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Efficacy of fungicides against *Pythium aphanidermatum* causing damping off of tomato seedling

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Abstract
Damping off (*Pythium aphanidermatum*) is one of the most wide spread, destructive disease of tomato (*Lycopersicon esculentum* Mill.) which accounts for about 50 to 80 per cent yield losses. All the fungicides tested significantly inhibited mycelial growth of *P. aphanidermatum*, over untreated control. Average mycelia growth inhibition recorded with test systemic fungicides was ranged from 22.09% (Carbendazim) to 100 per cent (Metalaxyl). However, it was cent per cent with Metalaxyl (100%) followed by Thiophanate methyl (82.94%), Difenconazole (66.46%), Hexaconazole (66.40%), Pyraclostrobin (65.34%) and Propiconazole (55.67%). Whearas, it was comparatively minimum with Carbendazim (22.09%).

Keywords: *Lycopersicon esculentum, Pythium aphanidermatum,* fungicides and management

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is the second most important vegetable crop next to potato belongs to family solanaceae. It is originated in tropical America and cultivated for thousands of year in Mexico and Peru. Present World production of tomato is about 152.9 Mt of fresh fruits produced on 4.2 Million ha. Tomato production has been reported from 144 countries. (Anonymous, 2016) [2]. Tomato is one of the most economically important crop of India. India has 8.65 lakh hectares under tomato with production of 168.26 Million tonnes in 2016-2017 (Anonymous, 2017) [3]. Among the major factors responsible for lower yields, diseases play an important role. Tomato is also affected by many biotic and abiotic stresses. Of the biotic agents, fungi cause major diseases, followed by nematodes, bacteria and viruses (Pawar, 2014) [9]. Among all diseases, damping off caused by *P. aphanidermatum* is most destructive and widespread disease causing very high crop loss under favorable conditions (Ramamoorthy *et al.* 2002) [12]. The disease has been reported to cause more than 60 per cent mortality of seedlings both in nursery and field condition. Rajagopalan (1961) [11] reported that *P. aphanidermatum* major species causing 75-80 per cent damping off in tomato and chilli. Damping-off is one of the worst diseases occurring in the nursery. Among various vegetable crops, tomato is highly susceptible to damping-off at seedling stage (Agnihotri and Sinha, 1986) [1].

Materials and Methods:
Efficacy of various seed dressing fungicides were evaluated at their recommended dosages against *P. aphanidermatum* by applying Poisoned food technique (Nene and Thapliyal, 1993) [8] and using Potato Dextrose Agar (PDA) as a basal culture medium. Based on active ingredient, requisite quantity of each test fungicide was calculated and mixed thoroughly with autoclaved and cooled (45 ^{0}C) PDA medium separately in conical flasks to obtain desired concentrations of the test fungicides. Fungicide amended PDA medium was then poured (20 ml / plate) separately and aseptically in Petri plates (90 mm dia.) and allowed to solidify at room temperature. After solidification of the medium, all the plates were inoculated aseptically by putting in the center a 5 mm culture disc obtained from a week old actively growing pure culture of *P. aphanidermatum.* Each of the test fungicides and its concentration was replicated three times. Test pathogens were assessed separately. A Petri plate filled with plain PDA (without fungicide) and inoculated with the culture disc of *P. aphanidermatum* was maintained as untreated control. Both treated and untreated plates were incubated at 26±2 ^{0}C, for a week.

Observations on radial mycelial growth/colony diameter was recorded at 24 hrs interval and continued till the untreated control plates were fully covered with mycelial growth of the test fungus. Per cent mycelial growth inhibition of the test pathogen over untreated control was calculated by applying the formula given by Vincent (1927) [14].

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

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

Result and Discussion

All of the seven systemic fungicides evaluated *in vitro* were found fungitoxic to *P. aphanidermatum* which is numerically and significantly inhibited mycelial growth and and its corresponding inhibition over untreated control (Table 1 and Fig 1).

Results (Table 1 and Fig 1) revealed that, at 100 ppm, mycelial growth inhibition was ranged from 11.11% Carbendazim to 100 per cent Metalaxyl. However, Metalaxyl gave (100%) mycelial inhibition. The next best fungicides found were Thiophanate methyl (77.41%), Difenconazole (55.20%), Hexaconazole (54.82%), Pyraclostrobin (52.60%) and Propiconazole (51.11%). However, Carbendazim was found less effective with minimum mycelial inhibition of 11.11per cent.

At 250 ppm, mycelial growth inhibition was ranged from 22.20% (Carbendazim) to 100% (Metalaxyl). However, Metalaxyl gave (100%) mycelia inhibition. The next best fungicides found were Thiophanate methyl (82.63%), Hexaconazole (66.66%) but it was statistically at par with Difenconazole and Pyraclostrobin, followed by Propiconazole (54.43%), respectively. However, Carbendazim was found less effective with minimum mycelial inhibition of 22.20 per cent.

