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In vitro efficacy of fungicides against *Fusarium oxysporum* f. sp. *ciceri*

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Abstract
Six systemic, six non-systemic and six combi fungicides were evaluated *in vitro* against *Fusarium oxysporum* f. sp. *ciceri*; All fungicides tested *in vitro* were found effective in inhibition of mycelial growth of *Fusarium oxysporum* f. sp. *ciceri*. Among systemic fungicide, Carbendazim and Tebuconazole were highly effective in arresting the mycelial growth of *Fusarium oxysporum* f. sp. *ciceri* with complete inhibition of pathogen at all tested concentration of 250, 500 and 1000 ppm. Among non systemic fungicide, the least radial mycelial growth with maximum inhibition of pathogen was recorded with Captan followed by Mancozeb at all concentration of 1000, 1500 and 2000 ppm. Combi products of fungicide *viz*., Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum inhibited the complete growth of pathogen at all tested concentration of 1000, 1500 and 2000 ppm.

Keywords: Chickpea, *in vitro*, fungicide, *Fusarium oxysporum* f. sp. *ciceri*

Introduction
Chickpea (*Cicer arietinum* L.) is a leguminous annual plant in the family Fabaceae grown for its edible seeds and variously known as gram, bengal gram, chana and chole. It is world's third most important pulse crop and preferred food legume due to its high nutritional value, high yield potential and low cost of cultivation. Chickpea suffers from several diseases but wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is the most serious disease which causes heavy losses up to 10 per cent in yield (Dubey *et al*., 2007) [2]. Seed treatment with fungicide is common practice to overcome the problem of wilt, hence present investigation was conducted to test the efficacy of various fungicides against *Fusarium oxysporum* f. sp. *ciceri in vitro.*

Materials and Methods
In vitro efficacy of fungicides against *Fusarium oxysporum* f. sp. *ciceri*
Six systemic, six non-systemic and six combi fungicides were evaluated *in vitro* against *Fusarium oxysporum* f. sp. *ciceri* (Table 1, 2 & 3) using Poisoned Food Technique (Nene and Thapliyal, 1993). Systemic fungicides were tested at 250, 500 and 1000 ppm concentration, where as non systemic fungicides and combi product were tested at 1000, 1500 and 2000 ppm. Observation on radial mycelial growth/colony diameter of the *F. oxysporum* f. sp. *ciceri* was recorded at an interval of 24 hours and continued till untreated control plates were fully covered with mycelial growth. Per cent of mycelial growth inhibition of the pathogen with the test fungicides over the untreated control were calculated by using the formula (Vincent, 1947) [8].

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

Where,
C = Growth of the test fungus in untreated control plates
T = Growth of the test fungus in treated plate

Experimental Details
Design	:	CRD
Replications	:	Four
Treatments	:	Six

Table 1: List of Systemic fungicide

Tr. No	Treatments	Trade Name
T_1	Hexaconazole 5% EC	Contaf
T_2	Carbendazim 50% WP	Bavistin
T_3	Propiconazole 25% EC	Tilt
T_4	Tebuconazole 25.9% EC	Folicore
T_5	Thiophanate methyl 70% WP	Roko
T_6	Control	-

Table 2: List of non systemic fungicide

Tr. No	Treatments	Trade Name
T_1	Propineb 70% WP	Dithane M -45
T_2	Copper oxychloride 50% WP	Blitox
T_3	Chlorothalonil 75% WP	Kavach
T_4	Mancozeb 50% WP	Antracol
T_5	Captan 50% WP	Captaf
T_6	Control	-

Table 3: List of combi fungicide

Tr. No	Treatments	Trade Name
T_1	Captan 70% + Hexaconazole 5% WP	Taqat
T_2	Carbendazim 25% + Mancozeb 50% WP	Sprint
T_3	Tebuconazole 50% WG + Trifloxystrobin25% WG	Nativo
T_4	Carboxin 37.5% WP + Thirum 37.5% WP	Vitavax power
T_5	Zineb 68% + Hexaconazole 5% WP	Supernate
T_6	Control	-

Result and Discussion

Evaluation of fungicides against *Fusarium oxysporum* f. sp. *ciceri* associated with wilt of chickpea

Systemic fungicides

Five systemic fungicides *viz*., Hexaconazole, Carbendazim, Propiconazole, Tebuconazole and Thiophanate methyl were evaluated against *Fusarium oxysporum* f. sp. *ciceri* at the concentration 250 ppm, 500 ppm and 1000 ppm. It was found that mycelial growth decreased drastically with increase in concentration of fungicides tested (PLATE 1 & Fig. 1).

