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Efficacy of different fungicides against *Rhizoctonia solani* causing sheath blight of rice

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Abstract
Sheath blight, caused by multinucleate *Rhizoctonia solani* Kuhn (teleomorph: *Thanatephorus cucumeris* Donk), a ubiquitous pathogen, is an important fungal disease of rice ranking only after blast and often rivaling it. The potential losses due to sheath blight alone in India has been up to 51.3%. In this study an attempt was made to investigate a new combination fungicide Flusilazole 12.5% + Carbendazim 25%SC (Lustre 37.5 SE) was found to be most effective in minimizing the severity of sheath blight with 31.34% and also showed less incidence (4.17%) of sheath blight at 80 DAT. Remaining other fungicides were significantly less effective than Flusilazole 12.5% + Carbendazim 25%SC but at par among themselves. The highest 1000 grain weight was noticed in treatment Kasugamycin 3%SL (35.67 g) followed by Flusilazole 12.5% + Carbendazim 25%SC (34.0 g), Hexaconazole 5%EC (33.67g) and Carbendazim 50%WP +Propiconazole 25% EC (30.00g). However, The highest number of healthy grain per 1000 grain were recorded in the treatment Kasugamycin 3%SL (848 grain/1000 grain) followed by Flusilazole 12.5% + Carbendazim 25%SC (836 grain/1000grain) and Propiconazole 25% EC (825 grain/1000 grain).The lowest average number of chaffy grain per 1000 grain was recorded in the treatment Hexaconazole 5%EC (87 grain/1000 grain) followed by Kasugamycin 3%SL (102 grains/1000grains) and Flusilazole 12.5% + Carbendazim 25%SC (107 grain/1000grain) whereas lowest number of discolored grain per 1000 grain was observed with the treatment, Kasugamycin 3%SL (51 grain/1000 grain) followed by Flusilazole 12.5% + Carbendazim 25%SC (58 grain/ 1000 grain) and Azoxystrobin 23%SC (75 grain/1000 grain) observed with control. Highest plant height with Carboxin 37.5% + Thiram 37.5% WP (66.85 cm), highest number of tillers per m^2 recorded in treatment Hexaconazole 5%EC (217 tillers/m^2), highest panicle length recorded the treatment Carbendazim 50%WP +Propiconazole 25% EC (27.80 cm) and number of seed per panicle were recorded in treatment Carboxin 37.5% + Thiram 37.5% WP (155 seed/ panicle). Highest biological yield was recorded with the application of Carboxin 37.5% + Thiram 37.5% WP (25.83 kg/plot). Highest grain yield recorded due to application of Azoxystrobin 23% SC (6.50 kg/plot) and straw yield recorded with Carboxin 37.5% + Thiram 37.5% WP (19.33 kg/plot) during both the years. Lowest AUDPC values were exhibited due to application of Flusilazole 12.5% + Carbendazim 25%SC (AUDPC 1523.70) followed byCarbendazim 50%WP +Propiconazole 25% EC (AUDPC of 2355.60) and Mancozeb 63% + Carbendazim 12%WP (AUDPC of 2375.70).

Keywords: Sheath blight, fungicides, disease incidence, disease severity and area under disease progress curve (AUDPC)

Introduction

Rice (*Oryza sativa* L.) is a major food constituent of human diet for more than two third population of our country. After China, India ranks second in rice production in the world. It is a major food crop in India, China and most of the other Asian countries, where 92% of the world's rice is grown (Rai, 2006) [18]. Globally, the annual rice production is around 497.9 million tonnes with average productivity of 3.9 tonnes/ha (Anonymous, 2016) [1]. The annual production of rice in the country is around 103.36 million tonnes (Anonymous, 2016) [1] and the average productivity in the country across all the eco-systems is still around 2 tonnes/hectare of milled rice. In India, Uttar Pradesh has 3rd ranks in the production of rice. The annual rice production is around 12 metric tons with the average productivity of about 2 tons/ha (Dwivedi, 2014) [3]. Efforts for enhancing the productivity are limited by a number of biotic and abiotic stresses. Fungal diseases alone are responsible for 12 to 20 per cent crop losses (Rajan, 1987) [19]. Sheath blight in rice is an important soil-borne fungal disease (*Rhizoctonia solani* Kuhn) causing up to 25% of yield losses (Zheng *et al.*, 2013) [30]. Sheath blight of rice caused by *Rhizoctonia solani* Kuhn (Teleomorph: *Thanatephorus cucumeris* (Frank) Donk) anastomosis group 1 and sub-group 1A) was first reported from Japan (Miyake, 1910) [12] is at present one of the most serious threat for Basmati rice production.

