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Integrated management of *Rhizoctonia solani* causing sheath blight of rice (*Oryza sativa*)

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ABSTRACT

The present investigation was carried out at CCSHAU Rice Research Station, Haryana, to manage sheath blight of rice (*Oryza sativa* L.) caused by *Rhizoctonia solani* Kuhn through host resistance, botanical extracts, and to develop a spray schedule of best two botanical extracts, i.e. garlic cloves and turmeric powder in combination with the best two fungicides, viz. azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC. Out of 307 rice genotypes screened during *kharif* 2016 and 2017, none was found highly resistant against sheath blight. However, only one genotype (RMS-BL-6) showed consistent resistance reaction during both the years while five entries (MR 8333, KNM 1730, PAU 7111-1-1-0, RP 5141-432-10-3-2 and VL 32197) showed a moderately resistant reaction. The rice genotype RMS-BL-6 also showed moderate resistance to bacterial blight, and was moderately susceptible to stem rot. Extracts of garlic cloves and turmeric powder were found effective and reduced the vertical disease spread (relative lesion height) by 36.62% and 35.38% along with 11.59% and 10.85% enhanced grain yield of paddy respectively. Among combination treatments, application of azoxystrobin 18.2% + difenoconazole 11.4% SC at 1 day after inoculation (DAI) followed by extract of garlic cloves at 11 days after inoculation was highly effective and statistically at par with two applications of azoxystrobin 18.2% + difenoconazole 11.4% SC (at 1 and 11 DAI) and thifluzamide 23.9% SC (at 1 and 11 DAI); application of thifluzamide 23.9% SC (1 DAI) followed by azoxystrobin 18.2% + difenoconazole 11.4% SC (11 DAI) and vice-versa.

Key words: Botanicals, Fungicides, Host resistance, *Rhizoctonia solani*, Sheath blight

Rice (*Oryza sativa* L.) is a staple food for majority of the world's population. India ranks first in the area under rice and second in production of rice in the world. In India, it is grown over 43.39 mha with production and productivity of 104.32 mt and 2404 kg/ha, respectively (Anonymous 2016). Besides ensuring food security of the nation, rice has been the leading agricultural export commodity earning a substantial foreign exchange. A continuous increase in rice productivity is needed to meet the ever-increasing global demand for food. However, biotic stresses like sheath blight caused by *Rhizoctonia solani* Kuhn (AG-1 IA) cause substantial economic losses in different rice growing countries (Singh *et al.* 2016, Laha *et al.* 2017). Sheath blight, earlier considered to be a minor disease in the state of Haryana, has attained the status of a major disease since last decade (Singh *et al.* 2013). Besides quality deterioration, it has been reported to cause yield losses ranging from 4 to 50% (Bhunkal *et al.* 2015, Singh *et al.* 2016). All the commercially grown varieties of rice in Haryana are susceptible to sheath blight (Singh and Dodan 1995) and the disease management is primarily dependent on the use of fungicides. Several fungicides including thiafluzamide and hexaconazole (Sunder *et al.* 2003), diniconazole and hexaconazole (Singh *et al.* 2010), azoxystrobin & tebuconazole 50% + trifloxystrobin 25% WG (Agarwal and Sunder 2013) and azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC (Kumar *et al.* 2018) have been reported to be highly effective in reducing sheath blight and enhancing the grain yield of rice.

Management of diseases through highly effective eco-friendly fungicides or botanicals is imperative for production of residue-free crop to promote international trade and enhance rice productivity. The commercial botanical formulations, viz. Spictaf, Tricure, Neemazal and Achook (Singh *et al.* 2016) have been found effective in suppressing sheath blight of rice. Realising the importance of the disease and availability of scarce information on integrated disease management, this study was undertaken to identify resistance sources and study the efficacy of commonly available botanicals alone and in combination

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with effective fungicides (Kumar *et al.* 2018) for developing an integrated disease management strategy.

MATERIALS AND METHODS

Screening of rice genotypes: A total of 307 rice genotypes were screened during *kharif* 2016 to identify the sources of resistance against *R. solani* under artificial inoculation conditions in the field following Singh *et al.* (2010). The genotypes showing resistance reaction (disease score 0–3) were re-tested during *kharif* 2017 to confirm their disease reaction. These genotypes were also evaluated against stem rot and bacterial leaf blight of rice in a sick plot and under artificial inoculation conditions, respectively, following Sunder and Singh (2017) to find out the sources of multiple disease resistance.

