academicJournals

Vol. 8(25), pp. 3303-3309, 4 July, 2013
DOI: 10.5897/AJAR2013.7182
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Foliar application of fungicides for the management of brown spot disease in rice (*Oryza sativa* L.) caused by *Bipolaris oryzae*

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Accepted 24 May, 2013

Major rice growing areas of Jammu sub-tropics (Jammu, Samba and Kathua Districts) were surveyed to ascertain the status and distributions of brown spot of rice during 2011 to 2012. The disease was reported from all the areas with area under brown spot progress curve (AUBSPC) ranging between 3150 and 3560, 3025.00 and 3100, and 2921 and 31050 in Jammu, Kathua and Samba districts, respectively. Under laboratory conditions, seven fungicides (propiconazole, hexaconazole, tricyclazole, carbendazim, triadimefon, mancozeb and azoxystrobin) were tested at 50, 100, 150, 200 and 250 ppm. Out of different fungicides, propiconazole was most effective with maximum inhibition of 97% at 250 ppm concentration. Under field conditions, three rice varieties viz., Basmati-370, Jaya and PC-19 were used for testing different fungicides at 0.1% concentration during 2011 to 2012 and application of propiconazole significantly reduced the disease severity (69, 73 and 70) and increased the grain yield (19, 12 and 21) of all the varieties as compared to their respective controls. It was concluded that timely spray of propiconazole reduce the disease severity and thereby increase the yield of the rice.

Key words: Brown spot, *Bipolaris oryzae*, severity, fungicides, management.

INTRODUCTION

Rice (*Oryza sativa* L.) has been regarded as one of the most important cereal crops and a major food grain contributor to the total world food grain basket. There is continuous increase in global demand of rice which is expected to reach 852 million tonnes by the year 2035 from its present production status of 676 million tonnes, and in order to produce 176 million tonnes of more rice to fill this deficit, there is a need to enhance the productivity of rice from 10 to 12.5 tonnes/hectare (Khush, 2011, personnel communication). In India, rice occupies an area of about 42 million hectares with production and productivity of about 102 million tonnes and 23 quintals/hectare, respectively (Anonymous, 2011a). Rice is also one of the major cereals grown in the State of

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Jammu and Kashmir. It occupies an area of 257 thousand hectares with a production and productivity of 5637 thousand quintals and 21 quintals/hectare, respectively (Anonymous, 2011b).

Out of different biotic stresses which influence the performance of rice crop , brown spot of rice caused by *Cochliobolus miyabeanus* (*Bipolaris oryzae, Drechslera oyyzae*, *Helminthosporium oryzae*) is disease that impairs grain quality and results in about 67% yield reduction (Kohls et al., 1987; Jones et al., 1993). Brown spot was responsible for the "Bengal Famine" in India in 1942 and 1943 (Padmanabhan, 1973). The disease becomes more severe under stress conditions, causes seed discolouration, reduced seedling vigour and the yield loss. In India, brown spot occurs every year on most on the cultivated rice varieties.

At present, there are very limited strategies for the control of brown spot and cultivars with an adequate level of resistance are not available (Srinivasachary et al., 2011). Application of fungicides for the control of brown spot is the most effective management option, but under high disease pressure effective control is not achieved (Lore et al., 2007). The objective of the present study was to determine the prevalence of brown spot of rice in the sub-tropics region of Jammu and Kashmir State of India and evaluate to work out the management strategies for brown spot of rice through the use of new fungicides molecules.

MATERIALS AND METHODS

Assessment of disease prevalence

Three locations in each district of major rice growing belts in sub-tropics of Jammu and Kashmir State comprising of Jammu (32.73°N 74.87°E), Samba (32.53°N 75.11°E) and Kathua (32.36°N 75.51°E) were surveyed at weekly intervals during *kharif* 2011 to ascertain the status and distribution of brown spot of rice (cv. Basmati-370). The locations were R. S. Pura, Bishnah and Marh in Jammu district; Kathua, Nagri and Dyalachak in Kathua district and Sanoora, Raipur and Vijaypur in Samba district. Disease severity (percent infection) was recorded on the basis of 0 to 9 scale (Aluko, 1970). The percent disease intensity (PDI) was computed using the following formula:

$$\text{PDI} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of observations x Maximum rating}} \times 100$$

The area under brown spot progress curve (AUBSPC) value was calculated as given by Pandey et al. (1989):

$$\text{AUBSPC} = D\,(1/2\,(Y_1 + Y_k) + (Y_2 + Y_3 + \ldots\ldots\ldots\ldots\, Y_k)$$

Where Y_1, $Y_2 \ldots\ldots Y_k$ are k disease scorings at a constant interval of D-days.