In India, the first report of its occurrence was by Paracer and Chahal (1963) [16] from Gurudashpur, Punjab and later it was reported from Uttar Pradesh (Kohli, 1966) [10]. Rice sheath blight, occurs throughout temperate and tropical production areas and is most prominent wherever rice is grown under intense production systems (Savary and Mew, 1996) [23] and is second only to rice blast as the most economically important fungal disease of rice (Savary *et al*., 2006) [26]. The widespread adoption of new, susceptible high yielding cultivars with large number of tillers and the changes in cultural practices associated with these cultivars favour the development of sheath blight and contribute greatly to the rapid increase in the incidence and severity of this disease in rice growing areas throughout the world (Srinivasachary *et al*., 2011) [28]. Apart from reducing from plant vigour and yield, the disease also causes grain discoloration at maturity, thus reducing the market value. Yield losses of 5-10% due to sheath blight have been estimated for tropical low land rice in Asia (Savary and Willocquet, 2000) [24]. However, losses due to sheath blight disease generally vary from 30 to 40 per cent and may be even 100 per cent in endemic areas. When the disease spreads to upper parts of the plant and panicles, a total crop loss was observed (Srinivas *et al.*, 2013) [27]. The pathogen survives as mycelial or resistant structures known as sclerotia in plant debris and on weeds in rice growing areas. The ability of *R. Solani* to produce sclerotia with a thick outer layer allows themto float and survive in water. *R.solani* survives asmycelium by colonizing soil organic matter as a saprophyte, particularly as a result of plant pathogenic activity (Zachow *et al.*, 2011) [29]. The sclerotia present in the soil or on plant tissue germinate to produce vegetative threads (hyphae) of the fungus that can attack a wide range of crops. The natural infection of the sheath blight disease occurs at the seedling, tillering and booting stages of rice. Infection usually starts near the water line of rice plants in paddy fields. Lesions develop upward to the upper leaf sheaths and leaf blades. The centre of lesion become grayish white with brown margin, later several spots coalesce and show blight symptoms (Ou, 1985) [15]. Thus entire plant often gets killed under severe cases (Rush and Lindberg, 1984) [21]. The disease is soil borne and remains, mainly confined to the leaf sheath but it also attacks all the aerial plant parts. Under North Indian conditions it is mainly soil borne; besides seed and air borne inoculums also plays an important role (Saksena, 1977) [22]. High genetic resistance is not available for sheath blight and this disease is currently managed through use of fungicides (Savary *et al*., 2012) [25]. In the absence of suitable resistant donors, fungicides remain the main option to check this disease. Chemical control of the sheath blight disease is successful at field level in majority of the cases (Kandhari *et al.* 2003) [8]. Fungicides with multiple effects on the pathogen like sclerotial germination, mycelial growth inhibition and reduction of the disease spread will be most ideal. Several new molecules are available in the market and farmers are going for 3-4 sprays for the control of sheath blight under field conditions. Hence, considering economic importance of the crop and the disease, the present investigation was under-taken to evaluate the efficacy of five new combination and five commercially available fungicides against *R. solani* and to find out the suitable management practice to mitigate the disease.

Material and Methods

Experiments were conducted for two consecutive crop seasons *i.e. Kharif* 2011 and 2012, using the susceptible cultivar Pusa Basmati-1(PB-1) under field conditions, to know the effect of recommended doses of fungicides, on percent disease severity, percent disease incidence, Area under disease progress curve (AUDPC), grain quality, plant height, number of tillers per m^2, panicle length, number of seeds per panicle and productivity (yield/plot) of rice crop.

Combination fungicides formulation namely Trifloxystrobin 25% +Tebuconazole 50% WG (Nativo 75%WG), Flusilazole 12.5% + Carbendazim 25%SC (Lustre 37.5%SE), Carboxin 37.5% + Thiram 37.5% WP (Vitavax Power), Mancozeb 63% + Carbendazim 12%WP (*SAAF* 75%WP) and Carbendazim 50%WP +Propiconazole 25% EC (Bavistin50WP + Tilt 25% EC) were evaluated for their efficacy against sheath blight of rice under field conditions as per following details. The trials were laid in a randomized block design with 10 treatments and three replications. Popular rice variety Pusa Basmati 1 (PB 1) which is highly susceptible to sheath blight disease, was used for this experiment. A spacing of 20x10 cm was adopted and the plot sizes were 5m x 4m ($20m^2$). The combination fungicide formulation was evaluated at different dosages. Standard check fungicide that was proven to be effective against sheath blight disease *viz.*, Validamycin 3%L (WILPOWER), Hexaconazole 5%EC (Contaf 5EC), Kasugamycin 3%SL (Biomycin), Azoxystrobin 23%SC (Amistar 25 EC) andPropiconazole 25% EC (Tilt 25% EC) were also included for their comparison. A check plot without any fungicides treatment was also maintained where only plain water was sprayed. The details of chemicals & their dosages etc. have been given in Table 1.