Radial mycelial growth

All systemic fungicide at all concentration were found effective in arresting the growth of test pathogen. It was found that mycelial growth decreased drastically with increase in concentration of fungicides tested (PLATE 1 & Fig. 1). At 250 ppm, Carbendazim (0 mm) and Tebuconazole (0 mm) arrested complete growth of pathogen. The other treatments were comparatively less effective and recorded radial mycelial growth 16.62 mm, 18.25 mm and 21.12 mm in Thiophanate methyl, Propiconazole and Hexaconazole, respectively.

All the fungicides showed significantly similar trend of radial mycelial growth as that of concentration 250 ppm with 500 and 1000 ppm concentration. The least (or no) mycelial growth was recorded in Carbendazim (0 mm) and Tebuconazole (0 mm). It was followed by Thiophenate methyl, Propiconazole and Hexaconazole .

Average radial mycelial growth of tested pathogen recorded in all systemic fungicides ranged from 0 mm (Carbendazim and Tebuconazole) to 18.37 mm (Hexaconazole) as against 90 mm in untreated control. The least (or no) average radial mycelial growth was recorded in Carbendazim (0 mm) and Tebuconazole (0 mm) followed by Thiophenate methyl (14.41 mm), Propiconazole (16.24 mm) and Hexaconazole (18.37 mm).

Inhibition of mycelial growth

Data presented in (Table 4) indicated that, all systemic fungicides tested at 250, 500 and 1000 ppm concentration significantly inhibited mycelial growth of pathogen over control (0.00 per cent). Further, the per cent mycelial growth inhibition increased with increased in the concentration of fungicides.

At 250 ppm concentration, mycelial growth inhibition of tested pathogen was ranged from 76.53 per cent (Hexaconazole) to 100 per cent (Carbendazim and Tebuconazole) as compare to control (0.00%). Carbendazim and Tebuconazole gave 100 per cent inhibition of mycelial growth. This was followed by Thiophenate methyl (81.53 per cent), Propiconazole (79.72 per cent) and Hexaconazole (76.53 per cent).

At 500 and 1000 ppm concentration, all the fungicides showed significantly similar trend of mycelial growth inhibition as that of concentration 250 ppm, but comparatively increased ranged of inhibition with increased in concentration.

Average mycelial growth inhibition of tested pathogen recorded in all systemic fungicides ranged from 79.58 per cent (Hexaconazole) to 100 per cent (Carbendazim and Tebuconazole) as against 00 per cent in untreated control. The highest mycelial growth inhibition was recorded in Carbendazim (100 per cent) and Tebuconazole (100 per cent) followed by Thiophenate methyl (83.98 per cent), Propiconazole (81.94 per cent) and Hexaconazole (79.58 per cent).

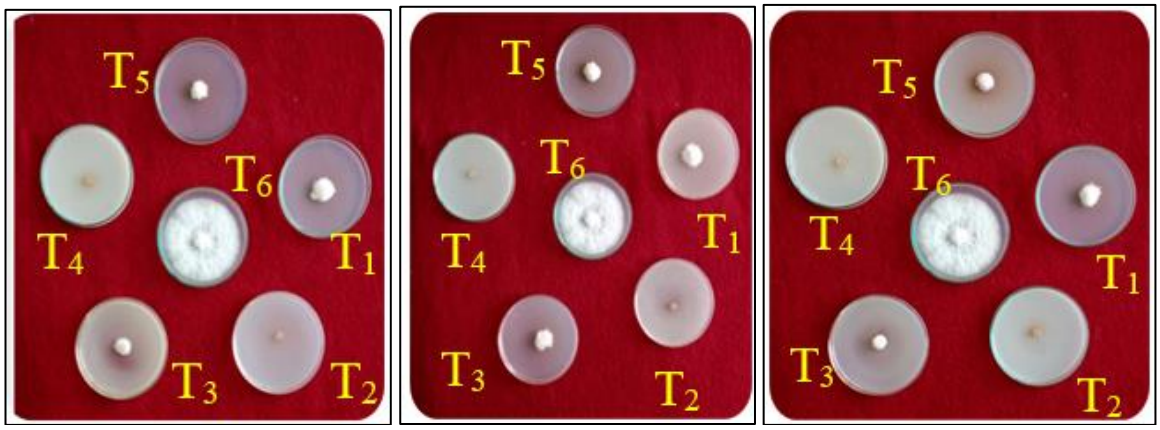


Plate 1: *Fusarium oxysporum* f. sp. *Cicero*

Table 4: *In vitro* efficacy of systemic fungicides against *Fusarium oxysporum* f. sp. *Cicero*

