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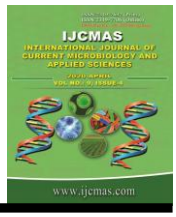

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Management of Sheath Rot and Grain Discolouration of Rice (*Oryzae sativa* L.)

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A B S T R A C T

Field trials were conducted during 2015-19 by planting commercially grown rice cultivar TPS5 and TPS3 varieties during *Kharif* season (June–Sept) and *Rabi* season (Oct – Feb) respectively to investigate the management strategy for sheath rot and grain discolouration by using bio control agent, plant products and fungicides. Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%) performed better with lowest per cent incidence of sheath rot 9.09 and grain discoloration 8.46 in TPS5 rice variety during Kharif season and sheath rot 10.73 and grain discoloration 9.53 in TPS3 rice variety during Rabi seasons of 2016 to 2019 respectively. This treatment also recorded highest yield of 5252 Kg/ha in TPS5 and 5286 Kg/ha in TPS3 with a cost benefit (C:B) ratio of 1:2.02. This was followed by seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit and has recorded comparatively better C:B ratio of 1:1.81.

Introduction

Rice contributes around 45 per cent of India's cereal production and it is a main food source for more than 60 percent population in the country. India accounts for about 20-25 percent of the rice in the world trade. Rice is cultivated in 43.86 m ha with the production level of 104.80million tones and annual productivity of 2390 kg/ha. Rice crop suffers with many biotic and abiotic stresses that incite severe economic yield losses. The major diseases of rice includes blast, sheath rot, sheath blight, brown spot and bacterial leaf blight that accounts yield losses by 15-20 percent. Rice grain discoloration was reported as independent disease causing significant yield losses (Prabhu *et al*., 2012; Ashfaq *et*

al., 2013; Chandramani and Awadhiya, 2014). Rice grain discoloration is becoming a serious problem and is increasing year after year by decreasing the yield potential of rice crop up to 6% (Savary *et al*., 2000).

Sheath rot has gained the status as a major disease of rice (Reddy and Gosh, 1985) and yield losses varies from 9.6 to 85% depending on the weather conditions during the crop growth-period (Phookan and Hazarika, 1992). Naeimi *et al.,* (2003) also reported that the Sheath rot occurs in most rice-growing regions of the world and usually causes yield losses ranging from 20 to 85%. Rice sheath rot is a disease complex that can be caused by various fungal and bacterial pathogens. Major pathogens associated with rice sheath rot are fungi such as *Sarocladium oryzae* and *Fusarium* sp. belonging to the *Fusarium fujikuroi* complex and the bacterial pathogen *Pseudomonas fuscovaginae* (Bigirimana *et al.,* 2015). The symptoms of rice discoloration are brown or black spots on grain, hollow light weight panicle, blackish brown stripes on grain and infected panicle with unfilled grains. Grain discoloration affects the grain morphology in term of grain size and shape. Rice grain discoloration affects the qualitative and quantitative traits (Sumangata *et al*., 2009, Tariq *et al*., 2012) that ultimately result in yield penalty. In Tamil Nadu yield losses due to rice grain discoloration were up to 39% and are a major limiting factor for rice yield (Rajappan *et al*., 2001, Shanmugam *et al*., 2006). Sakthivel and Gnanamanikam (1989) reported that *P.fluorescens* clearly demonstrated substantial reduction (up to 42%) in sheath rot severity and enhanced grain yield (up to 160%). Balgude *et.al.,* also reported the bio agent MPKPf was found to be more effective for the management of blast and sheath rot diseases thus increased the paddy yield to 25.57 q/ha with 26.58% increase.

The present study was conducted to investigate the management strategy for sheath rot and grain discolouration in rice by using bio control agent, plant products and fungicides.

Materials and Methods

Field trials were conducted at the Agricultural Research Station, Thirupathisaram, Kanyakumari district during 2015-19. Commercially grown cultivar viz., TPS5 was sown during Kharif season (June–Sept) and TPS3 during Rabi season (Oct – Feb). Standard agronomic practices were followed to raise the crop. Ten treatments at their recommended doses were tested against untreated check in a randomized block design (RBD) with three replicates keeping a plot size of 5 m x 2 m. The treatment details are as follows

T_1-Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit

T_2-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim @ 1g/lit.