Isolation and multiplication of the pathogen

Diseased leaves were collected and associated pathogen was isolated by standard tissue culture technique (Rangaswami and Bagyaraj, 1998). The culture of the pathogen was purified using single spore technique. Identification of the pathogen was carried out according to the cultural, morphological and microscopic characteristics described by Mew and Gonzals (2002). The isolated pathogen was multiplied on potato dextrose medium (PDA) and incubated in B.O.D. incubator at 26±1°C for 15 days. The mycelial mats harvested from 15-day old cultures grown in Petri-plates, were suspended in sterilized distilled water, homogenized and strained through double layered muslin cloth to get a clump-free uniform suspension of mycelial bits/fungal spores.

Pathogenicity test

Pathogenicity test was carried out in plastic cups. In each of these two cups (Treatment and control) 5 seeds of susceptible variety (Basmati-370) were placed containing sterilized soil. The spore suspension of the *Bipolaris oryzae* (1×10^5 spores/ml) was sprayed on the seedlings at two leaves stage and evaluation for the symptoms so developed was carried out after 7 days of inoculation.

In- vitro evaluation of fungicides against *B. oryzae*

The efficacy of systemic and non-systemic fungicides *viz*., Carbendazim (Bavistin 50% WP), Triadimefon (Bayleton 25% WP), Propiconazole (Tilt 25% EC), Tricyclazole (Beam 75%WP), Azoxystrobin (Quadris 2.08SC), Mancozeb (Dithane M-45) and Hexaconazole (Contaf 5% EC) were tested at different concentrations of 50, 100, 150, 200 and 250 ppm against *B. oryzae* by poisoned food technique (Dhingra and Sinclair, 1995). The efficacy of each fungicide was expressed as percent inhibition of mycelial growth over control calculated by using the formula suggested by Vincent (1947).

Field evaluation of fungicides against brown spot of rice

Three rice varieties *viz.,* Basmati-370 (Super fine), Jaya (Coarse) and PC-19 (Semi-fine) were selected for the study. The field experiment was laid out in factorial randomized block design with three replications having plot size of 3×2.5 m^2 with row to row and plant to plant spacing of 20 × 10 cm during *kharif* seasons of 2011 and 2012 cropping season at Research Farm, SKUAST-J, Chatha, of Jammu and Kashmir state (India). All the three rice varieties were grown with their respective package of cultivation. Efficacy of different fungicides *viz*., propiconazole, hexaconazole, carbendazim, mancozeb, tricyclazole and azoxystrobin at 0.1% concentration was evaluated against brown spot of rice. A control plot for each fungicide was also maintained. Single spray of respective fungicides was done in first week of August after the appearance of disease symptoms. Observations regarding disease severity were recorded periodically and yield/plot was calculated at harvest of crop.

Percent increase in yield was calculated using the formula:

$$\frac{b-c}{c} \times 100$$

Where, b = estimate of yield obtained in protected plot and c=estimate of yield obtained in unprotected plot.

Data was statistically analyzed by using OP software.

RESULTS AND DISCUSSION

During survey, brown spot disease of rice was observed in

Table 1. Prevalence of brown spot disease of rice in Jammu sub-tropics during 2011.