Treatments	Colony diameter (mm)			Average	% inhibition			Average
	250 ppm	500 ppm	1000 ppm		250 ppm	500 ppm	1000 ppm	
T_1	21.12	18.12	15.87	18.37	76.53 (57.12)	79.86 (63.33)	82.36 (65.16)	79.58 (63.13)
T_2	00.00	00.00	00.00	00.00	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90)
T_3	18.25	16.12	14.37	16.24	79.72 (63.23)	82.08 (64.95	84.03 (66.44)	81.94 64.85)
T_4	00.00	00.00	00.00	00.00	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90)
T_5	16.62	14.25	12.37	14.41	81.53 (64.54)	84.16 (66.54)	86.25 (68.23)	83.98 (66.40)
T_6	90.00	90.00	90.00	90.00	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
SE±	0.42	0.47	0.45		0.47	0.54	0.50	
CD at 1%	1.23	1.36	1.31		1.37	1.56	1.46	

Colony diameter = Average of four replications and figures in parenthesis are arcsine transformation value

The results of present investigation have resembling the finding of earlier records of scientist *viz*., Ravichandran and Hegde (2015) [6] tested four systemic fungicides against *Fusarium oxysporum* f. sp. *ciceri* and among all fungicides Carbendazim and Tebuconazole inhibited complete mycelial growth of pathogen followed by Hexaconazole (88.61%)). Bashir *et al*. (2017) [1] who evaluated five systemic fungicides against *Fusarium oxyspo*rum f. sp. *ciceri*. Among all fungicides Carbendazim (92.17%) showed maximum inhibition followed by Difenconazole (76.52%). Golkiya *et al.* (2018) [3] tested six systemic fungicides against *Fsarium oxysporum* f. sp. *ciceri*. Tebuconazole inhibited highest mycelial growth (89.19%) followed by Carbendazim (67.30%). The other scientists like Patra and Biswas (2016) [5] and Thaware *et al*. (2016) [7] had also found similar results.

