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## Integrated management of sheath rot and brown spot of paddy

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### Abstract

The trial was conducted subsequently during three years for development of integrated disease management module in rice with main plot treatments consisting of seed treatment (ST) of benomyl (0.3%) followed by *Pseudomonas fluorescens* (0.5%) and cultural practices (CP) like soil application of rice husk ash (RHA) at sowing on raised beds (1 kg m<sup>-2</sup>) + soil application of rice straw (RS) @ 2 tones ha<sup>-1</sup> at transplanting and no ST and CP together with eight fungicide treatments including absolute control as subplot treatments. The pooled results revealed that the lowest sheath rot (25.02%) and brown spot (11.11) diseases with highest disease reduction of 63.05 and 79.69 per cent, respectively were recorded in the treatment combination of ST + CP with three sprays of propiconazole (0.1%) at 15 days interval starting first spray at disease appearance. Thereby, this treatment produced highest grain (35.57 q/ha) and straw (40.09 q/ha) yield with substantial increase in the grain (101.23%) and straw (93.10%) yields as well as gave higher monetary benefits such as total monetary returns of Rs. 58048.85 ha<sup>-1</sup>, net profit of Rs. 30905.85 ha<sup>-1</sup>, and B : C ratio of 2.14. This was followed by ST + CP with sprays of bitertanol (0.25%), carbendazim (0.1%) and tricyclazole (0.10%).

**Keywords:** IDM, paddy, brown spot, sheath rot

### Introduction

Rice (*Oryza sativa* L.) is the most important staple food grain of humid and sub-humid Asia. The productivity of rice is less (1.8 t/ha) in Maharashtra as compared to India (2.41 t/ha) [Anonymous, 2014]<sup>[3]</sup>. The major constraints for low productivity are diseases occurring on this crop. More than 70 diseases are caused by fungi, bacteria, viruses or nematodes on rice. Among the several diseases infecting rice, the severe diseases infecting rice in Maharashtra are sheath rot (*Sarocladium oryzae* = *Acrocladium oryzae*) and brown spot *Bipolaris oryzae* (*Cochliobolus miyabeanus*) which cause about 30-40 per cent loss in paddy yield depending upon the location, variety infected and severity of diseases.

Sustainable agriculture depends on the use of chemical fungicides, pesticides, herbicides and fertilizers. Repeated use of these chemicals is causing severe concern from the health and environmental point of view. In view of these, the development of IDM based control method of diseases is now viewed not only as an eco-friendly but also sustainable agriculture.

Earlier, it is reported that the rice disease pathogens have been reduced in intensity by silicon (Si) application in rice due to increased resistance (Datnoff *et al.*, 1992 and 2001; Rodrigue *et al.*, 2003 and 2004 and Rodrigue and Datnoff, 2005)<sup>[10, 19, 20]</sup>. Hence, soils known to be low in plant-available silicon should be amended with calcium silicate slag or other silica sources. In addition, application of the plant growth promoting rhizobacteria (*Pseudomonas fluorescens*) as seed treatment, broadcasting and foliar spray significantly performed the best results in reduction of six-important diseases (bacterial leaf blight, blast, brown spot, narrow brown spot, sheath blight and dirty panicle caused by *Xanthomonas oryzae* pv. *oryzae*, *Pyricularia grisea*, *Helminthosporium oryzae*, *Cercospora oryzae*, *Rhizoctonia solani*; and complex pathogens including *C. oryzae*, *Curvularia lunata*, *H. oryzae*, *Fusarium semitectum*, *Alternaria padwickii*, and *Sarocladium oryzae*, respectively) and increased yield with 52.1 per cent in rice (Prathuangwong *et al.*, 2012)<sup>[17]</sup>.

Hence, looking to the severity of diseases, their economic importance and need of the rice growers, it was very necessary to manage these diseases by integration of all available disease management practices. Therefore, the field trials were conducted by integration of cultural,

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biological and chemical methods for management of brown spot and sheath rot of rice.

