spp. was inoculated in each petriplate. Observations on colony growth were taken by measuring the vertical and horizontal diameter of the colony. One set of 4 petriplates without botanical extract was maintained as control for comparison.

2.3. *In vitro* evaluation of fungicides against *Phytophthora* spp. by poisoned food technique

For evaluation of different fungicides "Poisoned Food Technique" developed by Nene and Thapliyal (1971) was followed calculated amount of each fungicide was added to sterile medium before pouring into petriplates. For each fungicidal treatment @ 150 ppm, 250 ppm and 500 ppm three plates were maintained. The 5 mm inoculum disc of pathogen was plated at the centre of each petriplates. The observations were recorded after 6 days of incubation at room temperature (28 $\pm$ 2^{o}C). The mycelia growth of *Phytophthora* spp. was measured in treated and controlled plates and per cent inhibition was calculated by the formula suggested by Vincent (1947) as follows:

$$I = \frac{C - T}{C} \times 100$$

Where,

I = Per cent inhibition of mycelia growth
C = Growth of mycelium in control (mm)
T = Growth of mycelium in treatment (mm)

3. Results and discussion

3.1. *In vitro* evaluation of bioagents

Six bioagents *viz*. *Trichoderma viride*, *T. hamatum*, *T. harzianum*, *Gliocladium virens*, *Pseudomonas fluorescens* and *T. koningi* were evaluated *in vitro* against *Phytophthora nicotianae, Phytophthora citrophthora* and *Phytophthora palmivora* by dual culture technique and the relevant data so obtained is presented in Table 1, 2 and 3. The data presented in Table 1 and Fig. 1 clearly indicated that there was significant reduction in mycelial growth of *Phytophthora nicotianae* by *T. harzinum* (7.73 cm^2) after 6 days inoculation as compared to other treatments. It was followed by the reduction brought about by *T. viride* (9.95 cm^2), *T. koningii* (14.15 cm^2), *T. hamatum* (15.65 cm^2), *Gliocladium virens* (18.01 cm^2) and *Pseudomonas fluorescens* (18.89 cm^2). The maximum mycelial growth of *Phytophthora nicotianae* was noted in control plates (90.00 cm^2). The maximum per cent inhibition of mycelial growth of *Phytophthora nicotianae* was observed in treatment. *T. harzianum* (87.85 %) followed by *T. viride* (84.36%), *T. koningii* (77.76%), *T. hamatum* (75.40%), *Gliocladium virens* (71.69%) and the minimum per cent inhibition of mycelial growth of *Phytophthora nicotianae* was observed in treatment *Pseudomonas fluroscence* (70.31%). Treatments with *Gliocladium virens* and *Pseudomonas fluroscence* were statistically at par to each other though there was no significant difference was found in both the treatments (Plate 1). The data from the Table 2 and Fig. 2 revealed that there was a significant reduction in the mycilial growth of *Phytophthora citrophthora* after 6 days of inoculation by *T. viride* (4.40 cm^2) as compared to other treatments. It was followed by the reduction brought about by *T. harzianum* (6.35 cm^2), *T. hamatum* (9.47 cm^2), *Gliocladium virens* (13.5 cm^2), *T. koningii* (13.8 cm^2) and *Pseudomonas fluorescens* (17.3 cm^2). The maximum mycelial growth of *Phytophthora citrophthora* was noted in control plates (63.63 cm^2). The maximum per cent inhibition of mycelial growth of *Phytophthora citrophthora* was noted in treatment *T. viride* (93.08%) followed by *T. harzianum* (90.02%), *T. hamatum* (85.10%), *G. virens* (78.79 %) and *T. koningii* (78.31%). The *Gliocladium virens* (78.79%) and *T. koningii* (78.31%) were statistically at par to each other, though there was no significant difference was found in the both treatments. The minimum per cent inhibition of mycelial growth of *Phytophthora citrophthora* was observed in treatment *Pseudomonas fluorescens* (72.78%) after incubation (Plate 2).

The data presented in Table 3 and Fig. 3 clearly indicated that there was significant reduction in mycelial growth of *Phytophthora palmivora* by *Trichoderma viride* (12.78 cm^2) after 6 days inoculation as compared to other treatments. It was followed by the reduction brought about by *T. harzianum* (15.87 cm^2), *T. hamatum* (18.31 cm^2), *T. koningii* (23.31 cm^2), *Gliocladium virens* (24.71 cm^2) and *Pseudomonas fluorescence* (27.86 cm^2).

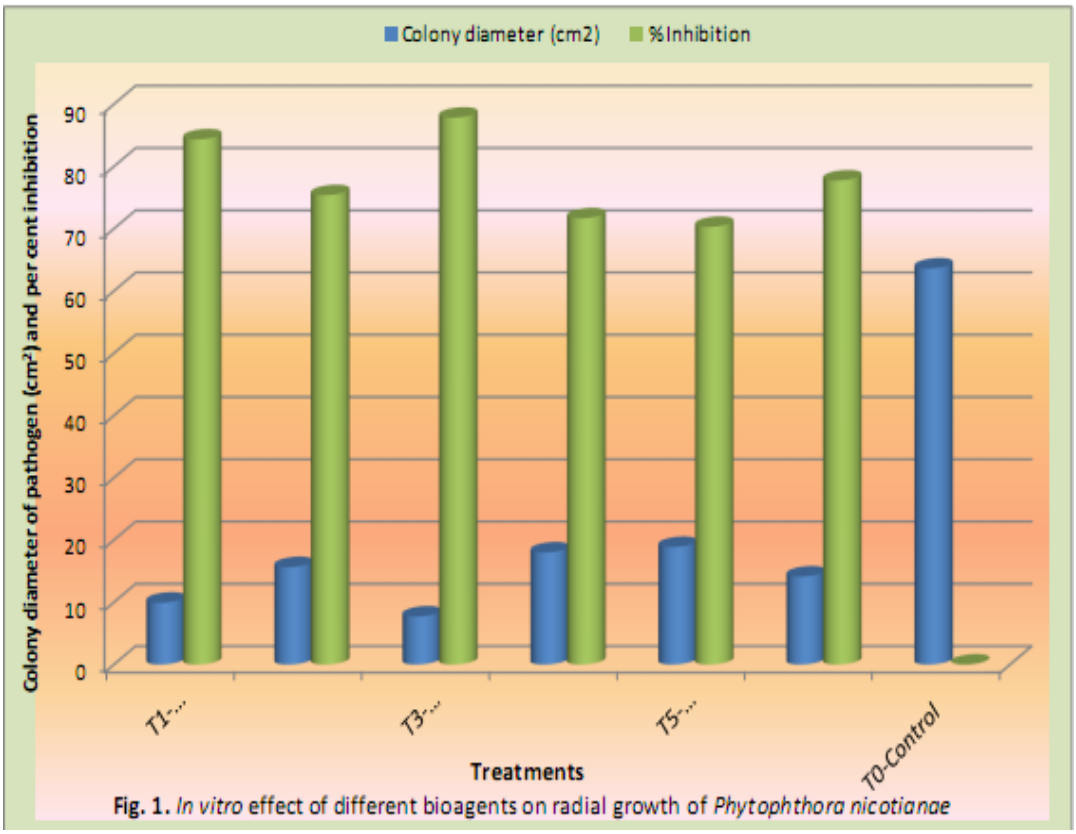

Fig. 1. *In vitro* effect of different bioagents on radial growth of *Phytophthora nicotianae*

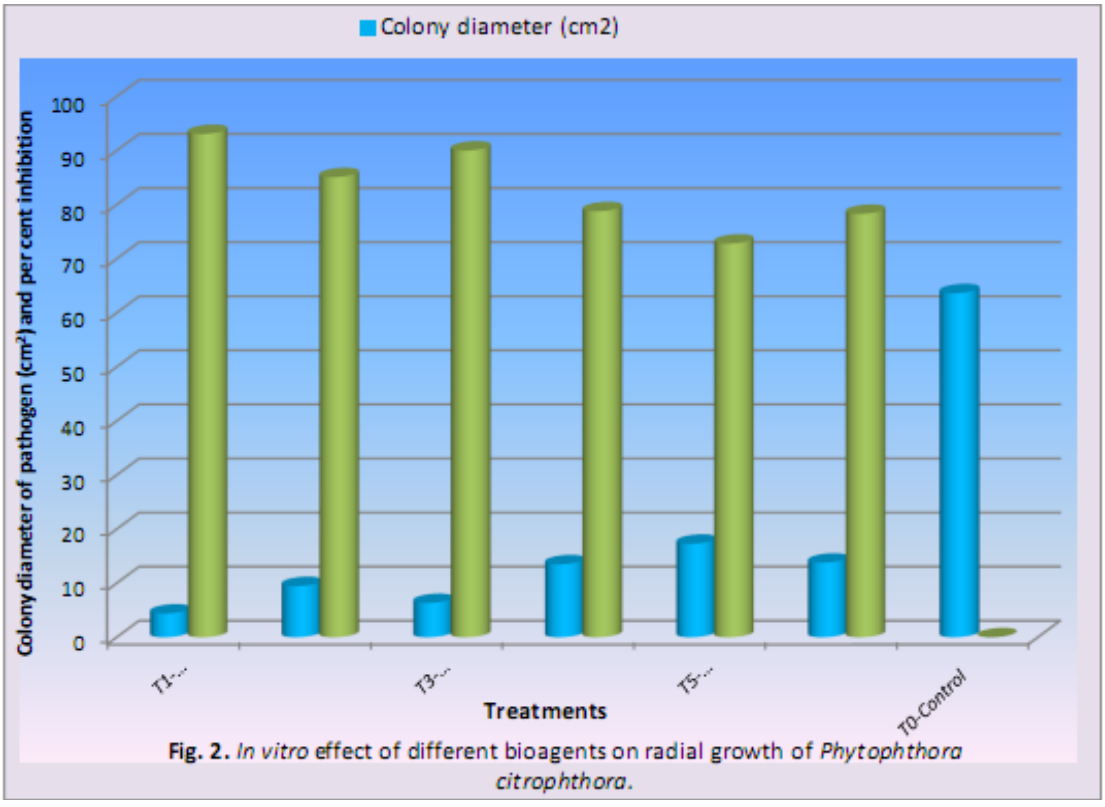

Fig. 2. *In vitro* effect of different bioagents on radial growth of *Phytophthora citrophthora*.