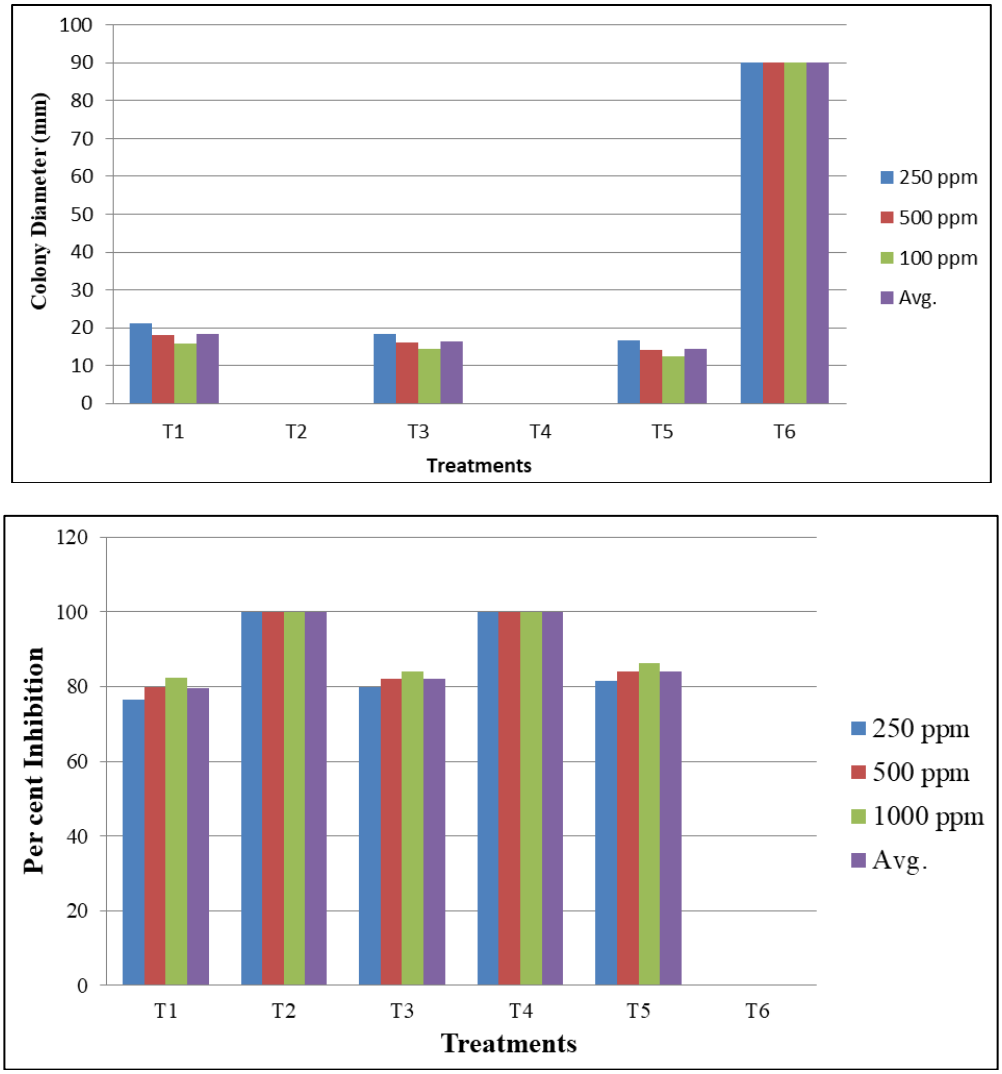


Fig 1: *In vitro* efficacy of systemic fungicides against *Fusarium oxysporum* f. sp. *ciceri*

Non systemic fungicides

Five non systemic fungicides *viz*., Propineb, Copper oxychloride, Chlorothalonil, Mancozeb and Captan were evaluated against *Fusarium oxysporum* f. sp. *ciceri* at the concentration 1000 ppm, 1500 ppm and 2000 ppm. It was found that mycelial growth decreased drastically and increased inhibition when increase concentration of fungicides tested (PLATE 2, Fig. 2).

Radial mycelial growth

At 1000 ppm concentration, radial mycelial growth of tested pathogen was found in the range of 20.12 mm to 51.50 mm

over control (90 mm). The least radial mycelial growth was recorded in Captan (20.12 mm) followed by Mancozeb (22.95 mm). The other treatments were comparatively less effective and recorded radial mycelial growth 23.87 mm, 27.87 mm and 51.50 mm in Propineb, Chlorothalonil and Copper oxychloride respectively.

At 1500 and 2000 ppm concentration, all the fungicides shown significantly similar trend of radial mycelial growth as that of concentration 1000 ppm, but comparatively reduced mycelial growth with increased in concentration of fungicide The least radial mycelial growth was recorded in Captan followed by Mancozeb. The other treatments of Propineb, Chlorothalonil and Copper oxychloride were comparatively less effective in arresting the radial growth of mycelium.

Average radial mycelial growth of tested pathogen recorded in all non-systemic fungicides ranged from 18.41 mm (Captan) to 47.50 mm (Copper oxychloride) as against 90 mm in untreated control. The least average radial mycelial growth was recorded in Captan (18.41 mm) followed by Mancozeb (20.89 mm). The fungicides Propineb, Chlorothalonil and Copper oxychloride were found comparatively less effective with maximum mycelial growth 22.78 mm, 25.45 mm and 47.50 mm respectively.

Inhibition of mycelial growth

Data presented in (Table 5) indicated that, all non systemic fungicides tested at 1000, 1500 and 2000 ppm concentration significantly inhibited mycelial growth of pathogen over control (0.00 per cent). Further, the per cent mycelial growth inhibition increase when increased the concentration of fungicides.

At 1000 ppm concentration, mycelial growth inhibition of tested pathogen was ranged from 42.77 per cent (Copper oxychloride) to 77.64 per cent (Captan) as compare to control (0.00%). Captan and Mancozeb gave 77.64 per cent 74.50 per cent inhibition of mycelial growth, respectively. This was followed by Propineb (73.47 per cent), Chlorothalonil (69.00 per cent) and Copper oxychloride (42.77 per cent).

At 1500 and 2000 ppm concentration, all the fungicides showed similar trend of mycelial growth inhibition as that of 1000 ppm concentration, but comparatively increased ranged of inhibition.

Average mycelial growth inhibition of tested pathogen recorded in all non systemic fungicides ranged from 47.21 per cent (Copper oxychloride) to 79.13 per cent (Captan) as against 00 per cent in untreated control. The highest mycelial growth inhibition was recorded in Captan (79.13 per cent) followed by Mancozeb (76.77 per cent). The fungicides Propineb, Chlorothalonil and Copper oxychloride were found comparatively less effective with minimum mycelial growth inhibition 74.67 per cent, 71.61 per cent and 47.21 per cent respectively.