### Materials and Methods

A field experiment was conducted at Agricultural Research Station, Lonavala, Tal.-Maval, Dist.-Pune (MS) for consecutive three years during the *kharif* seasons of 2009, 2010 and 2011. The experimental design was a split-plot with three replications. Main plot treatments consisted of seed treatment (ST) with benomyl (0.3%) followed by *Pseudomonas fluorescens* (0.5%) and cultural practices (CP) like soil application of rice husk ash (RHA) at sowing on raised beds ( $1 \text{ kg m}^{-2}$ ) + soil application of rice straw (RS) @ 2 tones  $\text{ha}^{-1}$  at transplanting and no ST + CP. The subplots included eight fungicide treatments *viz.*, carbendazim (0.1%), propiconazole (0.1%), bitertanol (0.25%), tricyclazole (0.1%), iprobenphos (0.25%), Kasugamycin (0.25%) and alternate sprays with mancozeb (0.25%) followed by benomyl (0.1%) and copper oxychloride (0.25%) including absolute control. Subplots ( $3.0 \times 1.95 \text{ m}$ ) of each of the treatment consisted of 13 rows of 3.0 m long at 0.20 m distance with 0.15 m plant to plant spacing. The fungicide and bioagent treated seeds of EK 70, a highly susceptible variety of rice, were sown on the raised beds mixed with the rice husk ash during the last week of June while, the transplanting of seedlings was carried out in the last week of July during every year of experimentation. The rice straw was added before transplanting in the puddled field. The crop was fertilized with 50N:50P:50K as basal dose and top dressed with 50 N one month after transplanting. The first spray of fungicides was taken immediately after appearance of disease and was followed by two sprays at 15 days interval thereafter. The observations on diseases were recorded by following 0-9 SES scale as per IRRI, Philippines (Anonymous, 2013) and then converting into per cent disease intensity by using the formula.

$$\text{Sum of the scores} \times 100$$

$$\text{Per cent disease intensity} = \frac{\text{Sum of the scores} \times 100}{\text{Number of observations} \times \text{highest rating i.e. 9}}$$

The data on the grain and straw yields were recorded in net plot as described by Seebold *et al.*, 2004<sup>[22]</sup> and tillers within the plot were cut and harvested in order to determine the yield.

### Results

The pooled data (Tables 1 to 4) of all diseases under study indicate that the treatment differences due to ST + CP and fungicides as well as their interactions were statistically significant.

#### Sheath rot

Three years pooled data of sheath rot depicted in Table 1 indicate that the ST + CP had significantly lowest incidence (73.63%) and intensity (33.01%) of sheath rot and thereby showed highest disease reduction of 51.25 per cent. The treatment with fungicide bitertanol (0.25%) recorded least incidence (66.68%) and intensity (23.00%) and thus maximum disease control of 66.04 per cent. However, it was at par with carbendazim (0.1%) and propiconazole (0.1%) in respect of intensity, which showed 60.81 and 56.60 per cent disease reduction over control, respectively. Thereafter, among interactions, the lowest incidence and intensity of 61.39 and 18.22 per cent, respectively with highest disease reduction of 73.09 per cent were recorded in the treatment

combination of ST + CP with sprays of bitertanol (0.25%). Whereas, it was at par with ST + CP with spray of carbendazim (0.1%) that had 22.29 per cent sheath rot severity with 67.08 per cent disease reduction. This was followed by ST + CP with sprays of propiconazole (0.1%) where disease intensity of 25.02 per cent with 63.05 per cent control was noticed.

#### Brown spot

Three years' pooled observations on brown spot disease given in Table 2 indicate that the ST + CP had significantly lowest incidence (48.24%) and intensity (22.48%) of brown spot and hence showed 58.91 per cent decrease in disease as compared to no ST and CP. As regard to bio-efficacy of fungicides, propiconazole (0.1%) recorded significantly least incidence of 41.58 and intensity of 14.75 per cent and thereby highest disease control of 73.04 per cent. However, as regards severity, propiconazole was on par with bitertanol (0.25%) that showed 19.16 per cent brown spot with 64.98 per cent disease reduction over control. The interaction between ST + CP with sprays of propiconazole (0.1%) had least disease incidence (36.03%) and severity (11.11%) and highest brown spot disease control of 79.69 per cent over control. This was followed by ST + CP with sprays of bitertanol (0.25%), wherein 72.39 per cent disease control was noticed.

