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RESEARCH ARTICLE

In vitro and *in vivo* efficacy of fungicides against *Pyricularia grisea* causing finger millet blast disease

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ABSTRACT

In vitro all the fungicides were effective in checking the growth and sporulation of *Pyricularia grisea*. Complete inhibition of mycelial growth was given by Tricyclazole followed by Ediphenphos and Mancozeb 65 per cent WP+Carbendazim12 per cent WP (Saff). *In vivo*, Ediphenphos and Tricyclazole were found effective in controlling leaf, neck and finger blast. Grain yield and cost benefit ratio were significantly higher in Ediphenphos followed by Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim12 per cent WP in *Kharif* 2009-10 and 2010-11.

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INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn.] commonly known as ragi is one of the most important crops and largely grown in Bastar region of Chhattisgarh. It is widely consumed as the staple food in place of rice in the rural community of Bastar, Chhattisgarh. Eventhough, finger millet is known to be one of the hardiest crops, it is affected by a number of diseases such as blast, foot rot, smut, streak and mottling virus (Govindu and Shivanandappa, 1967). Among these, blast disease caused by *Pyricularia grisea* is the most devastating disease affecting different aerial parts of the plant at all stages of its growth starting from seedling to grain formation. Yield loss due to blast may be around 28 per cent (Vishwanath *et al.*, 1997a and b), but under favourable conditions it may be up to 80-90 per cent.

Magnaporthe grisea (Hebert) Barr. (anamorph *Pyricularia grisea* Sacc.) is one of the most destructive and widespread plant pathogens which parasitizes more than 50 different grass species (Kumar and Singh, 1995). Among the cereals, it infects major crops *viz*., rice, finger millet and pearl millet. Due to extreme variation in the pathogen, resistance in the cultivars does not remain for long. Consequently, fungicides have to be used to manage the disease. It has been observed that the same fungicide is not equally effective against the pathogen on different hosts. Therefore, an attempt was made to test the efficacy of fungicides against *P. grisea* isolated from finger millet and pearl millet so that the most effective fungicide could be used against a pathogen host combination.

Singh and Prasad (2007) reported Tricyclazole (beam) as most effective fungicide for the control of rice blast and increasing the yield. Similar findings were reported by Prajapati *et al.* (2004), Vijaya (2002), Sood and Kapoor (1997), Saifulla *et al.* (1995) and Peterson (1990). Effectiveness of iprobenfos (Kitazin) in controlling rice blast and increasing grain yield has also been reported by Tiwari *et al.* (2002) and Sharma and Kumar (1992). Therefore, in the present study different

fungicides were tested for their efficacy under *in vitro* and *in vivo* conditions against *Pyricularia grisea*, the blast pathogen of finger millet.

MATERIAL AND METHODS

***In vitro* efficacy of fungicides against growth and sporulation of *Pyricularia grisea*:**

In vitro, evaluation of antifungal efficacy of fungicides at different concentrations (500, 1000 and 1500 ppm) was studied by poison food technique (Grover and Moore, 1962). Ten fungicides *i.e.* Benlate (Benomyl), Carbendazim (Bavistin), Tricyclazole, Kitazin (Kitazin), Kasugamycin (Kasu-B), Ediphenphos (Hinosan), Propineb 70 WP (Antracol 75WP), Mancozeb 75 per cent WP, Isoprothiolane (Fugione) and Mancozeb 65 per cent WP + Carbendazim 12 per cent WP (SAFF) were tested *in vitro* against *Pyricularia grisea*. 100 ml Potato dextrose agar medium was sterilized in each conical flask of 150 ml capacity. Fungicides were separately incorporated aseptically in PDA @ 500, 1000 and 1500 ppm. The amended medium was then poured in sterilized Petriplates. 6 mm discs of the test pathogen cut from the margin of 12 days old culture were then placed centrally in each Petriplate. The disc was kept inverted to allow the contact of the fungus with the medium. The inoculated Petriplates without fungicides served as control. The inoculated Petriplates were incubated at 27± 1^{0}C and colony diameter of the pathogen was measured after 4, 8 and 12 days interval. Sporulation was recorded after 12 days. Per cent growth inhibition by different fungicides was recorded using following formula (Verma and Kharwar, 2006).

