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To assess the effectiveness of fungicides against anthracnose disease of chilli *in vivo*

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Abstract
Economic losses caused by the disease are mainly attributed to lower fruit quality and marketability which was losses of up to 100% under congenial environment conditions (Pakdeevaraporn *et al*., 2005). In India, a calculated loss of from 10-54 per cent has been reported (Lakshmesha *et al*. 2005) and 10-80 per cent of the marketable yield loss of chilli fruits reported by Than *et al*., (2008). Hence the present study is aimed to assess the status of anthracnose disease prevailing on chilli so that future strategies for crop protection are devised with a focus on anthracnose disease Average disease intensity recorded during study of field efficacy of fungicides were ranged from 46.63 (Propineb) to 70.23 (Propiconazole). However, significantly maximum average disease intensity was recorded with Propineb fungicide. This was followed by the treatments *viz.*, Copper oxychloride Hexaconazole, Difenconazole, Tricyclazole, Tebuconazole, Azoxystrobin, Carbendazim 12% + Mancozeb 63% and Propiconazole.

Keywords: Anthracnose, integrated disease management, efficacy of fungicide

Introduction
Anthracnose of chilli was first reported from new Jersey, USA, described the causal agents as *Gloeopsorium piperatum* and *Colletotrichum nigrum.* These taxa were then considered as synonyms of *Colletotrichum gloeosporiodes* heavy crop losses worldwide. The disease has been reported from many countries including India, United States of America, Nigeria, Bangladesh and Indonesia. Anthracnose disease is a major problem in India and first reported in India from Coimbatore of Madras Presidency. These disease caused by more than one *Colletotrichum* species including; *Colletotrichum acutatum*, *Colletotrichum capsici*, *Colletotrichum gloeosporioides* and *Colletotrichum coccodes*. *Colletotrichum capsici* infection will be higher in the mature stage of chilli plant than in the early stage of plant. The fungus prefers warm humid environment for spreading the anthracnose disease uniformly and effectively.
The pathogen infects all parts of the host plant, including stems and leaves. Lesions on stems and leaves appear as small sunken grayish brown spots with dark margins, further on which development of acervuli in concentric rings could be easily seen. Fruit symptoms initially begins as water soaked lesions that become soft, slightly sunken and become tan. The lesions can cover most of the fruit surface and multiple lesions occurred. The surface of the lesions becomes covered with the wet, gelatinous spores from salmon-coloured fungal fruiting bodies with numerous black spines (setae) and in severe infections, necrotic spots enlarged and coalesced each other into large typical anthracnose lesions leading to premature drying and dropping off of leaves. The fungus survives in the field in plant debris on seed as acervuli and microsclerotia and the secondary spread takes place carry the primary inoculums.
Economic losses caused by the disease are mainly attributed to lower fruit quality and marketability which was losses of up to 100% under congenial environment conditions. In India, a calculated loss of from 10-54 per cent has been reported and 10-80 per cent of the marketable yield loss of chilli fruits. Hence the present study is aimed to assess the status of anthracnose disease prevailing on chilli so that future strategies for crop protection are devised with a focus on anthracnose disease. Hense, the objective of present study was to assess the effectiveness of fungicides against anthracnose disease of chilli *in vivo*.

Material and Methods

Nursery management

Experimental details

Design : C.R.D.
Replication : Four
Treatment : Six
Variety : Parbhani Tejas

Sr. No	Treatments	Dose
T_1	*Trichoderma harzianum*	5g/Kg
T_2	*Trichoderma viride*	5g/Kg
T_3	Carbendazim + Mancozeb	0.2%
T_4	Carbendazim	0.2%
T_5	Copper oxychloride	0.2%
T_6	Control	FYM 3kg/sqm

Observation

Observations on dieback disease incidence was taken at twenty five days after sowing for die back and fruit rot recorded after 75 DAS. The observations in terms of per cent disease intensity were recorded as per given scale.