Table 1: List of different new combination fungicides and other pesticides

S. No.	Technical Name (Common name)	Trade Name	Mode of Action	Time of application	Rate of application (g/ml per l)
1	Trifloxystrobin25% + Tebuconazole 50% WG	Nativo 75%WG	Preventive & Curative	Late Tillering stage, Jointig stage stage and Heading stage	0.4 g/l
2	Flusilazole 12.5%+ Carbendazim 25%SC	Lustre 37.5%SE	Preventive & Curative	Late Tillering stage, Jointig stage stage and Heading stage	3.14ml/l
3	Carboxin 37.5% + Thiram 37.5% WP	Vitavax Power	Systemic + protective	Seed treatment	1.5g/ kg of seeds
4	Mancozeb 63% + Carbendazim12%wp 12%WP	SAAF75%WP	Preventive & Curative	Late Tillering stage, Jointig stage stage and Heading stage	1.5g/l
5	Carbendazim 50%WP+ Propiconazole 25% EC	Bavistin50%WP P+Tilt 25% EC	Preventive & Curative	Carb. at Late Tillering stage, Heading stage and Prop. at Jointig stage	1.0 ml/l + 1.0ml/l
6	Validamycin 3% L	WILPOWER	Non systemic antibiotic	Jointig stage and Heading stage	1.5ml/l
7	Hexaconazole 5%EC	Contaf 5 EC	Preventive &Curative	Jointig stage and Heading stage	2.0 ml/l
8	Kasugamycin 3% SL	Biomycin	protective and curative	Jointig stage and Heading stage	1.5g/l
9	Azoxystrobin23%SC	Amistar 25EC	Protective and curative	Jointig stage and Heading stage	1.0 ml/t
10	Propiconazole 25% EC	Tilt 25% EC	Curative action	Jointig stage and Heading stage	1.0ml/l

Observations on disease incidence and disease severity were recorded for sheath blight and grain discolouration at various growth stages of rice starting from seedling stage to maturity as per standard evaluation system for rice (IRRI, 1996) [6]. The disease severity was calculated according to Ghazanfar *et al.* (2009) [4] by using following formula:

$$\text{Disease severity (\%)} = \frac{\text{Average of the disease score X 100}}{9}$$

The area under the disease progress curve was calculated according to Nagarajan and Muralidharan (1995) [14] by using following formula:

Area under disease progress curve (AUDPC) =

$$\sum_{i=1}^{K} 1/2\,(y_i + Y_{i-l}) \times d$$

Where Yi = disease incidence at i^{th} day of evaluation,
k= number of successive evaluations, and
d= interval between i and i-l evaluation of disease

Each plot was harvested separately leaving border rows from all sides to record yield and other observations. Threshing was done separately for each plot and grain and biological yields/plot were recorded after adjusting proper moisture as per standard protocol. Grain and straw yields were calculated on per hectare basis using the yields of net plot area of each treatment. Observations on thousand grain weight, number of filled, chaffy and discolored grains were taken from samples of each plot separately.

Result and Discussion

The pooled data for both the years presented in Table 2 & 3 indicated that the fungicide, Flusilazole 12.5% + Carbendazim 25%SC (Lustre 37.5 SE)was found to be most effective in minimizing the severity of sheath blight with 31.34% severity and 41.06% reduction in severity after 80 DAT. Remaining other fungicides were significantly less effective than Flusilazole 12.5% + Carbendazim 25%SC but at par among themselves as they resulted in reduction of disease severity within range of 16 to 41%. Flusilazole 12.5% + Carbendazim 25% SC also showed less incidence (4.17%) of sheath blight at 80 DAT and percent reduction in disease incidence by this molecules were 79.74%. Prasanna and Veerabhadraswamy (2014) [17] reported new combination fungicides against sheath blight of rice and documented Thifluzamide 24% SC, RIL-068/F1 48 WG (Kresoxim methyl 40% + Hexaconazole 8% WG), Propiconazole 25% EC (Tilt), Tricyclazole 75% WP (Beam) and a new combination fungicide, Fluxapyroxad 62.5 g/l + Epoxiconazlle 62.5 g/l EC (Adexar w/v EC) were found effective. Bag (2009) [18] also tested the efficacy of a new combination fungicide of two systemic fungicides *viz.* Trifloxystrobin 25% (Strobilurin compound) and Tebuconazole 50% (Triazole compound) along with two other commercially available fungicides viz. Hexaconazole and Validamycin under challenge inoculation condition. The new fungicide was most effective in decreasing disease severity and increasing grain yield. Reddy and Muralidharan (2007) [20] also advocated that Lustre 37.5 SE, a new combination product of Flusilazole (12.5%) with Carbendazim (25%) reduced sheath blight disease severity and increased the grain yields as well as a prophylactic foliar application; it gave good protection when compared to the curative application, although grain yields remained same. It is safe combination fungicide, as it did not induce any phytotoxic symptoms on rice plants.