At 500 ppm, mycelial growth inhibition was ranged from 32.98% (Carbendazim) to 100% (Metalaxyl). However, Metalaxyl gave (100%) mycelial inhibition. The next best fungicides found were Thiophanate methyl (88.80%), Hexaconazole (77.67%) but it was statistically at par with Difenconazole and Pyraclostrobin and followed by Propiconazole (61.50%). However, Carbendazim was found less effective with minimum mycelial inhibition of 32.98 per cent.

Average mycelial growth inhibition recorded with test systemic fungicides ranged from 22.09 (Carbendazim) to 100 per cent (Metalaxyl). However, it was cent per cent with Metalaxyl (100%) followed by Thiophanate methyl (82.94%), Difenconazole (66.46%) but it was statistically at par with Hexaconazole and Pyraclostrobin, followed by Propiconazole (55.67%). Whereas, it was comparatively minimum mycelia growth inhibition recorded with Carbendazim (22.09%).

These results was in conformity with the earlier findings of those workers, who reported systemic fungicides *viz.* Carbendazim, Metalaxyl, Hexaconazole, Difenconazole, Thiophanate methyl, Pyraclostrobin and Propiconazole were effective for the management of *P. aphanidermatum* (Jacob, *et al.* 1988 and Rahman and Bhattiprolu, 2005) [6, 10]. (Dohroo, 2001, Kulkarni, 2011 and Suleiman, 2011) [5, 7, 13] *P. aphanidermatum* infecting ginger, (Yadav and Joshi 2012) [15] *P. aphanidermatum* infecting tobacco and *P. aphanidermatum* infecting turmeric (Chavan *et al.* 2017) [4].

Table 1: *In vitro* efficacy of fungicides against *P. aphanidermatum* causing damping off of tomato.

Tr. No.	Treatments	Colony Dia. *(mm) at ppm			Av.(mm)	% Inhibition *at ppm			Av. Inhibition (%)
		100	250	500		100	250	500	
T_1	Carbendazim 50 WP	80.00	70.00	60.00	70.11	11.11(19.47)	22.20(28.11)	32.98(35.04)	22.09
T_2	Difenconazole 25 EC	40.33	30.00	20.00	30.11	55.20(47.98)	66.63(54.71)	77.63 (61.77)	66.46
T_3	Propiconazole 25 EC	44.00	41.00	34.66	39.88	51.10(45.63)	54.43(47.54)	61.50 (51.64)	55.67
T_4	Hexaconazole 5 EC	40.66	30.00	20.00	30.22	54.82(47.76)	66.66(54.73)	77.67 (61.80)	66.40
T_5	Pyraclostrobin 20 WG	42.66	30.66	20.00	31.10	52.60(46.49)	65.90(54.27)	77.60 (61.75)	65.34
T_6	Thiophanate methyl 70 WP	20.33	15.66	10.00	15.33	77.41(61.62)	82.63(65.36)	88.80 (39.23)	82.94
T_7	Metalaxyl (Apron 35 SD)	0.00	0.00	0.00	0.00	100(90.00)	100(90.00)	100 (90.00)	100
T_8	Control	90.00	90.00	90.00	90.00	0.00	0.00	0.00	0.00
	SE	0.66	0.62	0.55		0.51	0.47	0.32	
	C.D (P=0.01)	1.94	1.82	1.61		1.51	1.38	0.94	

*- Mean of three replications, Dia.: Diameter
** Figures in parentheses are arc sine values

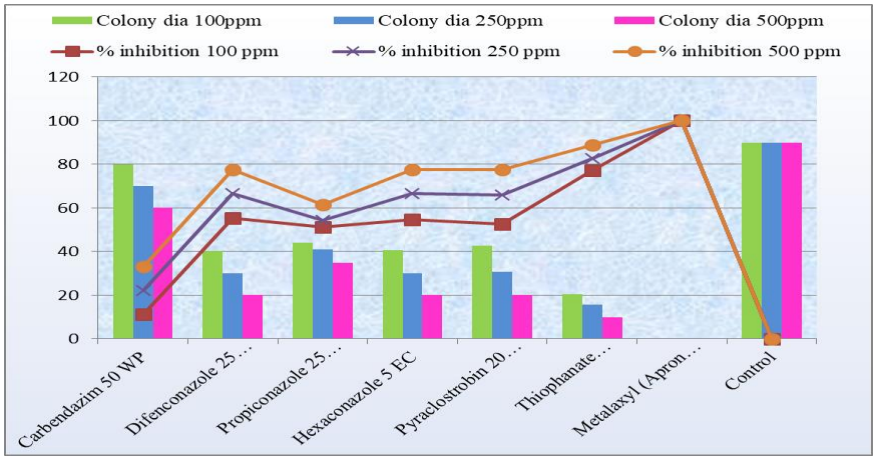

Fig 1: *In vitro* efficacy of systemic fungicides against *Pythium aphanidermatum*

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