District	Location	Percent disease index (PDI)	AUBSPC value
	R.S. Pura	37.13	3560
	Bishnah	33.8	3150.45
Jammu	Marh	35.42	3363.25
	Mean ± S.E.(m)	35.45 ± 0.97	3357.93±1182.53
	Range	33.80 - 37.13	3150.45-3560.00
	Nagri	28.43	3076.55
	Kathua	27.55	3025
Kathua	Dyalachak	29.02	3100.42
	Mean ± S.E.(m)	28.33 ± 0.42	3067.30±1592.93
	Range	27.55 - 29.02	3025.00-3100.42
	Sanoora	26.51	2921.75
	Raipur	28.16	3063.75
Samba	Vijaypur	29.34	3105
	Mean ± S.E.(m)	28.00 ± 0.82	3030.23±55.51
	Range	26.51-29.34	2921.75-3105.00
Overall mean ± S.E.(m)		30.59 ± 2.43	3151.83±1036.02
Overall range		26.51 - 37.13	2921.75-3560.00

all the rice growing areas of Jammu sub-tropics during *kharif*-2011 with maximum percent disease index (PDI) of 37.13 and Area Under Brown Spot Progress Curve (AUBSPC) value of 3560.00 at R.S. Pura in Jammu district, whereas, minimum per cent disease index (PDI) of 26.51 and AUBSPC of 2921.75 were observed at Sanoora in district Samba (Table 1). The variation in PDI and AUBSPC at different locations may be due to the variations of environmental factors prevailing in these areas coupled with cultivation of susceptible varieties. Jones et al. (1993) have also reported that incidence and severity of brown spot under low land irrigated conditions in Cameroon region was higher as compared to the uplands.

In vitro evaluation of fungicides against *B. oryzae*

The data recorded revealed that among the different fungicides tested against *B. oryzae*, propiconazole was observed to be most effective with 97.89, 92.14, 91.92, 91.90 and 90.87% inhibition at 250, 200, 150, 100 and 50 ppm concentrations, respectively, as compared to control (Table 2). The minimum percent inhibition was exhibited by triademefon (26.29%) at 50 ppm concentration. However, there were significant differences among the different fungicides tested at various concentrations. Ahmad et al. (2002) had reported that propiconazole under *in-vitro* conditions was most effective in inhibiting the mycelial growth of *B. oryzae* with percent inhibition of 95.98 at 500 ppm concentration. Sisterna and Ronco (1994) also reported that propiconazole at 500 ppm concentration significantly reduced the mycelial growth of *B. oryzae*.

Effect of foliar application of fungicides on the severity of brown spot of rice

Data presented in Table 3 exhibited that during 2011, the mean brown spot severity was found to range from 19.60 to 41.67% in untreated plots among the respective tested varieties. Propiconazole was followed by mancozeb, tricyclazole and azoxystrobin in reducing the disease severity of brown spot in Basmati-370 (12.67, 13.33, 16.67 and 20.23%) Jaya (5.53, 7.13, 10.63 and 15.33%), PC-19 (6.24, 7.87, 11.43 and 16.69%) and the percent reduction in diseases severity of theses varieties to the tune of 69.60, 68.00, 60.00 and 51.45, 71.77, 63.61, 45.75 and 21.77 and 68.32, 61.89, 44.65 and 19.17, respectively, as compared to their respective controls (Figure 1). The disease reduction due to the application of propiconazole and mancozeb were statistically at par with each other in all the varieties, however, maximum disease reduction was recorded in Jaya followed by Basmati-370. Similar pattern for suppression of brown spot disease by fungicides was also observed during the second year (2012). This may be due to demethylation of C-14 during ergosterol biosynthesis that leads to accumulation of C-14 methyl sterols. Biosynthesis of ergosterols is critical to the formation of cell walls of fungi which was effectively inhibited by propiconazole prevented further infection or invasion of host tissues. Interaction of fungicides with varieties showed that all the application of fungicide in