Table 2: Effect of different fungicides on per-cent of disease severity (relative lesion height) of sheath blight of rice

S. No.	Fungicide	Percent disease severity			Percent reduction in disease severity		
		80DAT 2011	80DAT 2012	Average at 80 DAT	80DAT 2011	80DAT 2012	Average at 80 DAT
1	Trifloxystrobin 25% +Tebuconazole 50% WG	40.59 (39.56)	45.25 (42.28)	42.92 (40.92)	23.89 (15.67)	14.62 (9.50)	19.26 (12.59)
2	Flusilazole 12.5% + Carbendazim 25%SC	30.17 (33.31)	32.50 (34.71)	31.34 (34.01)	43.43 (28.99)	38.68 (25.70)	41.06 (27.35)
3	Carboxin 37.5% + Thiram 37.5% WP	37.82 (37.90)	39.14 (38.69)	38.48 (38.29)	29.08 (19.20)	26.15 (17.19)	27.62 (18.20)
4	Mancozeb 63% + Carbendazim 12%WP	43.72 (41.39)	42.91 (40.92)	43.32 (41.15)	18.02 (11.76)	19.03 (12.41)	18.53 (12.09)
5	Carbendazim 50%WP+Propiconazole 25% EC	44.00 (41.53)	44.44 (41.81)	44.22 (41.67)	17.49 (11.46)	16.15 (10.51)	16.82 (10.99)
6	Validamycin 3%L	43.98 (41.54)	42.18 (40.50)	43.08 (41.02)	17.53 (11.45)	20.41 (13.31)	18.97 (12.38)
7	Hexaconazole 5%EC	43.85 (41.46)	42.51 (40.69)	43.18 (41.08)	17.78 (11.61)	19.79 (12.91)	18.79 (12.26)
8	Kasugamycin 3%SL	43.35 (41.17)	42.62 (40.75)	42.99 (40.96)	18.71 (12.23)	19.58 (12.78)	19.15 (12.51)
9	Azoxystrobin 23%SC	40.27 (39.39)	38.97 (38.63)	39.62 (39.01)	24.49 (16.03)	26.47 (17.31)	25.48 (16.67)
10	Propiconazole 25% EC	44.40 (41.77)	40.38 (39.44)	42.39 (40.61)	16.74 (10.96)	(23.81) 15.58	20.28 (13.27)
11	Control	53.33 (46.91)	53.00 (46.72)	53.17 (46.82)			
	Overall Mean	42.32 (40.54)	42.17 (40.47)				
	CD (p=0.05)=	(4.06)	(3.76)				

Data in the parentheses are angular transformed value

Table 3: Effect of different fungicides on the per-cent diseases incidence of sheath blight of rice

S. No.	Fungicides (Treatments)	Percent disease incidence			Percent reduction in disease incidence		
		80DAT 2011	80DAT2012	Average at 80DAT	80DAT 2011	80DAT 2012	Average at 80DAT
1	Trifloxystrobin 25% +Tebuconazole 50% WG	5.00 (12.64)	7.50 (15.75)	6.25 (14.19)	82.35 (60.69)	72.73 (50.17)	77.54 (55.43)
2	Flusilazole 12.5% + Carbendazim 25%SC	3.33 (10.37)	5.00 (12.64)	4.17 (11.50)	77.66 (67.75)	81.82 (60.01)	79.74 (63.88)
3	Carboxin 37.5% + Thiram 37.5% WP	10.00 (17.19)	14.17 (21.75)	12.08 (19.47)	64.70 (46.55)	48.47 (31.19)	56.59 (38.87)
4	Mancozeb 63% + Carbendazim 12%WP	6.67 (14.48)	7.50 (15.23)	7.08 (14.85)	76.46 (54.97)	72.73 (51.81)	74.60 (53.39)
5	Carbendazim 50%WP+Propiconazole 25% EC	3.33 (10.37)	6.67 (14.24)	5.00 (12.31)	88.24 (67.75)	75.74 (54.95)	81.99 (61.35)
6	Validamycin 3%L	4.17 (11.36)	4.17 (11.36)	4.17 (11.36)	85.28 (64.68)	84.84 (64.06)	85.06 (64.37)
7	Hexaconazole 5%EC	5.83 (13.48)	5.83 (13.48)	5.83 (13.48)	79.42 (58.08)	78.80 (57.35)	79.11 (57.71)
8	Kasugamycin 3%SL	10.83 (18.46)	10.83 (18.46)	10.83 (18.46)	61.77 (42.60)	60.62 (41.60)	61.20 (42.10)

9	Azoxystrobin 23%SC	5.00 (12.64)	5.00 (12.64)	5.00 (12.64)	82.35 (60.70)	81.82 (60.01)	82.09 (60.35)
10	Propiconazole 25% EC	7.50 (15.23)	7.50 (15.23)	7.50 (15.23)	73.53 (52.64)	72.73 (51.82)	73.13 (52.23)
11	Control	28.33 (32.16)	27.50 (31.61)	27.92 (31.88)			
	Overall Mean	8.18 (15.31)	9.24 (16.58)				
	CD (p=0.05)=	(7.56)	(8.54)				

