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RESEARCH ARTICLE

Management of black spot of papaya caused by *Asperisporium caricae*

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ABSTRACT

The black spot disease caused by *Asperisporium caricae* on papaya leaves and fruits causes defoliation and deteriorates the market value of fruits. The disease symptoms observed on upper surface of leaves were round light brown necrotic spots encircled by yellow halo. On the lower surface of the same leaves, the growth of fungus observed as black colour in the area corresponding to the spots, initially they are black later became brown in colour. The different chemicals (fungicides) such as Difenoconazole, Propiconazole, Hexoconazole, Bitertanol, Chlorothalonil, Copper oxychloride, Saaf (Carbendazim 12 % + Mancozeb 63 %) and Quintal (Carbendazim 25 % + Iprodine 25 %) were tested at different concentrations *in vitro* and *in vivo* in a field experiment laid out in Randomized Complete Block Design. Among the chemicals, Chlorothalonil inhabited 100 per cent spore germination at 150 and 250 ppm when tested *in vitro* spore germination inhibition technique. In field experiment, each chemical as treatment was sprayed on leaves and fruits. Among the treatments, Difenconazole @ 0.1 per cent showed effective against the pathogen on leaves (PDI 33.88%) and decrease over control (53.63%) followed by Chlorothalonil @ 0.2% (46.94%). On fruits Difenconazole @ 0.1% showed effective control of disease (PDI 17.26%).

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INTRODUCTION

Papaya (*Carica papaya* L.) is an important fruit crop which belongs to family *Caricaceae*. Papaya is a good source of vitamin A, vitamin C and calcium (Arriola *et al.*, 1980 and Hayes, 1993). The raw fruits contain an alkaloid or proteolytic enzyme "Papain", which is a commercial product of several tropical American nations and is used in several medicines and food preparations.

Papaya is attacked by several diseases like, anthracnose, powdery mildew, black spot, brown spot and papaya ring spot. Among the emerging diseases in papaya, black spot disease caused by *Asperisporium caricae* is most lethal. Both leaves and fruits of papaya can be affected by the black spot caused by *Asperisporium caricae* (Fig. A.) The fruits are affected on the surface, reducing the fresh-market value, but there is no reduction in quality. The disease can affect papaya plants at any stage of growth. Periods of wet weather may increase the development of the disease. The use of fungicides is the most appropriate management option. This disease has been reported from different parts of the country and is found to be serious in recent years. This study is supported by field survey in Southern Karnataka, India.

In earlier study, laboratory tests showed that *A. caricae* was more sensitive to difenoconazole (EC_{50} of 2 ppm) than tebuconazole ($EC_{50}$of 14 ppm) (Vawdrey *et al.*, 2008). Vawdrey

Table A : List of fungicides evaluated under *in vitro* and *in vivo*

Sr. No.	Common name	Trade name	Company
	Contact fungicides		
1.	Chlorothalonil	Kavach 75 %	Syngenta
2.	Copper oxy chloride	Blitox 50 % (Wetable powder)	Rallis company
	Systemic fungicides		
3.	Difenoconazole	Score 25 % (Emulsifying concentration)	Syngenta
4.	Propiconozole	Tilt 25 % (Emulsifying concentration)	Syngenta
5.	Hexaconozole	Contaf 5 % (Soluble concentration)	Rallis company
6.	Bitertanol	Baycor	Syngenta
	Combi products		
7.	Carbendazim (12%) + Mancozeb (63%)	Saaf 75 % (Wetable powder)	Agro chemicals
8.	Carbendazim (25%)+ Iprodine (25%)	Quintal 50 % (Wetable powder)	Agro chemicals