Evaluation of botanicals: Aqueous extracts of nine botanicals, viz. onion bulbs (*Allium cepa*), garlic cloves (*Allium sativum*), neem leaves (*Azadirachta indica*), jamun leaves (*Syzygium cumini*), turmeric powder (*Curcuma longa*), bathu leaves (*Chenopodium* sp.), morpankhi leaves (*Thuja compacta*), tulsi leaves (*Ocimum sanctum*) and henna leaves (*Lawsonia alba*) were evaluated for their efficacy against *R. solani*. The plant extracts were prepared by macerating surface washed plant parts with an equal amount of water (1:1, weight/volume). Macerated extracts were centrifuged to remove plant debris. The extract (as supernatant) was then passed through bacteria proof filter paper lining over Buchener's funnel. This extract was used as stock solution (100%). Further required dilutions were made from stock solution.

For *in vitro* evaluation, various concentrations (10, 20, 30, 40, 50 and 60%) extracts were prepared by adding required quantity of sterile distilled water to the aqueous stock solution of each plant extract. The solutions of these concentrations were added in an equal volume of double strength PDA in Petri plates to get the final concentration of 5, 10, 15, 20, 25 and 30%. Un-amended plates served as control. Hyphal plugs (5 mm diameter) were cut from the periphery of active growing colonies (3 days old culture) and transferred aseptically to three replicate plates containing PDA medium supplemented with plant extracts. The plates were sealed with parafilm and incubated at 28 ± 1°C. Radial growth was measured at two perpendicular colony diameters when the growth in the control plates reached the periphery of Petri plates. The antifungal activity was expressed in terms of percentage of mycelial growth inhibition (MGI). The sclerotia formation in amended and un-amended plates was also counted after 10 days of incubation, and per cent inhibition of sclerotia formation in different treatments was calculated.

Field experiments were also conducted during *kharif* 2016 and 2017 at CCSHAU Rice Research Station, Kaul to study the efficacy of above-mentioned botanicals against sheath blight. Seedlings attaining the age of 30 days of susceptible rice variety HKR 127 were transplanted in 3 × 2 m plots at 20 × 15 cm spacing following randomized block design (RBD). The recommended agronomic practices were followed to raise the crop except 25% higher dose of nitrogenous fertilizer was used to enhance disease development. The inoculum multiplication and inoculation was done as described above. Plots were sprayed with 50 ml of crude extract prepared with water (equal weight of plant parts and equal volume of water) and then mixed with 1 litre of water at 1 and 11 DAI. The observations on vertical disease spread (relative lesion height) were recorded on 25 plants per plot 15 days after the second spray following Anonymous (2002). The grain yield was recorded on plot basis and expressed as kg/ha.

Development of spray schedule by integrating effective fungicides and botanicals: Two fungicides (azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC) found to be environmentally safe and highly effective against sheath blight in an earlier study (Kumar *et al.* 2018) were integrated with the aqueous extract of best two botanical extracts (garlic cloves and turmeric powder) in all possible combinations to find out an alternative of repeated fungicidal applications and to develop an integrated disease management strategy against sheath blight of rice. The fungicides and botanicals were sprayed twice, i.e. 1 and 11 DAI alone and as an alternative of each other along with two sprays of the recommended check fungicide validamycin 3% L. The observations on vertical disease spread and grain yield were recorded.

RESULTS AND DISCUSSION

Screening of rice genotypes for identifying resistance sources: Out of 307 rice genotypes screened against sheath blight under high disease pressure with a location severity index of 7.68 (on 0–9 scale) during *kharif* 2016, none was found highly resistant. However, four rice genotypes, viz. MR 8333, RMS-BL-6, RNSK 1100 and RSK 1103 were resistant and five genotypes, viz. PUR-K-67, KNM 1730, PAU 7111-1-1-0, RP 5141-432-10-3-2 and VL 32197 showed a moderately resistant reaction. Remaining genotypes were found moderately susceptible (26 genotypes), susceptible (119 genotypes) and highly susceptible (153 genotypes). Retesting of resistant and moderately resistant genotypes under artificial inoculation conditions during *kharif* 2017 revealed that only one genotype—RMS-BL-6 showed consistent resistance reaction while five genotypes, viz. KNM 1730, MR 8333, PAU 7111-1-1-0, RP 5141-432-10-3-2 and VL 32197 showed a moderately resistant reaction. The rice genotype RMS-BL-6 also showed moderate resistance to bacterial blight, and was moderately susceptible to stem rot.

