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In vitro evaluation of systemic fungicides on turmeric anthracnose [*Colletotrichum capsici* (Syd.) butler and bisby]

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Abstract
Turmeric (*Curcuma longa* L.) is one of the most important spice crop cultivated in India. India is considered as the largest producer, consumer and exporter of turmeric in the globe. Turmeric is affected by anthracnose so for its management systemic fungicides evaluated under *in vitro* condition, the highest per cent inhibition was obtained by tebuconazole followed by benomyl, carbendazim, propiconazole and thiophanate methyl in inhibiting the growth C. capsici at all the four different concentrations tested viz. 50, 100, 250 and 500 ppm.

Keywords: Evaluation of systemic fungicides on turmeric anthracnose [*Colletotrichum capsici* (Syd.) butler and bisby]

Introduction

Turmeric (*Curcuma longa* L.) is one of the most important spice crop cultivated in India. The crop yield is affected by several biotic and abiotic factors, among them, anthracnose of turmeric caused by *Colletotrichum capsici* was found increasing and occurring regularly every year. It has become as major constraint in successful cultivation of turmeric in Gujarat. Leaf spot disease of turmeric caused by *C. capsici*was reported for the first time from Coimbatore district of Madras by Mc Rae in 1917. Later, it was reported from turmeric growing regions like Cuddapah, Kurnool, Guntur, Krishna and Godavari districts of Andhra Pradesh and Coimbatore of Madras State (Ramakrishnan 1954) [13]. Disease is soil-borne noticed on the leaves from July to October. In Gujarat, leaf spot of turmeric caused by *C. gloeosporioides* was first time reported by Patel *et al*. (2005) [12].

Leaf spot is the most important disease of turmeric resulting in losses of 25.83-62.12 per cent fresh weight and 42.10-62.10 per cent dry weight of rhizomes (Nair and Ramakrishnan, 1973) [10]. It causes extensive spottingof leaves. The leaves may eventually dry and thusadversely affect the formation of rhizomes. The incidence of turmeric leaf spot caused by *C. capsici* reported 50 percent yield loss (Ramakrishnan, 1954) [13]. The disease appears usually during August and September. Hence, different systemic fungicides tested against *Colletotrichum capsici.*

Materials and Methods

Different systemic fungicides (Table 1) were tested for their effect on mycelium growth of *C. capsici* using poisoned food technique (Sinclair and Dhingra, 1985) at four concentrations. The technique involves cultivation of test organism on a medium containing the test chemical.

In experiment PDA was used as a basal medium. The calculated quantities of fungicides were thoroughly mixed in the molten almost cool PDA medium before pouring into Petri plates aseptically, so as to get desired concentration of each fungicide separately. 20 ml of fungicide amended medium was poured in each 90 mm sterilized Petri plates and allowed to solidify. The plates were aseptically inoculated with 5 mm disc cut from the periphery of 7 days of old actively growing cultures of *C. capsici*. Controls without fungicides amended were maintained for comparison. The experiments were conducted in completely randomized design with three replication of each treatment and the inoculated plates were incubated at 28±2°C. The colony diameter was measured after 7 days when the control plates were full of fungal growth. Per cent inhibition of growth of mycelium for each treatment was calculated by using the formula given by Vincent (1947).

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

Where,
I = Percent inhibition
C = Radial growth in control
T = Radial growth in treatment

Result and discussion

The relative efficacy of seven different systemic fungicides was tested at 50, 100, 250 and 500 ppm concentrations. The observations regarding per cent inhibition of linear growth are presented in Table 4.2 and depicted in plate 5.

The perusal of data makes it clear that the systemic fungicides showed maximum inhibition at their higher concentrations than in their lower concentrations. Tebuconazole, benomyl, carbendazim and propiconazole executed better inhibition at all the four concentrations with 99.98, 91.39, 90.68 and 85.41 per cent respectively, while 84.33, 78.44 and 76.38 per cent inhibition was observed in thiophanate methyl, azoxystrobin and hexaconazole, respectively. Maximum toxicity index (399.92) was observed in tebuconazole followed by benomyl (357.46).

Within fungicides, all four levels of fungicides significantly differed from each other. Higher concentration of all the fungicides gave significantly more inhibition as compared to their lower levels of concentration.

The outcome of per cent growth inhibition at 50 ppm indicated that the significantly highest growth inhibition was obtained in the treatment of tebuconazole (99.98 %) which was followed by benomyl (87.43 %) and carbendazim (84.84 %). The next effective treatment was thiophonate methyl (80.86 %). Hexaconazole showed minimum growth inhibition among all treatments.

Whereas at 100 ppm, the significantly highest growth inhibition was again obtained in the treatment of tebuconazole (99.98 %) which was followed by benomyl (88.63 %), carbendazim (86.94 %) and thiophonate methyl (82.57 %).

