

## Efficacy of Fungicides and Bioagents against *Colletotrichum gloeosporioides* Causing Anthracnose of Mango (*Mangifera indica* L.)

K. V. Shivakumar, P. Palaiah, S. B. Mallesh,  
 Gururaj Sunkad, Y. Pampanna

Received 17 September 2017 ; Accepted 20 October 2017 ; Published on 8 November 2017

**Abstract** Mango (*Mangifera indica* L.) commonly called as King of fruits is the most important fruit crop in India. Among the various diseases anthracnose, caused by *Colletotrichum gloeosporioides* (Penz.) Penz and Sacc. is the major constraint on extension of export of mango. Therefore affords were made to screen the different systemic and combination of six fungicides, were screened *in vitro*. Among systemic fungicides, propiconazole 25% EC was successful in completely (100%) inhibiting the growth of *C. gloeosporioides* at all four concentrations (0.025, 0.05, 0.1 and 0.15%). Thiophanate methyl 70% WP and tebuconazole 25% EC gave 100% mycelial inhibition at three (0.05, 0.10 and 0.15%) concentrations and combination of fungicides carbendazim 12% WP+ mancozeb 63% WP was found the most effective and gave cent per cent growth inhibition at all four concentrations (0.05, 0.1, 0.2 and 0.3%). Among the

biocontrol agents, *Trichoderma viride* (Tv-2) and *Trichoderma viride* (Tv-1) gave maximum inhibition of mycelial growth (78.22%) and (75.92%) of *C. gloeosporioides* respectively.

**Keywords** Mango, *Colletotrichum gloeosporioides*, Fungicides, Microbial antagonists.

### Introduction

Mango (*Mangifera indica* L.) is one of the most popular seasonal fruit found mainly in the tropical and subtropical countries. It is widely grown in different countries of the world and is attacked by a number of diseases of which anthracnose is one of the most common especially in India. Anthracnose caused by *C. gloeosporioides* is reported on a wide variety of crop, including almond, avocado, apple, arabica coffee, guava, mango, dragon fruit, cassava, sorghum and strawberry [1]. However, huge losses of the crop are incurred mostly by fungal diseases of which anthracnose caused by the fungus *C. gloeosporioides* which develops under humid and warm conditions is the most important pre and post-harvest pathogen. In India, losses in the field due to this disease have been estimated to be 2–39%. Considering seriousness of the disease, the present stud-

---

K. V. Shivakumar\*, S. B. Mallesh, Gururaj Sunkad  
 Department of Plant Pathology, University of Agriculture  
 Sciences, Raichur 584104, Karnataka, India

P. Palaiah, Y. Pampanna  
 Agriculture Research Station, Kawadimatti, University of  
 Agriculture Sciences, Raichur 584104, Karnataka, India  
 e-mail : shivny2044@gmail.com

\*Correspondence

**Table 1.** *In vitro* evaluation of systemic fungicides against *C. gloeosporioides* of mango. \*Figures in parentheses indicate angular transformed value.

Sl. No.	Fungicides	Trade names	Per cent inhibition Concentration (%)				Mean
			0.025	0.05	0.1	0.15	
1	Thiopluzamide 24% SC	Pulsar	00.00 (0.00)*	00.00 (0.00)	39.63 (38.99)	41.57 (40.13)	20.30 (26.77)
2	Azoxystrobin 23% SC	Amistar	46.29 (42.85)	48.33 (49.96)	100.00 (89.96)	100.00 (89.96)	73.65 (59.09)
3	Thiophenate methyl 70% WP	Topsin-M	79.81 (63.27)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	94.95 (76.98)
4	Hexaconazole 5% EC	Contaf	76.94 (61.28)	78.33 (62.23)	83.61 (66.09)	85.00 (67.19)	80.97 (64.11)
5	Propiconazole 25% EC	Tilt	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)
6	Triadimefon 25% WP	Bayleton	66.94 (54.88)	74.91 (59.91)	77.03 (61.33)	86.20 (68.16)	76.27 (60.82)
7	Tebuconazole 25% EC	Folicure	83.89 (66.30)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	95.97 (78.39)
8	Carbendazim 50% WP	Bavistin	76.30 (60.84)	85.46 (67.55)	100.00 (89.96)	100.00 (89.96)	90.44 (71.96)
	Mean		66.27 (54.47)	73.38 (58.91)	75.03 (59.99)	76.57 (61.02)	72.82 (58.55)
			Fungicides		Concentration (C)		FxC
	SEm±		0.22		0.16		0.45
	CD at 1%		0.61		0.43		1.21