$$\% \text{ inhibition} = 100 - \frac{(\text{Mycellial growth in control} - \text{Mycellial growth in treatment})}{\text{Mycellial growth in control}}$$

***In vivo* efficacy of fungicides against *Pyricularia grisea* causing blast in finger millet :**

Field experiments were conducted during the years 2009-10 and 2010-11 at Instructional Farm, S. G. College of Agriculture and Research Station, Jagdalpur, Bastar (C.G). Ten fungicides *viz.*, Benlate (Benomyl) 0.2 per cent, Carbendazim (Bavistin) 0.2 per cent, Tricyclazole 0.05 per cent, Kitazin (Kitazin) 0.05 per cent, Kasugamycin (Kasu-B) 0.05 per cent, Ediphenphos (Hinoshan) 0.1 per cent, Propineb 70 WP (Antracol 75WP) 0.1 per cent, Mancozeb 75 per cent WP 0.2 per cent, Isoprothiolane (Fugione) 0.1 per cent and Mancozeb 65 per cent WP + Carbendazim 12 per cent WP (SAFF) 0.2 per cent, were tested with one water spray control check. The experiment was laid out in augmented randomized block design with three replications. The highly susceptible finger millet variety PR-202 was sown in 3 x 2 m^2 plots with recommended package of practices. The fungicides were applied twice as foliar spray, first at 50 per cent flowering and second at 10 days after first spray.

Observations for leaf, neck and finger blast were recorded separately. Leaf blast severity was scored on a 0-5 scales (0 = no visual symptoms; 1= brown specks smaller than 0.5 mm in diameter; 2 = brown specks about 0.5-1 mm in diameter;3 = roundish to elliptical lesions about 1-3 mm in diameter with gray centres and brown margins; 4 = typical spindle-shaped blast lesions, 3mm or longer with little or no coalescence of lesions; 5 = same as 4 but half of or more leaf killed by coalescence of lesion) (Mackill and Bonman, 1992). Whereas, neck blast and finger blast incidence was recorded by counting the number of infected panicles and fingers from total population (Mackill and Bonman, 1992). Disease severity scoring for leaf blast was recorded at the seedling and booting stage, whereas for neck blast and finger blast at the physiological maturity and at harvest. Further per cent disease index (PDI) for leaf blast was calculated (Dubey, 1995).The grain yield was recorded after harvesting of crop from individual plots. The per cent disease control was worked out using the formula given by Abbott (1925).

$$\text{Percentage reduction} = C - T/C \times 100$$

where, C is the population of control and T is the population of treated plots.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

***In vitro* efficacy of fungicides against growth and sporulation of *Pyricularia grisea*:**

Data on mycelial growth and sporulation of *Pyricularia grisea* as influenced by different fungicides are presented in Table 1. The data revealed that all fungicides were significantly effective in checking the growth of pathogen. However, fungicides *i.e.* Tricyclazole, Ediphenphos and Mancozeb 65 per cent WP + Carbenazim 12 per cent WP were completely checked the growth of *Pyricularia grisea* at 500 ppm,1000 ppm and 1500 ppm concentrations as compared to control. Moreover, fungicides *i.e.* Benlate, Carbendazim, Propineb 70 per cent WP, Mancozeb 75 per cent WP, Kasugamycin and Isoprothiolane were also effective and significantly showed higher per cent zone inhibition. Poor sporulation was recorded in Ediphenphos, Mancozeb 65 per cent WP + Carbendazim 12 per cent WP, Kitazin and Kasugamycin, over control (145.67 × 10^2 / ml). Inhibitory effect of fungicides, *i.e.* Tebuconazole, Propiconazole, Difenconazole, Dithane-78, Kasugamycin, Azoxystrobin + Difenconazole, Tricyclazole and Tricyclazole + Mancozeb on growth and sporulation of *Pyricularia grisea* has been reported by Chander *et al.* (2011).