T_3-Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Metominostrobin @ 500ml /ha

T_4-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with propiconzole @ 500ml/ha

T_5-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Hexaconazole 5% EC (0.2%)

T_6-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%)

T_7-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2%

T_8-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Coleus forskholii* leaf extract 10%

T_9-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Ipomoea* leaf extract 10%

T_{10}-Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with neem oil 3%.

T_{11}-control (no spray)

Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg was uniformly adopted in all the ten treatments except control for rice variety TPS 5 during Kharif season and Rice variety TPS 3 during Rabi season. The first spray was given at booting stage and the second spray was given at 50 per cent flowering stage. The numbers of healthy and discoloured grains were counted for each treatment by selecting ten ear heads at random and the percentage of grain discolouration was calculated. The grain yield was recorded at the time of harvest. Sheath rot disease intensity was recorded at maturity of the crop in 0-9 scales by following the procedure of Standard Evaluation System of International Rice Testing Programme (IRRI, 1980). Randomly 20 panicles of each treatment plot were selected for taking the observations. The observation percent disease intensity and yield kg/ha were also recorded for each treatment at maturity of the crop.

Results and Discussion

It was observed that among the different treatments evaluated, statistically significant reduction was noted in the incidence of sheath rot and grain discolouration with increased grain yield over untreated check. Among the various treatments, seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%) performed better with lowest incidence of sheath rot 9.09 % and 8.46 % grain discoloration in TPS 5 rice variety during Kharif season and 10.73% sheath rot incidence and 9.53 percent grain discoloration in TPS3 rice variety during Rabi seasons of 2016 to 2019 (Table 1 & 2) and with highest yield of 5252 Kg/ha in TPS5 and 5286 Kg/ha in TPS3 (Table 3 & 4). It was also observed that per cent reduction of 66.70 and 68.27 in sheath rot and grain discolouration in TPS5 variety and 65.86 and 90 in TPS3 variety over control respectively. In addition there was an increase of 11.58 and 11.80 per cent grain yield over control. This treatment was followed by seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2% as compared to untreated in three successive years during Kharif and Rabi season respectively reduced the sheath rot and grain discolouration in rice. Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit also recorded 18.80 and 21.91 per cent sheath rot incidence in TPS5 and TPS3 and 17.05 and 19.42 per cent incidence of grain discolouration in TPS5 and TPS3 which ultimately enhanced the yield 6.64 and 7.40 per cent over control respectively.

Balgude and Gaikwad (2016) also reported the most effectiveness of trifloxystrobin + tebuconazole against sheath rot of rice. Similary Balgude *et al.,* 2019 reported that treatment with trifloxystrobin + tebuconazole had lowest sheath rot incidence followed by Azoxystrobin + Tebuconazole against sheath rot of rice.

Table.1 Per cent Sheath Rot (Sh.R) and Grain Discolouration (G.D) incidence in Rice variety TPS 5 during 2016, 2017 and 2018 *kharif* season

S. No	Treatments	2016		2017		2018		Mean (%)		Per cent Sh.R incidence decreased over control	Per cent G.D incidence decreased over control
		Sh.R	G.D	Sh.R	G.D	Sh.R	G.D	Sh.R	G.D		
T_1	Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit	17.48 (24.70)^{f}	15.56 (23.21)^{d}	22.86 (28.37)^{d}	20.34 (26.80)^{d}	16.05 (26.63)^{d}	15.25 (22.95)^{c}	18.80 (26.57)	17.05 (24.32)	31.21	36.05
T_2	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim @ 1g/lit.	19.01 (25.87)^{c}	16.92 (24.30)^{ef}	23.88 (29.24)^{df}	21.25 (27.44)^{d}	17.48 (24.70)^{ef}	16.43 (23.91)^{cd}	20.12 (26.60)	18.20 (25.22)	26.38	31.73
T_3	Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Metominostrobin @ 500ml /ha	18.15 (25.87)^{c}	16.77 (24.17)^{e}	24.70 (29.78)^{e}	21.00 (27.27)^{d}	16.70 (24.14)^{de}	15.74 (23.37)^{cd}	19.85 (26.60)	17.84 (24.94)	27.36	33.08
T_4	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with propiconzole @ 500ml/ha	13.67 (21.70)^{b}	12.16 (20.41)^{c}	17.24 (24.53)^{c}	15.34 (23.05)^{c}	12.04 (20.30)^{c}	11.47 (19.75)^{b}	14.32 (22.18)	12.99 (21.07)	46.60	51.27
T_5	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray	13.16 (21.25)^{b}	11.89 (20.18)^{c}	17.24 (24.52)^{c}	15.68 (23.32)^{c}	12.10 (20.35)^{c}	11.88 (20.11)^{b}	14.17 (22.04)	13.15 (21.20)	48.15	50.67