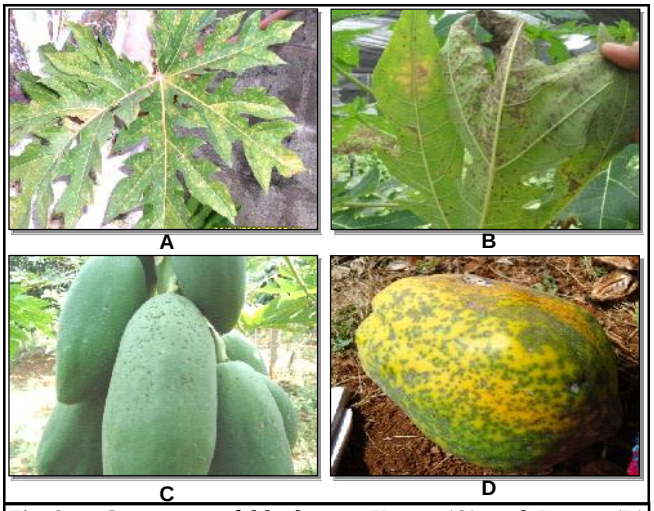

Fig. A : Symptoms of black spot Upper (A) and Lower (B) surface of the leaves on immature (C) and mature (D) fruits of papaya

et al. (2008) also studied on field evaluation of fungicides. This study supports to *in vitro* evaluation of fungicides. The field experiment is also supported by studies of Ventura (2008).

This paper reports the field and laboratory experiments conducted to evaluate a range of chemicals including Difenoconazole, Propiconazole, Hexaconazole, Bitertanol, Chlorothalonil, Copper-oxy-chloride, Saaf (Carbendazim 12% + Mancozeb 63%) and Quintal (Carbendazim 25% + Iprodine 25%) against black spot of papaya.

MATERIAL AND METHODS

***In vitro* evaluation of fungicides :**

Under *in vitro* condtion, different fungicides *viz.*, Difenoconazole, Propiconazole, Hexaconazole, Bitertanol, Chlorothalonil, Copper-oxy-chloride and combi-product like Saaf (Carbendazim 12% + Mancozeb 63%) and Quintal (Carbendazim 25% + Iprodine 25%) were tested against *Asperisporium* by employing spore germination inhibition technique. Each fungicide was tested at 2, 5, 10, 25, 50, 100, 150 250, 500 and 1000 ppm. For spore germination inhibition, desirable concentrations were prepared directly by dissolving the necessary amount of each fungicide. These suspensions were placed in the centre of slide and spores of *A. caricae* obtained from infected leaves were mixed with fungicides with the help of sterilized needle. Treated slides were kept in moisture chamber and incubated at 15^0C. Slides were examined under microscope after 48 hours and per cent germination inhibition was noted. The list of evaluated fungicides is presented in Table A.

Per cent inhibition of spores was calculated by the following formula :

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

where,

I = Inhibition percentage.

C = No. of spores germinated in control.

T = No. of spores germinated in treatment.

***In vivo* evaluation of fungicides** :

The field experiment was conducted with the same fungicides used *in vitro* test. Each chemical fungicide as a treatment was compared with a control treatment replicating thrice in Randomized Complete Block Design. The details of fungicides evaluated are presented in Table A.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

***In vitro* evaluation of fungicides against *A. caricae* by spore inhibition technique :**

The effect of different fungicides on spore inhibition of *Asperisporium caricae* is presented in Table 1 and Fig. 1 Difenoconazole inhibited 100 per cent spore germination at

150 ppm followed by Chlorothalonil and Propiconazole. Bitertanol and Copper oxychloride had less effect on inhibition of spore germination of *A. caricae.*

***In vivo* evaluation of fungicides against *A. caricae* :**

Eight fungicides were evaluated under field condition for their efficacy in controlling the black spot disease. Per cent disease index of papaya leaves and fruits are presented in Table 2 and 3 (Fig. 2 and 3).