Similarly at 250 ppm, the significantly highest growth inhibition was again obtained in the treatment of tebuconazole (99.98 %) which was followed by benomyl (90.01 %), carbendazim (88.75 %), thiophonate methyl (82.94 %) and propiconazole (80.53 %).

Growth inhibition at 500 ppm showed the significantly highest growth inhibition again in tebuconazole (99.98 %) at all four concentrations which was followed by benomyl (91.39 %), carbendazim (90.68 %), propiconazole (85.41 %) and thiophonate methyl (84.33 %).

The results revealed that among seven systemic fungicides tested, tebuconazole, benomyl, carbendazim and propiconazole were proved to be best and inhibited growth at all concentrations.

The present results are in line with the findings of Chakraborty and Shyam (1988) [2] and Nageshwar (1995) [9] they found benomyl and carbendazim as highly effective in inhibiting the mycelium growth of *C. capsici*. Mesta (1996) [8] noted carbendazim as best fungicide. Banik *et al*. (1998) [1], Ushakiran *et al*. (2006) [15] and Narasimhudu and Balasubramanian (2001) [11] evaluated and found carbendazim and thiophanate-methyl as best fungicides. Chidanandaswamy (2001) [3] has recorded carbendazim and propiconazole as superior fungicides. Hegde *et al*. (2002) [5] reported hexaconazole (0.1 %), propiconazole (0.1 %) and triadimefon (0.1 %) as effective fungicides. Gorawar et al. (2005) reported that carbendazim, penconazole, propiconazole, hexaconazole and thiophanate-methyl showed cent per centinhibition of the fungus at different concentrations (0.025, 0.05 and 0.1 %) tested. Gopinath *et al.* (2006) [4] and Jagtap *et al*. (2013) [6] reported that the propiconazole exhibited the highest level of inhibition of mycelium growth.

Table 1: List of different systemic fungicides tested and their concentrations

S. No.	Technical/active Ingredient	Concentration in ppm*			
		1	2	3	4
1.	Carbendazim 50%WP	50	100	250	500
2.	Thiophanate methyl 70% WP	50	100	250	500
3.	Azoxystrobin23% SC	50	100	250	500
4.	Benomyl 50% WP	50	100	250	500
5.	Hexaconazole 5% SC	50	100	250	500
6.	Tebuconazole 25.9% EC	50	100	250	500
7.	Propiconazole 25% EC	50	100	250	500
8.	Control	-			

Table 2: Effect of different systemic fungicides on growth inhibition of *C. capsici*

S. No.	Technical/Active Ingredient	Per cent inhibition*				Mean	Toxicity Index#
		50 Ppm	100 ppm	250 ppm	500 ppm		
1.	Tebuconazole 25.9 % EC	89.19	89.19	89.19	89.19	89.19	356.76
		(99.98)	(99.98)	(99.98)	(99.98)	(99.98)	(399.92)
2.	Benomyl 50 % WP	69.24	70.29	71.58	72.94	71.01	284.05
		(87.43)	(88.63)	(90.01)	(91.39)	(89.37)	(357.46)
3.	Carbendazim 50 % WP	67.08	68.82	70.40	72.23	69.63	278.53
		(84.84)	(86.94)	(88.75)	(90.68)	(87.80)	(351.21)
4.	Thiophanate methyl 70 % WP	64.06	65.33	65.61	66.68	65.42	261.68
		(80.86)	(82.57)	(82.94)	(84.33)	(82.68)	(330.70)
5.	Propiconazole 25 % EC	61.51	62.22	63.82	67.55	63.78	255.10

		(77.24)	(78.28)	(80.53)	(85.41)	(80.37)	(321.46)
6.	Azoxystrobin 23 % SC	56.13	58.55	59.21	62.34	59.06	236.23
		(68.95)	(72.78)	(73.79)	(78.44)	(73.49)	(293.96)
7.	Hexaconazole 5 % SC	55.08	56.36	58.44	60.92	57.70	230.80
		(67.23)	(69.31)	(72.60)	(76.38)	(71.38)	(285.52)
	Mean	66.04 (83.51)	67.25 (85.05)	68.32 (86.35)	70.26 (88.60)	-	-
		Fungicide (F)		Concentration (C)		F × C	
	S. Em. ±	0.24		0.18		0.48	
	C. D. at 5 %	0.68		0.52		1.36	
	C. V. %	1.23					

***** Mean of three replications
Maximum toxicity index = 400.00
Data were arcsine transformed before analysis; values in parentheses are retransformed value.

Summary and conclusion

Availability of new fungicides necessitates evaluation of fungicides under *in vitro* conditions to know their efficacy, and apply them in field conditions. Hence in the present study systemic fungicides were found to be effective for controlling anthracnose. Among the all fungicides evaluated under *in vitro* condition, the highest per cent inhibition was obtained by tebuconazole followed by benomyl, carbendazim, propiconazole and thiophanate methyl in inhibiting the growth *C. capsici* at all the four different concentrations tested viz. 50, 100, 250 and 500 ppm.

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