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Management of sheath rot (*Sarocladium oryzae* (Sawada)) disease in Rice under aberrant weather field conditions

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Abstract
Among all the fungicidal treatments evaluated under field conditions, foliar sprays of Azoxystrobin 11% + Tebuconazole 18.30% SC @ 1.5 ml/l proved effective in reducing the sheath rot disease intensity (23.2%), highest grain yield of 5818 kg/ha with cost benefit ratio of 1: 2.71and was significantly superior over all other treatments followed by Triflaxystrobin 25% EC + Tebuconazole 50% WG @ 0.4 g/l (25.1%) (or) Propiconazole 25% EC @ 1 ml/l and Azoxystrobin 23% EC @ 1 ml/l (27.7%) compared to control which recorded highest per cent disease index of 40.8% with lowest yield of 4439 kg/ha.

Keywords: Sheath rot, disease intensity, disease index, yield, cost benefit

Introduction
Rice is one of the most important staple food crops in the world with India and China being the lead producing countries. Among all the rice growing states of India, Chhattisgarh state is popularly known as "Rice bowl of India" because of its maximum area under cultivation during *kharif* and contributes for major share in national rice production. The crop suffers from many biotic and abiotic stresses that incite severe economic yield losses. More than 70 diseases are caused by Fungi, bacteria, viruses, nematodes on rice. 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. Among all the rice diseases, Sheath rot caused by *Sarocladium oryzae* has become serious problem in most of the rice growing areas of the country and the disease has gained the status as a major disease of rice (Reddy and Gosh, 1985) [8].
In India the disease was first time reported by Agnihothrudu (1973) [1]. Densely planted rice fields are more susceptible to *Sarocladium* in fection. The fungus tends to attack the leaf sheaths enclosing young panicles, which retards the emergence of panicles. Seed from the infected panicles becomes discoloured and sterile and thereby reducing the grain yield and the yield losses varies from 9.6 to 85% depending on the weather conditions prevailing during the crop growth period (Phookhan and Hazarika, 1992) [6].Hence, the present investigation was planned with different fungicidal treatments and combinations to find out the most effective and economical fungicide treatment/ combination to manage sheath rot of rice caused by *S. oryzae* under field conditions.

Materials and Methods
A field experiment was conducted with paddy variety NLR-3041, susceptible to sheath rot disease during *kharif* seasons of 2019, 2020 and 2022 at Agricultural Research Station, Utukur, Kadapa (During *kharif*, 2021 there was no incidence of the sheath rot disease and hence grain yield was recorded)in Randomized Block Design (RBD) with nine treatments (including untreated check) and three replications in a plot size of 5 m × 2.2 m by adopting all the recommended package of practices suggested by ANGRAU.

Table 1: The treatments details are listed below

S. No	Name of the Treatment	Dosage
1	Tebuconazole 25% EC	1.0 ml/l
2	Triflaxystrobin 25% + Tebuconazole 50% WG	0.4 g/l
3	Carbendazim 50% WP	1.0 g/l
4	Carbendazim 12% + Mancozeb 63% WP	2.0 g/l
5	Azoxystrobin 23% EC	1.0 ml/l
6	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml/l
7	Propiconazole 25% EC	1.0 ml/l
8	Hexaconazole5% EC	2.0 ml/l
9	Untreated check (Control)	--

All thefungicidal treatments were applied uniformly in all eight treatment plots (in three replications) except control. Two sprayings were given with first spray at 5-7 days prior to booting stage and the second spray was given at 50% of booting stage. Randomly 20 panicles from each treatment were selected for recording the observations. Yield /plot was recorded at maturity of the crop and converted to kg/ha. Cost economics were also worked out. Sheath rot disease intensity was recorded at maturity of the crop in 0-9 scale by following the procedures of Standard Evaluation System of International Rice Research Institute, IRRI (Anonymous, 2002) [3] as given in Table 2. From the numerical values of the scale, the Per cent Disease Index (PDI) was calculated using the formula:

Percent Disease Index (PDI)

$$\text{PDI} = \frac{\text{Sum of numerical ratings}}{\text{Total number of panicles observed}} \times \frac{100}{\text{Maximum disease grade in score chart}}$$