Table 2. *In- vitro* evaluation of fungicides against *B. oryzae*

Treatment	Mean radial growth (mm) of *Bipolaris oryzae* at different concentrations									
	50 ppm	Inhibition (%)	100 ppm	Inhibition (%)	150 ppm	Inhibition (%)	200 ppm	Inhibition (%)	250 ppm	Inhibition (%)
Hexaconazole	43.87	28.67	42.94	30.19	30.07	41.35	28.67	53.39	19.67	68.02
Tricyclazole	43.00	29.81	33.30	45.85	23.47	61.39	14.33	76.70	5.80	90.57
Azoxystrobin	31.73	48.40	28.47	53.71	23.37	62.00	22.50	63.40	18.37	70.14
Propiconazole	5.60	90.87	5.00	91.90	4.97	91.92	4.84	92.14	1.30	97.89
Carbendazim	35.04	43.03	35.63	42.06	32.20	47.64	27.67	55.01	21.30	65.36
Mancozeb	17.34	71.81	14.34	76.70	12.34	79.95	11.34	81.57	7.50	87.80
Triademefon	45.34	26.29	41.83	31.98	34.67	43.63	30.67	50.14	25.34	58.81
Control	61.50	0.00	61.50	0.00	61.50	0.00	61.50	0.00	61.50	0.00
S.E(±)						0.82				
C.D. (p=0.05)						2.55				

Table 3. Effect of foliar application of fungicides on the severity of brown spot of rice.

Treatment	Disease Severity (%)						Mean
	Basmati-370		Jaya		PC-19		
	2011	2012	2011	2012	2011	2012	
Control	41.67	43.25	19.60	21.00	20.65	22.05	28.03
Propiconazole	12.67	13.17	05.53	05.44	06.24	06.41	08.24
Mancozeb	13.33	14.42	07.13	06.94	07.87	07.74	09.57
Tricyclazole	16.67	17.36	10.63	10.45	11.43	11.21	12.95
Azoxystrobin	20.23	20.99	15.33	15.55	16.69	17.00	17.63
Carbendazim	24.00	24.25	18.25	18.64	18.95	19.15	20.54
Hexaconazole	26.40	26.93	18.96	18.47	19.84	19.40	21.66
Mean	22.13	22.91	13.63	13.78	14.52	14.70	
C.D. (p=0.05)							
Variety	0.560	1.578					
Chemical	0.856	1.033					
Variety × Chemical	1.483	2.734					

Basmati 370 differs significantly with other varieties; however, fungicides application was at par with each other in Jaya and PC 19 during both years. Hossain et al. (2011) have reported that azoxystrobin and propiconazole at 0.1% resulted in reduction in disease severity of brown spot of rice and increased (32.17 and 26.76%) in yield. Lore et al. (2007) also reported that propiconazole 25 EC at 0.1% was found to be effective against sheath blight, sheath rot, brown spot and glume discoloration in rice.

Effect of foliar application of fungicides on yield of rice varieties

The data presented in Table 4 revealed that during 2011, among all the six fungicides tested against brown spot of rice, propiconazole was followed by mancozeb and tricyclazole in increasing the yield of all the rice varieties *viz*., Basmati-370 (28.67, 26.69, 26.02q/ha), Jaya (42.44, 40.17 and 39.88 q/ha) and PC-19 (44.56,42.23 and 41.17 q/ha) and the percent increase in yield of these varieties over their respective controls were to the tune of 27.19, 18.41 and 15.43; 15.10, 8.95 and 8.16; and 28.60, 21.87 and 18.81, respectively (Figure 2). The yield obtained with the application of different fungicides also followed the similar trend during the second year, that is, kharif 2012. During both years, interaction of fungicides with varieties showed that all the treatments of fungicide application in Basmati 370 differ significantly with Jaya and PC-19, however, fungicides application was at par with each other in Jaya and PC 19. Perich and Hout (1989) also recorded that inoculated plants which received one application of propiconazole followed by two applications of mancozeb had higher yields (38 to 120%), as compared to untreated plots. It is concluded that continuous cultivation of susceptible varieties has resulted increase in disease