Out of eight fungicides evaluated Difenconazole was found most effective against pathogen on leaves (PDI 33.88%) and decrease over control (53.63%) followed by Chlorothalonil (PDI 38.33%) and decrease over control (46.94%). The fungicide Bitertanol was least effective (PDI 57.44%) and

Table 1 : Effect of fungicides against *A. caricae* by inhibition of spore germination technique

Sr. No.	Fungicides	Per cent spore germination inhibition Concentrations (ppm)									
		2	5	10	25	50	100	150	250	500	1000
1.	Difenoconazole	50.77	55.08	60.50	71.67	86.83	95.17	100.00	100.00	100.00	100.00
		(7.13)	(7.42)	(7.78)	(8.47)	(9.32)	(9.76)	(10.00)	(10.00)	(10.00)	(10.00)
2.	Propiconazole	35.58	45.33	49.50	54.5	65.58	75.07	86.23	95.75	100.00	100.00
		(5.96)	(6.73)	(7.04)	5(7.39)	(8.10)	(8.66)	(9.29)	(9.79)	(10.00)	(10.00)
3.	Hexaconazole	33.00	44.07	48.20	52.33	62.00	70.45	83.83	90.17	97.50	100.00
		(5.74)	(6.64)	(6.94)	(7.23)	(7.87)	(8.39)	(9.16)	(9.50)	(9.87)	(10.00)
4.	Chlorothanonil	46.02	50.00	55.87	65.33	76.33	85.43	95.25	100.00	100.00	100.00
		(6.78)	(7.07)	(7.47)	(8.08)	(8.74)	(9.24)	(9.76)	(10.00)	(10.00)	(10.00)
5.	Copper oxychloride	30.50	35.50	41.00	46.58	52.00	58.83	65.27	72.17	82.00	90.33
		(5.52)	(5.96)	(6.40)	(6.82)	(7.21)	(7.67)	(8.08)	(8.50)	(9.06)	(9.50)
6.	Bitertanol	23.42	27.57	31.03	35.00	40.17	47.73	50.17	55.53	57.83	60.08
		(4.84)	(5.25)	(5.57)	(5.92)	(6.34)	(6.91)	(7.08)	(7.45)	(7.60)	(7.75)
7.	Carbendazim + Mancozeb	35.17	45.33	50.00	55.00	65.73	75.45	87.42	96.75	100.00	100.00
		(5.93)	(6.73)	(7.07)	(7.42)	(8.11)	(8.69)	(9.35)	(9.84)	(10.00)	(10.00)
8.	Carbendazim + Iprodine	33.75	39.50	47.33	52.17	60.00	67.48	76.83	85.25	92.58	95.30
		(5.81)	(6.28)	(6.88)	(7.22)	(7.75)	(8.21)	(8.77)	(9.23)	(9.62)	(9.76)
		F	C	F×C							
	S.Em	0.18	0.12	0.36							
	C.D. (P=0.01)	0.66252	0.44168	1.32504							

Table 2 : Effect of fungicides on black spot of papaya under field condition (papaya leaves)

Sr. No.	Chemicals	PDI* after first spray	(%) Decrease over control	PDI after second spray	(%) Decrease over control	PDI after third spray	(%) Decrease over control	Mean PDI	Mean (%) decrease over control
1.	Difenoconazole (0.1%)	41.33	32.24	35.33	46.63	25.00	82.02	33.88	53.63
2.	Propiconazole (0.1%)	48.00	21.31	42.67	35.54	31.40	71.01	40.69	42.62
3	Hexaconazole (0.1%)	51.33	15.85	47.00	29.00	34.67	67.68	44.33	37.51
4.	Chlorothalonil (0.2%)	45.33	25.68	40.33	39.07	29.33	75.07	38.33	46.94
5.	Copper oxychloride (0.2%)	49.67	18.57	46.67	29.50	40.67	63.76	45.67	13.68
6	Bitertanol (0.1%)	59.33	2.73	58.00	12.38	55.00	20.28	57.44	11.79
7.	Saaf (carbendazim12%+mancozeb 6s3%) (0.2%)	48.00	21.31	40.00	39.57	28.67	72.46	38.89	44.44
8.	Quintal (carbendazim 25% + iprodiane 25%) (0.2%)	48.00	21.31	45.00	32.02	30.00	69.42	41.00	40.91
9.	Control (without chemical)	61.00		66.20		69.00		65.4	
	SE m	1.32		2.84		2.06			
	C.D. (P=0.05)	3.95		8.51		6.19			