***In vivo* efficacy of fungicides against *Pyricularia grisea* causing finger millet blast :**

In vivo data revealed that leaf blast severity was found

Table 1 : Efficacy of fungicides and their concentrations on the growth and sporulation of *Pyricularia grisea*

Fungicides	Growth in (mm)			% Zone inhibition			Sporulation × 10^2/ml		
	500 ppm	1000 ppm	1500 ppm	500 ppm	1000 ppm	1500 ppm	500 ppm	1000 ppm	1500 ppm
Benlate (Benomyl)	70.67	60.67	53.33	21.48	32.59	40.74	70.67	60.00	51.67
Carbendazim (Bavistin)	59.33	45.67	40.00	34.07	49.26	55.56	60.67	64.00	40.67
Tricyclazole	0.00	0.00	0.00	100.00	100.00	100.00	0.00	0.00	0.00
Kitazin (Kitazin)	16.67	11.67	0.00	81.48	87.04	100.00	0.00	0.00	0.00
Kasugamycin (Kasu-B)	29.33	20.00	16.33	67.41	77.78	81.85	7.67	0.00	0.00
Ediphenphos (Hinosan)	0.00	0.00	0.00	100.00	100.00	100.00	0.00	0.00	0.00
Propineb 70 WP (Antracol 75WP)	45.67	35.33	20.67	49.26	60.74	77.04	50.67	45.67	30.67
Mancozeb 75% WP	35.67	30.33	16.67	60.37	66.30	81.48	29.33	20.67	16.67
Isoprothiolane (Fugione)	24.33	12.00	9.33	72.96	86.67	89.63	31.00	38.33	25.00
Mancozeb65%WP+Carbendazim12%WP (SAFF)	0.00	0.00	0.00	100.00	100.00	100.00	0.00	0.00	0.00
Control	90.00	90.00	90.00				142.33	151.67	145.67
CD (P=0.05)	2.00	1.74	3.62				2.72	2.38	2.36

Average of three replications

Table 2 : Efficacy of fungicides against leaf blast severity of finger millet caused by *Pyricularia grisea* during *Kharif* 2009-10 and 2010-11

Fungicides	Leaf blast severity %			% disease control
	2009	2010	Mean	
Benlate (Benomyl) @ 0.2%	29.33 (32.73)	32.00 (34.44)	30.67	60.34
Carbendazim (Bavistin) @ 0.2%	32.00 (34.42)	31.33 (33.97)	31.67	59.05
Tricyclazole @ 0.05%	15.33 (22.94)	14.00 (21.94)	14.67	81.03
Kitazin (Kitazin) @ 0.05%	18.00 (25.08)	23.33 (28.85)	20.67	73.28
Kasugamycin (Kasu-B) @ 0.05%	33.33 (35.26)	32.00 (34.44)	32.67	57.76
Ediphenphos (Hinosan) @ 0.1%	15.33 (22.94)	13.33 (21.37)	14.33	81.47
Propineb 70 WP(Antracol 75WP) @ 0.1%	42.67 (40.78)	42.67 (40.76)	42.67	44.83
Mancozeb 75% WP @ 0.2%	66.00 (54.41)	47.33 (43.47)	56.67	26.72
Isoprothiolane (Fugione) @ 0.1%	62.00 (51.96)	55.33 (48.09)	58.67	24.14
Mancozeb 65% WP+Carbendazim12% WP(SAFF) @ 0.2%	34.67 (36.04)	25.33 (30.19)	30.00	61.21
Control	78.67 (62.51)	76.00 (60.68)	77.33	
CD (P=0.05)	4.60	4.35		

Data in parenthesis shows Arc sine percentage transformation. Average of three replications

Table 3: Efficacy of fungicides against neck blast incidence of finger millet caused by *Pyricularia grisea* during *Kharif* 2009-10 and 2010-11