Percent reduction of disease severity over untreated control

The per cent reduction of disease severity over untreated control (% ROC) was calculated by Abbott's (1925) [2] formula:

$$\text{Percent Reduction} = \frac{C - T}{C} \times 100$$

Where, C - Disease severity in untreated control and
T - Disease severity in treatment

Table 2: Standard evaluation systems of rating scale for the assessment of sheath rot disease severity

Scale	Description
0	No lesion/spots on flag leaf sheath
1	Spots visible on the tillers upon very careful examination (<1% flag leaf sheath covered)
3	Spots visible on the tillers upon careful examination (1-5% flag leaf sheath covered)
5	Spots easily visible on the tillers (6-25% flag leaf sheath covered)
7	Spots present on almost whole the tillers parts (26-50% flag leaf sheath covered)
9	Spots very common on the whole tillers parts(51-100% flag leaf sheath area covered), death of the plants common, severe yield loss

Results and Discussion

Per cent Disease Severity (%)

It was observed that among the different treatments evaluated, statistical significant reduction was noted in the incidence of sheath rot with increased grain yield over untreated check during all the three years of experimentation under field conditions. During *kharif*, 2019 two foliar sprays of Azoxystrobin + Tebuconazole @ 1.5 ml/l performed better with lowest intensity of sheath rot (21.45%) followed by Azoxystrobin @ 1 ml/l with 23.39% PDI. However, during second year of study i.e *kharif*, 2020 foliar spray of Azoxystrobin + Tebuconazole @ 1.5 ml/l proved effective by recording sheath rot disease intensity of 23.11% followed by Triflaxystrobin + Tebuconazole @ 0.4 g/l with 23.33% intensity compared to untreated check (39.52%). Similar trend was noticed during *kharif*, 2022 in which lowest percent disease intensity of 25.2% was observed in Azoxystrobin + Tebuconazole @ 1.5 ml/l followed by Triflaxystrobin + Tebuconazole @ 0.4 g/l with 26.6% PDI compared to control with disease intensity of 44.3%.

Three years pooled data of sheath rot depicted in the Table 3 clearly revealed that all the tested fungicides significantly reduced the disease intensity over control. The per cent disease incidence of the sheath rot ranged from 23.2% to 40.8%. Among which, foliar sprays of Azoxystrobin 11% + Tebuconazole 18.30% SC @ 1.5 ml/l found highly effective in reducing the disease intensity (23.2%) and recorded 43% reduction of sheath rot disease over control and was significantly superior over other treatments followed by Triflaxystrobin 25% EC +Tebuconazole 50% WG @ 0.4g/l (25.1%) with 39% reduction over control while control plot recorded highest per cent disease intensity of 40.8%.

The current results documented are in conformity with Sreekanth *et al.*, 2023 [10] proved that Triflaxystrobin 25% + Tebuconazole 50% WG @ 0.4 g/l was found significantly superior in reducing the disease and increasing the yield. Sharma *et al.*, 2020 [9] confirmed in a study that two foliar sprays (First spray at boot leaf stage and second spray at 10 days after first spray) of Tricyclazole 18% WP + Mancozeb 62% WP @ 2 g/l recorded lowest sheath rot disease severity of 9.05% compared to control and Pramesh*et al.*, 2017 [7] reported that the superiority of a combination fungicide (Captan 70% + Hexaconazole 5%) over other solo fungicides by recording lowest sheath rot disease incidence both during *kharif*, 2013 and *rabi*, 2013-14 and proved that combination fungicides are more better than solo fungicides because of their broad range of action, lower dosage and also low risk of fungicide resistance development in target fungal population.

Grain Yield (kg/ha)

Increase in grain yields over untreated checkwas observed during all the three years of experimentation under field conditions. Highest grain yield of 5600 kg/ha was recorded in the treatment combination of Azoxystrobin + Tebuconazole @ 1.5 ml/l followed by alone application of Azoxystrobin @ 1 ml/l with grain yield of 5300 kg/ha during first year of study i.e *kharif*, 2019. In the second year of study i.e *kharif*, 2020 foliar sprays of Azoxystrobin + Tebuconazole @ 1.5 ml/l proved effective by recording maximum grain yield of 5430 kg/ha followed by Triflaxystrobin + Tebuconazole @ 0.4 g/l

with 5308 kg/ha compared to untreated check (4333 kg/ha). During *kharif*, 2022 highest grain yield of 6424 kg/ha was observed in Azoxystrobin + Tebuconazole @ 1.5 ml/l followed by Triflaxystrobin + Tebuconazole @ 0.4 g/l with grain yield of 6151 kg/ha compared to control with grain yield of 5484 kg/ha.