	with Hexaconazole 5% EC (0.2%)										
T_6	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%)	8.45 (16.91)[a]	7.52 (15.89)[a]	11.06 (19.40)[a]	9.87 (18.30)[a]	7.76 (16.11)[a]	7.98 (16.39)[a]	9.09 (17.47)	8.46 (16.86)	66.70	68.27
T_7	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2%	10.34 (18.75)[a]	9.20 (17.56)[b]	13.22 (21.32)[b]	11.72 (20.00)[b]	9.37 (17.82)[b]	8.99 (17.44)[a]	10.98 (19.30)	9.97 (18.33)	63.52	62.60
T_8	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Coleus forskholii* leaf extract 10%	19.98 (24.51)[c]	17.78 (24.93)[f]	26.18 (30.74)[f]	23.02 (28.66)[e]	18.38 (25.39)[f]	17.20 (24.49)[e]	21.51 (26.88)	19.33 (26.03)	21.22	27.49
T_9	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Ipomoea* leaf extract 10%	22.35 (28.22)[c]	19.90 (26.25)[g]	29.28 (32.75)[g]	26.07 (30.70)[f]	22.46 (28.29)[g]	21.11 (27.34)[f]	24.70 (29.75)	22.36 (28.10)	9.62	16.13
T_{10}	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with neem oil 3%.	22.30 (28.19)[d]	19.90 (26.49)[g]	29.28 (32.77)[g]	26.00 (30.66)[f]	22.30 (28.18)[g]	21.25 (27.44)[f]	24.63 (29.71)	22.38 (28.20)	9.88	16.05
T_{11}	control	25.38 (30.24)[e]	22.58 (28.36)[h]	33.25 (35.22)[h]	29.61 (32.96)[g]	23.35 (28.90)[h]	27.80 (31.82)[h]	27.33 (31.45)	26.66 (31.05)	-	-
	CD (P=0.05)	**1.89**	**0.71**	**0.73**	**0.99**	**0.72**	**1.12**				

Table.2 Per cent Sheath Rot (Sh.R) and Grain Discolouration (G.D) incidence in Rice variety TPS 3 during 2016 – 17,2017-18, 2018-19 *Rabi* season

S.no	Treatments	2016 - 17		2017 -18		2018 -19		Mean (%)		Per cent Sh.R incidence decreased over control	Per cent G.D incidence decreased over control
		Sh.R	G.D	Sh.R	G.D	Sh.R	G.D	Sh.R	G.D		
T_1	Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit	20.63 (27.01)^{d}	18.36 (25.35)^{d}	22.52 (28.56)^{d}	20.04 (26.57)^{d}	22.58 (23.36)^{d}	19.86 (26.47)^{d}	21.91 (26.31)	19.42 (26.13)	30.28	32.55
T_2	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim @ 1g/lit.	22.42 (28.25)^{e}	19.95 (26.53)^{e}	25.56 (30.37)^{e}	22.66 (28.43)^{e}	24.54 (29.60)^{e}	21.60 (27.69)^{de}	24.17 (29.41)	21.40 (27.55)	23.10	25.67
T_3	Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Metominostrobin @ 500ml /ha	22.46 (28.29)^{e}	19.98 (26.55)^{e}	23.60 (29.06)^{d}	21.05 (27.30)^{d}	22.60 (28.36)^{d}	19.89 (26.49)^{d}	22.89 (28.57)	20.31 (26.78)	27.17	29.45
T_4	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with propiconzole @ 500ml/ha	16.14 (23.68)^{c}	14.36 (22.26)^{c}	18.40 (25.40)^{c}	16.38 (23.52)^{c}	17.66 (24.85)^{c}	15.54 (23.14)^{c}	17.40 (24.64)	15.43 (22.97)	44.64	46.40
T_5	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Hexaconazole 5% EC (0.2%)	16.20 (23.75)^{c}	14.36 (22.26)^{c}	18.47 (25.45)^{c}	16.43 (23.91)^{c}	13.36 (24.63)^{c}	15.28 (23.66)^{c}	16.01 (24.61)	15.36 (23.28)	49.06	46.65