Field experiment: The field experiment was conducted during the year (2019-20) at College of Agriculture, Parbhani. Treatments were laid out in the plots (4.80 x 3.60 m) arranged in Randomized Rlock Design (RBD) with three replications. Thirty five days old seedlings were planted into the field plots with row to row distance of 60 cm and plant to plant distance of 60 cm with a total population of 48 plants per plot. The fungicides were applied at three phenological stages *viz*. pre-flowering, fruit set and maturity. The plots were inoculated first with inoculum of *Colletotrichum capsici* on chilli cultivar and after 72 hours of incubation of pathogen, the respective fungicides were sprayed on chilli plants. Adequate level of moisture maintained under field condition for the proper development of disease.

Details of experiment

Design : RBD
Replication : Three
Treatments : Nine
Spacing : 60 x 60 cm
Variety : Parbhani Tejas
Season : Kharif

Table 1: Field efficacy of fungicides for management of chilli anthracnose

Tr. No.	Common Name of Fungicide	Trade name of Fungicide	Group of fungicide	Concentration
T_1	Copper oxychloride	Blitox 50WP	Contact	0.25%
T_2	Carbendazim 12% + Mancozeb 63%	SAAF 75WP	Systemic + Contact	0.25%
T_3	Propineb	Antracol 70WP	Contact	0.25%
T_4	Hexaconazole	Contaf 5% EC	Systemic	0.05%
T_5	Propiconazole	Tilt 25 EC	Systemic	0.05%
T_6	Difenconazole	Score 25 EC	Systemic	0.05%
T_7	Tebuconazole	Folicur 25 EC	Systemic	0.05%
T_8	Azoxystrobin	Amistrar 25 EC	Systemic	0.05%
T_9	Tricyclazole	Beam 75%WP	Systemic	0.05%

Observation

Data on disease intensity was recorded 15 days after the last spray adopting the formulae. The green yield of chilli from plot of different treatment was taken for calculating the total yield/hectare (tons). All the agronomical practices were followed as per the recommended Package and practices of vegetable crops.

Results and Discussion

Integrated disease management strategies

Nursery management

The study of nursery management trials revealed that all the treatments significantly reduced the disease (dieback and fruit rot) as compared to control.

Table 2: Integrated management of anthracnose of chilli. (Pot culture)

Tr. No.	Treatments	Dose	Disease intensity		Die back control (%)	Fruit rot control %
			Die back (25 DAT)	Fruit rot (75 DAT)		
T_1	*Trichoderma harzianum*	5g/Kg	17.02 (24.36)	24.54 (29.69)	45.51 (42.42)	39.43 (38.89)
T_2	*Trichoderma viride*	5g/Kg	15.00 (22.78)	21.87 (27.88)	51.98 (46.13)	46.02 (42.71)
T_3	Carbendazim + Mancozeb	0.2%	8.36 (16.80)	12.25 (20.48)	73.23 (58.84)	69.76 (56.63)
T_4	Carbendazim	0.2%	10.23 (18.65)	14.32 (22.23)	67.25 (55.09)	64.65 (53.51)
T_5	Copper oxychloride	0.2%	12.25 (20.48)	15.36 (23.07)	60.78 (51.22)	62.09 (51.99)
T_6	Control	FYM 3kg/sqm	31.24 (33.98)	40.52 (39.53)	00.00	00.00
	S.E. ±		0.57	0.57	0.52	0.49
	C.D. (P=0.01)		1.80	1.79	1.64	1.52

Figures in parenthesis are arc sine transformed value

The most effective treatment was Carbendazim + Mancozeb resulting in least intensity of dieback (8.36%) and fruit rot (12.25%). This was followed by Carbendazim recording dieback intensity of 10.23% and fruit rot intensity (14.32%). The next efficacious treatment was Copper oxychloride which showed dieback intensity of 12.25% and fruit rot intensity of 15.36%, respectively. Treatment comprising *viz*. *Trichoderma viride* Tv-1 ($1x10^6$ spore/ml) and *Trichoderma harzianum* Th-1 (1x107 spore/ml) observed dieback intensity of 15.00 and 17.02 per cent and fruit rot intensity of 21.87 and 24.54 per cent, respectively than control (21.12 and 40.66%).