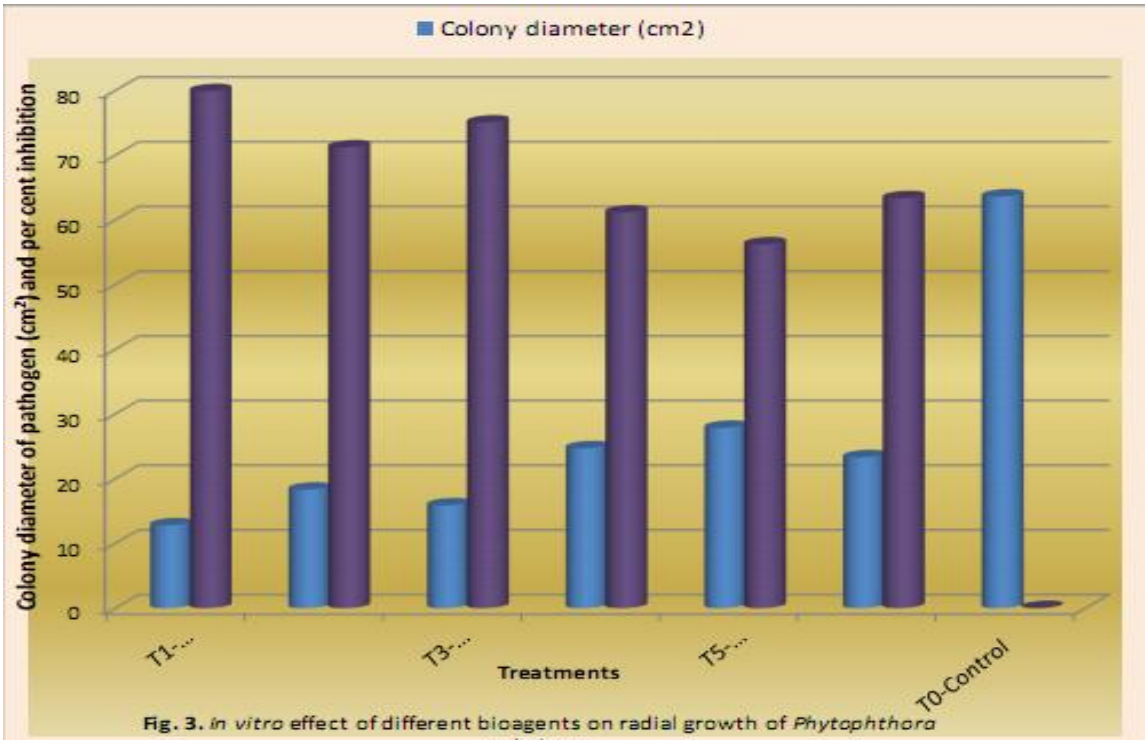

Fig. 3. *in vitro* effect of different bioagents on radial growth of *Phytophthora palmivora*

The maximum per cent inhibition of mycelial growth of *Phytophthora palmivora* was observed in treatment *T. viride* (79.91%) followed by *T. harzianum* (75.05%), *T. hamatum* (71.22%), *T. koningii* (63.36%), *Gliocladium virens* (61.16%) and the minimum per cent inhibition of mycelial growth of *Phytophthora palmivora* was observed in treatment *Pseudomonas fluorescens* (56.21%) after inoculation (Plate 3). Bioagents tested were found effective in the inhibition of the test pathogen. However, colony diameter at 5 days caused maximum (range 93.08 to 72.78%) inhibition of mycelial growth of *Phytophthora citrophthora* as compared to *Phytophthora nicotianae* and *Phytophthora palmivora* which recorded comparatively minimum inhibition of mycelial growth in the range of 87.85 to 70.20 per cent and 79.91 to 56.21 per cent, respectively. Several workers in the past have reported inhibitory effect of *Trichoderma* spp. against various pathogens. Puri *et al*. (1994) reported that growth of *Phytophthora parasitica* var. *piperina* was inhibited by *T. viride*, *T. harzianum*, *T. hamatum* and *T. piluliferum*, *Phytophthora* capsici by *T. harzianum* and *Phytophthora parasitica* var. *nicotianae* by *T. hamatum*. Chamber and Scott (1995) observed that antibiotics produced by young *T. hamatum* cultures and *G. virens* in culture filtrate experiments inhibited growth of *Phytophthora cinnamoni* and *P. citricola*.

Etebarian *et al*. (2000) reported that cell free metabolites of *T. virens* DAR 74290 completely inhibited growth of *Phytophthora* erythroseptica *in vitro*. Naqvi (2001b) reported that none of the *Trichoderma* spp. could develop any inhibition zone against the growth of *Phytophthora nicotianae* after 15 days at 25^{o}C but *Trichoderma* spp. over grew on *Phytophthora* growth on PDA. The observations in the present investigation are in full agreement with those reported in the past (El-Kafrawy, 2002; Faruk *et al*., 2002; Gopalikrshnan *et al*., 2003; Sharma *et al*., 2003 and Gangwar *et al*., 2004). Kattaleewan Sookchaoy *et al*. (2009) recorded 65% inhibition of myceial growth of *P. parasitica* by *Trichoderma* spp. Tran (2010) noted that *T. harzianum* and *T. viride* inhibitory to *Phytophthora spp*. Aketeke *et al*. (1997) recorded 58.3-83.4 % inhibition of *Phytophthora citrophthora* by *Trichoderma* spp. Sing and Islam (2010) noted 61% reduction of radial growth of *Phytophthora nicotianae* by *T. harzianum* in Blank sank disease of tobacco. Kanokmedhakul *et al*. (2007) noted inhibitory effect of Trichotoxin 9 against *P. parasitica* of sweet orange. Srivastav and Prasad (2000) recorded 62.7% inhibition of *P. capisici* by *T. viride*. Paul *et al*. (2005) noted inhibitory effect of *Pseudomnas fluorescens* and *Trichoderma* spp. against *P. capsici*.

Table 1

In vitro effect of different bioagents on radial growth of Phytophthora nicotianae

Sr. No.	Treatments	Colony diameter of pathogen (cm2)			Colony diameter of antagonist (cm2)			Inhibition %
		O.V.	% value	Arc. Sin.	O.V.	% value	Arc. Sin.	
1	T1-Trichoderma viride	9.95	15.63	8.99	53.68	84.36	57.54	84.36
2	T2-Trichoderma hamatum	15.65	24.59	14.23	47.98	75.40	48.93	75.40
3	T3-Trichoderma harzianum	7.73	12.13	6.96	55.90	87.77	61.37	87.85
4	T4-Gliocladium virens	18.01	28.30	16.44	45.62	71.68	45.80	71.69
5	T5-Pseudomonas fluorescens	18.89	29.79	17.33	44.67	70.19	44.59	70.31
6	T6-Trichoderma koningii	14.15	22.23	12.84	49.48	77.75	51.04	77.76
7	T0-Control	63.63	100.00	89.98	63.63	100.00	89.98	00.00
SE +		0.43	0.66	0.39	0.42	0.66	0.60	
CD at 5%		1.27	1.96	1.16	1.25	1.96	1.76	

Table 2

In vitro effect of different bioagents on radial growth of *Phytophthora citrophthora.*

Sr. No.	Treatments	Colony diameter of pathogen (cm^2)			Colony diameter of antagonist (cm^2)			Inhibition %
		O.V.	% value	Arc. Sin.	O.V.	% value	Arc. Sin.	
1	T_1-*Trichoderma viride*	4.40	6.91	3.96	59.23	93.08	68.63	93.08
2	T_2-*Trichoderma hamatum*	9.47	14.88	8.56	54.15	85.10	58.35	85.10
3	T_3-*Trichoderma harzianum*	6.35	9.97	5.72	57.28	90.01	64.18	90.02
4	T_4-*Gliocladium virens*	13.50	21.19	12.23	50.14	78.80	52.07	78.79
5	T_5-*Pseudomonas fluorescens*	17.30	27.20	15.78	46.31	72.78	46.71	72.81
6	T_6-*Trichoderma koningii*	13.80	20.44	11.79	50.61	79.54	52.71	78.31
7	T_0-Control	63.63	100.00	89.98	63.63	100.00	89.98	0.00
SE $\pm$		0.56	0.88	0.51	0.56	0.88	0.91	
CD at 5%		1.66	2.58	1.51	1.65	2.58	2.68	

3.2. *In vitro* evaluation of botanicals

Six botanicals/plant extracts *viz*., Neem, Tulasi, Turmeric, Ginger, Onion and Garlic were evaluated (@ 5%, 10% and 15% concentration) *in vitro* against *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora* applying poisoned food technique. Results (Table 4 and Fig. 4) indicated that all the botanicals tested were found inhibitory and caused significant inhibition of mycelial growth of the *Phytophthora nicotianae* over untreated control (Plate 4). Among six aqueous plant extracts (@ 5, 10 and 15 %), Garlic extract recorded minimum mean colony diameter (47.45 mm) and highest mean mycelial growth inhibition (47.26%). This was followed by Neem, Onion, Ginger, Tulasi and Turmeric which recorded the mycelial growth of 55.20 mm, 60.85 mm, 65.46 mm, 69.46 mm and 71.75 mm, respectively. The maximum mycelial growth of *Phytophthora*

nicotianae was noted in control plate (90.00 mm). The maximum per cent inhibition of mycelial growth of *Phytophthora nicotianae* was noted in treatment Garlic (47.26%) followed by Neem (38.65%), Onion (32.38%), Ginger (27.26%) and Tulasi (22.81%). The minimum per cent inhibition of mycelial growth of *Phytophthora nicotianae* was found in treatment Turmeric extract (20.27%) and which was found least effective. All the concentration (@ 5, 10 and 15%) of plant extracts tested was found effective in the inhibition of the *Phytophthora nicotianae*. However, higher concentration (@ 15%) recorded maximum inhibition (range 51.24 to 23.05%) followed by 10% concentration (range 47.36 to 19.72%) and 5% concentration (range 43.20 to 18.05% inhibition).