Three years pooled observations presented in Table 4 illustrated that significant increase in grain yields were observed in the combination fungicides compared to individual fungicides during all the three years of study. The grain yield among the different treatments varied from 5818 kg/ha to 592 kg/ha. Maximum grain yield of 5818 kg/ha and highest per centage of increase over control (24) was recorded in Azoxystrobin 11% + Tebuconazole 18.30% SC @ 1.5 ml/l followed by Triflaxystrobin 25% + Tebuconazole 50% WG @ 0.4 g/l with 5536 kg/ha grain yield.

Present findings are in agreement withthose of earlier reports (Usman *et al.*, 2009, Naik *et al*., 2012, Bhuvaneshwari and Raju, 2012) [11, 5, 4], Pramesh *et al*., 2017 [7] also reported that combination fungicide (Captan + Hexaconazole @ 750 g/ha) application increased the grain yield of rice which is mainly due to the reduced severity of the sheath rot disease in the field conditions. Combination fungicides proved effective compared to solo fungicides because of their broad range of action, lower dosage and also low risk of fungicide resistance development in target fungal population. Sharma *et al.*, 2020 [9] proved two foliar sprays (First spray at boot leaf stage and second spray at 10 days after first spray) of Tricyclazole 18% WP + Mancozeb 62% WP @ 2 g/l as most effective by recording maximum grain yields of 39.50 q/ha compared to other treatments under field conditions during *kharif*, 2017-18.

Cost Benefit ratio

The data from the Table 5 showed the cost economics by taking grain yield (kg/ha), treatmental cost of the fungicide/combination, cost of cultivation, cost benefit ratio was worked out. Among all the treatments tested against sheath rot disease under field conditions during three years of *kharif*, 2019, 2020 and 2022 showed that highest gross returns and cost benefit ratio were recorded in the treatments i.e Azoxystrobin 11% + Tebuconazole 18.30% SC (Rs. 1,16,360), 1: 2.71followed by Triflaxystrobin 25% + Tebuconazole 50% WG (Rs.1,10,720), 1:2.71 respectively. Hence, it is evident that Azoxystrobin 11% + Tebuconazole 18.30% SC @ 1.5 ml/l was proved as most effective for the management of sheath rot disease with lowest per cent disease incidence, maximum grain yield and highest cost benefit ratio with next best treatments as Triflaxystrobin 25% + Tebuconazole 50% WG @ 0.4 g/l (or) Propiconazole 25% EC @ 1 ml/l.

Table 3: Efficacy of fungicides on the sheath rot incidence of rice during *kharif* 2019, 2020 and 2022 (Pooled data)

T. No	Name of the Treatment	Dosage/ litre of water	Sheath rot Per cent Disease Index (PDI)				% Reduction Over Control (ROC)
			2019	2020	2022	Pooled mean	
T_1	Tebuconazole 25% EC	1.0 ml	*35.4 (36.5)	33.77(35.5)	35.9(36.8)	35.4 (36.5)	13
T_2	Triflaxystrobin 25% + Tebuconazole 50% WG	0.4 g	25.1 (30.6)**	23.33(28.9)	26.6(31.0)	25.1(30.6)	39
T_3	Carbendazim 50% WP	1.0 g	33.1 (35.1)	28.00(31.9)	37.2(37.5)	33.1 (35.1)	19
T_4	Carbendazim 12% + Mancozeb 63% WP	2.0 g	30.7 (33.6)	28.66(32.3)	36.6(37.2)	30.7(33.6)	25
T_5	Azoxystrobin 23% EC	1.0 ml	27.7 (31.7)	31.11(33.9)	28.2(32.2)	27.7(31.7)	32
T_6	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml	23.2 (28.8)	23.11(28.7)	25.2(30.1)	23.2(28.8)	43
T_7	Propiconazole 25% EC	1.0 ml	30.5 (33.5)	34.44(35.9)	31.5(34.2)	30.5(33.5)	25
T_8	Hexaconazole 5% EC	2.0 ml	32.7 (34.9)	36.00(36.7)	33.6(35.4)	32.7(34.9)	20
T_9	Untreated check (Control)	-	40.8 (39.7)	39.52(38.9)	44.3(41.7)	40.8(39.7)	-
	CD @ 5%	-	3.20	5.75	3.48	1.09	-
	SE (m)±	-	1.59	1.92	1.15	0.31	-
	C.V.	-	13.90	3.83	5.68	5.62	-