Fungicides	Neck blast incidence %			% disease control
	2009	2010	Mean	
Benlate (Benomyl) @ 0.2%	4.67 (12.42)	6.67 (14.93)	5.67	84.11
Carbendazim (Bavistin) @ 0.2%	6.67 (12.23)	4.00 (11.28)	5.33	85.05
Tricyclazole @ 0.05 %	0.00 (0.00)	4.67 (12.42)	2.33	93.46
Kitazin (Kitazin) @ 0.05%	2.67 (7.69)	4.00 (11.28)	3.33	90.65
Kasugamycin (Kasu-B) @ 0.05%	2.67 (7.69)	8.67 (17.10)	5.67	84.11
Ediphenphos (Hinosan) @ 0.1%	0.00 (0.00)	1.33 (5.42)	0.67	98.13
Propineb 70 WP(Antracol 75WP) @ 0.1%	14.00 (21.94)	3.33 (10.40)	8.67	75.70
Mancozeb 75% WP @ 0.2%	6.67 (14.45)	6.67 (14.33)	6.67	81.31
Isoprothiolane (Fugione) @ 0.1%	6.67 (12.23)	10.67 (19.05)	8.67	75.70
Mancozeb 65% WP + Carbendazim 12%WP(SAFF) @ 0.2%	3.00 (8.15)	6.00 (14.05)	4.50	87.38
Control	60.00 (50.79)	11.33 (19.66)	35.67	
C.D. (P=0.05)	10.10	4.93		

Data in parenthesis show Arc sine percentage transformation. Average of three replications

to be significantly less in all treated plots over check (Table 2). Among different fungicides used as foliar spray, Ediphenphos (22.94%) and Tricyclazole (22.94%) were significantly more effective and at par with Kitazin (25.08%) during *Kharif* 2009-10. Similarly, during 2010-11 significantly less leaf blast severity of 21.37 and 21.94 per cent was recorded from Ediphenphos and Tricyclazole, respectively. Two years mean data indicated that Ediphenphas and Tricyclazole were the most effective having 14.33 and 14.67 per cent severity, respectively and maximum per cent disease control of 81.47 and 81.03 (Table 2).

Neck blast incidence was not observed in Ediphenphos and Tricyclazole treated plots during *Kharif* 2009-10. Whereas neck blast incidence occurred in rest of the treatments and was significantly low in Kitazin (7.69 %) and Mancozeb 65 per cent WP+ Carbendazim 12 per cent WP (8.15%) compared to control (50.79%). Whereas, during *Kharif*, 2010-11, neck blast incidence was observed in all treated plots and was significantly less than the control. Pooled mean data indicated the neck blast incidence of 0.67, 2.33, 3.33 and 4.50 per cent, respectively in Ediphenphos, Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim12 per cent WP treated plots. Greater per cent disease control was recorded from Ediphenphos, Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim12 per cent WP treated plots (Table 3).

Similarly, finger blast incidence was also significantly less in all the treatments over control. Ediphenphos, Kitazin, Mancozeb 65 per centWP + Carbendazim 12 per cent WP and Tricyclazole treated plots were having significantly less finger blast incidence (23.56- 34.28%) during *Kharif* 2009-10 and 2010-11 as compared to control (52.09%).Two years mean data revealed that Ediphenphos, Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim12 per cent WP were

Table 4 : Efficacy of fungicides against finger blast incidence of finger millet caused by *Pyricularia grisea* during *Kharif* 2009-10 and 2010-11

Fungicides	Finger blast incidence%			% disease control
	2009	2010	Mean	
Benlate (Benomyl) @ 0.2%	53.33 (46.92)	33.89 (35.58)	43.61	27.65
Carbendazim (Bavistin) @ 0.2%	61.67 (51.92)	23.33 (28.86)	42.50	29.49
Tricyclazole @ 0.05%	31.75 (34.28)	33.31 (35.25)	32.53	46.04
Kitazin (Kitazin) @ 0.05%	26.00 (30.65)	48.33 (44.04)	37.17	38.34
Kasugamycin (Kasu-B) @ 0.05%	53.60 (47.44)	25.76 (30.49)	39.68	34.17
Ediphenphos (Hinosan) @ 0.1%	16.00 (23.56)	14.89 (22.68)	15.45	74.38
Propineb 70 WP (Antracol 75WP) @ 0.1%	62.22 (52.09)	25.00 (30.00)	43.61	27.65
Mancozeb 75% WP @ 0.2%	35.36 (36.43)	36.11 (36.93)	35.73	40.72
Isoprothiolane (Fugione) @ 0.1%	48.15 (43.94)	58.89 (50.12)	53.52	11.21
Mancozeb 65% WP + Carbendazim 12% WP (SAFF) @ 0.2%	30.55 (33.48)	35.35 (36.48)	32.95	45.34
Control	62.22 (52.09)	58.33 (49.80)	60.28	
C.D. (P=0.05)	9.13	2.20		