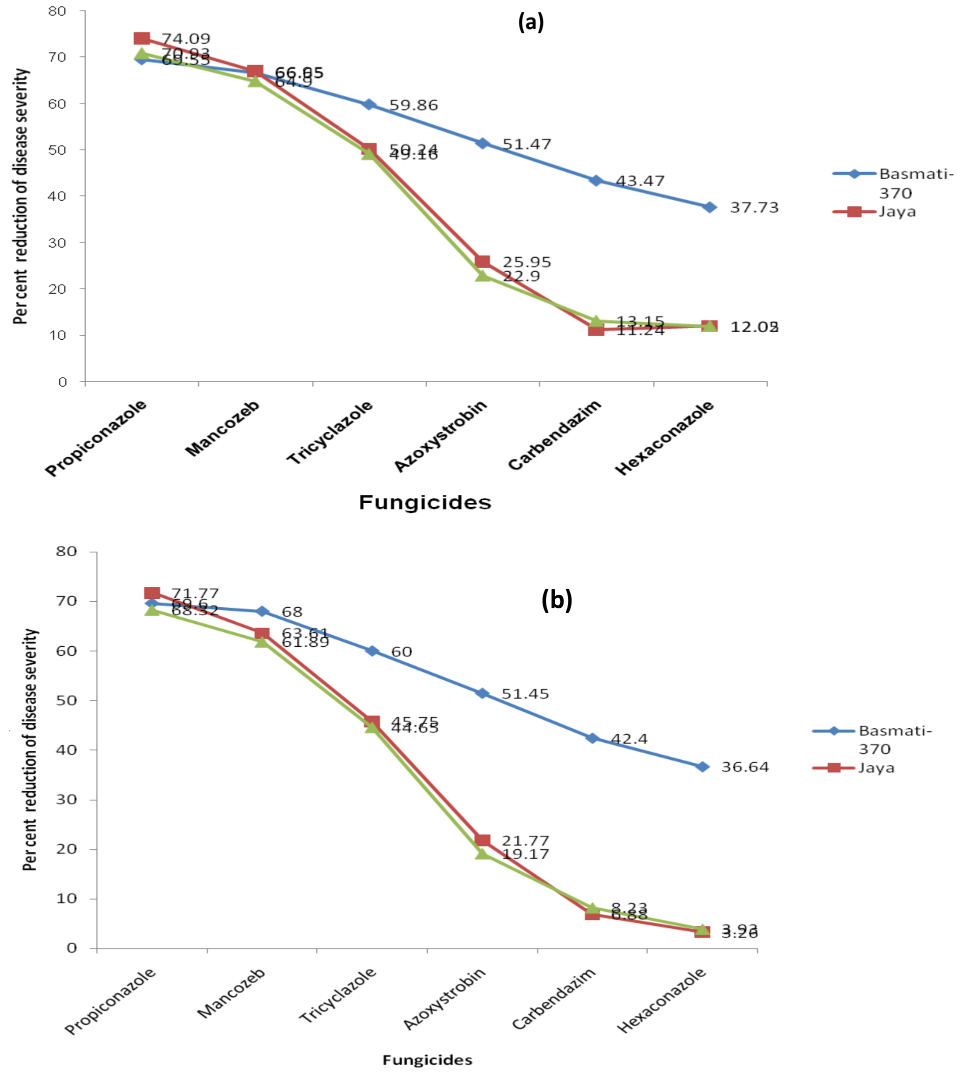

Figure 1. Effect of fungicides on percent reduction of severity of brown spot of rice (1) During 2011 and (2) During 2012.

Table 4. Effect of foliar application of fungicides on yield (q/ha) in different varieties of rice.

Treatment	Yield (q/ha)						Mean
	Basmati-370		Jaya		PC-19		
	2011	2012	2011	2012	2011	2012	
Control	22.54	23.2	36.87	37	34.65	35.03	31.54
Propiconazole	28.67	28	42.44	42.11	44.56	43.89	38.27
Mancozeb	26.69	26.02	40.17	39.5	42.23	41.56	36.02
Tricyclazole	26.02	25.35	39.88	39.21	41.17	40.5	35.35
Azoxystrobin	25.99	25.25	39.04	38.37	40.1	39.43	34.69
Carbendazim	25.1	24.43	38.75	38.08	39.46	38.79	34.10
Hexaconazole	24.64	23.97	38.22	37.55	37.86	37.19	33.23
Mean	25.66	25.17	39.33	38.83	40.00	39.48	
C.D. (p=0.05)							
Variety	0.733	1.208					
Chemical	1.196	0.740					
Variety × Chemical	1.988	2.094					