*Mean of three replications

**Figures in paranthesis are angular transformed values

Table 4: Efficacy of fungicides on grain yield of rice during *kharif*2019, 2020 and 2022 (Pooled data)

T. No	Name of the Treatment	Dosage/ litre of water	Grain Yield (kg/ha)				% Increase over control
			2019	2020	2022	Pooled mean	
T_1	Tebuconazole 25% EC	1.0 ml	3755	4975	5666	4799	8
T_2	Triflaxystrobin 25% + Tebuconazole 50% WG	0.4 g	5150	5308	6151	5536	20
T_3	Carbendazim 50% WP	1.0 g	3800	5096	5878	4925	10
T_4	Carbendazim 12% + Mancozeb 63% WP	2.0 g	4950	5157	5938	5348	17
T_5	Azoxystrobin 23% EC	1.0 ml	5300	5066	6090	5485	19
T_6	Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml	5600	5430	6424	5818	24
T_7	Propiconazole 25% EC	1.0 ml	5110	4942	5969	5340	17
T_8	Hexaconazole 5% EC	2.0 ml	4925	4912	5939	5259	16
T_9	Untreated check (Control)	-	3500	4333	5484	4439	-
	CD @ 5%	-	425.4	543	NS	592.7	-
	SE (m)±	-	228.3	181	345	196	-
	C.V.	-	-	-	10	6.51	-

*Mean of three replications

**Figures in paranthesis are angular transformed values

Table 5: Efficacy of fungicides on Cost Benefit Ratio of Rice during *kharif*, 2019, 2020 and 2022 (Pooled data)

T. No	Name of the Treatment	Grain yield (kg/ha)	Treatment cost (Rs/ha)	Cost of cultivation/ha (Rs.)	Gross Returns (Rs/ha)	Cost Benefit Ratio
T_1	Tebuconazole 25% EC	4,799	1,750	39,250	95,980	1:2.45
T_2	Triflaxystrobin 25% + Tebuconazole 50% WG	5,536	3,400	40,900	1,10,720	1:2.71
T_3	Carbendazim 50% WP	4,925	830	38,330	98,500	1:2.57
T_4	Carbendazim 12% + Mancozeb 63% WP	5,348	2,100	39,600	1,06,960	1:2.70
T_5	Azoxystrobin 23% EC	5,485	5,000	42,500	1,09,700	1:2.58
T_6	Azoxystrobin 11% + Tebuconazole 18.3% SC	5,818	5,400	42,900	1,16,360	1:2.71
T_7	Propiconazole 25% EC	5,340	1,900	39,400	1,06,800	1:2.71
T_8	Hexaconazole 5% EC	5,259	1,550	39,050	1,05,180	1:2.69
T_9	Untreated check (Control)	4,439	-	37,500	88,780	-

Treatment cost (Rs/ha) includes 2 times spray applications

Total cost of cultivation:	cost of fungicides + other cost of cultivation	(Rs. 37,500)
Cost of fungicides:	(Single spray cost) T_1: Rs. 875/ha, T_2: Rs. 1700/ha	T_3: Rs. 415 /ha
	T_4: Rs. 1,050/ha, T_5: Rs. 2500/ha, T_6: Rs. 1700/ha	T_7: Rs. 950/ha, T_8: Rs. 775/ha

Conclusion

The current study concluded that foliar sprays of Azoxystrobin 11% + Tebuconazole 18.30% SC @ 1.5 ml/l (or)Triflaxystrobin 25% EC +Tebuconazole 50% WG @ 0.4g/l (or) Propiconazole 25% EC @ 1 ml/l with first spray at 5-7 days prior to booting stage and the second spray was given at 50% of booting stage proved highly effective and also economical (with highest cost benefit ratio of 1: 2.71) in reducing the sheath rot disease incidence by achieving highest grain yields in rice. Fungicides like triazoles in combination with strobiliurins were highly effective against sheath rot disease of rice. Since these fungicides have site specific action and efficacy at lower doses with high B:C ratio, it could be used as a better alternative to the conventionally using fungicides.

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