Plate 2: *Fusarium oxysporum* f. sp. *ciceri*

Table 5: *In vitro* efficacy of non-systemic fungicides against *Fusarium oxysporum* f. sp. *Cicero*

Treatments	Colony diameter (mm)			Average	% inhibition			Average
	1000 ppm	1500 ppm	2000 ppm		1000 ppm	1500 Ppm	2000 ppm	
T_1	23.87	23.12	21.37	22.78	73.47 (58.99)	74.31 (59.54	76.25 (60.83)	74.67 (59.78)
T_2	51.50	47.75	43.25	47.50	42.77 (40.84)	46.94 (43.24)	51.94 (46.11)	47.21 (43.40)
T_3	27.87	25.87	22.62	25.45	69.00 (56.16)	71.25 (57.57)	74.58 (59.72)	71.61 (57.80)
T_4	22.95	20.37	19.37	20.89	74.50 (59.67)	77.36 (61.58)	78.47 (62.35)	76.77 (61.18)
T_5	20.12	18.62	16.50	18.41	77.64 (61.77)	79.31 (62.94)	81.66 (64.64)	79.13 (62.81)
T_6	90.00	90.00	90.00	90.00	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
SE±	0.84	0.89	0.66		0.95	0.99	0.73	
CD at 1%	2.43	2.57	1.90		2.74	2.86	2.11	

Colony diameter = Average of four replications and figures in parenthesis are arcsine transformation value

The results of present investigation have resembling with earlier records of scientist Bashir *et al*. (2017) [1] evaluated five non-systemic fungicides *viz*., Captan, Copper oxychloride, Dodine, Mancozeb and Antracol against *Fusarium oxysporum* f. sp. *ciceri*. Among all fungicides maximum per cent inhibition observed in Dodine (66.13%) and Captan (66.13%) followed by Antracol (41.75%) and least effective is Copper oxychloride (23.79%).

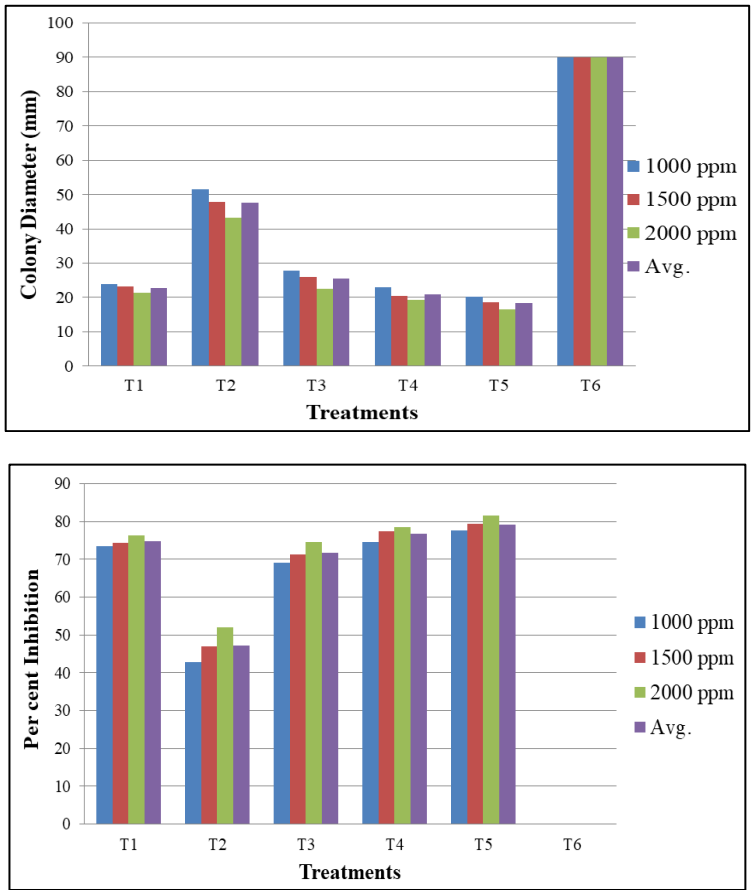


Fig 2: *In vitro* efficacy of non systemic fungicides against *Fusarium oxysporum* f. sp. *ciceri*

Combi fungicides

Five combi fungicides *viz*., Captan + Hexaconazole, Carbendazim +Mancozeb, Tebuconazole + Trifloxystrobin, Carboxin + Thirum and Zineb + Hexaconazole were evaluated against *Fusarium oxysporum* f. sp. *ciceri* at the concentration 1000 ppm, 1500 ppm and 2000 ppm. It was found that mycelial growth decreased drastically and increased inhibition when increase concentration of fungicides tested (PLATE 3 and Fig. 3).