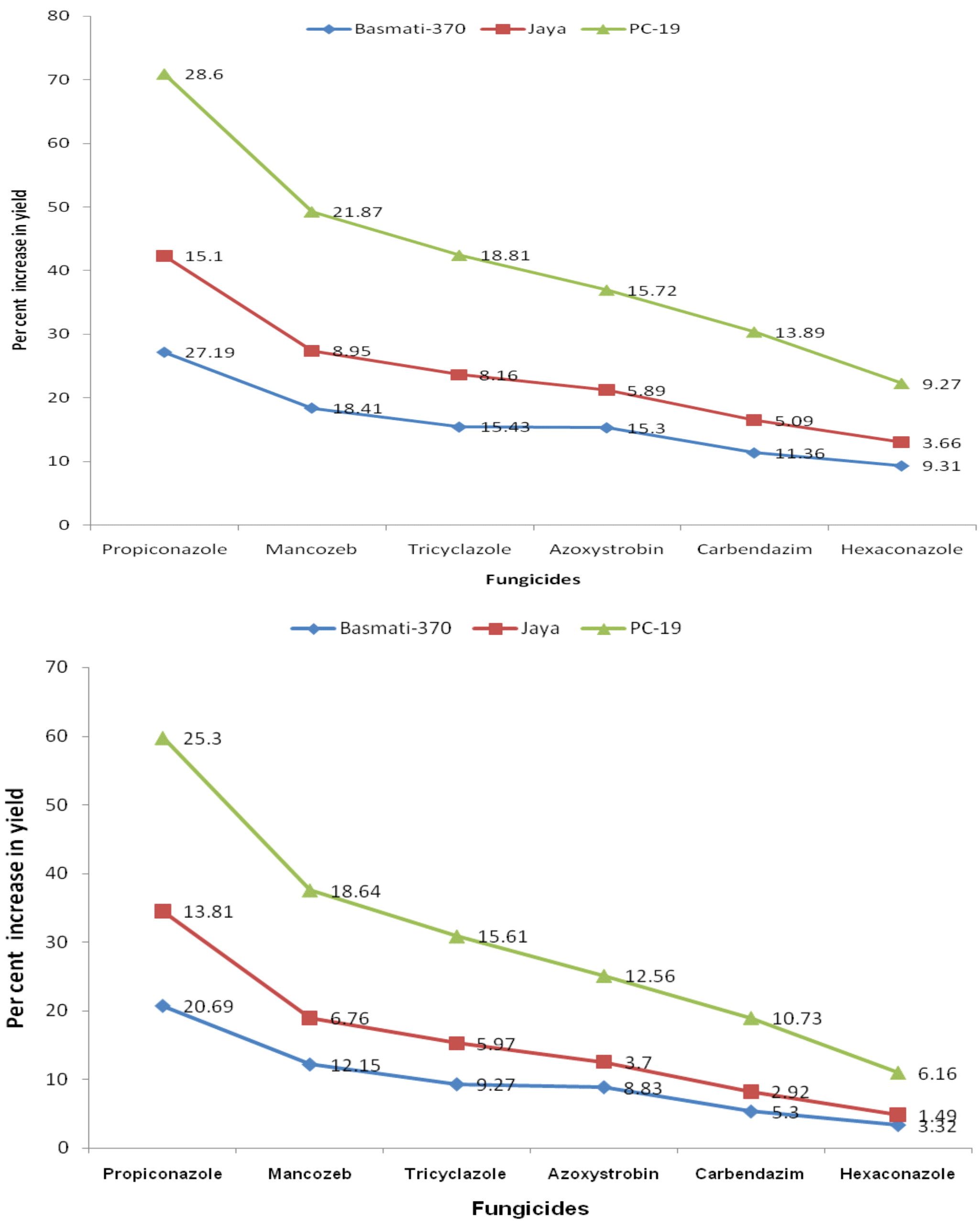

Figure 2. Effect of fungicides on percent increase of yield in rice.

severity of brown spot of rice. Propiconazole at 0.1% concentration can be applied as foliar spray for reducing the disease severity of brown spot of rice and simultaneously increased the grain yield.

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