#### Grain and straw yield

Three years pooled observations presented in Table 3 illustrate that the ST + CP yielded significantly highest grain ( $29.90 \text{ q ha}^{-1}$ ) and straw ( $32.14 \text{ q ha}^{-1}$ ) yield with 66.94 and 54.80 per cent increase in respective yields. Similarly, significantly highest grain ( $33.69 \text{ q ha}^{-1}$ ) and straw ( $37.85 \text{ q ha}^{-1}$ ) yields with 90.57 and 82.28 per cent increase in grain and straw yield, respectively were noticed in propiconazole (0.1%). Further, propiconazole was followed by carbendazim (0.1%) and bitertanol (0.25%) those recorded 31.73 and 29.76 q grain as well as 35.32 and 32.71 q straw yields  $\text{ha}^{-1}$  thus, 79.50 and 68.36 and 70.10 and 57.52 per cent increase in grain and straw yields over control, respectively. The treatment combination of ST+CP with sprays of propiconazole (0.1%) yielded significantly highest grain ( $35.57 \text{ q ha}^{-1}$ ) and straw ( $40.10 \text{ q ha}^{-1}$ ) yield thereby, substantial increase in the grain (101.23%) and straw (93.10%) yields over control. However, it was at par with ST + CP with sprays of carbendazim (0.1%) wherein, 33.61 and 37.37 q grain and straw yields  $\text{ha}^{-1}$  were obtained with 90.14 and 79.98 per cent increase in grain and straw yields, respectively.

#### Economics of IDM in paddy

The data regarding monetary returns and B: C ratio presented in Table 4 reveal that ST + CP gave significantly highest total monetary returns of Rs. 46891.47  $\text{ha}^{-1}$ , net profit of Rs. 19106.85  $\text{ha}^{-1}$ , additional monetary returns of Rs. 19747.57  $\text{ha}^{-1}$  and B: C ratio of 1.69 as against no ST and CP where these parameters were Rs. 39730.66  $\text{ha}^{-1}$ , Rs. 13940.04  $\text{ha}^{-1}$ , Rs. 12586.76  $\text{ha}^{-1}$  and 1.54, respectively. Similarly, significantly highest monetary returns (Rs. 53650.13  $\text{ha}^{-1}$ ), net profit (Rs. 27504.13  $\text{ha}^{-1}$ ), additional monetary returns (Rs. 26506.23  $\text{ha}^{-1}$ ) and B: C ratio (2.05) were noticed in propiconazole (0.1%). This was followed by carbendazim (0.1%), tricyclazole (0.1%), Kasugamycin (0.2%) and alternate sprays, which showed B: C ratios of 1.98, 1.66, 1.54 and 1.52, respectively. Further, the treatment combination of ST + CP with sprays of propiconazole (0.1%) gave

significantly highest monetary returns (Rs. 58048.85 ha<sup>-1</sup>), net profit (Rs. 30905.85 ha<sup>-1</sup>), additional monetary returns (Rs. 30904.94 ha<sup>-1</sup>) and B: C ratio (2.14). This was followed by ST + CP with sprays of carbendazim, tricyclazole (0.10%), alternate sprays and Kasugamycin (0.20%) wherein, B: C ratios of 2.05, 1.73, 1.60 and 1.60 were recorded, respectively.

### Discussion

The seed treatment with benomyl and *Pseudomonas fluorescens* + cultural practices reduced the severity of sheath rot and brown spot of paddy to a considerable extent.

Among the fungicides, propiconazole (0.1%) recorded significantly least incidence and intensity and thereby highest disease control of brown spot while, it was on par with carbendazim (0.1%) and bitertanol (0.25%). However, the fungicides, bitertanol were found to be more effective for management of sheath rot and was followed by propiconazole. Das and Nayak (1997) [6] and Nagrale *et al.* (2013) [15] recorded significant reduction in sheath rot due to sprays of carbendazim at 0.1 per cent. The findings are also in agreement with the reports of Dodan and Ram Singh (1996) [11], Venkateswarlu and Venkateswarlu (2004) [25] and Venkateswarlu *et al.* (2004) [25] who noticed that carbendazim and propiconazole at 0.1 per cent each were the most effective fungicides for reducing sheath rot incidence in paddy. As regards brown spot, the results are in conformity with the findings of Sunder *et al.* (2005) [23] wherein they also reported best control of brown spot of rice by propiconazole (78.7%).