Data in the parentheses are angular transformed value

On the basis of average data (Table-4) of the grain quality parameters, recorded during both years, it was observed that the highest 1000 grain weight was noticed in treatment Kasugamycin 3%SL (35.67 g) followed by Flusilazole 12.5% + Carbendazim 25%SC (34.0 g), Hexaconazole 5%EC (33.67g) and Carbendazim 50%WP +Propiconazole 25% EC (30.00g). However, The highest number of healthy grain per 1000 grain were recorded in the treatment Kasugamycin 3%SL (848 grain/1000 grain) followed by Flusilazole 12.5% + Carbendazim 25%SC (836 grain/1000grain) and Propiconazole 25% EC (825 grain/1000 grain). The lowest average number of chaffy grain per 1000 grain was recorded in the treatment Hexaconazole 5%EC (87 grain/1000 grain) followed by Kasugamycin 3%SL (102 grains/1000grains) and Flusilazole 12.5% + Carbendazim 25%SC (107 grain/1000grain) whereas lowest number of discolored grain per 1000 grain was observed with the treatment, Kasugamycin 3%SL (51 grain/1000 grain) followed by Flusilazole 12.5% + Carbendazim 25%SC (58 grain/ 1000 grain) and Azoxystrobin 23%SC (75 grain/1000 grain) observed with control which was higher to all remaining treatments. Prasanna and Veerabhadraswamy (2014) [17] documented various fungicides against blast (leaf and neck) and sheath blight disease of rice. Among them, Conika 50% WP (Kasugamycin 5% + Copper Oxychloride 45% WP), Dhanucop Team (Tricyclazole 75% WP) and RIL-068/F1 48 WG (Kresoxim methyl 40% + Hexaconazole 8% WG) were found effective against blast diseases. While, the seed treatment fungicide Isotianil SC 200 and its combination with Trifloxystrobin 500 SC were found least effective against leaf and neck blast diseases. However, in case of sheath blight, Thifluzamide 24% SC, RIL-068/F1 48 WG (Kresoxim methyl 40% + Hexaconazole 8% WG), Propiconazole 25% EC (Tilt), Tricyclazole 75% WP (Beam) and a new combination fungicide, Fluxapyroxad 62.5 g/l + Epoxiconazlle 62.5 g/l EC (Adexar w/v EC) were found effective. All the combination treatments involving fungicides were effective against sheath blight. These combination treatments had no adverse effect and recorded higher grain yield (Mukherjee, 2009) [13]. Jones *et al*. (1987) [7] observed that Propiconazole applied twice or Propiconazole followed by Benomyl, significantly reduced disease severity and increase yield. Yield response was correlated to incidence of sheath blight at the panicle initiation stage. Benomyl applied twice did not reduces disease or increase yield significantly. An economic return from Propiconazole/Benomyl application could be anticipated even when 75 per cent diseased tillers have been infected at the panicle stage of crop growth. During present investigation, single fungicides *i.e.* Kasugamycin was found to be most effective, which have not been tested in any of the studies reported by the scientists mentioned above.

Table 4: Effect of different fungicides on the grain quality of basmati rice

S. No.	Fungicide	1000 Grain Weight (g)	1000 Grain Weight (g)	Average of 1000 grain weight (g)	Healthy Grain/ 1000 Grain	Healthy Grain/ 1000 Grain	Average healthy grain/ 1000 grain	Chaffy Grain/ 1000 Grain	Chaffy Grain/ 1000 Grain	Average of chaffy grain/ 1000 grain	Discolored Grain/ 1000 Grain	Discolored Grain/ 1000 Grain	Average of discolored grain/ 1000 grain
		2011	2012		2011	2012		2011	2012		2011	2012	
1	Trifloxystrobin 25% +Tebuconazole 50% WG	27.67	27.67	27.67	685	681	683	197	199	198	118	120	119
2	Flusilazole 12.5% + Carbendazim 25%SC	34.00	34.00	34.00	835	837	836	100	113	107	65	50	58
3	Carboxin 37.5% + Thiram 37.5% WP	28.00	28.00	28.00	683	686	685	175	171	173	130	71	101
4	Mancozeb 63% + Carbendazim 12%WP	27.67	27.67	27.67	687	681	684	174	177	175	140	142	141
5	Carbendazim 50%WP +Propiconazole 25% EC	30.00	30.00	30.00	734	735	735	164	161	163	102	103	103
6	Validamycin 3%L	27.67	27.67	27.67	792	795	794	113	115	114	95	90	93
7	Hexaconazole 5%EC	33.67	33.67	33.67	806	814	810	96	78	87	98	108	103
8	Kasugamycin 3%SL	35.33	36.00	35.67	847	849	848	102	101	102	51	50	51
9	Azoxystrobin 23%SC	28.00	30.00	29.00	697	690	693	213	102	158	80	70	75
10	Propiconazole 25% EC	30.00	28.00	29.00	823	827	825	101	102	102	76	131	103
11	Control	21.67	20.00	20.83	657	646	652	223	223	223	141	143	142
	Overall Mean	29.42	29.33		750	749		151	153		100	98	
	CD (p=0.05)=	1.61	0.57		16.1	2.36		16.71	2.55		17.81	1.36	

