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Yuvraj Sopan Balgude
Agricultural Research Station, Lonavala, Tal. Maval, Pune, Maharashtra, India

Anil Parshuram Gaikwad
Agricultural Research Station, Lonavala, Tal. Maval, Pune, Maharashtra, India

Correspondence
Yuvraj Sopan Balgude
Agricultural Research Station, Lonavala, Tal. – Maval, Pune, Maharashtra, India

Integrated management of blast of rice

Yuvraj Sopan Balgude and Anil Parshuram Gaikwad

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^{-2}) + soil application of rice straw (RS) @ 2 tones ha^{-1} 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 leaf blast (10.95%), neck blast (28.71%) and node blast (16.72%) with highest disease reduction of 78.09, 63.84 and 72.32per 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 (leaf blast) 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 monitory benefits such as total monetary returns of Rs. 58048.85 ha^{-1}, net profit of Rs. 30905.85 ha^{-1}, 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; diseases

Introduction
Rice (*Oryza sativa* L.) is the most widely cultivated food crop in the world. It is the most important staple food grain for the people living in the rural and urban areas 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] [3]. 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, one of the most severe diseases infecting rice in Maharashtra is blast caused by *Pyricularia grisea* (*Magnaporthe oryzae*) which cause about 30-80 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 blast 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) [5, 9]. 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 rhizobacterium (*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) [16].

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, biological and chemical methods for management of rice diseases.

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 kg m^{-2}) + soil application of rice straw (RS) @ 2 tones 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 × 1.95 m) of each of the treatment consisted of 13 rows of 3.0 m long at 0.20 m distance with 0.15m 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 any pathogen (i.e. *Pyricularia grisea*) 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, 2002) [2] and then converting into per cent disease intensity by using the formula.

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

The data on the grain and straw yields were recorded in net plot as described by Seebold *et al.*, 2004 [6] and tillers within the plot were cut and harvested in order to determine the yield.

Results

The pooled data (Tables 1 to 2) of all diseases under study indicate that the treatment differences due to ST + CP and fungicides as well as their interactions were statistically significant.

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

Sr. No.	Fungicides	Conc. (%)	Per cent leaf blast								
			Incidence			Intensity					
			Weighted pooled means			Pooled means			Reduction over control (%)		
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1	Carbendazim	0.1	39.59	50.02	44.80	12.59	19.01	15.80	74.80	61.97	68.39
			39.27	46.36	42.82	20.31	35.65	22.98			
2	Propiconazole	0.1	35.20	46.44	40.82	10.95	16.89	13.92	78.09	66.21	72.15
			36.45	42.86	39.66	19.00	23.94	21.48			
3	Bitertanol	0.25	43.36	52.27	47.81	15.85	22.80	19.33	68.29	54.37	61.33
			41.04	48.30	44.67	23.26	28.24	25.75			
4	Tricyclazole	0.1	50.95	60.03	55.49	21.12	28.27	24.69	57.75	43.44	50.59
			44.16	50.48	47.32	27.16	31.91	29.53			
5	Iprobenphos	0.25	60.58	69.02	64.80	33.70	42.78	38.24	32.57	14.40	23.48
			51.09	56.02	53.56	35.34	40.77	38.05			
6	Kasugamycin	0.25	53.98	65.33	59.66	23.69	31.49	27.59	52.60	37.00	44.80
			46.10	53.49	49.80	28.99	34.06	31.53			
7	Alternate sprays	-	56.63	65.86	61.24	28.65	36.36	32.51	42.67	27.25	34.96
			47.85	53.91	50.88	32.08	37.00	34.54			
8	Control	-	69.78	79.64	74.71	39.23	49.98	44.61	21.50	0.00	10.75
			56.95	65.26	61.11	38.71	44.98	41.84			
	Mean		51.26	61.08		23.22	30.95		53.53	38.08	
			46.02	52.52		28.11	33.31				

Source	Incidence			Intensity		
	S.E. ±	C.D. (0.05)	CV (%)	S.E. ±	C.D. (0.05)	CV (%)
Main plots	0.41	1.37	10.24	0.25	0.80	11.23
Sub plots	0.53	1.06		1.42	4.28	
Main X Sub plots	0.75	1.49		2.99	8.63	

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

Sr. No.	Fungicides	Conc. (%)	Per cent incidence of												
			Neck blast						Node blast						
			Pooled means			Reduction over control (%)			Pooled means			Reduction over control (%)			
			M1	M2	Mean	M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
1	Carbendazim	0.1	33.28	41.65	37.46	58.09	47.54	52.81	19.27	26.97	23.12	68.11	55.35	61.73
			35.21	40.18	37.72				25.77	31.07	28.42			
2	Propiconazole	0.1	28.71	37.60	33.15	63.84	52.64	58.24	16.72	24.56	20.64	72.32	59.34	65.83
			32.28	37.75	35.02				23.86	29.48	26.67			
3	Bitertanol	0.25	35.92	45.53	40.73	54.75	42.66	48.70	21.68	30.87	26.28	64.12	48.89	56.51