The most effective treatment was Carbendazim + Mancozeb which was controls disease upto 73.23% (dieback disease) and 69.76% (fruit rot disease). This was followed by treatment of Carbendazim recording dieback control of 67.25% and fruit rot control upto (64.65%) over untreated Nursery pots. The next efficacious treatment was Copper oxychloride which showed dieback control upto 60.78% and fruit rot control upto 62.09%, respectively. Treatment comprising *viz*. *Trichoderma viride*

and *Trichoderma harzianum* controls die back disease upto 15.00% and 17.02% and fruit rot disease can be controlled over untreated control by 21.87% and 24.54%, respectively than control (00.00%).

(a) (b)

Fig 1: Integrated management of anthracnose of chilli. (Pot culture)

Field evaluation of fungicides, during the year, 2019-20

All tested nine fungicides tested during the year, 2019-20, were further the management of anthracnose disease in chilli during the year, 2019-20. (PLATE). The results obtained on per cent disease incidence and intensity are presented in the Table.

Table 3: Field efficacy of fungicide for management of chilli anthracnose

Tr. No.	Treatments	Conc. (%)	Percent disease intensity (PDI)*				Avg. PDI	- Avg. PDC	Yeild q/ha
			Before Spray	After 1st Spray	After 2nd spray	15 Days After 3rd Spray			
T_1	Copper oxychloride	0.25 (2.86)	26.76 (31.15)	29.47 (32.87)	23.42 (28.94)	15.13 (22.89)	23.69 (29.12)	51.39 (45.79)	10.53
T_2	Carbendazim 12 % + Mancozeb 63%	0.25 (2.86)	31.52 (34.15)	26.52 (30.99)	21.52 (27.63)	13.37 (21.44)	23.23 (28.81)	56.08 (48.49)	12.32
T_3	Propineb	0.2 (2.86)	28.76 (32.43)	28.63 (32.97)	25.31 (30.20)	19.06 (25.88)	25.44 (30.29)	48.54 (44.16)	11.35
T_4	Hexaconazole	0.05 (1.28)	28.48 (32.25)	29.25 (32.74)	24.98 (29.98)	16.88 (24.25)	24.89 (29.92)	49.50 (44.71)	12.00
T_5	Propiconazoe	0.05 (1.28)	26.54 (31.00)	29.35 (32.80)	23.11 (28.73)	13.91 (21.89)	23.22 (28.80)	52.39 (46.36)	12.88
T_6	Difenconazole	0.05 (1.28)	25.78 (30.51)	29.88 (33.13)	22.13 (28.06)	12.38 (20.60)	22.54 (28.34)	53.50 (47.00)	13.54
T_7	Tebuconazole	0.05 (1.28)	21.25 (27.45)	31.75 (34.29)	23.55 (29.03)	13.40 (21.47)	22.48 ((28.30)	50.43 (45.24)	14.56
T_8	Azoxystrobin	0.05 (1.28)	21.20 (27.41)	26.85 (31.20)	18.15 (25.21)	07.70 (16.11)	18.47 (25.45)	61.35 (51.56)	16.21
T_9	Tricyclazole	0.05 (1.28)	18.33 (25.34)	27.00 (31.30)	18.25 (25.29)	12.25 (20.48)	18.25 (25.29)	58.60 (49.95)	16.32
S.E. ±			0.012			0.007		0.019	
C.D. (P=0.01)			0.035			0.021		0.057	

Disease incidence: Results (Table and Fig) revealed that all the treatment sprays significantly influenced the percentage anthracnose disease incidence of chilli. The disease was found to appear about 35 to 40 days after transplanting of the crop and its incidence at first appearance was ranged from 18.33 to 31.52 per cent, which increased steadily upto second spray treatment and subsequently decreased thereafter second spray treatment.

After first spraying, the disease incidence was ranged from 26.52% (Carbendazim 12% + Mancozeb 63%) to 31.75% (Tebuconazole) as against 41.25% in unsprayed control and all the treatments were found significantly superior over unsprayed control. However, significantly least

(a) (b)

Plate 1: Field efficacy of fungicide for management of chilli anthracnose

Disease incidence was recorded with the fungicides Carbendazim12% + Mancozeb 63% (26.52%) followed by Azoxystrobin (26.85%), Tricyclazole (27.00%), Propineb (28.63%), Hexaconazole (29.25%), Propiconazole (29.35%), Copper oxychloride (29.47%), Difenconazole (29.88%) while minimum disease intensity recorded with Tebuconazole (31.75%).