Radial mycelial growth

At 1000 ppm concentration, the radial mycelial growth of tested pathogen was ranged from 0 mm (Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum) to 17.92 mm (Captan + Hexaconazole) as against 90 mm untreated control. The least radial mycelial growth was recorded in Carbendazim + Mancozeb (0 mm), Tebuconazole + Trifloxystrobin (0 mm) and Carboxin + Thirum (0 mm). The other treatments were comparatively less effective and recorded radial mycelial growth 16.87 mm and 17.92 mm in Zineb + Hexaconazole and Captan + Hexaconazole respectively.

At 1500 and 2000 ppm concentration, all the fungicides showed significantly similar trend of radial mycelial growth as that of concentration 1000 ppm, but comparatively reduced mycelial growth.

Average radial mycelial growth of tested pathogen recorded in all combi fungicides ranged from 0 mm (Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum) to 14.65 mm (Captan + Hexaconazole) as against in 90 mm untreated control. The least (or no) radial mycelial growth was recorded in Carbendazim + Mancozeb (0 mm), Tebuconazole + Trifloxystrobin (0 mm) and Carboxin + Thirum (0 mm). The other treatments were comparatively less effective and recorded radial mycelial growth 13.83 mm and 14.65 mm in Zineb + Hexaconazole and Captan + Hexaconazole respectively.

Inhibition of mycelial growth

Data presented in (Table 6) indicated that, all combi fungicides tested at 1000, 1500 and 2000 ppm concentration significantly inhibited mycelial growth of pathogen over control (0.00 per cent). Further, the per cent mycelial growth inhibition increase when increased the concentration of fungicides.

At 1000 ppm concentration, mycelium growth inhibition of tested pathogen was ranged from 80.07 per cent (Captan + Hexaconazole) to 100 per cent (Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum) as compare to control (0.00%). Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum gave 100 per cent inhibition of mycelial growth. This was followed by Zineb + Hexaconazole (81.24 per cent) and Captan + Hexaconazole (80.07 per cent).

At 1500 and 2000 ppm concentration, all the fungicides showed significantly similar trend of mycelial growth inhibition as that of concentration 1000 ppm, but comparatively increased inhibition.

Average mycelial growth inhibition of tested pathogen recorded in all combi fungicides ranged from 83.72 per cent (Captan + Hexaconazole) to 100 per cent (Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum) as compare to control (0.00%). Carbendazim + Mancozeb, Tebuconazole + Trifloxystrobin and Carboxin + Thirum gave 100 per cent inhibition of mycelial growth. This was followed by Zineb + Hexaconazole (85.83 per cent) and Captan + Hexaconazole (83.72 per cent).