In an earlier study, three rice genotypes, viz. CB 05-22, HKR 05-81 and OR 2351-6 have been reported to have multiple resistance to sheath blight and stem rot while two genotypes PAU 3832-196-4-1-2 and RPDN 117 have resistance to sheath blight, bacterial blight and stem rot (Sunder and Singh 2017). A high level of sheath blight resistance has been observed in rice lines LSBR 5, LSBR 33, YSBR 1, BPL 7-12, BML 27-1 and Pecos in different countries (Singh *et al.* 2016). Besides, moderate level of resistance has also been observed in accessions of traditional rice cultivars like Tetep, Jasmine 85, Tequing, Bhasamanik, Lalsatkara, ARC 15762, ARC 18119, ARC 18275, ARC 18545, D 256, MTU 1010, YSBR 1 (Wang *et al.* 2009, Srinivasachary *et al.* 2011, Lore *et al.* 2015), HKR 99-103, HKRH 1059 and IR 64683-87-2-2-3-3 (Singh *et al.* 2010) and N-22 (Acc. 4819), N-22 (Acc. 6264), N-22 (Acc. 19379), HKR 05-476 and Tetep (Bhunkal *et al.* 2015).

Evaluation of botanical extracts: The aqueous extracts of all nine botanicals significantly inhibited the mycelial growth and sclerotial formation of *R. solani* over the check. Increase in concentration of botanical extracts in the amended PDA increased the inhibition of mycelial growth and sclerotial formation. On mean basis, extract of garlic cloves was most effective treatment which completely inhibited the mycelial growth and sclerotia formation at the concentration of 10% and 5% followed by turmeric powder in which complete inhibition of mycelia and sclerotia formation was recorded at 25% and 15% respectively. The extracts of tulsi leaves and onion bulbs (statistically at par) were the least effective treatments concerning mycelial growth inhibition while extract of onion bulbs was least effective in inhibiting the sclerotia formation (Table 1, 2).

A significant interaction between botanical extracts and their concentrations concerning mycelial growth and sclerotial inhibition revealed that all the botanical extracts at 5% concentration inhibited the mycelial growth and sclerotia formation. Further increase in concentration beyond 5% significantly increased the inhibition of mycelial growth and sclerotial formation. But the concentration up to which the inhibition occurred differed with the botanical extract. The mycelial growth inhibition in garlic was observed up to a concentration of 10% while in case of jamun and bathu leaves and onion bulbs, growth inhibition occurred up to a concentration of 30%. Likewise, sclerotial inhibition was observed up to 20% concentration in extracts of onion bulbs and neem leaves, and upto a concentration of 25% in extracts of morpankhi and henna leaves (Table 1, 2).

In the present study, the extract of neem leaves provided mean mycelial growth and sclerotia formation inhibition of 40.29% and 72.60% respectively. However, Verma and Ram (2006) reported 88.1% and 89.9% inhibition of fungal growth and sclerotial production using neem product Neemachron. Spray application of 0.03% neem formulations (300 ppm azadirachtin) at 4.5 ml/l has been reported very effective in suppressing the disease (Biswas 2007). Several commercial botanical pesticides like Tricure (Muralidharan *et al.* 2003), Spictaf and Neemazal (Biswas and Roychoudhury 2003), Achook (Kandhari 2007) and Spictaf and Tricure (Singh *et al.* 2010) have also been found promising in reducing the disease severity and in

Table 1 Effect of botanical extract on mycelial growth inhibition (%) of *Rhizoctonia solani*