			36.76	42.42	39.59				27.48	33.50	30.49			
4	Tricyclazole	0.1	39.79 39.07	48.28 44.01	44.04 41.54	49.87	39.18	44.53	24.61 29.53	33.77 35.42	29.19 32.48	59.26	44.10	51.68
5	Iprobenphos	0.25	49.97 45.02	62.18 52.16	56.07 48.59	37.06	21.68	29.37	34.26 35.74	43.49 41.20	38.88 38.47	43.28	28.01	35.64
6	Kasugamycin	0.25	41.84 40.28	50.37 45.21	46.11 42.74	47.29	36.56	41.93	28.42 32.06	36.34 36.97	32.38 34.51	52.95	39.84	46.40
7	Alternate sprays	-	46.93 43.24	57.30 49.25	52.12 46.24	40.89	27.82	34.36	32.90 34.90	40.45 39.41	36.67 37.15	45.54	33.05	39.29
8	Control	-	67.75 57.30	79.39 64.83	73.57 60.95	14.66	0.00	7.33	49.28 44.61	60.41 51.33	54.84 47.96	18.43	0.00	9.21
	Mean		43.02 41.15	52.79 46.98		45.81	33.51	Wt. Mean	28.39 34.81	37.11 40.77		53.00	38.57	

Source	Neck blast			Node blast		
	S.E. ±	**C.D. (0.05)**	**CV (%)**	**S.E. ±**	**C.D. (0.05)**	**CV (%)**
Main plots	0.84	5.09	11.59	0.08	0.24	7.57
Sub plots	2.18	6.60		0.92	2.80	
Main X Sub plots	2.18	6.29		0.96	2.77	

Note: The figures in the bold faces are arcsin values, M1: Seed treatment and cultural practices, M2: No seed treatment and cultural practices

Leaf blast

The three years pooled data of leaf blast (Table 1) reveal that the ST with benomyl (0.3 %) + CP had significantly lowest incidence (51.26 %) and intensity (23.22 %) with 53.53 per cent reduction of disease as compared to no ST and CP wherein, the incidence and intensity were 61.08 and 30.95 per cent, respectively. Further, the treatment with fungicide propiconazole (0.1%) recorded significantly least incidence of 40.82 and intensity of 13.92 per cent and thereby highest disease control of 72.15 per cent. Whereas, propiconazole was on par with carbendazim (0.1%) and bitertanol (0.25%) those had 15.80 and 19.33 per cent leaf blast severity with 68.39 and 61.33 per cent disease reduction over control, respectively. Thereafter, significantly least leaf blast incidence (35.20 %) and intensity (10.95 %) with highest leaf blast reduction of 78.09 per cent over control was recorded in the treatment combination of ST + CP with sprays of propiconazole (0.1%). This was followed by ST + CP with sprays of carbendazim (0.1%) and bitertanol (0.25 %) wherein 74.80 and 68.29 per cent disease control was noticed, respectively. In respect of severity, these treatments were at par with ST + CP with propiconazole (0.1%) spray.

Neck and node blasts

The pooled observations presented in Table 2 show that the ST + CP recorded significantly lowest incidence of neck (43.02 %) and node (28.39 %) blasts with disease control of 45.81 and 53.00 per cent, respectively as against no ST and cultural practices. The fungicidal treatment with propiconazole (0.1%) had significantly least incidence of neck (33.15 %) and node (20.64 %) blasts and thus showed highest disease control of 58.24 and 65.83 per cent of these diseases, respectively. The fungicide next in order of superiority was carbendazim (0.1%) that recorded 52.81 and 61.73 per cent neck and node blast reduction over control, respectively. This was at par with propiconazole (0.1%) in respect of node blast. The treatment combination of ST + CP with sprays of propiconazole (0.1%) had significantly least neck (28.71 %) and node (16.72 %) blast incidence with highest reduction of 63.84 and 72.32 per cent of these diseases, respectively. However, this treatment combination was at par with ST + CP with sprays of carbendazim (0.1%) wherein, 58.09 and 68.11 per cent reduction in neck and node blasts was noticed, respectively.

Grain and straw yield

Three years pooled observations presented in Table 3 illustrate that the ST + CP yielded significantly highest grain (29.90 q ha^{-1}) and straw (32.14 q ha^{-1}) yield with 66.94 and 54.80 per cent increase in respective yields. Similarly, significantly highest grain (33.69 q ha^{-1}) and straw (37.85 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 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 q ha^{-1}) and straw (40.10 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 ha^{-1} were obtained with 90.14 and 79.98 per cent increase in grain and straw yields, respectively.

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^{-1})						Straw (q ha^{-1})					
			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	

Note: M1: Seed treatment and cultural practices, M2: No seed treatment and cultural practices

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 ha^{-1}, net profit of Rs. 19106.85 ha^{-1}, additional monetary returns of Rs. 19747.57 ha^{-1} and B: C ratio of 1.69 as against no ST and CP where these parameters were Rs. 39730.66 ha^{-1}, Rs. 13940.04 ha^{-1}, Rs. 12586.76 ha^{-1} and 1.54, respectively. Similarly, significantly highest monetary returns (Rs. 53650.13 ha^{-1}), net profit (Rs. 27504.13 ha^{-1}), additional monetary returns (Rs. 26506.23 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^{-1}), net profit (Rs. 30905.85 ha^{-1}), additional monetary returns (Rs. 30904.94 ha^{-1}) 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.