The interaction of ST + CP with sprays of propiconazole (0.1%) had significantly brown spot severity with highest reduction of these diseases however, this treatment combination was at par with ST + CP with sprays of carbendazim (0.1%).

Thereafter, among interactions, the lowest incidence and intensity of sheath rot with highest disease reduction were recorded in the treatment combination of ST + CP with sprays of bitertanol (0.25%) whereas; it was at par with ST + CP with spray of carbendazim (0.1%). This was followed by ST + CP with sprays of propiconazole (0.1%). These findings are in consonance with the work of Bag *et al.* (2010) [4] who while evaluating new commercially available botanicals, biopesticides and fungicides against sheath rot of rice under West Bengal conditions found that all the treatments including *Pseudomonas fluorescens* and carbendazim reduced the disease incidence compared to the control plot Prabhu (1989) [16] mentioned that integrated management involving cultural methods, selection of resistant cultivars and chemical treatments reduced the principal diseases of rice *viz.*, brown spot in central Brazil that is in conformity with present findings. The foregoing results are nearly matching with the report of Raja and Saravanan (1993) [18] who developed an integrated diseases management module in paddy consisting of seed treatment with carbendazim (2 g/kg) and *Pseudomonas fluorescens* (10g/kg seed) and sprays with fungicide carbendazim (0.05%) or tricyclazole (0.08%) for management of important rice diseases. Datnoff *et al.* (2001) [1] in their integrated disease management studies, including use of silica and fungicides, indicated that levels of several important diseases of rice *viz.*, blast, brown spot, sheath blight, leaf scald and grain discoloration reduced to a greater extent hence, the number of fungicide applications and rates can be reduced significantly worldwide. Similarly, Datnoff and Rodrigues (2005) [9] also reported that application of silicon in combination with fungicide sprays with

propiconazole (0.44 liters/ha) greatly reduced the rice diseases *viz.*, leaf blast, neck blast, brown spot, grain discoloration, leaf scald and sheath blight. In addition, Rodrigues and Datnoff (2005) [9] noticed that the element silicon (Si) effectively managed the rice diseases such as blast, brown spot and sheath blight. Further, Lore *et al.* (2007) [13] noticed that fungicide propiconazole @ 0.1% was the most effective against rice diseases *viz.*, sheath blight, sheath rot, brown spot and grain discoloration and was followed by carbendazim @ 0.1%, which is in agreement with the present studies. Besides, Prathuangwong *et al.* (2012) [17] noticed the most effectiveness of plant growth promoting rhizobacteria *Pseudomonas fluorescens* SP007s as seed treatment, broadcasting, and foliar spray for suppression of the incidence of various rice diseases like bacterial leaf blight, blast, brown spot, narrow brown spot, sheath blight and dirty panicle.

The data regarding yield and monetary benefits indicated that the ST+CP yielded significantly highest grain and straw yields with considerable increase in yields, total monetary returns and B: C ratio. Similarly, significantly highest grain and straw yields as well as total monetary returns and B : C ratio were noticed in propiconazole (0.1%) that was followed by carbendazim (0.1%), tricyclazole (0.1%), Kasugamycin (0.2%) and alternate sprays. Datnoff and Rodrigues (2005) [9] reported that application of silicon in combination with fungicide sprays of propiconazole greatly reduced the rice diseases and increased the grain yield to great extent that is matching with the present findings. The results are also in agreement with the work of Hossain and Kulkarni (2001) and Sunder *et al.* (2005) [23] who recorded propiconazole as the best fungicide in managing the rice diseases and getting higher yields. Further, propiconazole was followed by carbendazim (0.1%) and bitertanol (0.25%) that also recorded increase in grain and straw yields over control. Dodan and Ram Singh (1996) [11] and Venkateswarlu and Venkateswarlu (2004) [25] also noticed that propiconazole and carbendazim were the most effective fungicides for reducing paddy diseases with a corresponding increase in grain and straw yields. Similarly, Das and Nayak (1997) [6], Tirmali *et al.* (2001) and Nagrale *et al.* (2013) [15] also noticed carbendazim at 0.1 per cent as highly effective in controlling the rice diseases and significantly increased grain yield.