Treatment	Concentration (%)							
	0	5	10	15	20	25	30	Mean
Onion bulbs (*Allium cepa*)	0.00 (0.57)*	16.30 (23.75)	25.74 (30.46)	29.44 (32.84)	31.67 (34.23)	40.37 (39.43)	51.48 (45.83)	27.86 (29.59)
Garlic cloves (*Allium sativum*)	0.00 (0.57)	94.07 (75.89)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	84.87 (74.77)
Neem leaves (*Azadirachta indica*)	0.00 (0.57)	11.11 (19.37)	27.59 (31.64)	50.56 (45.30)	58.15 (49.67)	64.26 (53.27)	70.37 (57.01)	40.29 (36.69)
Jamun leaves (*Syzygium cumini*)	0.00 (0.57)	12.96 (21.05)	25.56 (30.32)	34.44 (35.91)	50.19 (45.09)	52.41 (46.36)	60.56 (51.08)	33.73 (32.91)
Turmeric powder (*Curcuma longa*)	0.00 (0.57)	64.07 (53.16)	82.96 (65.61)	85.93 (67.96)	91.11 (72.65)	100.00 (89.39)	100.00 (89.39)	74.87 (62.68)
Bathu leaves (*Chenopodium* sp.)	0.00 (0.57)	54.81 (47.75)	56.30 (48.60)	66.30 (54.50)	71.11 (57.49)	83.70 (66.25)	92.22 (73.80)	60.63 (49.85)
Morpankhi leaves (*Thuja compacta*)	0.00 (0.57)	52.96 (46.68)	60.00 (50.75)	63.52 (52.83)	65.93 (54.27)	68.52 (55.85)	71.11 (57.47)	54.58 (45.49)
Tulsi leaves (*Ocimum sanctum*)	0.00 (0.57)	14.63 (22.45)	18.52 (25.45)	27.04 (31.31)	31.67 (34.22)	45.56 (42.43)	51.85 (46.04)	27.04 (28.93)
Henna leaves (*Lawsonia alba*)	0.00 (0.57)	18.33 (25.27)	32.41 (34.68)	36.11 (36.92)	49.81 (44.88)	58.89 (50.11)	67.04 (54.95)	37.51 (35.34)
Mean	0.00 (0.57)	37.70 (37.26)	47.67 (45.21)	54.81 (49.66)	61.07 (53.54)	68.19 (59.17)	73.85 (62.77)	
CD (P=0.05)	Treatment					(0.85)		
	Concentration					(0.75)		
	Treatment × concentration					(2.26)		

*Figures in parentheses represent angular transformed values

Table 2 Effect of botanical extarct on sclerotial formation inhibition (%) of *Rhizoctonia solani*

Treatment	Concentration (%)							
	0	5	10	15	20	25	30	Mean
Onion bulbs	0.00 (0.57)*	11.43 (19.37)	41.78 (40.23)	49.28 (44.57)	60.00 (50.76)	63.93 (53.07)	69.28 (56.35)	42.24 (37.85)
Garlic cloves	0.00 (0.57)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	85.71 (76.70)
Neem leaves	0.00 (0.57)	51.07 (45.60)	75.36 (60.24)	81.79 (64.82)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	72.60 (62.77)
Jamun leaves	0.00 (0.57)	45.36 (42.31)	51.07 (45.60)	65.00 (53.74)	68.93 (56.12)	75.00 (60.03)	87.14 (69.10)	56.07 (46.78)
Turmeric powder	0.00 (0.57)	98.21 (82.38)	99.28 (85.82)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	100.00 (89.39)	85.36 (75.19)
Bathu leaves	0.00 (0.57)	48.57 (44.16)	51.43 (45.80)	60.36 (50.96)	65.71 (54.16)	87.86 (69.73)	100.00 (89.39)	59.13 (50.68)
Morpankhi leaves	0.00 (0.57)	74.64 (59.77)	88.21 (70.01)	92.50 (74.40)	96.43 (79.10)	98.93 (84.99)	99.64 (87.60)	78.62 (65.21)
Tulsi leaves	0.00 (0.57)	51.07 (45.60)	66.43 (54.58)	83.57 (66.13)	86.07 (68.20)	89.64 (71.26)	92.86 (74.66)	67.09 (54.43)
Henna leaves	0.00 (0.57)	38.93 (38.57)	41.43 (40.00)	55.71 (48.27)	61.43 (51.65)	75.36 (60.24)	86.79 (68.68)	51.38 (44.00)
Mean	0.00 (0.57)	57.70 (51.91)	68.33 (59.07)	76.47 (64.63)	82.06 (69.80)	87.86 (74.17)	92.86 (79.33)	
CD (P=0.05)	Treatment				(1.39)			
	Concentration				(1.22)			
	Treatment × concentration				(3.67)			

*Figures in parentheses represent angular transformed values

increasing grain yield of rice.