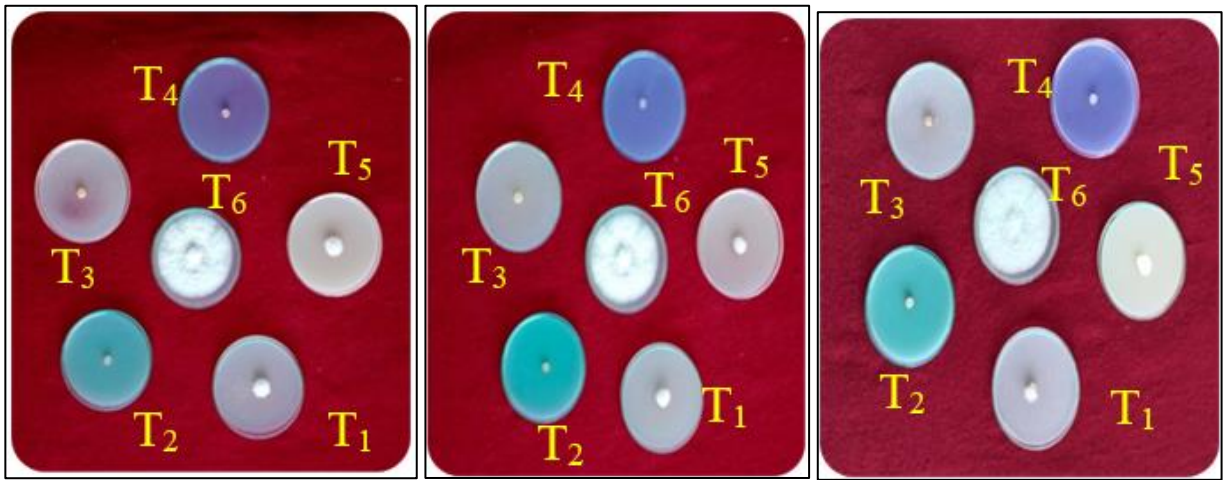


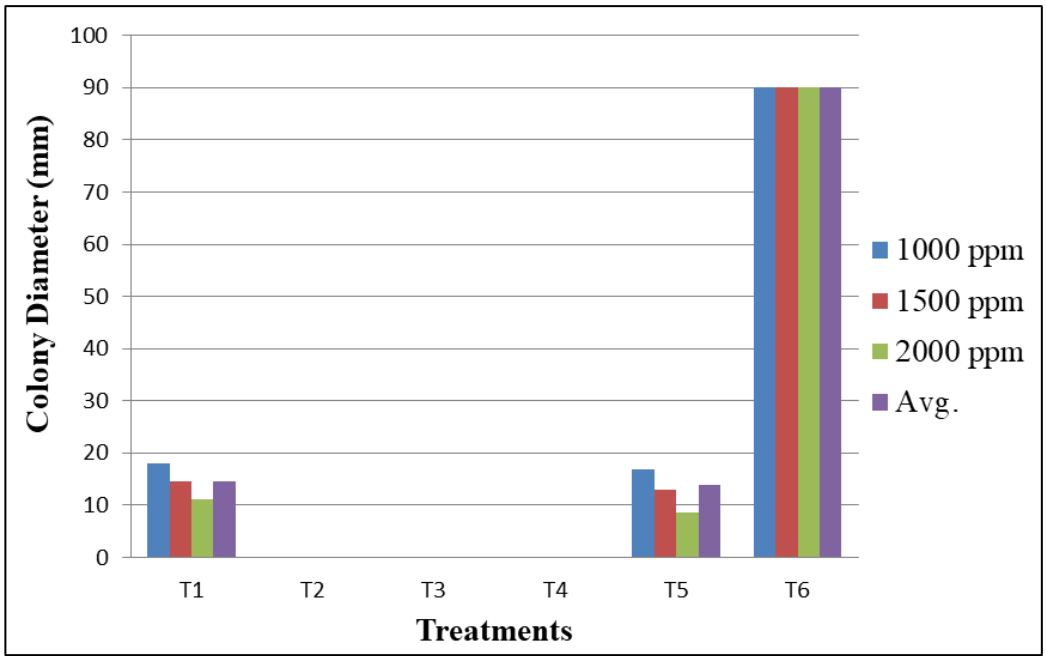
Plate 3: *Fusarium oxysporum* f. sp. *Cicero*

Table 6: *In vitro* efficacy of combi fungicides against *Fusarium oxysporum* f. sp. *Cicero*

Treatments	Colony diameter (mm)			Average	% inhibition			Average
	1000 ppm	1500 ppm	2000 ppm		1000 ppm	1500 ppm	2000 ppm	
T_1	17.92	14.62	11.12	14.65	80.07 (63.48)	83.74 (66.21)	87.63 (69.40)	83.72 (66.20)
T_2	00.00	00.00	00.00	00.00	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90)
T_3	00.00	00.00	00.00	00.00	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90)
T_4	00.00	00.00	00.00	00.00	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90)
T_5	16.87	12.87	8.50	13.83	81.24 (64.33)	85.69 (67.77)	90.55 (72.09)	85.83 (67.88)
T_6	90.00	90.00	90.00	90.00	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
SE±	0.38	0.46	0.44		0.42	0.51	0.49	
CD at 1%	1.10	1.34	1.20		1.23	1.49	1.42	

Colony diameter = Average of four replications and figures in parenthesis are arcsine transformation value

The results of present investigation have resembled with earlier records of scientists *viz*., Patra and Biswas (2016) [5] tested efficacy of ten fungicides against *F. oxysporum* f. sp. *ciceri* and found that fungicides *viz*., Carbendazim, Propiconazole, Carbendazim + Mancozeb and Tebuconazole + Trifloxystrobin were effective in complete inhibition of mycelial growth of pathogen. Thaware *et al.* (2016) [7] evaluated efficacy of six non systemic and contact fungicides at various concentrations against *F. oxysporum* f. sp. *ciceri*. Among the tested fungicides complete inhibition of pathogen was observed with Carbendazim + Mancozeb, Benomyl + Thiram and Carbendazim + Thiram. Golkiya *et al.* (2018) [3] who evaluated six combi fungicides against *Fusarium oxysporum* f. sp. *ciceri*. Among combi fungicides Tebuconazole + Trifloxystrobin (73.50%) was most effective followed by Carbendazim + Mancozeb (72.19%).