T_6	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%)	10.02 (18.46)[a]	8.92 (17.37)[a]	11.43 (19.76)[a]	10.21 (18.62)[a]	10.74 (19.12)[a]	9.45 (17.90)[a]	10.73 (19.11)	9.53 (17.96)	65.86	66.90
T_7	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2%	12.20 (20.43)[b]	10.86 (19.55)[b]	13.90 (21.89)[b]	12.18 (20.40)[b]	13.07 (21.18)[b]	11.50 (19.82)[b]	13.06 (21.17)	11.51 (19.92)	58.45	60.02
T_8	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Coleusforskholii* leaf extract 10%	23.57 (29.04)[e]	20.98 (27.24)[e]	26.86 (31.22)[e]	22.90 (28.59)[e]	25.26 (30.17)[e]	22.23 (28.13)[e]	25.23 (30.14)	22.04 (27.99)	19.73	23.44
T_9	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Ipomoea* leaf extract 10%	26.36 (30.89)[f]	23.45 (28.96)[f]	30.05 (33.25)[f]	26.68 (31.09)[f]	28.28 (32.07)[f]	24.82 (29.87)[f]	28.23 (32.07)	24.98 (29.97)	13.84	13.23
T_{10}	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with neem oil 3%.	26.32 (30.87)[f]	23.42 (28.93)[f]	30.05 (33.23)[f]	26.71 (31.10)[f]	28.21 (32.07)[f]	24.80 (29.87)[f]	28.19 (32.06)	24.98 (29.97)	10.31	13.23
T_{11}	control	29.32 (32.81)[g]	28.85 (32.82)[g]	33.50 (35.36)[g]	29.82 (33.10)[g]	31.48 (34.12)[g]	27.70 (31.76)[g]	31.43 (34.10)	28.79 (32.56)	-	-
	CD (P=0.05)	**1.06**	**0.79**	**0.99**	**0.98**	**0.86**	**1.30**				

Table.3 Yield (kg/ha) of the variety TPS 5

S.No	Treatments	2016	2017	2018	Mean yield	Per cent increase over control
T_1	Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit	4985^{b}	4780^{b}	5295^{b}	5020	6.64
T_2	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim @ 1g/lit.	4802^{def}	4561^{e}	5131^{c}	4831	2.63
T_3	Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Metominostrobin @ 500ml /ha	4818de	4573de	5145^{c}	4845	2.93
T_4	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with propiconzole @ 500ml/ha	4955^{c}	4700^{cd}	5287^{b}	4981	5.82
T_5	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Hexaconazole 5% EC (0.2%)	4952^{c}	4704^{c}	5292^{b}	4983	5.86
T_6	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%)	5220^{a}	5026^{a}	5510^{a}	5252	11.58
T_7	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2%	5084^{b}	4890^{b}	5445^{a}	5140	9.20
T_8	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Coleusforskholii* leaf extract 10%	4760^{ef}	4522^{e}	5088^{cd}	4790	1.76
T_9	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Ipomoea* leaf extract 10%	4760^{ef}	4520^{e}	5100^{cd}	4793	1.83
T_{10}	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with neem oil 3%.	4762^{ef}	4523^{e}	5005^{d}	4763	1.19
T_{11}	Control	4682^{f}	4448^{e}	4990^{d}	4707	
	CD (P=0.05)	**128.65**	**129.21**	**124.83**		