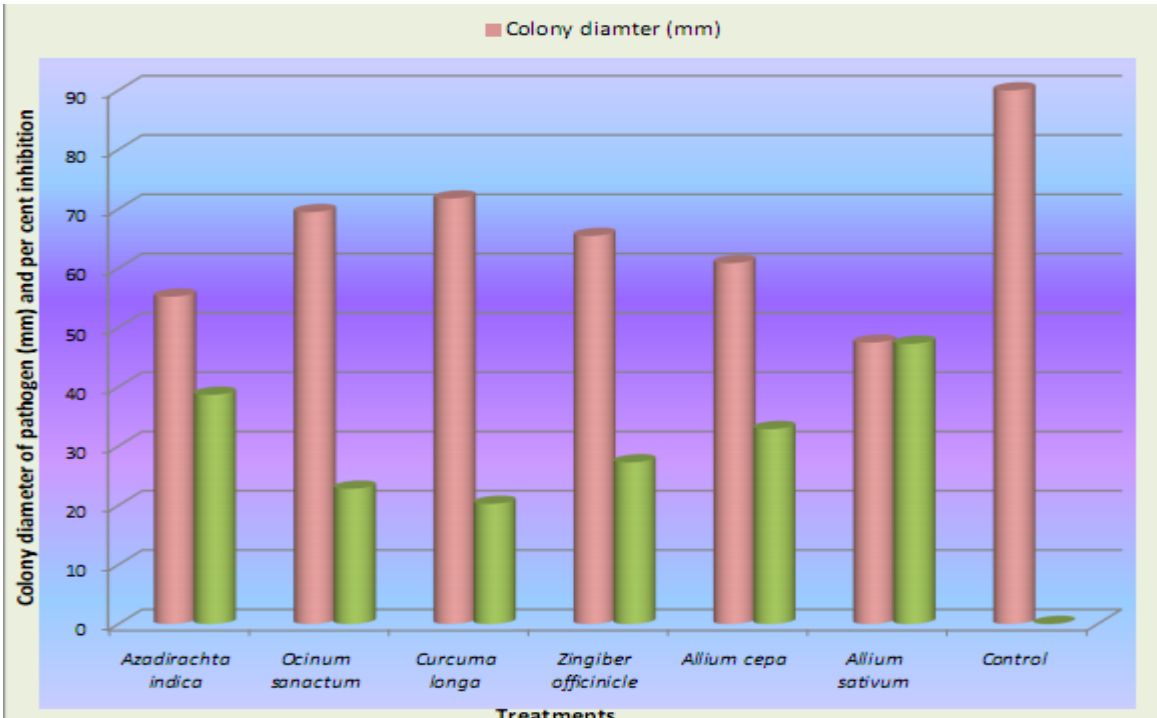

Fig. 4. *In vitro* effect of different plant extracts on radial growth of *Phytophthora nicotianae*

Table 3

In vitro effect of different bioagents on radial growth of *Phytophthora palmivora*

Sr. No.	Treatments	Colony diameter of pathogen (cm^2)			Colony diameter of antagonist (cm^2)			Inhibition %
		O.V.	% value	Arc. Sin.	O.V.	% value	Arc. Sin.	
1	T_1-*Trichoderma viride*	12.78	20.09	11.59	50.84	79.89	53.06	79.91
2	T_2-*Trichoderma hamatum*	18.31	28.77	16.72	45.31	71.21	45.41	71.22
3	T_3-*Trichoderma harzianum*	15.87	24.94	14.44	47.75	75.04	48.64	75.05
4	T_4-*Gliocladium virens*	24.71	38.83	22.84	38.91	61.15	37.70	61.16
5	T_5-*Pseudomonas fluorescens*	27.86	43.78	25.96	35.76	56.20	34.19	56.21
6	T_6-*Trichoderma koningii*	23.31	36.63	21.49	40.31	63.35	39.32	63.36
7	T_0-Control	63.63	100.00	89.98	63.63	100.00	89.98	0.00
SE ±		0.49	0.77	0.46	0.49	0.77	0.65	
CD at 5 %		1.45	2.29	1.37	1.45	2.29	1.93	

Results (Table 5 and Fig. 5) clearly revealed that all the botanicals tested were found inhibitory and caused significant inhibition of mycelial growth of the *Phytophthora citrophthora* over untreated control (Plate 5). Among six aqueous plant extracts tested (@ 5, 10 and 15%) Garlic recorded least mean colony diameter (43.95mm) and highest mean mycelial growth inhibition (51.15%). This was followed by Neem, Onion, Tulasi, Turmeric and Ginger which recorded mean colony diameter of 57.08 mm, 61.08 mm, 62.75 mm, 63.12 mm, 68.08 mm and mean mycelial growth inhibition of 37.57%, 32.12%, 30.27%, 28.83%, respectively. Ginger was found least effective and caused minimum inhibition (24.34 %) of the test pathogen. All the concentration (@ 5, 10 and 15%) of plant extracts tested was found effective in the inhibition of the *Phytophthora citrophthora*. However, higher concentration (@ 15%) recorded maximum inhibition (range 55.70 to 26.66%) followed by 10% concentration (range 50.00 to 24.16%) and 5% concentration (range 47.77 to 22.22% inhibition).

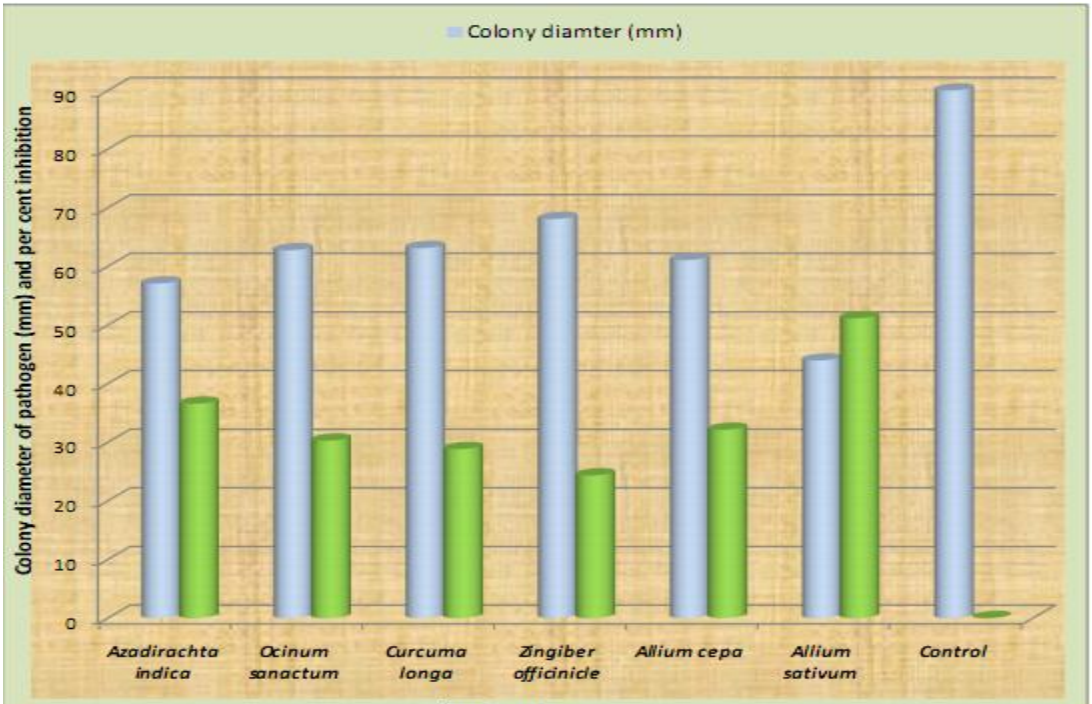

Fig. 5. *In vitro* effect of different plant extracts on radial growth of *Phytophthora citrophthora*

Results (Table 6 and Fig. 6) indicated that all the botanicals tested were found inhibitory and caused significant inhibition of mycelial growth of the *Phytophthora palmivora* over untreated control (Plate 6). Among six aqueous plant extracts tested (@ 5, 10 and 15%) Garlic recorded least mean colony diameter (44.41 mm) and highest mean mycelial growth inhibition (50.64%). This was followed by Neem, Onion, ginger, Tulasi, Turmeric which recorded mean colony diameter of 59.83 mm, 63.37 mm, 65.04 mm, 65.58 mm 68.45 mm and mean mycelial growth inhibition of 33.51%, 29.58%, 27.72% and 27.12 %, respectively. Turmeric was found least effective and caused minimum inhibition (23.93%) of the test pathogen.