On the basis of two years average data (Table-5), it was found that, Highest plant height with Carboxin 37.5% + Thiram 37.5% WP (66.85 cm), highest number of tillers per m^2 recorded in treatment Hexaconazole 5%EC (217 tillers/m^2), highest panicle length recorded the treatment Carbendazim 50%WP +Propiconazole 25% EC (27.80 cm) and number of seed per panicle were recorded in treatment Carboxin 37.5% + Thiram 37.5% WP (155 seed/ panicle). Hazra and Roy (2001) [5] reported that single doses of Carbendazim, gave better results than Iprodione under field conditions; but *in vitro*, single doses of Iprodione and the combination of Iprodione and Carbendazim showed better results than single doses of Carbendazim. Fungicide treatment significantly reduced root and shoot length. Kannaiyan and Prasad (1979) [9] reported that Daconil, Vitavax and Agrosan GN reduced the seed borne infection of *R. solani* and improved the seed germination, shoot and root growth, seedling vigour and preserved the seed viability upto 8 months.

Table 5: Effect of different fungicides on the plant height, number of tillers, panicle length and seed/panicle of rice against sheath blight of rice

S. No.	Fungicide (Treatments)	Plant Height (cm)	Plant Height (cm)	Average of plant height	Tillers/ m^2	Tillers/ m^2	Average of tillers/ m^2	Panicle Length (cm)	Panicle Length (cm)	Average of panicle length	Seed/ Panicle	Seed/ Panicle	Average of seed /panicle
		2011	2012		2011	2012		2011	2012		2011	2012	
1	Trifloxystrobin 25% +Tebuconazole 50% WG	59.34	59.34	59.34	173	174	174	27.57	26.46	27.02	152	153	153
2	Flusilazole 12.5% + Carbendazim 25%SC	65.03	64.27	64.65	152	153	153	27.67	26.86	27.27	150	151	151
3	Carboxin 37.5% + Thiram 37.5% WP	66.96	66.74	66.85	201	203	202	27.44	27.07	27.26	154	155	155
4	Mancozeb 63% + Carbendazim 12%WP	67	66.54	66.77	205	206	206	26.76	26.53	26.65	136	137	137
5	Carbendazim 50%WP +Propiconazole 25% EC	63.27	62.80	63.04	201	202	202	28.20	27.40	27.80	77	78	78
6	Validamycin 3%L	63.06	62.06	62.56	169	170	170	27.20	26.47	26.84	132	133	133
7	Hexaconazole 5%EC	62.13	61.20	61.67	216	218	217	27.13	26.14	26.64	119	120	120
8	Kasugamycin 3%SL	55.2	51.94	53.57	160	133	145	26.30	27.74	27.02	113	114	114
9	Azoxystrobin 23%SC	66.04	64.34	65.19	151	152	152	25.74	24.44	25.09	125	126	126
10	Propiconazole 25% EC	65.13	63.33	64.23	210	212	211	27.77	27.13	27.45	72	73	73
11	Control	51.79	50.10	50.95	132	131	131	24.10	23.33	23.72	58	60	59
	Overall Mean	62.27	61.15		179	178		26.90	26.32		117	118	
	CD (p=0.05)=	0.473	0.366		2.78	1.11		0.55	0.328		6.10	0.72	

On the basis of average data of productivity for two crop seasons, it was observed (Table-6) that highest biological yield was recorded with the application of Carboxin 37.5% + Thiram 37.5% WP (25.83 kg/plot). Highest grain yield recorded due to application of Azoxystrobin 23% SC (6.50 kg/plot) and straw yield recorded with Carboxin 37.5% + Thiram 37.5% WP (19.33 kg/plot) during both the years. Prasanna and Veerabhadraswamy (2014) [17] reported that Thifluzamide 24% SC, RIL-068/F1 48 WG (Kresoxim methyl 40% + Hexaconazole 8% WG), Propiconazole 25% EC (Tilt), Tricyclazole 75% WP (Beam) and a new combination fungicide, Fluxapyroxad 62.5 g/l + Epoxiconazlle 62.5 g/l EC (Adexar w/v EC) were found effective for management of sheath blight of rice.

Table 6: Effect of different fungicides on total biological yield, grain yield and straw yield of basmati rice