Field experiments conducted during *kharif* 2016 and 2017 for the evaluation of botanical extracts against sheath blight indicated that on mean basis, foliar application of botanical extracts significantly reduced the vertical disease spread over the check. Extract of garlic cloves and turmeric powder were found effective and reduced the vertical disease spread by 36.62% and 35.38% along with 11.59% and 10.85% enhanced grain yield of paddy, respectively (Table 3). The reduction in sheath blight severity by these botanical extracts could be due to their direct toxic effect on mycelial growth and sclerotia formation of the pathogen. The effectiveness of leaf extract of tulsi in suppressing sheath blight has been established by Karthikeyan and Chandrasekaran (2007). However, field experiments of the present study indicated that tulsi extract was least effective in reducing sheath blight severity.

Evaluation of combination treatments of effective fungicides and botanicals: Field experiments conducted on evaluation of combination treatments of fungicides (azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC) with aqueous extract of botanicals (garlic cloves and turmeric powder) depicted that application of azoxystrobin 18.2% + difenoconazole 11.4% SC at 1 DAI followed by thifluzamide 23.9% SC at 11 DAI was the best treatment reducing sheath blight severity by 64.39%. However, it was statistically at par with two applications of azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC at 1 and 11 DAI and with application of thifluzamide 23.9% SC at 1 DAI followed by azoxystrobin 18.2% + difenoconazole 11.4% SC at 11 DAI.

Among combination treatments, application of azoxystrobin 18.2% + difenoconazole 11.4% SC at 1 DAI followed with extracts of garlic cloves at 11 DAI was highly effective and statistically on par with two applications of azoxystrobin 18.2% + difenoconazole 11.4% SC and thifluzamide 23.9% SC; application of thifluzamide 23.9% SC followed by azoxystrobin 18.2% + difenoconazole 11.4% SC and vice-versa. The integration of such fungicides with botanical extract of garlic cloves as an alternative spray will further help in reducing the number of fungicidal applications and minimising the risk of pesticide residues in rice production. The combination treatment of thifluzamide 23.9% SC at 1 DAI followed by an extract of garlic cloves proved less effective in suppressing the disease severity. However, it was superior to validamycin 3% L. All the botanical-botanical combinations gave least disease control (Table 4).

The reduction in disease severity corresponded to increase in grain yield of paddy. The highest grain yield (8726.67 kg/ha) was harvested from the plots treated with azoxystrobin 18.2% + difenoconazole 11.4% SC applied

Table 3 Effect of botanical extarct on sheath blight severity and grain yield of rice cultivar HKR 127

Treatment	Vertical disease spread (%)			Disease control (%)	Grain yield (kg/ha)			Increase in grain yield (%)
	2016	2017	Pooled mean		2016	2017	Pooled mean	
Onion bulbs	43.06 (40.99)*	43.47 (41.22)	43.27 (41.11)	23.07	7233.33	7956.67	7595.00	7.93
Garlic cloves	36.84 (37.34)	34.79 (36.12)	35.81 (36.73)	36.32	7466.67	8239.00	7852.84	11.59
Neem leaves	43.24 (41.09)	45.42 (42.35)	44.33 (41.72)	21.18	7200.00	7854.00	7527.00	6.96
Jamun leaves	46.98 (43.25)	47.32 (43.44)	47.15 (43.35)	16.17	6933.33	7546.00	7239.67	2.88
Turmeric powder	39.19 (38.74)	33.49 (35.33)	36.34 (37.04)	35.38	7233.33	8367.33	7800.33	10.85
Bathu leaves	45.03 (42.13)	45.10 (42.17)	45.07 (42.15)	19.87	7166.67	7802.67	7484.67	6.36
Morpankhi leaves	44.51 (41.83)	43.36 (41.17)	43.94 (41.50)	21.87	7133.33	7546.00	7339.67	4.30
Tulsi leaves	50.51 (45.27)	47.87 (43.76)	49.19 (44.52)	12.54	6800.00	7751.33	7275.67	3.39
Henna leaves	45.47 (42.38)	44.07 (41.57)	44.77 (41.98)	20.39	6833.33	7802.67	7318.00	3.99
Check	58.32 (49.78)	54.15 (47.36)	56.24 (48.57)		6733.33	7340.67	7037.00	
CD (P=0.05)	(2.98)	(2.34)			362.765	494.809		
CV (%)	4.07	3.26			2.98	3.66		

*Figures in parentheses represent angular transformed values.