All the concentration (@ 5, 10 and 15%) of plant extracts tested was found effective in the inhibition of the *Phytophthora palmivora*. However, higher concentration (@ 15%) recorded maximum inhibition (range 55.96 to 26.66%) followed by 10% concentration (range 50.27 to 23.47%) and 5% concentration (range 45.70 to 21.66% inhibition). Thus, all the plant extracts tested at various concentrations significantly inhibited the mycelial growth of *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora*. However, Garlic extract was found most effective followed by Neem, Onion, Ginger, Tulasi and Turmeric extract in case of *Phytophthora nicotianae* and *Phytophthora palmivora*. While in case of *Phytophthora citrophthora*, Garlic extract was found most effective followed by Neem, Onion, Tulasi, Turmeric and Ginger. Ginger extract was found comparatively least effective against the *Phytophthora citrophthora*. Several workers in the past have reported inhibitory effect

of different plant extracts against various Oomycetes pathogens. Kassa *et al*. (2006) reported inhibition of *P. infestans* by 2% garlic crude extract.

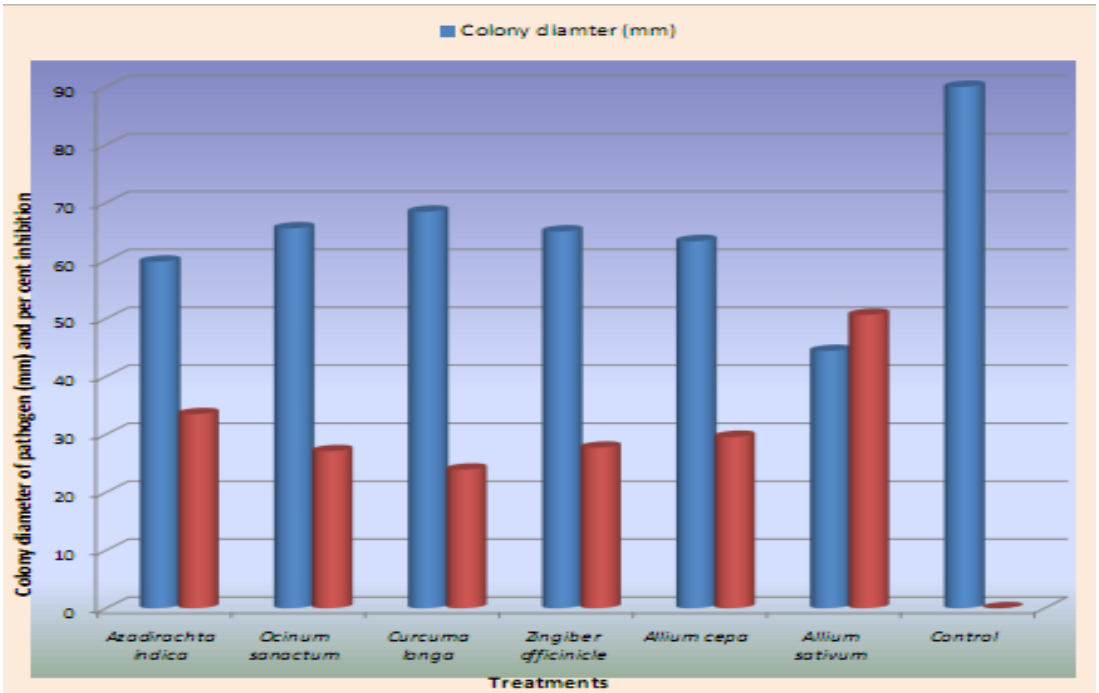

Fig. 6. *In vitro* effect of different plant extracts on radial growth of *Phytophthora palmivora*

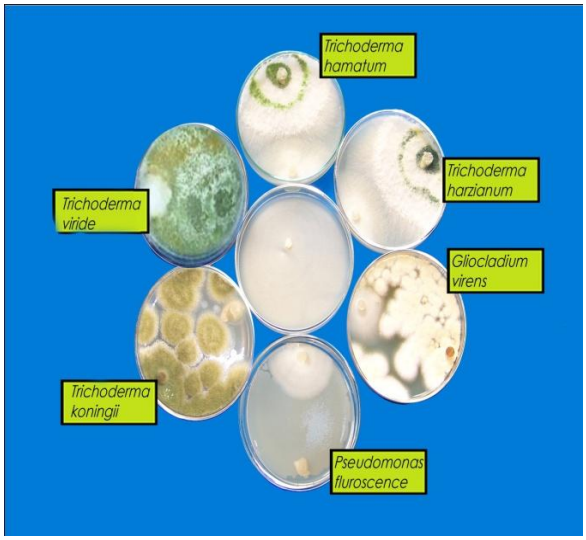

Plate 1. *In vitro* evaluation of bioagents on radial growth of *Phytophthora nicotianae.*

Plate 2. *In vitro* evaluation of bioagents on radial growth of *Phytophthora citrophthora.*

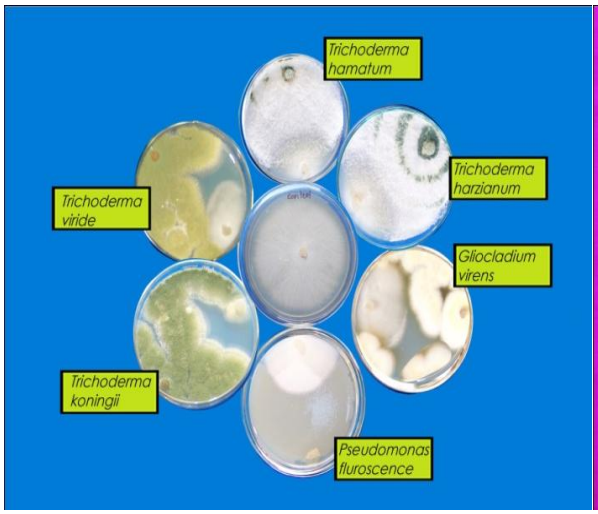

Plate 3. *In vitro* evaluation of bioagents on radial growth of *P. palmivora.*

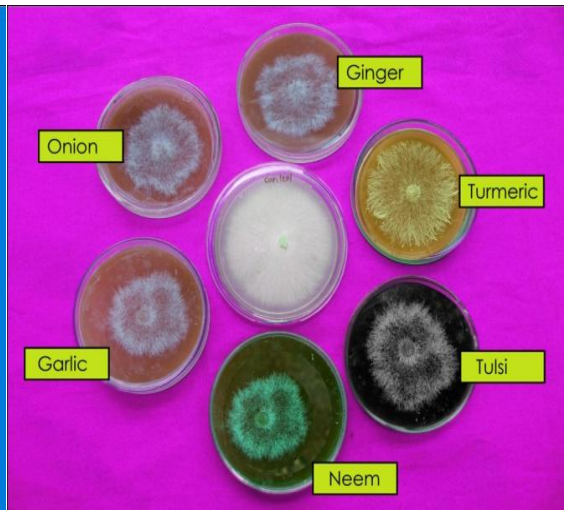

Plate 6. *In vitro* evaluation of botanicals at 10% conc. on radial growth of *P. palmivora*

Plate 4. *In vitro* evaluation of botanicals at 5%, 10% and 15% concentration on radial growth of *P. nicotianae.*

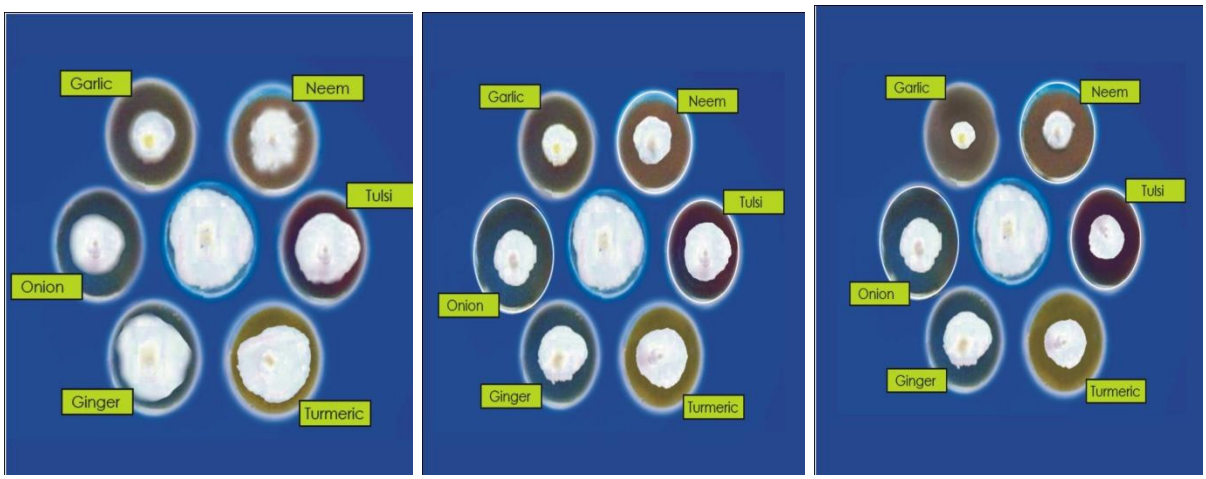

Plate 5. *In vitro* evaluation of botanicals at 5%, 10% and 15% concentration on radial growth of *P. citrophthora.*

Table 4

In vitro effect of different plant extracts on radial growth of *Phytophthora nicotianae.*

Tr. No.	Tr. Name	Colony diameter at 5% conc. (mm)			Colony diameter at 10% conc. (mm)			Colony diameter at 15% conc. (mm)			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		5% conc.	10% conc.	15% conc.	
T_1	*Azadirachta indica*	58.87	65.41	40.88	55.25	61.39	37.87	51.50	57.23	34.90	55.20	34.59	38.61	42.77	38.65
T_2	*Ocinum sanactum*	70.75	78.61	51.82	69.50	77.23	50.56	68.13	75.69	49.19	69.46	21.38	22.77	24.30	22.81
T_3	*Curcuma longa*	73.75	81.94	55.03	72.25	80.27	53.41	69.25	76.94	50.29	71.75	18.05	19.72	23.05	20.27
T_4	*Zingiber officinicle*	67.37	74.86	48.47	65.88	73.19	47.04	63.13	70.14	44.53	65.46	25.14	26.80	29.85	27.26
T_5	*Allium cepa*	62.05	68.88	43.53	61.25	68.05	42.88	59.25	65.83	41.17	60.85	31.05	31.94	34.16	32.88
T_6	*Allium sativum*	51.12	56.80	34.74	47.37	52.64	31.77	43.88	48.75	29.17	47.45	43.2	47.36	51.24	47.26
T_0	Control	90.00	100.00	89.98	90.00	100.00	89.98	90.00	100.00	89.98	90.00	0.00	0.00	0.00	0.00
	SE ±	1.42	1.59	1.18	0.68	0.76	0.60	0.45	0.50	0.38					
	CD at 5 %	4.19	4.67	3.45	2.00	2.23	1.78	1.32	1.47	1.11					

Table 5

In vitro effect of different plant extracts on radial growth of *Phytophthora citrophthora*.