S. No.	Fungicide	Biological Yield (Kg/ plot)	Biological Yield (Kg/ plot)	Average of biological yield (Kg/ plot)	Grain Yield (Kg/ plot)	Grain Yield (Kg/ plot)	Average of grain yield (Kg/plot)	Straw Yield (Kg/ plot)	Straw Yield (Kg/ plot)	Average of straw yield (Kg/plot)
		2011	2012		2011	2012		2011	2012	
1	Trifloxystrobin 25% +Tebuconazole 50% WG	19.00	20.33	19.67	4.67	5.33	5.00	14.33	15.00	14.67
2	Flusilazole 12.5% + Carbendazim 25%SC	20.67	20.33	20.50	5.67	5.00	5.33	15.00	15.33	15.17
3	Carboxin 37.5% + Thiram 37.5% WP	25.33	26.33	25.83	6.17	6.84	6.50	19.17	19.50	19.33
4	Mancozeb 63% + Carbendazim 12%WP	23.00	23.67	23.33	5.84	6.17	6.00	17.17	17.50	17.34
5	Carbendazim 50%WP +Propiconazole 25% EC	18.34	20.66	19.50	4.33	5.34	4.84	14.00	15.34	14.67
6	Validamycin 3%L	20.33	20.00	20.17	4.50	4.50	4.50	15.67	16.34	16.00
7	Hexaconazole 5%EC	21.00	21.00	21.00	5.50	5.84	5.67	15.50	15.16	15.33
8	Kasugamycin 3%SL	23.66	23.34	23.50	6.00	6.34	6.17	17.66	17.00	17.33
9	Azoxystrobin 23%SC	20.67	21.00	20.83	6.33	6.67	6.50	14.33	14.33	14.33
10	Propiconazole 25% EC	18.66	20.00	19.33	4.84	5.84	5.34	13.84	14.16	14.00
11	Control	17.67	17.34	17.50	4.66	3.66	4.16	13.17	12.84	13.00
	Overall Mean	20.76	21.27		5.32	5.59		15.44	15.68	
	CD (p=0.05)=	3.71	3.45		0.83	1.21		3.53	3.37	

During crop season 2011and 2012, it was noticed (Table-7) that lowest AUDPC values were exhibited due to application of Flusilazole 12.5% + Carbendazim 25%SC (AUDPC 1523.70) followed byCarbendazim 50%WP +Propiconazole 25% EC (AUDPC of 2355.60) and Mancozeb 63% + Carbendazim 12%WP (AUDPC of 2375.70). Maji and Shaibu (2012) [11] tested the effects of four antibiotics on the growth of four strains of biological control agents (BCA) B-916(*Bacillus subtilis*), P7-14 (*Pseudomonas fluorescens),* P9409 (*P. resinovorans)* and P10353 (*P.malculicola*) by growing them on peptone potassium nitrate medium (PPM) ranged from 0.5 to 1000 ug/mL of four antibiotitics. The three antibiotics (ampicilin, hygromycin and kanamycin) at 50 ug/mL) reduced sheath blight by 60-80% asmeasured by area under the disease progress curve (AUDPC). B-916 and P9409 controlled thedisease over 75%, whereas P7-14 and P10353 were less effective. B-916 + ampicilin, P10353 + rifampicin and P9409 + rifampicin. (25 ug/mL) was mixed with a BCA (0.5 X 107 CFU/mL) were sensitive resulted, disease suppression was consistently weakened. When an antibiotic and a tolerant BCA were combined as P7-14 + hygromicin and P9409 + hygromycin, their efficacy was unchanged or enhanced. Compared with the parent BCA, bio-control efficacy of hygR -714 and hygR -9409 was significantly enhanced or unchanged in other cases.

Table 7: Area under the disease progress curve (AUDPC) for sheath blight of rice under various fungicides at 80 DAT

S. No.	Treatment (Fungicides)	Area under disease progress curve (AUDPC) for sheath blight disease		
		2011	2012	Average
1	Trifloxystrobin 25% +Tebuconazole 50% WG	2329.80	2501.00	2415.40
2	Flusilazole 12.5% + Carbendazim 25%SC	1573.60	1473.80	1523.70
3	Carboxin 37.5% + Thiram 37.5% WP	2583.80	2590.00	2586.90
4	Mancozeb 63% + Carbendazim 12%WP	2394.60	2356.80	2375.70

5	Carbendazim 50%WP +Propiconazole 25% EC	2258.20	2453.00	2355.60
6	Validamycin 3%L	2486.80	2327.60	2407.20
7	Hexaconazole 5%EC	2613.00	2563.80	2588.40
8	Kasugamycin 3%SL	2492.20	2430.20	2461.20
9	Azoxystrobin 23%SC	2559.00	2434.80	2496.90
10	Propiconazole 25% EC	2477.20	2358.60	2417.90
11	Control	3021.60	2974.60	2998.10
	Mean	2435.44	2405.84	
	CD=(p=0.05)=	4.22	3.37	