The treatment combination of ST + CP with sprays of propiconazole (0.1%) yielded significantly highest grain as well as straw yield with more total monetary returns and B: C ratio and thereby substantial increase in respective parameters over control. However, it was at par with ST + CP with sprays of carbendazim (0.1%). The findings are in conformity with the report of Bag *et al.* (2010) [4] wherein they found that integration of botanicals, biopesticides (*Pseudomonas fluorescens*) and fungicide (carbendazim) reduced the rice disease incidence and increased grain yield compared to the control plot. The results are also in agreement with Alvarez and Datnoff (2001) [1] Datnoff who also noticed the beneficial effects of integrated management including silicon application on disease management and world rice production that have been translated to monetary values using a yield and cost-price structure. In addition, Datnoff and Rodrigues (2005) [9] reported that application of silicon in combination with fungicide sprays with propiconazole greatly reduced the rice diseases and increased the grain yield as well as monetary returns to great extent that is in agreement with the present findings.

**Table 1:** Influence of seed treatment, cultural practices and fungicides on management of sheath rot of paddy (Three years' pooled results: 2009, 2010 and 2011)

Sr. No.	Fungicides	Conc. (%)	Per cent sheath rot								
			Incidence			Intensity			Reduction (%)		
			Weighted pooled means			Pooled means					
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1.	Carbendazim	0.1	66.04	74.07	70.06	22.29	30.78	26.54	67.08	54.54	60.81
			47.60	52.71	50.16	28.07	33.65	30.86			
2.	Propiconazole	0.1	67.89	76.50	72.19	25.02	33.76	29.39	63.05	50.15	56.60
			49.29	54.77	52.01	30.00	35.45	32.73			
3.	Bitertanol	0.25	61.39	71.98	66.68	18.22	27.77	23.00	73.09	58.98	66.04
			45.38	51.84	48.61	25.02	31.44	28.23			
4.	Tricyclazole	0.1	75.06	82.47	78.77	33.35	42.89	38.12	50.74	36.65	43.70
			54.16	59.28	56.72	35.08	39.88	37.48			
5.	Iprobenphos	0.25	77.87	86.05	81.96	37.81	49.33	43.57	44.16	27.14	35.65
			56.33	61.81	59.07	37.85	44.69	41.27			
6.	Kasugamycin	0.25	71.47	78.29	74.88	28.79	38.32	33.56	57.48	43.41	50.44
			51.86	57.07	54.46	32.40	38.22	35.31			
7.	Alternate sprays	-	80.19	87.91	84.05	42.96	52.85	47.91	36.56	21.94	29.25
			57.95	63.95	60.95	40.88	46.70	43.79			
8.	Control	-	89.18	98.36	93.77	55.62	67.71	61.67	17.86	0.00	8.93
			68.18	82.61	75.40	48.36	55.64	52.00			
	Mean		73.63	81.95		33.01	42.93		51.25	36.60	
			60.91	68.10		34.70	40.83				

Source	Incidence			Intensity		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (0.05)	CV (%)
Main plots	0.37	1.20	12.74	0.28	0.93	12.11
Sub plots	0.83	1.65		1.55	4.70	
Main X Sub plots	1.17	2.34		1.56	4.49	

**Table 2:** Influence of seed treatment, cultural practices and fungicides on management of brown spot of paddy (Three years' pooled results: 2009, 2010 and 2011)

Sr. No.	Fungicides	Conc. (%)	Per cent brown spot								
			Incidence			Intensity			Reduction (%)		
			Weighted pooled means			Pooled means					
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1.	Carbendazim	0.1	47.60	58.62	53.11	21.50	31.41	26.46	60.70	42.59	51.64
			41.09	46.84	48.37	30.79	36.98	33.88			
2.	Propiconazole	0.1	36.03	47.13	41.58	11.11	18.39	14.75	79.69	66.39	73.04
			34.80	37.90	41.86	22.72	28.38	25.56			
3.	Bitertanol	0.25	40.27	51.36	45.81	15.10	23.22	19.16	72.39	57.57	64.98
			36.94	40.02	44.39	25.71	31.20	28.46			
4.	Tricyclazole	0.1	45.04	55.13	50.09	19.93	29.29	24.61	63.58	46.47	55.02
			39.96	46.23	46.80	29.71	35.58	32.65			
5.	Iprobenphos	0.25	55.36	65.24	60.30	27.43	36.96	32.19	49.87	32.45	41.16
			45.85	51.59	52.89	35.99	41.05	38.52			
6.	Kasugamycin	0.25	42.44	53.74	48.09	16.87	25.87	21.37	69.17	52.71	60.94
			39.63	46.28	46.02	24.81	33.25	30.52			
7.	Alternate sprays	-	52.30	62.45	57.38	24.47	33.68	29.08	55.27	38.44	46.86
			44.53	49.93	50.58	33.70	38.51	36.11			
8.	Control	-	66.88	79.51	73.19	43.43	54.71	49.07	20.61	0.00	10.30
			50.67	58.35	59.66	45.46	51.47	48.47			
	Mean		48.24	59.15		22.48	31.69		58.91	42.08	
			41.60	47.98		27.55	33.89				