Tr. No.	Tr. Name	Colony diameter at 5% conc. (mm)			Colony diameter at 10% conc. (mm)			Colony diameter at 15% conc. (mm)			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		5% conc.	10% conc.	15% conc.	
T_1	*Azadirachta indica*	60.37	67.08	42.14	55.87	62.08	38.37	55.00	61.11	37.67	57.08	32.92	37.92	38.88	36.57
T_2	*Ocinum sanactum*	65.00	72.22	46.24	62.75	69.72	44.19	60.50	67.23	42.23	62.75	27.77	30.27	32.77	30.27
T_3	*Curcuma longa*	66.75	74.16	47.86	62.25	72.49	46.46	60.37	67.08	42.14	63.12	25.83	27.75	32.92	28.83
T_4	*Zingiber officinicle*	70.00	77.76	51.06	68.25	75.83	49.31	66.00	73.19	47.05	68.08	22.22	24.16	26.66	24.34
T_5	*Allium cepa*	64.13	71.39	45.55	60.25	66.94	42.03	58.7	65.42	40.85	61.08	28.74	33.05	34.58	32.12
T_6	*Allium sativum*	47.00	52.22	31.47	45.00	49.99	29.99	39.87	44.30	26.30	43.95	47.77	50.00	55.70	51.15
T_0	Control	90.00	100.00	89.98	90.00	100.00	89.98	90.00	100.00	89.98	90.00	0.00	0.00	0.00	0.00
	SE ±	0.56	0.62	0.50	0.59	0.65	0.48	0.66	0.74	0.53					
	CD at 5 %	1.64	1.82	1.48	1.73	1.92	1.42	1.94	2.17	1.56					

Table 6

In vitro effect of different plant extracts on radial growth of *Phytophthora palmivora.*

Tr. No.	Tr. Name	Colony diameter at 5% conc. (mm)			Colony diameter at 10% conc. (mm)			Colony diameter at 15% conc. (mm)			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		5% conc.	10% conc.	15% conc.	
T_1	*Azadirachta indica*	62.75	69.71	44.22	59.87	66.53	41.70	56.87	63.19	39.19	59.83	30.27	33.47	36.81	33.51
T_2	*Ocinum sanactum*	66.63	74.02	47.79	66.25	73.61	47.43	63.88	70.97	45.22	65.58	25.96	26.38	29.02	27.12
T_3	*Curcuma longa*	70.50	78.33	51.56	68.87	76.52	49.93	66.00	73.19	47.06	68.45	21.66	23.47	26.66	23.93
T_4	*Zingiber officinicle*	66.63	74.02	47.75	65.62	72.91	46.80	62.88	69.86	44.31	65.04	25.96	27.08	30.13	27.72
T_5	*Allium cepa*	65.37	72.64	46.59	63.62	70.69	44.99	61.13	67.91	42.77	63.37	27.36	29.31	32.07	29.58
T_6	*Allium sativum*	48.87	54.30	33.04	44.75	49.72	29.83	39.63	44.02	26.12	44.41	45.70	50.27	55.96	50.64
T_0	Control	90.00	100.00	89.98	90.00	100.00	89.98	90.00	100.00	89.98	90.00	0.00	0.00	0.00	0.00
	SE ±	1.77	1.98	1.38	0.84	0.94	0.73	0.67	0.76	0.61					
	CD at 5 %	5.2	5.80	4.07	2.47	2.75	2.14	1.96	2.23	1.78					

Table 7

In vitro effect of fungicides at different concentrations on radial growth of *Phytophthora nicotianae.*

Tr. No.	Tr. Name	Colony diameter (mm) 150 ppm			Colony diameter (mm) 250 ppm			Colony diameter (mm) 500 ppm			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		150 ppm	250 ppm	500 ppm	
T_1	Metalaxyl	65	72.22	46.25	59.33	65.92	41.24	51.83	57.58	35.16	58.72	27.77	34.07	42.41	34.75
T_2	Fosetyl-Al	57.66	64.07	39.84	51.67	57.40	35.04	46.83	52.03	31.36	52.05	35.93	42.59	42.16	40.22
T_3	Cymoxynil 8% + Mancozeb 64%	19.58	21.84	12.61	17.67	19.62	11.32	11.00	12.21	70.16	16.12	78.13	80.37	87.77	82.09
T_4	Metyram	25	27.77	16.12	21.50	23.88	13.82	14.00	15.55	89.47	20.16	72.22	76.11	84.44	77.59
T_5	Mancozeb	71.33	79.25	52.42	65.83	73.14	47.00	64.16	71.29	45.47	67.10	20.74	26.85	28.11	25.23
T_6	Chlorothalonil	31.83	35.36	20.72	25.33	28.14	16.34	15.33	17.03	98.06	24.16	64.63	71.85	82.96	73.14
T_7	Azoxystrobin	69.83	77.59	50.89	64.33	71.47	45.62	58.33	64.81	40.39	64.16	22.41	28.52	35.18	28.70
T_8	Metalaxyl-M 4% + Mancozeb 64%	24.17	26.85	15.57	17.33	19.25	11.10	9.33	10.36	59.49	16.94	73.14	80.74	89.63	81.17
T_9	Pyraclostrobin 5% + Metyram 55%	37.67	41.84	24.74	28.16	31.29	18.24	21.33	23.69	13.70	29.05	58.14	68.71	76.3	67.71
T_0	Control	90.00	100	89.98	90.00	100	89.98	90.00	100	90.98	90.00	0.00	0.00	0.00	0.00
	SE ±	0.81	0.89	0.65	0.75	0.83	0.56	0.65	0.72	0.47					
	CD at 5 %	2.37	2.64	1.92	2.21	2.45	1.66	1.91	2.11	1.38					

Table 8

***In vitro* effect of fungicides at different concentrations on radial growth of *Phytophthora citrophthora*.**

Tr. No.	Tr. Name	Colony diameter (mm) 150 ppm			Colony diameter (mm) 250 ppm			Colony diameter (mm) 500 ppm			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		150 ppm	250 ppm	500 ppm	
T_1	Metalaxyl	57.33	63.69	39.56	54.66	60.73	37.40	49.33	54.81	33.23	53.77	36.30	39.26	45.18	40.25
T_2	Fosetyl-Al	53.16	59.07	36.20	49.83	55.36	33.61	46.66	51.4	31.23	49.88	40.93	44.63	48.15	44.57
T_3	Cymoxynil 8% + Mancozeb 64%	13.50	14.99	8.62	10.83	12.03	6.91	7.5	8.33	4.77	10.61	85.00	87.96	91.66	88.20
T_4	Metyram	17.33	19.25	11.10	14.66	16.29	9.37	11.83	13.14	7.55	14.60	80.74	83.71	86.85	83.77
T_5	Mancozeb	68.16	75.73	49.23	65.33	72.40	46.39	63.33	70.36	44.72	65.60	24.26	27.41	29.63	27.10
T_6	Chlorothalonil	24.16	26.84	15.57	16.83	18.70	10.77	14.00	15.55	8.94	18.33	73.15	81.30	84.44	79.63
T_7	Azoxystrobin	58.83	65.36	40.81	55.83	62.03	38.33	51.66	57.40	35.07	55.44	34.63	37.96	42.60	38.39
T_8	Metalaxyl-M 4% + Mancozeb 64%	14.33	15.92	9.16	12.33	13.70	7.87	7..83	86.96	49.88	11.49	84.07	86.30	91.30	87.22
T_9	Pyraclostrobin 5% + Metyram 55%	25.83	28.70	16.67	21.50	23.88	13.81	18.66	20.73	11.96	21.99	71.3	76.11	79.26	75.55
T_0	Control	90.00	100	89.98	90.00	100	89.98	90.00	100	89.98	90.00	0.00	0.00	0.00	0.00
	SE ±	0.58	0.65	0.42	0.69	0.78	0.51	0.61	0.68	0.43					
	CD at 5 %	1.73	1.92	1.25	2.04	2.30	1.51	1.81	2.01	1.29					

Table 9

In vitro effect of fungicides at different concentrations on radial growth of *Phytophthora palnivora*.