After second spraying, the disease incidence was ranged from

18.15% (Azoxystrobin) to 25.31% (Propineb) as against 47.96 per cent in unsprayed control, and all the treatments were found significantly superior over unsprayed control. However, significantly least disease incidence was recorded with the fungicides Azoxystrobin (18.15%), Tricyclazole (18.25%), Carbendazim 12% + Mancozeb 63% (21.52%), Difenconazole (22.13%), Propiconazole (23.11%) Copper oxychloride (23.42%) followed by Tebuconazole (23.55%) and Hexaconazole (24.98%). While minimum disease intensity recorded with Propineb (25.31%).

After third spraying, the disease incidence was ranged from 7.70% (Azoxystrobin) to 19.06% (Propineb) as against 59.25% in unsprayed control, and all the treatments were found significantly superior over unsprayed control. However, significantly least disease incidence was recorded with the fungicides Azoxystrobin (7.70%), Tricyclazole (12.25%), Difenconazole (12.38%), Carbendazim12% + Mancozeb 63% (13.37%), followed by Tebuconazole (13.40), Propiconazole (13.91%), Copper oxychloride (15.13%), Hexaconazole (16.88%), while minimum disease intensity recorded with Propineb (17.36%).

Average disease incidence recorded with all the spray treatments were ranged from 18.25% (Tricyclazole) to 25.44% (Propineb). However, significantly least average disease incidence (18.25%) was recorded with Tricyclazole. This was followed by the treatments *viz.* Azoxystrobin (18.47%), Tebuconazole (22.48%), Difenconazole (22.54%), Propiconazole (23.22%), Carbendazim12% + Mancozeb 63% (23.23%), Copper oxychloride (23.69%), Hexaconazole (24.89%) with average disease incidence was recorded with Propineb (26.78%); all of which were at par.

The table revealed highest yield (16.32 q/ha) was recorded with Tricyclazole followed by 16.21 q/ha with fungicide Azostrobin. While as lowest yield (11.35 q/ha) was recorded with Propineb. Fungicide *viz* Tebuconazole, Difenoconazole, Propiconazole, Carbendazim 12% + Mancozeb, Copper oxychloride, Hexaconazole were recorded 14.56, 13.54, 12.88, 12.32 and 12.00q/ha yield respectively which were significantly superior to control.

The present results confirms results of evaluated three fungicides *viz.,* Carbendazim, Hexaconazole and Propiconazole against *Colletotrichum capsici*, causing anthracnose or fruit rot of chilli and reported least per cent disease intensity with Propiconazole (0.1%) with maximum yield of red chilli and highest cost: benefit ratio.

Summary and Conclusions

- Integrated management for die back and fruit of chilli, nursery trials revealed that most effective treatment was Carbendazim + Mancozeb recorded least disease intensity. Order of effective treatments for control of dieback and fruit rot infeststion was Carbendazim followed by Copper oxychloride, *Trichoderma viride* and *Trichoderma harzianum* respectively.
- Average disease incidence recorded after three sprays, during study of field efficacy of nine fungicides, for control of chilli anthracnose, were ranged from 17.02% (Carbendazim 12% + Mancozeb 63%) to 26.78% (Propineb). Order of effective treatments was Azoxystrobin, Propiconazole, Tricyclazole, Hexaconazole, Tebuconazole, Copper oxychloride, Difenconazole, and Propineb respectively.
- Average disease intensity recorded during study of field efficacy of fungicides were ranged from 46.63 (Propineb) to 70.23 (Propiconazole). However, significantly maximum average disease intensity was recorded with Propineb fungicide. This was followed by the treatments *viz.,* Copper oxychloride Hexaconazole, Difenconazole, Tricyclazole, Tebuconazole, Azoxystrobin, Carbendazim 12% + Mancozeb 63% and Propiconazole.

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