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^{-1})			Total cost of cultivation (Rs. ha^{-1})			Net profit (Rs. ha^{-1})		
			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^{-1})		
	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 4: Continued …….

Tr. No.	Name of fungicides	Dose (%)	Additional MROC (Rs. ha^{-1})			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 = Monetory returns over conctrol

Rates of fungicides

Fungicides	**Rs kg/L^{-1}**	Cost of *Pseudomonas fluorescens*: Rs. 40 ha^{-1}
Carbendazim	560.0	Cost of benomyl for seed treatement: Rs. 124 ha^{-1}
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^{-1}
Kasugamycin	910.0	Straw: Rs. 335 q^{-1}
Benomyl	1030.0	Cost of cultivation common to all treatments: Rs. 22467/-
Mancozeb	290.0	
Copper oxychloride	430.0	

Discussion

The seed treatment with benomyl and *Pseudomonas fluorescens* + cultural practices reduced the severity of all diseases under study such as leaf, neck and node blasts to a considerable extent. In respect of blast, it is in agreement with the work of Zavareh and Tehrani (2003) who studied the systemic properties of benomyl fungicide and reported its best effectiveness against leaf blast of paddy. The results in respect of bioagents are in conformity with the reports of Lucas *et al.* (2009) who obtained good control of blast disease in paddy fields by seed treatment with *P. fluorescens.* In addition, the results are in agreement with the work of Shyamala and Sivakumaar (2012) who reported that *P. fluorescens* tested in combination with salicylic acid was highly efficient in management of rice blast diseases.

Among the fungicides, propiconazole (0.1%) recorded significantly least incidence and intensity and thereby highest disease control of leaf, neck and node blasts while, it was on par with carbendazim (0.1%) and bitertanol (0.25%). Hossain and Kulkarni (2001) [11] also recorded propiconazole as the best fungicide in managing the blast disease of paddy.

The interaction of ST + CP with sprays of propiconazole (0.1%) had significantly least leaf, neck and node blast, brown spot and seed discolouration severity with highest reduction of these diseases however, this treatment combination was at par with ST + CP with sprays of carbendazim (0.1%). These findings are in consonance with the reports of Dodan and Roshan (1999) wherein they managed neck blast very effectively in scented rice along with stem borer by integration of burnt rice husk (BRH) incorporated pre-transplanting at 10 t/ha + biopesticide and bioagents and pesticides (carbendazim at 0.1% + monocrotophos at 0.25%). Tirmali *et al.* (2001) in their IDM experiment consisting with sprays of carbendazim (0.2%) noticed that neck blast disease severity was significantly reduced as compared to the untreated plots in highly susceptible variety of rice (Chimansal-39). Silva *et al.* (2003) [23] also developed adequate measures for rice blast management by integrating cultivar resistance, cultural practices and chemical control, wherein they reported that two applications of fungicide reduced panicle blast severity in both tillage systems.

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. Further, in respect of leaf scald, the treatment combination of ST + CP with sprays of carbendazim (0.1%) had significantly least disease that was followed by ST + CP with sprays of propiconazole (0.1%) and bitertanol (0.25%).

Prabhu (1989) [15] mentioned that integrated management involving cultural methods, selection of resistant cultivars and chemical treatments reduced the principal diseases of rice *viz.*, blast, brown spot, scald and glume blight in central Brazil that is in conformity with present findings. The foregoing results are nearly matching with the report of Raja and Saravanan (1993) [17] 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) in their integrated disease management studies, including use of silica and fungicides, indicated that levels of several important diseases of rice blast reduced to a greater extent hence, the number of fungicide applications and rates can be reduced significantly worldwide. Similarly, Datnoff and Rodrigues (2005) 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 and neck blast. In addition, Rodrigues and Datnoff (2005) noticed that the element silicon (Si) effectively managed the rice blast. Further, Lore *et al.* (2007) noticed that fungicide propiconazole @ 0.1% was the most effective against various rice and was followed by carbendazim @ 0.1%, which is in agreement with the present studies. Besides, Prathuangwong *et al.* (2012) [16] noticed the most effectiveness of plant growth promoting rhizobacterium *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 monitory 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) [5] 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) [11] and Sunder *et al.* (2005) 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. Similarly

Tirmali *et al.* (2001) also noticed carbendazim at 0.1 per cent as highly effective in controlling the rice blast 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 blast disease incidence and increased grain yield compared to the control plot. The results are also in agreement with Alvarez and Datnoff (2001) 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) [5] 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 monitory returns to great extent that is in agreement with the present findings.

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^{-2} as well as soil application of rice straw (RS) @ 2 tones ha^{-1} 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 leaf blast, neck blast and node blast diseases and increasing the grain and straw yields of paddy as well as monitory returns.

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