Tr. No.	Tr. Name	Colony diameter (mm) 150 ppm			Colony diameter (mm) 250 ppm			Colony diameter (mm) 500 ppm			Mean of O.V.	% inhibition			Mean
		O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin	O.V.	% value	Arc. Sin		150 ppm	250 ppm	500 ppm	
T_1	Metalaxyl	70.50	78.33	51.56	64.00	71.10	45.31	57.33	63.70	39.56	63.94	21.66	28.88	36.30	28.94
T_2	Fosetyl-Al	60.33	67.03	42.09	54.50	60.55	37.27	50.00	55.55	33.74	54.94	32.96	39.44	44.44	38.94
T_3	Cymoxynil 8% + Mancozeb 64%	18.33	20.36	11.75	16.83	18.70	10.78	10.83	12.03	69.10	15.33	79.63	81.30	87.96	82.96
T_4	Metyram	23.67	26.29	15.24	19.83	22.03	12.72	12.33	13.70	78.73	18.61	73.70	77.96	86.30	79.32
T_5	Mancozeb	75.66	84.07	57.29	70.00	77.77	51.06	62.33	69.25	43.83	69.33	15.93	22.22	30.74	22.96
T_6	Chlorothalonil	32.16	35.73	20.94	23.17	25.74	14.91	16.83	18.70	10.77	24.05	64.26	74.25	81.30	73.27
T_7	Azoxystrobin	69.66	77.40	50.73	64.33	71.47	45.61	59.33	65.92	41.24	64.44	22.60	28.52	34.07	28.39
T_8	Metalaxyl-M 4% + Mancozeb 64%	20.50	22.77	13.16	16.33	18.14	10.45	14.66	16.29	93.76	17.16	77.22	81.85	83.71	80.92
T_9	Pyraclostrobin 5% + Metyram 55%	37.33	41.47	24.50	30.66	34.07	19.91	21.33	23.69	13.70	29.77	58.52	65.93	76.30	66.91
T_0	Control	90.00	100	89.98	90.00	100	89.98	90.00	100	89.98	90.00	0.00	0.00	0.00	0.00
	SE ±	0.99	1.11	0.88	0.77	0.86	0.57	0.61	0.67	0.43					
	CD at 5 %	2.93	3.26	2.59	2.29	2.55	1.68	1.79	1.99	1.27					

Rasid *et al*. (2004) noted neem leaf diffuse and neem leaf powder completely inhibitory to *Phytophthora infestans*. Bunny and Tippett (1988) recorded 50.00% inhibition of *Phytophthora nicotianae* and *P. citricola* with botanical *Pinus radiata*. Masuduzzaman *et al*. (2008) recorded that 1:3 concentration of Allamanda leaf extract was completely inhibitory to *Phytophthora capsici*. Hyder *et al*. (2004) recorded 81% inhibition of *P. capsici* by botanical coir extract after 8 days at 0.24 mg/ml concentration. Bowers and Locke (2004) recorded 98.4 to 99.9% inhibition of *Phytophthora nicotianae* in Greenhouse by10% aqueous emulsion of clove oil and cinamom oil. Del Rio *et al*. (2003) noted inhibitory effect of olive extract (*Olea europaea* L.) against *Phytophthora spp*. Ramanathan *et al*. (2004) and Bhat (2000) also tested botanicals against *Pythium aphinidermatum*. Ramanathan *et al*. (2004) noted total inhibitory effect of spider lilly (*Crinum asiaticum*) against *P. aphinidermatum*. Sharma *et al*. (2005) reported 60% inhibition *P. aphinidermatum* with neem formulations. Rama and Thakore (2005) noted inhibitory effect of *Allium sativum* and *Azadirachta indica* against *P. aphinidermatum*

3.3. *In vitro* evaluation of fungicides

A total of nine fungicides (@ 150, 250, 500 ppm each) *viz.*, Metalaxyl 35 EC (Ridomil), Fosetyl-al 80 WP (Aliette), Cymoxynil 8 % + Mancozeb 64% (Curzate M-8), Azaxystrobin 23% SC (Amistar), Pyraclostrobin 5% + Metyram 55% (Cabrio-Top), Metyram 70 WG (Polyram), Metalaxy-M 4% + Mancozeb 64% (Ridomil Gold), Mancozeb 75 WP (Diathane M-45), Chlrothalonil 75 WP (Kavach) were evaluated (@ 150, 250 and 500 ppm each) *in vitro* applying "Poisoned Food Technique" as described earlier against *Phytophthora citrophthora, Phytophthora nicotianae* and *Phytophthora palmivora.*

The result (Table 7 and Fig. 7) indicated that all the fungicides tested significantly inhibited the mycelial growth of *Phytophthora nicotianae* over untreated control at all the concentration tested. Among the fungicides tested Cymoxynil 8%+ Mancozeb 64% (Curzate-M8) recorded least mean colony diameter (16.12 mm) and highest inhibition (82.09%) of mycelial growth of the test pathogen over untreated control. This was followed by the fungicides, Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold) which recorded mean colony diameter of (16.94 mm) and mean mycelail growth inhibition of (81.17%) followed by Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-Top), Fosetyl-Al (Aliette), Metalaxyl (Ridomil), Azaxystrobin (Amistar) which recorded mean colony diameter of 20.16 mm, 24.16 mm, 29.05 mm, 52.05 mm, 58.72 mm, 64.16 mm, and mean mycelial inhibition of 77.59%, 73.14%, 67.71%, 40.22%, 34.75%, 28.70 %, respectively. Fungicide Mancozeb (Diathane M-45) was found comparatively least effective and recorded 67.10 mm and 25.23 per cent, mean colony diameter and mean myceial growth inhibition, respectively (Plate 6).

Treatments Cymoxynil 8% + Mancozeb 64% (Curzate M-8) and Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold) were statistically at par, though there was no significant difference found among the treatments.

All the concentrations of the fungicides tested significantly inhibited mycelial growth of the test pathogen. However, higher concentration (@ 500 ppm) recorded maximum inhibition range 89.63 to 28.11%) followed by 250 ppm (range 80.74 to 26.85%) and 150 ppm (range 78.13 to 20.74 per cent inhibition).

Thus, all the fungicides tested at various concentrations significantly inhibited the mycelial growth of *Phytophthora nicotianae*. However, Cymoxynil 8% + Mancozeb 64% (Curzate M-8) and Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold) was found most effective followed by Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-Top), Fosetyl-Al (Aliette), Metalaxyl (Ridomil), Azoxystrobin (Amistar). Fungicide Mancozeb (Diathane M-45) was found comparatively least effective against the test pathogen.

Results (Table 8 and Fig. 8) indicated that all the fungicides tested significantly inhibited the mycelial growth of *Phytophthora citrophthora* over untreated control at all the concentration tested. Among the fungicides, tested Cymoxynil 8% + Mancozeb 64% (Curzate M-8) recorded least mean colony diameter (10.61 mm) and highest inhibition (88.20%) of mycelial growth of the test pathogen over untreated control. This was followed by the fungicides, Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Carbrio-Top), Fosetyl-Al (Aliette), Metalaxyl (Ridomil), Azoxystrobin (Amistar) which recorded the mean colony diameter of 11.49 mm, 14.60 mm, 18.33 mm, 21.99 mm 49.88 mm, 53.77 mm, 55.44 mm and mean per cent inhibition of mycelial growth of *Phytophthora citrophthora* 87.22%, 83.77%, 79.63%, 75.55%, 44.57%, 40.25% and 38.39%, respectively. Fungicide Mancozeb (Diathane M-45) was found comparatively least effective and recorded 65.60 and 27.10 per cent, mean colony diameter and mean mycelial growth inhibition, respectively (Plate 7).

All the concentrations of the fungicides tested significantly inhibited mycelial growth of the test pathogen. However, higher concentration (@ 500 ppm) recorded maximum inhibition (range 91.66 to 29.63%) followed by 250 ppm (range 87.96 to 27.41%) and 150 ppm (range 85.00 to 24.26 % inhibition).

Thus all the fungicides tested at various concentration significantly inhibited the mycelial growth of *Phytophthora citrophthora*. However, Cymoxynil 8% + Mancozeb 64% (Curzate M-8) was found most effective followed by Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-top), Fosteyl-Al (Aliette), Metalaxyl (Ridomil), Azoxystrobin (Amistar). Fungicide Mancozeb (Diathane M-45) was found comparatively least effective against the test pathogen *Phytophthora citrophthora*.

Results (Table 9 and Fig. 9) indicated that all the fungicides tested significantly inhibited the mycelial growth of *Phytophthora plamivora* over untreated control at all the concentrations tested. Among the fungicides tested Cymoxynil 8% + Mancozeb 64% (Curzate M-8) recorded least mean colony diameter (15.33 mm) and highest inhibition (82.96%) of mycelial growth of the test pathogen over untreated control. This was followed by the fungicides, Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-top), Fosetyl-Al (Aliette), Metalaxyl (Ridomil), Azoxystrobin (Amistar) which recorded the mean colony diameter of 17.16 mm, 18.61 mm, 24.05 mm, 29.77 mm, 54.94, mm, 63.94 mm, 64.44 mm, and mean per cent inhibition of mycelial growth of *Phytophthora plamivora* 80.92%, 79.32%, 73.27%, 66.91%, 38.94%, 28.94% and 28.39%. Fungicide Mancozeb (Diathane M-45) was comparatively least effective and recorded 69.33 mm and 22.96 per cent, mean colony diameter and mean mycelial growth inhibition, respectively (Plate 8).