ies were undertaken to test the efficacy of different fungicides and bioagents *in vitro* against *C. gloeosporioides* causing anthracnose of mango.

### Materials and Methods

#### Pathogen isolation and identification

The pathogen was isolated from the mango leaves showing typical anthracnose symptoms by tissue segment method on potato dextrose agar medium (PDA). Small bits measuring about 3mm size were cut off from the leaves showing lesions in such a way that it contained both infected and healthy portions and these bits were surface sterilized in 0.1% mercuric chloride (HgCl<sub>2</sub>) for 30 seconds followed by three washings in sterile distilled water. The bits were further transferred to sterile discs of blotting paper. The dried bits were subsequently transferred to potato dextrose agar (PDA) medium under aseptic conditions. The petri-plates were incubated at 27±1°C for seven days for the growth of the fungus. The developed

fungal colonies were purified by single spore isolation method. The pathogen was identified as *Colletotrichum gloeosporioides* Penz., based on its mycelial and conidial characteristics [2] and maintained on PDA slants under controlled temperature.

#### *In vitro* evaluation of fungicides

The efficacy of eight systemic fungicides viz., Azoxystrobin, carbendazim, hexaconazole, propiconazole, tebuconazole, thiophenate methyl, thiopluzamide and triadimefon (at the concentration of 0.025, 0.05, 0.1 and 0.15%) six combi products viz., Nativo, Merger, Saaf, Taqat, Avatar, Quintal and one contact fungicide chlorothalonil (at the concentrations of 0.5, 0.1, 0.2 and 0.3%) were assayed against *C. gloeosporioides*. These fungicides were evaluated under laboratory conditions by Poison food technique. The plates were incubated at room temperature and the radial growth was measured when fungus attained maximum growth in control plates. The efficacy of the fungicides was expressed as per cent inhibition

**Table 2.** *In vitro* evaluation of combi and contact fungicides against *C. gloeosporioides* of mango. \*Figures in parentheses indicate angular transformed values.

Sl. No.	Fungicides Common name	Trade names	Per cent inhibition Concentration (%)				Mean
			0.05	0.1	0.2	0.3	
1	Trifloxystrobin 25% +Tebuconazole 50% 75 WP	Native	81.76 (64.69)*	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	95.44 (77.64)
2	Tricyclozole 18%+ Mancozeb 62% 80 WP	Merger	35.46 (36.53)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	83.86 (66.28)
3	Carbendazim 12%+ Mancozeb 63% 75 WP	Saaf	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)
4	Capton 70%+ Hexaconazole 5% 75 WP	Taqat	77.59 (61.72)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	94.39 (76.27)
5	Zineb 68%+Hexaconazole 4% 72 WP	Avatar	64.35 (53.32)	79.91 (63.34)	80.00 (63.41)	80.28 (63.61)	76.13 (60.73)
6	Iprodione 25% + Carbendazim 25% 50 WP	Quintal	65.46 (53.98)	100.00 (89.96)	100.00 (89.96)	100.00 (89.96)	91.36 (72.88)
7	Chlorothalonil 75 WP	Kavach	51.02 (45.57)	52.13 (46.20)	54.16 (47.38)	57.31 (49.18)	53.65 (47.07)
	Mean		67.95 (55.49)	90.29 (71.81)	90.59 (72.11)	91.08 (72.59)	84.97 (67.16)
			Fungicides (F)		Concentration (C)		FxC
	SEm±		0.23		0.17		0.47
	CD at 1%		0.63		0.48		1.26

of mycelial growth over control, calculated by using the formula,  $I = (C - T) / C \times 100$  Where, I = Per cent inhibition of mycelium, C = Growth of mycelium in control and T= Growth of mycelium in treatment.