Table 4 Effect of combination treatments of effective fungicides and botanicals on sheath blight and grain yield of rice cultivar HKR 127

Treatment (1st spray + 2nd spray)	Dosage	Vertical disease spread (%)	Disease control (%)	Grain yield (kg/ha)	Increase in yield over check (%)
A+A	1 ml/l	21.38 (27.48)*	60.92	8726.67	15.25
B+B	1 ml/l	22.61 (28.36)	58.67	8521.33	12.54
X+X	50 g/l	38.70 (38.45)	29.26	8110.67	7.12
Y+Y	50 g/l	36.85 (37.36)	32.64	8059.33	6.44
A+B	1 ml/l + 1 ml/l	19.48 (26.06)	64.39	8470.00	11.86
B+A	1 ml/l + 1 ml/l	24.04 (29.32)	56.07	8418.67	11.19
A+X	1 ml/l + 50 g/l	25.31 (30.16)	53.74	8264.67	9.15
A+Y	1 ml/l + 50 g/l	28.92 (32.37)	47.14	8187.67	8.14
B+X	1 ml/l + 50 g/l	34.94 (36.22)	36.14	8213.33	8.47
B+Y	1 ml/l + 50 g/l	33.39 (35.27)	38.97	8085.00	6.78
X+Y	50 g/l + 50 g/l	34.25 (35.79)	37.40	7982.33	5.42
Y+X	50 g/l + 50 g/l	36.46 (37.12)	33.36	8059.33	6.44
X+A	50 g/l + 1 ml/l	34.31 (35.81)	37.28	8264.67	9.15
X+B	50 g/l + 1 ml/l	34.48 (35.90)	36.98	8213.33	8.47
Y+A	50 g/l + 1 ml/l	30.05 (33.22)	45.07	8316.00	9.83
Y+B	50 g/l + 1 ml/l	32.49 (34.71)	40.61	8110.67	7.12
Validamycin 3% L (1 and 11 DAI)	2.5 ml/l	28.23 (32.07)	48.39	8162.00	7.80
Check		54.71 (47.69)	60.92	7571.67	
CD (P=0.05)		(4.09)		444.483	
CV (%)		7.206		3.25	

*Figures in parentheses represent angular transformed values. A, Azoxystrobin 18.2% + difenoconazole 11.4% SC; B, Thifluzamide 23.9% SC; X, Garlic cloves; Y, Turmeric powder.

at 1 and 11 DAI. However, it was statistically at par with combination treatments of application of thifluzamide 23.9% SC at 1 and 11 DAI; applications of azoxystrobin 18.2% + difenoconazole 11.4% SC at 1 DAI followed by thifluzamide 23.9% SC at 11 DAI and vice-versa. The lowest grain yield was obtained in combination treatments of an extract of garlic cloves and turmeric powder and vice-versa.

The effectiveness of thiafluzamide and hexaconazole against sheath blight has been established by earlier researchers (Sunder *et al.* 2003). Review of the literature indicated that there is no published document on efficacy of botanical extracts in combination with fungicides against sheath blight of rice. However, integration of soil amendments, antagonistic fungus and fungicide (Rajan and Alexander 1988), and integration of bio-control agents with fungicides and antibiotics (Mew *et al.* 2004) has been advocated for the management of sheath blight. Seedling treatment with *Trichoderma viride* and foliar spray of drek extract and SAAF gave promising results in lowering down the disease severity and enhancing grain yield (Dutta and Kalha 2011). The ready mix fungicidal formulations like azoxystrobin 18.2% + difenoconazole 11.4% SC have been reported to have a low risk of resistance development in pathogen due to their broad-spectrum and curative action (Singh *et al.* 2016, Pal *et al.* 2017).

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