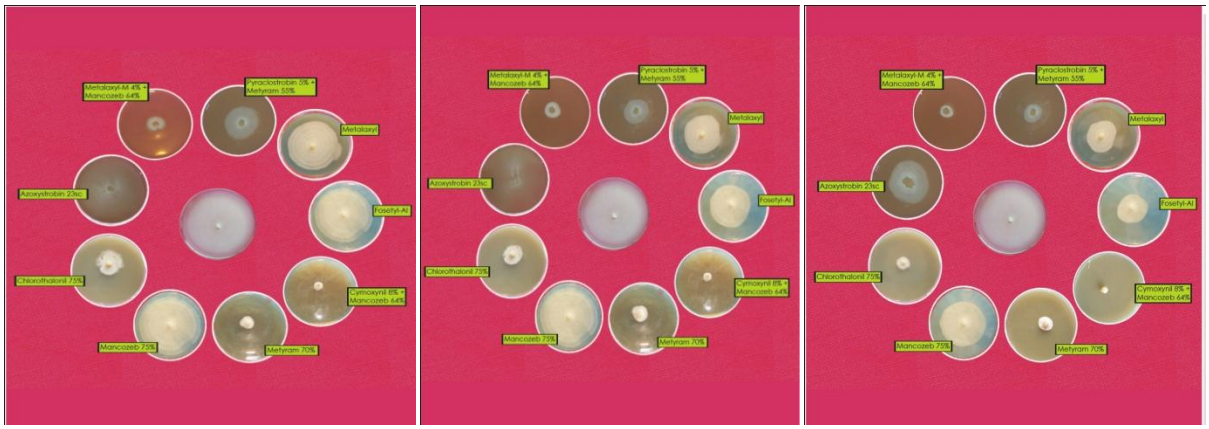

Plate 6. *In vitro* evaluation of fungicidess at 150 ppm, 250 ppm and 500 ppm concentration on radial growth of *P. nicotianae*

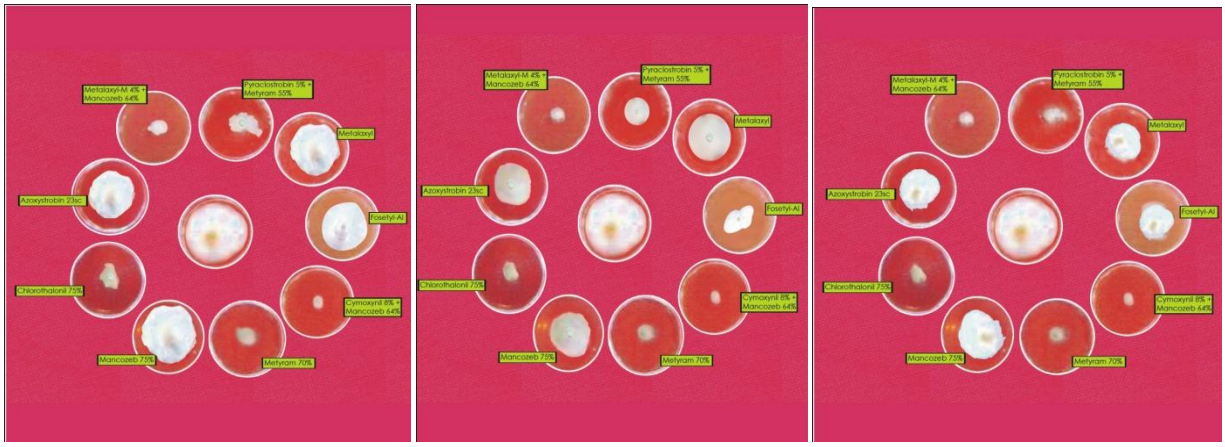

Plate 7. *In vitro* evaluation of fungicidess at 150 ppm, 250 ppm and 500 ppm concentration on radial growth of *P. citrophthora*

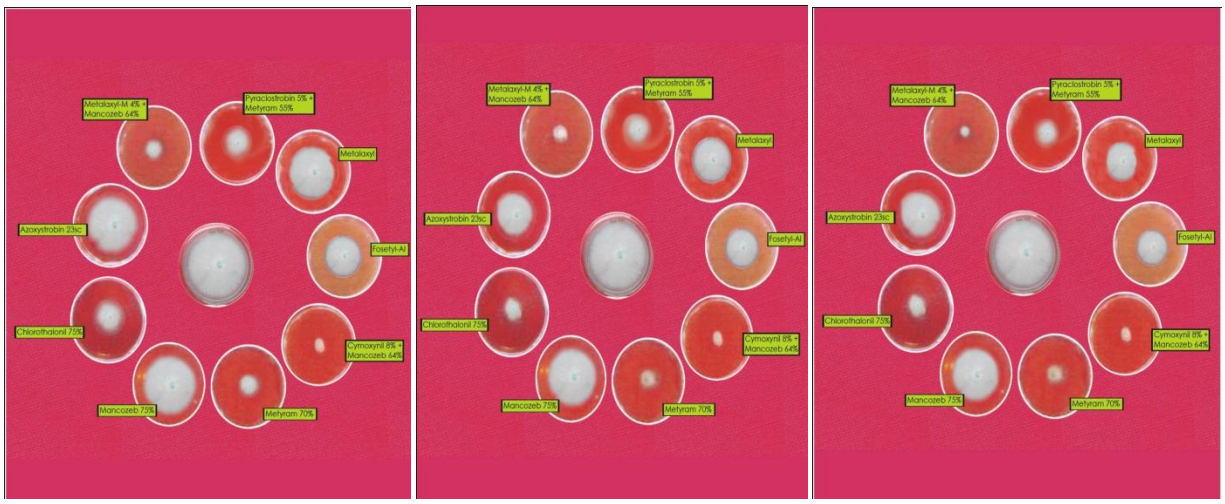

Plate 8. *In vitro* evaluation of fungicidess at 150 ppm, 250 ppm and 500 ppm concentration on radial growth of *P. palmivora*

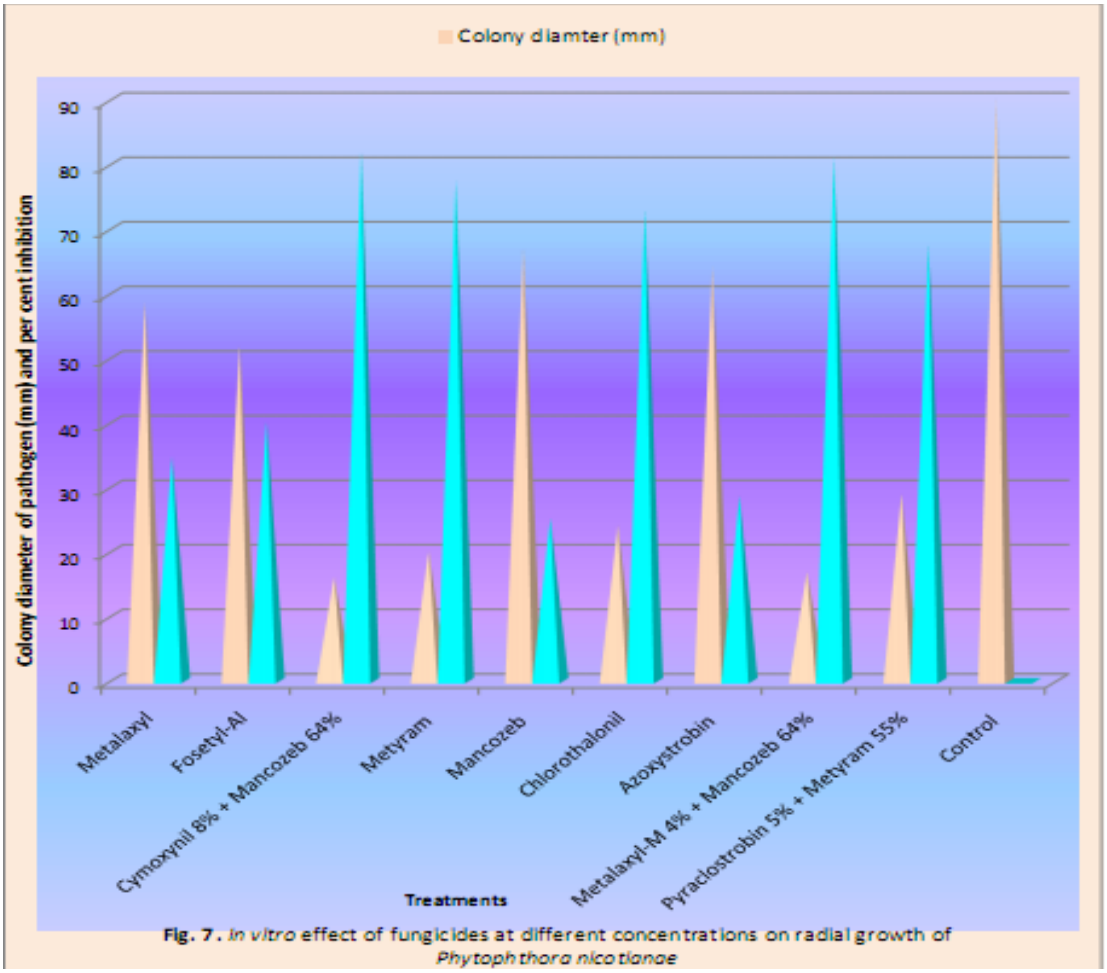

Fig. 7. *In vitro* effect of fungicides at different concentrations on radial growth of *Phytophthora nicotianae*