#### *In vitro* evaluation of bioagents

*In vitro* evaluation was carried out with eight bioagents viz., *Trichoderma viride* (Tv-1), *T. viride* (Tv-2), *T. harzianum* (Th-1), *T. harzianum*, *Pseudomonas fluorescens*-RP-31, *P. fluorescens*-RP-46, *Bacillus subtilis* (Bs-1) and *B. subtilis* (NES-1) (Biocontrol Lab UAS, Raichur, Karnataka) by dual culture technique for their antagonistic effect against *C. gloeosporioides*. Three replications were maintained for each treatment. The petri plates were incubated at  $27 \pm 1^\circ\text{C}$  till the growth of colony touches the periphery in the control plate. Colony diameter of both the

test fungus and bioagents were measured and per cent inhibition was calculated. Data were analyzed statistically by using completely randomized design (CRD).

#### Results and Discussion

The data from the present study revealed that there was significant difference among the systemic fungicides in inhibiting the growth of *C. gloeosporioides*. Propiconazole 25% EC was successful in completely (100%) inhibiting the growth of *C. gloeosporioides* at all the four concentrations (0.025, 0.05, 0.1 and 0.15%) tested. Thiophanate methyl 70% WP and tebuconazole 25% EC gave 100% mycelial inhibition at three (0.05, 0.10 and 0.15%) concentrations, while the azoxystrobin 23% SC and carbendazim 50% WP also showed 100% inhibition at 0.10 and 0.15% followed by triadimefon

**Table 3.** *In vitro* evaluation of bio-agents against *C. gloeosporioides*. \*Figures in parentheses indicate angular transformed values.

Sl. No.	Bioagents	Per cent inhibition
1	<i>Trichoderma viride</i> (Tv-1)	75.92 (60.59)*
2	<i>Trichoderma viride</i> (Tv-2)	78.22 (62.36)
3	<i>Trichoderma harzianum</i> (Th-1)	48.27 (44.03)
4	<i>Trichoderma harzianum</i> (Th-2)	51.00 (45.59)
5	<i>Pseudomonas fluorescens</i> (RP-46)	61.11 (51.40)
6	<i>Pseudomonas fluorescens</i> (RP-31)	65.28 (53.87)
7	<i>Bacillus subtilis</i> (Bs-1)	63.89 (53.04)
8	<i>Bacillus subtilis</i> (NES)	53.05 (46.73)
	SEm±	0.26
	CD at 1%	1.09

25% WP (86.20%) and hexaconazole 5% EC (85.00%) inhibition and least inhibition of mycelial growth was observed in thiopuzamide 24% SC (41.57%) at 0.15% concentration (Table 1). The effectiveness of the triazoles fungicides may be attributed to their interference with the biosynthesis of fungal sterols and inhibition of ergosterol biosynthesis. In many fungi, ergosterol is essential to the structure of cell wall and its absence cause irreparable damage to cell wall leading to death of fungal cell. These results are in agreement with [3] who evaluated of systemic fungicides *in vitro* against *C. gloeosporioides* causing anthracnose disease of coffee and found that propiconazole 25 EC was found most effective and inhibited cent per cent colony growth of *C. gloeosporioides* at 100 ppm concentration.