Data in parenthesis show Arc sine percentage transformation. Average of three replications

Table 5 : Effect of fungicides on grain yield and cost -benefit ratio of finger during *Kharif* 2009-10 and 2010-11

Fungicides	Grain yield (kg/ha)			Increase yield over control	B:C ratio		
	2009	2010	Mean		2009	2010	Mean
Benlate (Benomyl) @ 0.2%	19.03	18.75	18.89	9.09	2.52	2.35	2.44
Carbendazim (Bavistin) @ 0.2%	19.17	19.17	19.17	9.37	2.47	2.35	2.41
Tricyclazole @ 0.05%	20.97	21.64	21.31	11.50	2.54	2.53	2.54
Kitazin (Kitazin) @ 0.05%	19.31	19.97	19.64	9.84	2.30	2.31	2.31
Kasugamycin (Kasu-B) @ 0.05%	19.72	20.72	20.22	10.42	2.29	2.34	2.32
Ediphenphos (Hinosan) @ 0.1%	23.50	22.83	23.17	13.36	2.99	2.75	2.87
Propineb 70 WP(Antracol 75WP) @ 0.1%	18.89	19.96	19.43	9.62	2.19	2.26	2.22
Mancozeb 75% WP @ 0.2%	17.36	18.36	17.86	8.06	2.03	2.10	2.06
Isoprothiolane (Fugione) @ 0.1%	17.50	18.17	17.84	8.03	1.95	1.97	1.96
Mancozeb 65% WP+Carbendazim 12% WP(SAFF) @ 0.2%	20.42	20.75	20.59	10.78	2.47	2.41	2.44
Control	9.64	9.97	9.81		1.03	1.02	1.02
CD (P=0.05)	4.63	6.26					

Data in parenthesis show Arc sine percentage transformation. Average of three replications

significantly effective and gave maximum per cent disease control over control (Table 4).

Grain yield and cost benefit ratio recorded from various treatments indicated that both the teatments were significantly higher in Ediphenphos, Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim12 per cent WP during both years over control (9.81) and ranged between 23.17 - 20.59 q/ha and cost-benefit ratio from 2.87 - 2.44, respectively. Pooled data of grain yield revealed that fungicides *i.e.*; Ediphenphos (13.36 q/ha), Tricyclazole (11.50 q/ha), Kitazin (19.64 q/ha) and Mancozeb 65 per cent WP + Carbendazim12 per cent WP (20.59 q/ha) were found effective in increasing grain yield of finger millet (Table 5). Efficacy of Ediphenphos in reducing neck infection and increasing grain yield was reported by Keshi and Mohanty (1970). Prajapati *et al.* (2004) also reported that Tricyclazole proved significantly superior in decreasing the leaf blast severity and neck blast incidence with corresponding increase of grain yield over control. Similarly, Haider (1992) reported that two sprays of Ediphenphos (0.1%) gave good control of the disease and highest grain and fodder yield. Tricyclazole found most effective in the present study was also reported by Singh and Prasad (2007) for the control of rice blast caused by the same pathogen. Similar findings were reported by several works Gohel *et al.* (2009), Madhukeshwara *et al.* (2004); Peterson (1990), Prajapati *et al.* (2004); Saifulla *et al*. (1995); Sood and Kapoor (1997) and Vijaya (2002). Effectiveness of iprobenfos (Kitazin) in controlling rice blast and increasing grain yield has also been reported by Tiwari *et al.* (2002) and Sharma and Kumar (1992). Viswanath *et al*. (1997 a and b) suggested application of one spray of tricylazole or two sprays of Carbendazim for the effective control of neck blast of finger millet. *In vivo* study indicated that fungicides *i.e.* Ediphenphos, Tricyclazole, Kitazin and Mancozeb 65 per cent WP + Carbendazim 12 per cent WP can be used for the control of blast of finger millet appearing as leaf blast, neck blast and finger blast.

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