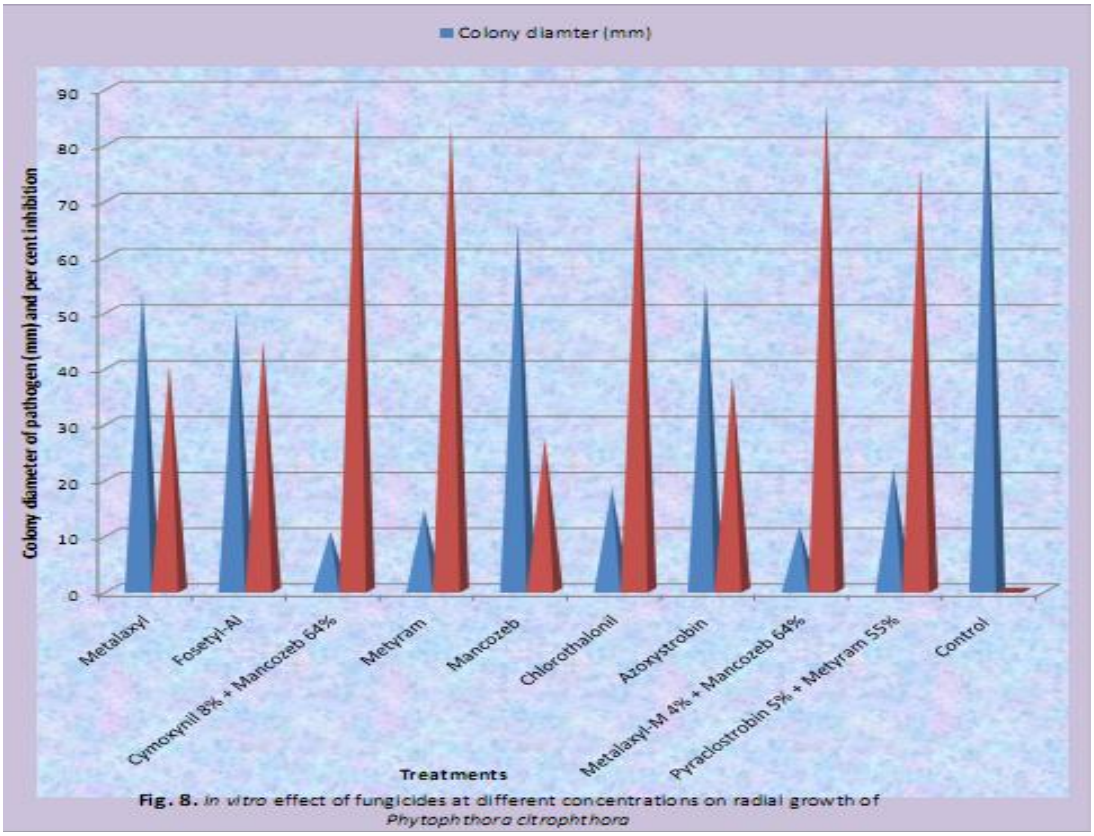

Fig. 8. *In vitro* effect of fungicides at different concentrations on radial growth of *Phytophthora citrophthora*

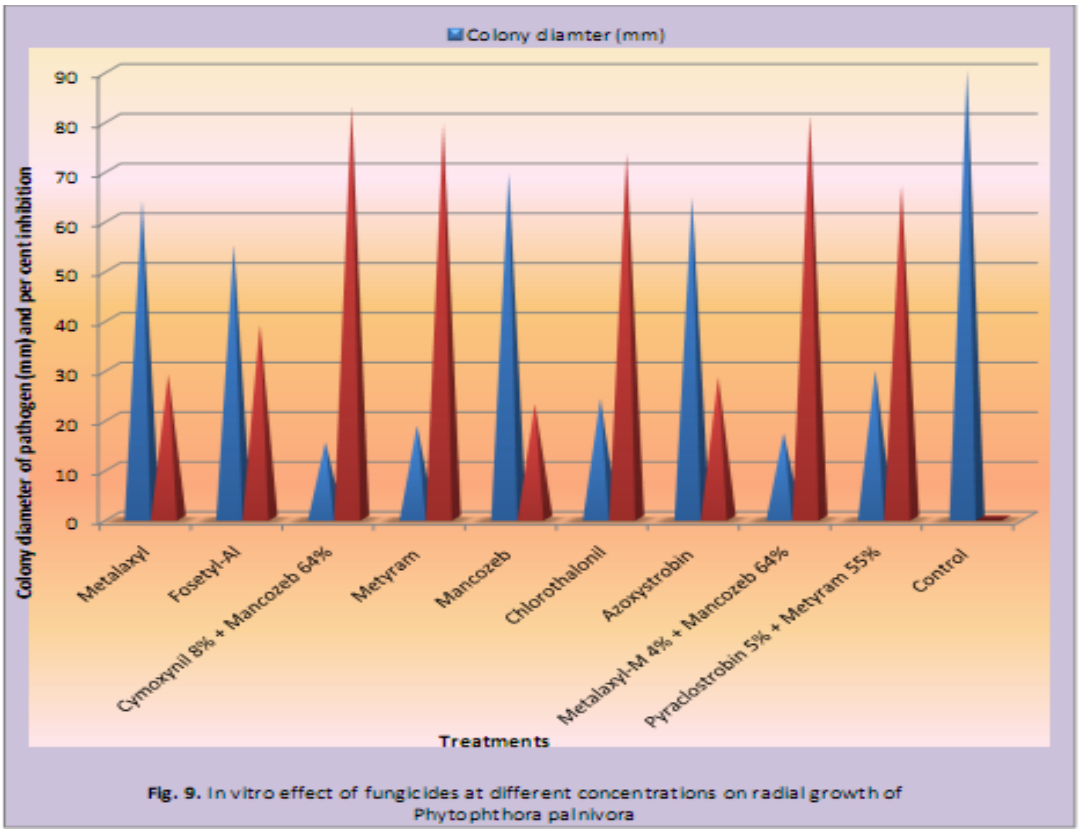

Fig. 9. In vitro effect of fungicides at different concentrations on radial growth of Phytophthora palnivora

All the concentrations of the fungicides tested significantly inhibited mycelial growth of the test pathogen. However, highest concentration (@ 500 ppm) recorded maximum inhibition (range 87.66 to 30.74%) followed by 250 ppm (range 81.30 to 22.22%) and 150 ppm (range 79.63 to 15.93% inhibition).

Thus, all the fungicides tested at various concentrations significantly inhibited the mycelial growth of *Phytophthora palmivora*. However, Cymoxynil 8% + Mancozeb 64% (Curzate M-8) and Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), was found most effective followed by Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-top), Fosetyl-Al (Aliette), Metalaxyl (Ridomil), Azoxystrobin. Fungicide Mancozeb (Diathane M-45) was found comparatively least effective against the test pathogen.

Similar results were obtained by Feichtenberger (2008); Chitzanidis and Argyri (2008); Tuset and Portilla (2008) Davis (1982); Dasgupta *et al*. (2005) Gade and Giri (2005) in case of Fosetyl-Al (Aliette), Metalaxyl (Ridomil) and Mancozeb (Diathane M-45) fungicides. Anju rani *et al*. (2007) recorded 55.6 to 100% inhibition of *P. infestans* by Cymoxynil 8% + Mancozeb 64% (Curzate M-8) while, with Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), 94.4 to 100% at 6 ppm concentration; metyram 10 ppm caused cent per cent inhibition of *P. infestans*. Singh (2008) noted inhibitory effect of Cymoxynil 8% + Mancozeb 64% (Curzate M-8) and Ridomil MZ against *P. infestans*, similar results were obtained by Bhat *et al*. (2009) and Kaur *et al*. (2010) in case of Cymoxynil 8% + Mancozeb 64% (Curzate M-8) against *P. infestans*. Tabassum and Nema (2007) noted inhibitory effect of Ridomil MZ 72 wp, Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), MZ 68, Chlorothalonil (Kavach), Apron 35 SD, Propineb, Diathane M-45 against *P. capsici* (Bell pepper) and *Phytophthora nicotianae* var. *nicotianae* (Brinjal). Naqvi (2005) noted inhibitory effect of Fosteyl-Al, Metalaxyl-M 4% + Mancozeb 64% (Ridomil Gold), and Metalaxyl against *Phytophthora spp*. of citrus.

4. Conclusion

Gummosis caused by *Phytophthora nicotianae* (Breda de Hann), *Phytophthora citrophthora* (Smith and Smith) and *Phytophthora palmivora* (Butler E.G.) is one of the most important diseases inflicting considerable quantitative and qualitative losses in sweet orange (*Citrus sinensis* Osbeck). All the six bioagents tested significantly inhibited the mycelial growth of *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora*. However, *T. harzianum* was found most effective followed by *T. viride*, *T. koningii*, *T. hamatum, G. virens* and *P. fluorescens* in case of *Phytophthora nicotianae*. In case of *Phytophthora citrophthora*, *T. viride* was found most effective followed by *T. harzianum*, *T. hamatum*, *G. virens*, *T. koningii* and *P. fluorescens*. In case of *Phytophthora palmivora*, *T. viride* was found most effective followed by *T. harzianum*, *T. hamatum*, *T. koningii*, *G. virens* and *P. fluorescens*. Jeyalakshmi *et al*. (1998) who reported the biological control potential of T. harzianum. Trichoderma spp. and bacterial bioagents produce mycolytic enzymes, thus playing an important role in the degradation of target pathogens (Elad *et al*., 1982; Aziz *et al*., 1993; Baker and Dickman, 1993; Sivakumar and Narayanaswamy, 1998). All the six botanicals/plant extracts tested at various concentrations significantly inhibited the mycelial growth of *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora*. However, Garlic extract was found effective followed by Neem, Onion, Ginger, Tulasi and Turmeric extract in case of *Phytophthora nicotianae* and *Phytophthora palmivora* while in case of *Phytophthora citrophthora* Garlic extract was found most effective followed by Neem, Onion, Tulasi, Turmeric and Ginger extract. The inhibitory action of neem may be due to azadirchtin present in seed kernels which retards the growth and activation of the pathogen. The effectiveness of onion bulb extract may be due to presence of antifungal compounds such as cycloallin and carbohydrate propenyl sulphuric acid. *In vitro* evaluations of fungicides provide useful preliminary information regarding its efficacy against a pathogen within a shortest period of time and therefore, serve as guide for further field testing in future. All the nine fungicides tested at various concentrations significantly inhibited the mycelia growth of *Phytophthora nicotianae*, *Phytophthora citrophthora* and *Phytophthora palmivora*. However, Cymoxynil 8 % + Mancozeb 64% (Curzate M-8) and Metalaxyl M-4% + Mancozeb 64% (Ridomil Gold) were found most effective followed by Metyram (Polyram), Chlorothalonil (Kavach), Pyraclostrobin 5% + Metyram 55% (Cabrio-Top), Fosteyl-Al (Aliette), Metalaxyl (Ridomil), and Azoxystrobin (Amistar) while fungicide Mancozeb (Dithane M-45) was found comparatively least effective against all the *Phytophthora* species. Thus the study indicated that suitable integration of more efficient eco-friendly treatments like bio-agents and botanicals with lesser use of fungicides may provide a better management of the disease.

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