Source	Incidence			Intensity		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (0.05)	CV (%)
Main plots	0.22	0.73	5.33	0.49	2.98	7.10
Sub plots	0.42	0.83		0.38	0.76	
Main X Sub plots	1.35	3.91		0.54	1.08	

**Note:** The figures in the bold faces are arcsin values

**M1:** Seed treatment and cultural practices

**M2:** No seed treatment and cultural practices

**Table 3:** Influence of integrated management of different diseases on yield of paddy (Three years' pooled results: 2009, 2010 and 2011)

Sr. No.	Fungicides	Conc. (%)	Yield of											
			Grains (q ha <sup>-1</sup> )						Straw (q ha <sup>-1</sup> )					
			Weighted pooled means			Increase over control (%)			Pooled means			Increase over control (%)		
M1	M2	Mean	M1	M2	Mean	M1	M2	Mean	M1	M2	Mean			
1.	Carbendazim	0.1	33.61	29.85	31.73	90.14	68.86	79.50	37.37	33.27	35.32	79.98	60.22	70.10
2.	Propiconazole	0.1	35.57	31.80	33.69	101.23	79.91	90.57	40.09	35.60	37.85	93.10	71.46	82.28
3.	Bitertanol	0.25	31.63	27.89	29.76	78.96	57.76	68.36	34.50	30.91	32.71	66.18	48.87	57.52
4.	Tricyclazole	0.1	30.16	26.74	28.45	70.60	51.30	60.95	32.26	28.82	30.54	55.37	38.82	47.10
5.	Iprobenphos	0.25	26.70	23.67	25.19	51.07	33.92	42.49	28.41	25.05	26.73	36.84	20.66	28.75
6.	Kasugamycin	0.25	28.44	25.56	27.00	60.87	44.60	52.74	30.74	27.21	28.98	48.04	31.06	39.55
7.	Alternate sprays	-	27.26	24.32	25.79	54.22	37.57	45.90	29.00	25.97	27.49	39.69	25.08	32.38
8.	Control	-	22.70	17.68	20.19	28.43	0.00	14.21	24.75	20.76	22.75	19.18	0.00	9.59
	Mean		29.90	26.10		66.94	46.74		32.14	28.45		54.80	37.02	

Source	Grain yield			Straw yield		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (0.05)	CV (%)
Main plots	0.28	0.92	12.79	0.2	0.66	14.87
Sub plots	0.72	1.44		1.0	2.84	
Main X Sub plots	1.02	2.04		1.33	3.71	

**Table 4:** Total monetary returns, net profit and B: C ratio as influence by IDM in paddy (Three years' pooled results: 2009, 2010 and 2011)

Tr. No.	Name of fungicides	Dose (%)	Total monetary returns (Rs. ha <sup>-1</sup> )			Total cost of cultivation (Rs. ha <sup>-1</sup> )			Net profit (Rs. ha <sup>-1</sup> )		
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1.	Carbendazim	0.1	54078.71	46408.39	50243.55	26373	24379	25376	27705.71	22029.39	24867.55
2.	Propiconazole	0.1	58048.85	49251.41	53650.13	27143	25149	26146	30905.85	24102.41	27504.13
3.	Bitertanol	0.25	51589.08	43970.65	47779.87	33149	31155	32152	18440.08	12815.65	15627.87
4.	Tricyclazole	0.1	48126.30	41223.00	44674.65	27829	25835	26832	20297.30	15388.00	17842.65
5.	Iprobenphos	0.25	41248.99	34958.22	38103.61	28284	26290	27287	12964.99	8668.22	10816.61
6.	Kasugamycin	0.2	45147.91	38782.37	41965.14	28137	26143	27140	17010.91	12639.37	14825.14
7.	Alternate sprays	0.1	42925.02	36107.36	39516.19	26901	24907	25904	16024.02	11200.36	13612.19
8.	Control	--	33966.92	27143.90	30555.41	24461	22467	23464	9505.92	4676.90	7091.41
	Mean		46891.47	39730.66		27785	25791		19106.85	13940.04	