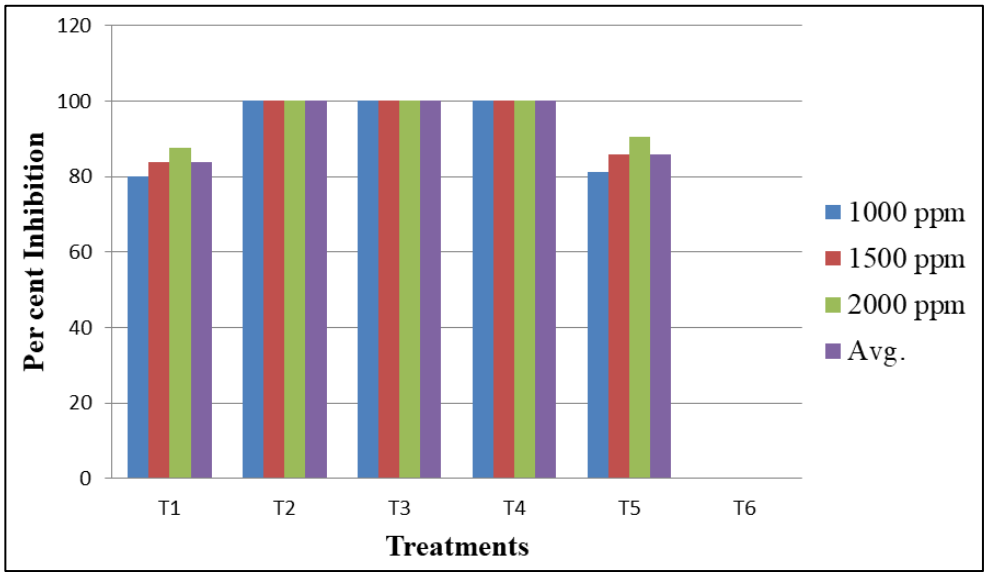


Fig 3: *In vitro* efficacy of combi fungicides against *Fusarium oxysporum* f. sp. *ciceri*

References

1. Bashir S, Najeeb MM, Dar SA, Nissa SU, Hakeem S, Wani RA *et al. In vitro* efficacy of fungicides and bio-control agents against wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceri* (FOC). Int. J Curr Microbiol App Sci 2017;6(11):1392-1399.
2. Dubey SC, Suresh M, Singh B. Evaluation of *Trichoderma* species against *Fusarium oxysporum* f. sp. *ciceri* for integrated management of chickpea wilt. Biol. Cont 2007;40:118-127.
3. Golakiya BB, Bhimani MD, Akbar LF. Efficacy of different fungicides for the management of chickpea wilt (*Fusarium oxysporum* f. sp. *ciceri*). Int. J Chem Stud 2018;6(2):199-205.
4. Nene YL, Thapliyal PN. Evaluations of fungicides in fungicides for plant disease control (3rd ed.) Oxford, IBH Publishing Co. New Delhi 1993, 531-532.
5. Patra S, Biswas MK. Efficacy of fungicides for the management of chickpea wilt disease caused by *Fusarium oxysporum* f. sp. *ciceri.* Int. J Adv Res 2016;4(10):1457-1461.
6. Ravichandran S, Hegde YR. Evaluation of fungicides against *Fusarium oxysporum* f. sp. *ciceri* causing chickpea wilt. Chem. Sci. Rev. Lett. 2015;4(16):1042-1046.
7. Thaware DS, Kohire OD, Gholve VM, budgujar SL, Chavan AA. Exploration of fungicides against *Fusarium oxysporum* f. sp. *ciceri* (Padwick) Snyder and Hansen causing wilt of chickpea. Int. J Pl Sci 2016;11(2):255-261.
8. Vincent JM. Distortion of fungal hypha in the presence of certain inhibitors. Nature 1947;159:850.