Table.4 Yield (kg/ha) of the variety TPS 3

S.No	Treatments	2016 - 2017	2017-2018	2018-2019	Mean yield	Per cent increase over control
T_1	Seed treatment with *P.fluorescens* (Pf1) @ 10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit	5040^{b}	4914^{b}	5281^{a}	5078	7.40
T_2	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim @ 1g/lit.	4907^{cdef}	4702^{d}	4977^{c}	4862	2.83
T_3	Seed treatment with *P. fluorescens* (Pf1) @ 10g/kg + two foliar spray with Metominostrobin @ 500ml /ha	5026^{cd}	4714^{d}	5085^{bc}	4942	4.53
T_4	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with propiconzole @ 500ml/ha	5064^{bc}	4846^{c}	5130^{b}	5013	6.03
T_5	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Hexaconazole 5% EC (0.2%)	5047^{bc}	4841^{c}	5128^{b}	5005	5.86
T_6	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%)	5406^{a}	5107^{a}	5345^{a}	5286	11.80
T_7	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with carbendazim + thiram + mancozeb (1:1:1) 0.2%	5195^{b}	4979^{b}	5281^{a}	5152	8.97
T_8	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Coleusforskholii* leaf extract 10%	4864^{ef}	4662de	4940^{cd}	4822	1.99
T_9	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with *Ipomoea* leaf extract 10%	4880^{def}	4652de	4940^{cd}	4824	2.03
T_{10}	Seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with neem oil 3%.	4863^{ef}	4651de	4940^{cd}	4818	1.90
T_{11}	Control	4780^{f}	4585^{d}	4818^{d}	4728	
	CD (P=0.05)	**160.61**	**115.97**	**148.62**		

Table.5 Cost benefit ratio

Treatments	Yield (Kg/ha)		Mean yield (Kg/ha) `	Mean increased yield over control	Additional income over control @ Rs.16 per kg	Additional expenditure (Rs.)	Cost Benefit Ratio
	TPS 3	TPS 5					
T_1	5078	5020	5049	331	5296	2920	1 : 1.81
T_2	4862	4831	4847	129	2060	3140	1 : 0.66
T_3	4942	4845	4894	176	2816	4040	1 : 0.69
T_4	5013	4981	4997	279	4464	3265	1 : 1.37
T_5	5005	4983	4994	276	4416	3360	1 : 1.32
T_6	5286	5252	5269	551	8816	4360	1 : 2.02
T_7	5152	5140	5146	428	6848	4520	1 : 1.51
T_8	4822	4790	4806	88	1408	3020	1 : 0.47
T_9	4824	4793	4809	91	1456	3035	1 : 0.48
T_{10}	4818	4763	4791	73	1168	3260	1 : 0.36
T_{11}	4728	4707	4718	-	-	-	-

Deepmala Kindo and Tiwari 2015 reported that Hexaconazole 5 SC (Contaf) treatment was highly effective in reducing the sheath rot intensity and was statistically on at par with Tebuconazole 250 EC (Folicur) and Carbendazim 50% WP (Bavistin) and increased the grain yield. 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 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. Adhikari and Bhowmic 2010 reported that combination of fungicides (Carbendazim+ mancozeb) reduced the panicle infection and improve paddy yield. Bodalkar and Awadhiya (2014) concluded that application of three sprays Carbendazim at tillering stage, milk stage and dough stage recorded the lower disease incidence. Islam and Manzoor 2017 reported that treatment of Infested seeds with Carbendazim and Diathene-M45 were comparatively improved seed germination percentage.

In conclusion it was also observed that seed treatment with *P. fluorescens* (Pf1)@ 10g/kg + two foliar spray with Azoxystrobin 23SC (0.1%) to one week before booting and at 50% flowering stage was found to be most effective in management of sheath rot and grain discoloration diseases and thereby enhancing the grain yield in paddy with a benefit cost ratio (B:C) of 1: 2.02 (Table 9). However the above treatment was followed by seed treatment with *P. fluorescens* (Pf1) @

10g/kg + two foliar spray with liquid formulation of *P. fluorescens* (Pf1) @ 5ml /lit has recorded comparatively better cost benefit ratio of 1:1.81. The enhanced yield attributed because of complexity of biological control and plant growth promotion phenomenon due to bacterization of *P.fluorescens* (Sakthivel and Gnanamanikam 1989).

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