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References

1. Anonymous. Area, production and yield of rice in India. Krishi Darshika I.G.K.V. Raipur (C.G.), 2016, 4-5.
2. Bag MK. Efficacy of a new fungicide 'Trifloxystrobin 25%+Tebuconazole 50%' 75wg against sheath blight (*Rhizoctonia solani* Kuhn) of rice. Journal of Crop and Weed. 2009; 5(1):224-226.
3. Dwivedi JL. Status paper on Rice in Uttar Pradesh. Rice Knowledge Management Portal (RKMP). Direc-torate of Rice Research, Rajendra nagar. Hyderabad, 2014.
4. Ghazanfar MU, Wakil W, Sahi ST, Yasin SI. Influence of various fungicides on the management of rice blast disease. Mycopath. 2009; 7(1):29-34.
5. Hazra SP, Roy AS. Efficacy of Iprodione and Carbendazim against rice sheath blight and their compatibility with biocontrol agents. Journal of Interacademicia. 2001; 5(1):11-18.
6. IRRI. Standard Evaluation System for rice. INGER Genetic Resource Centre, 4th Edn. July, 1996.
7. Jones RK, Belnary SB, Jager MJ. Evaluvation of benomyl of Propiconazole for controlling sheath blight of rice caused by *R. solani*. Plant Diseases. 1987; 71:222-225.
8. Kandhari J, Gupta RL, Kandhari J. Efficacy of fungicides and resistance inducing chemicals against sheath blight of rice. Journal of Mycopathological Research. 2003; 41:67-69.
9. Kannaiyan S, Prasad NN. Control of sheath blight of rice. Int. Rice. Res. Nwsl. 1979; 2:6.
10. Kohli CK. Pathogenicity and host range studies on paddy sheath blight pathogen *Rhizoctonia solani* Kuhn. Journal and Research. 1966; 3:7-40.
11. Maji EA, Shaibu AA. Effects of antibiotics on biological control agents and their efficacy to control rice sheath blight (*R. solani* AG-I.1). Journal of Agricultural Technology. 2012; 8(3):993-997.
12. Miyake I. Studies uber die pilze der Reispflanze in Japan, J coll. Agric. Tokyo. 1910; 2:237-276.
13. Mukherjee SK, Mishra PR, Dash D, Rath LK, Karmakar SK. Studies on compatibility of insecticides and fungicides on plant hopper and sheath blight of rice. Journal of Plant Protection and Environment. 2009; 6(1):70-73.
14. Nagarajan S, Muralidharan K. Dynamics of Plant Diseases. Allied Publishers Ltd., New Delhi, 1995, 247.
15. Ou SH. Rice disease Commonwealth Mycological Institute, Kew, Surray, UK, 1985.
16. Paracer CS, Chahal DS. Sheath blight of rice caused by *Rhizoctonia solani* Kuhn. A New record in India. Curr. Sci. 1963; 32:328-329.
17. Prasanna MKK, Veerabhadraswamy AL. Appraise a combination of fungicides against blast and sheath blight diseases of paddy (*Oryza sativa* L.) Journal of Experimental Biology and Agricultural Sciences. 2014; 2(1):49-56.
18. Rai M. Rice- the cereal that feeds billions. Indian Farming. 2006; 56(7):4-9.
19. Rajan CPD. Estimation of yield loss due to sheath blight of rice. Indian Phytopatholog. 1987; 40:174-177.
20. Reddy CS, Muralidharan K. Luster 37.5 SE - an effective combination product of Flusilazole and Carbendazim against sheath blight of rice. Indian Journal of Plant Protection. 2007; 35(2):287-290.
21. Rush MC, Lindberg CD. Controlling sheath blight in rice. Lousiana Agriculture. 1984; 27:16-18.
22. Saksena HK. Reminiscences and observations on the growth of plant pathology in India. Indian Phytopathology. 1977; 30:165-170.
23. Savary S, Mew TW. Analyzing crop losses due to *Rhizoctonia solani*: rice sheath blight, a case study. In: SnehB, Javaji-Hare S, Neate S, Dijst G (eds) *Rhizoctonia* species: taxonomy, molecular biology, ecology, pathology and disease control, Kluwer, Dordrecht, 1996, 237-244.
24. Savary S, Willocquet L. Rice pest constraints in Tropical Asia: Quantification of yield losses due to rice pests in a range of production situation. Plant Dis. 2000; 84:357-369.
25. Savary S, Horagan F, Willocqueet L, Heong KL. A review of principles for sustainable pest management in rice. Crop Protection. 2012; 32:54-63.
26. Savary S, Teng PS, Willocquet L, Nutter FW Jr. Quantification and modeling of crop losses: a review of purposes. Annual Review of Phytopathology. 2006; 44:89-112.
27. Srinivas P, Ved Ratan, Atm Prakash Patel, Bindu Madhavi G. Review on banded leaf and sheath blight of rice caused by *Rhizoctonia solani* Kuhn. International Journal of Applied Biology and Pharmaceutical Technology. 2013; 61(2):80-97.
28. Srinivasachary Willocquet L, Savary S. Resistance to rice sheath blight (*Rhizoctonia solani* Kuhn.) [(teleomorph: *Thanatophorus cucumeris* (A.B. Frank) Donk.] disease: current status and perspectives. Euphytica. 2011; 178:1-22.
29. Zachow C, Grosch R, Berg G. Impact of biotic and a-biotic parameters on structure and function of microbial communities living on sclerotia of the soilborne pathogenic fungus *Rhizoctonia solani*. Appl. Soil Ecol. 2011; 48:193-200.
30. Zheng A, Lin R, Zhang D, Qin P, Xu L, Ai P *et al*. The evolution and pathogenic mechanisms of the rice sheath blight pathogen. Nature Communic. 2013; 4:14-24.