PDI*:

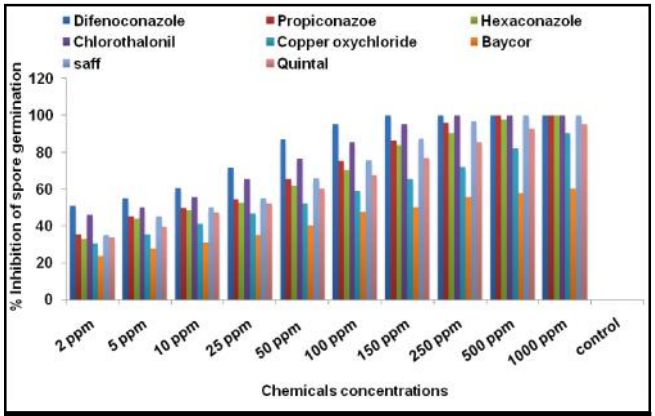

Fig. 1 : Effect of different fungicides on inhibition of spore germination of *A. caricae*

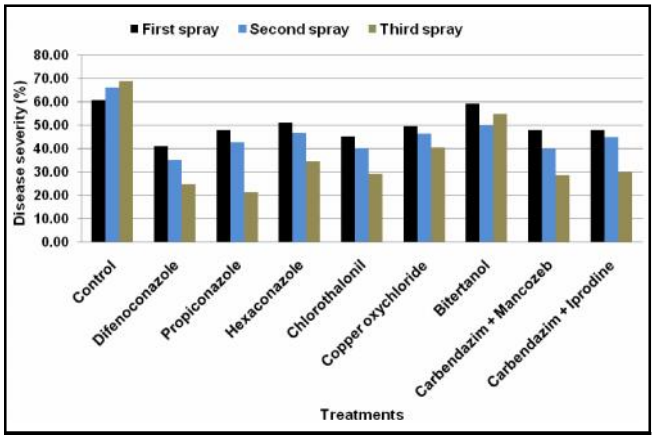

Fig. 2 : Effect of different fungicides against *A. caricae* under *in vivo* (leaves)

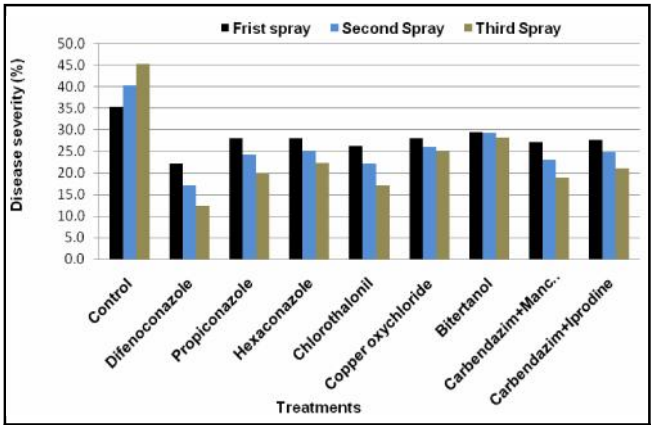

Fig. 3 : Effect of different fungicides against *A. caricae* under *in vivo* (fruits)

decreased over control (11.79%) compared to control (PDI 65.4%). On fruits also, Difenoconazole was most effective against the pathogen (PDI 17.26%) and decrease over control (55.71%) followed by Chlorothalonil (PDI 21.83%) and decrease over control (44.32%) and Bitertanol was least effective (PDI 28.53%) and decrease over control (27.2%) compared to control (PDI 40.30%).