Source	Total monetary returns			Net profit (Rs. ha <sup>-1</sup> )		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (5%)	CV (%)
Main plots	455.53	2771.84	6.92	455.53	2771.84	18.14
Sub plots	1223.74	3545.04		1223.74	3545.04	
Main X Sub plots	1730.63	5013.44		1730.63	5013.44	

**Table 5:** Continued.....

Tr. No.	Name of fungicides	Dose (%)	Additional MROC (Rs. ha <sup>-1</sup> )			Per cent increase in MROC			B:C ratio		
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1.	Carbendazim	0.1	26934.80	19264.49	23099.65	103.66	75.74	89.70	2.05	1.90	1.98
2.	Propiconazole	0.1	30904.94	22107.51	26506.23	119.46	86.59	103.02	2.14	1.96	2.05
3.	Bitertanol	0.25	24445.17	16826.75	20635.96	93.92	66.25	80.09	1.56	1.41	1.48
4.	Tricyclazole	0.1	20982.39	14079.09	17530.74	81.50	56.07	68.78	1.73	1.60	1.66
5.	Iprobenphos	0.25	14105.09	7814.31	10959.70	54.79	32.79	43.79	1.46	1.33	1.39
6.	Kasugamycin	0.2	18004.00	11638.46	14821.23	68.41	45.77	57.09	1.60	1.48	1.54
7.	Alternate sprays	0.1	15781.12	8963.46	12372.29	60.71	36.84	48.78	1.60	1.45	1.52
8.	Control	--	6823.02	0.00	3411.51	25.96	0.00	12.98	1.39	1.21	1.30
	Mean		46891.47	19747.57	12586.76		76.05	50.01		1.69	1.54

Source	Additional MROC			B : C ratio		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (0.05)	CV (%)
Main plots	455.53	2771.84	18.54	0.02	0.09	7.05
Sub plots	1223.74	3545.04		0.05	0.13	
Main X Sub plots	1730.63	5013.44		0.07	0.19	

**Note:** M1 = Seed treatment and cultural practices  
M2 = No seed treatment and cultural practices  
MROC = Monetary returns over control

#### Rates of fungicides

Fungicides	Rs kg/L <sup>-1</sup>	Cost of <i>Pseudomonas fluorescens</i> : Rs. 40 ha <sup>-1</sup>
Carbendazim	560.0	Cost of benomyl for seed treatment: Rs. 124 ha <sup>-1</sup>
Propiconazole	1110.0	RHA + rice straw (waste) with application: Rs. 1870

Bitertanol	2160.0	
Tricyclazole	1600.0	Selling rates of produce
Iprobenphos	770.0	Grains: Rs. 1100 to 1300 q <sup>-1</sup>
Kasugamycin	910.0	Straw: Rs. 335 q <sup>-1</sup>
Benomyl	1030.0	Cost of cultivation common to all treatments: Rs. 22467/-
Mancozeb	290.0	
Copper oxychloride	430.0	

## Conclusions

The seed treatment with benomyl (0.3%) and *Pseudomonas fluorescens* (0.5%) to rice seeds along with cultural practices like soil application of rice husk ash (RHA) at sowing on raised beds @ 1 kg m<sup>-2</sup> as well as soil application of rice straw (RS) @ 2 tones ha<sup>-1</sup> at transplanting followed by three sprays of propiconazole (0.1%) or carbendazim (0.1%) at 15 days interval starting first spray at disease appearance are recommended as a IDM module for effective management of sheath rot and brown spot diseases and increasing the grain and straw yields of paddy as well as monetary returns.

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