#### Evaluation of combi products and contact fungicides

Out of six combi products viz., Saaf (Carbendazim 12% + Mancozeb 63% WP) successful in completely (100%) in inhibiting the growth of *C. gloeosporioides* at all the four concentrations (0.05, 0.1, 0.2 and 0.3%) tested. Similarly 100% inhibition was observed in case of Natio (Trifloxystrobin 25% + Tebuconazole 50% WP), Merger (Tricyclozole 18% +Mancozeb 62% WP), Taqat (Captan 70% + Hexaconazole 5% WP)

and Quintal (Iprodione 25% + Carbendazim 25% WP) at three (0.1, 0.2 and 0.3%) concentrations. Least inhibition of mycelial growth was observed in chlorothalonil 75% WP (57.31%) at 0.15% concentration (Table 2). These results are in agreement with [4] who reported that carbendazim 12% + Mancozeb 63% WP successful was successful in completely (100%) inhibiting the growth of *C. gloeosporioides* at all three concentrations (0.02%, 0.05% and 0.1%). The effectiveness of carbendazim against fungi could be due to the inhibition of biosynthesis process and synthesis of DNA of the fungus.

#### Evaluation of bioagents

At 7 days inoculation of *C. gloeosporioides*, it was noticed that maximum reduction in colony growth was observed in *T. viride* (Tv-2) (78.22%) which was significantly superior over all the bioagents tested. Next best in inhibiting the mycelia growth of fungus was *T. viride* (Tv-1) (75.92%). Least mycelial growth inhibition was observed in *T. harzianum* (Th-1) with 48.27% followed by *T. harzianum* (Th-2) isolate with 51.00% (Table 3). These results are in accordance with [5] who evaluated antagonists against *C. gloeosporioides in vitro*. He concluded that *Trichoderma viride* was most effective antagonist against *C. gloeosporioides*. Similarly, [6] showed that, *T. viride* gave maximum inhibition of mycelial growth (79.12%) of *C. gloeosporioides*. In the present study also *T. viride* was found effective in inhibiting the growth of *C. gloeosporioides*. The antagonistic activity of the fungus may be due to toxin production trichodermin by the fungus and fast growing ability which retards the activation of the pathogen. *Trichoderma* are well known for production of chitinase enzymes which degrade cell wall content of higher fungi [7].

The present study revealed that propiconazole 25% EC and carbendazim 12% WP+mancozeb 63% WP was successful in completely (100%) inhibiting the growth of *C. gloeosporioides* at all four concentrations tested. Among the bioagents, *Trichoderma viride* (Tv-2) and *Trichoderma viride* (Tv-1) gave maximum inhibition of mycelial growth (78.22%) and (75.92%) of *C. gloeosporioides* respectively. 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.

#### References

1. Erpelding JE (2010) Field assessment of anthracnose disease response for the sorghum germplasm collection from the mopti region. *Am J Agric Biol Sci* 5 : 363—369.
2. Sampath Kumar A, Eswara Reddy NP, Hariprasad RK (2008) Variations in cultural, morphological and nutritional characters of *C. gloeosporioides* Penz., isolates from mango. *Geobios* 35 : 86—90.
3. Shyam Singh, Kiran Kumar KC, Daivasikamani S, Sudhakar SB, Jayarama (2012) *In vitro* evaluation of fungicides against *Colletotrichum gloeosporioides*, the causal agent of anthracnose disease of coffee. *Acta Biologica Indica* 1 : 249—251.
4. Darshana CN, Praveena R, Ankegowda SJ, Biju CN (2014) Morphological variability, mycelial compatibility and fungicidal sensitivity of *Colletotrichum gloeosporioides* causing leaf spot of ginger (*Zingiber officinale* Rosc.). *J Spices Arom Crop* 23 : 211—223.
5. Patil CU, Zape AS, Chacharkar BS (2009) *In vitro* efficacy of fungicides and bioagents against *Colletotrichum* blight of betalvine. *Int J Pl Prot* 2 : 108—110.
6. Prashanth (2007) Investigations on anthracnose (*Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc.) of pomegranate (*Punica granatum* L.). MSc (Agric) thesis. Univ Agric Sci Dharwad, India.
7. Ramanujam B, Prasad RD, Sriram S, Rangeswaran R (2010) Mass production, formulation, quality control and delivery of *Trichoderma* for plant disease management. *The J Pl Prot Sci* 2 : 1—8.