In vitro evaluation of fungicides by spore inhibition technique provided useful preliminary information regarding effect of fungicides against pathogen within a shortest period of time. In the present study, two non-systemic fungicides, four systemic fungicides and two combi-products were tested at 11 concentrations. Among the systemic fungicides, Difenoconazole was most effective in inhibiting the spore germination and this was supported by Vawdrey *et al.* (2008), followed by non-systemic fungicide, Chlorothalonil and combi-

Table 3 : Effect of fungicides on black spot of papaya under field condition (papaya fruits)

Sr. No.	Chemicals	PDI after first spray	(%) Decrease over control	PDI after second spray	(%) Decrease over first spray	PDI after third spray	(%) Decrease over second spray	Mean PDI
1.	Difenoconazole (0.1%)	22.20	37.11	17.20	22.52	12.40	27.90	17.26
2.	Propiconazole (0.1%)	28.00	20.67	24.30	13.21	20.00	17.35	24.2
3.	Hexaconazole (0.1%)	28.10	20.39	25.20	10.32	22.30	11.50	25.2
4.	Chlorothalonil (0.2%)	26.20	25.77	22.10	15.64	17.20	22.17	21.83
5.	Copper oxychloride (0.2%)	28.00	20.67	26.10	6.78	25.00	4.21	26.3
6.	Bitertanol (0.1%)	29.40	16.71	29.30	0.34	28.20	3.75	28.53
7.	Saaf (Carbendazim12% + Mancozeb 63%) (0.2%)	27.10	23.22	23.00	15.1	19.00	17.39	23.03
8.	Quintal (carbendazim 25% + iprodiane 25%) (0.2%)	27.60	21.81	24.90	11.59	21.10	15.26	24.53
9.	Control (without chemical)	35.30		40.30		45.30		40.3
	S.Em	1.32		0.20		0.46		
	C.D. (P=0.05)	3.95		0.59		1.39		

product Saaf (Carbendazim12% + Mancozeb 63%). Difenoconazole inhibited spore germination 100 per cent at 150 ppm. Among non-systemic fungicides, Chlorothalonil inhibited 100 per cent spore germination at 250 ppm. In the case of combi-products, Saaf (carbendazim 12% + mancozeb 63%) inhibited 100 per cent spore germination at 500 ppm. Similar studies have been reported by Raj Kumar *et al.* (2011) on an evalution of different fungicides *viz.,* carbendazim, propiconazole, copper oxychloride and triadimefon against *Cecospora canescens* causing the cercospora leaf spot in mungbean under laboratory condition by spore inhibition technique.

In field condition eight fungicides were tested against *A. caricae*. Among these fungicides, Difenoconazole was highly effective against the disease followed by chlorothalonil and saaf compared to control. These results are supported by evaluation of chemicals *viz.*, strobilurins (Pyraclostrobin and Azoxystrobin); triazoles (Difenoconazole and Tebuconazole), dithiocarbamates (Propineb, Metiram, Ziram and Mancozeb) and Pthalimide (Chlorothalonil) in field experiments at North Queensland, Australia for the control of papaya black spot (Vawdrey *et al.*, 2008). Among these chemicals, Difenoconazole, Pyraclostrobin and Chlorothalonil were better than Mancozeb and Tebuconazole.

Conclusion :

The black spot of papaya caused by *Asperisporium caricae* is economically important disease even though it will not effect on quality of fruit but it deteriorates the fresh market value. But it is lethal disease when it occurs on leaves because it may defoliate entire plant causing premature senescence of leaves. Several chemicals have been evaluated to find the effective fungicides for disease control *in vitro* and *in vivo*. The *in vitro* studies reported that the chemical fungicide, Difenoconazole completely inhabited the spore germination and it also showed the effective control of disease in field experiment also.

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