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Research Article

Evaluation of Fungicides Efficacy against Rice Sheath Rot *Disease (Sarocladium oryzae)* in Rain Fed Low Land Rice (*Oryzae sativa* L.) in Fogera hub

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ABSTRACT

Rice **(**Oryzae sativa L.) is by far the most stable food crop for over half of the world society, they are dependent for half of their calorie, and its production is enhancing gradually even with in developing nations. Rice sheath rot is a disease complex which can be caused by fungi (Sarocladium oryzae) pathogen and it infects the upper most important plant part (panicle). The study was aimed to evaluate the efficacy of different fungicides and recommend the most effective ones. The experiment was conducted at Fogera National Rice Research and Training Center experimental station for two consecutive years (2017-2019) using X-Jigina cultivar. Nine treatments, four seed dressing (carboxin+ thiram + imidacloprid, imidacloprid + tebuconazol, thiamethoxam 20% + metalaxyl- 20 % + ifenoconazol 2% and imidaclopride 250 gm/kg) and four foliar applied fungicides (epoxiconazole + thiophanate-methyl, mancozeb + metalaxyl WP, tebuconazole, and mancozeb 80% WP were used including untreated check. The treatments were arranged in randomized complete block design with three replications. Disease incidence and severity data were recorded before maturity of the crop in 0-9 scale. The result revealed that seed dressing fungicides were by far better over foliar fungicides. Proseed plus 63 WS (carboxin+ thiram + imidacloprid), Joint 246 FS (imidacloprid + tebuconazol) and ImidalmT 450 WS (imidaclopride 250 gm/kg) fungicides were effective against rice sheath rot disease control, respectively. Furthermore, the study had proved that the highest marginal rate of return was obtained from application of Imidaclopride 250 gm/kg fungicide which was 32.17 extra birr beyond covering cost of investment. In a net shell, effective seed dressing fungicides were much better to manage rice sheath rot disease since its source of transmission is seed.

Key words: Rice diseases, Sheath rot, Fungicides, Disease incidence, Disease severity, Seed dressing, Disease control

INTRODUCTION

Rice (*Oryzae sativa* L.) is an important crop worldwide, serving as the staple food for half of humanity and additionally being used in industry and for animal feed. Rice is grown in various agro-ecological zones in tropical and subtropical areas, especially in Asia, the continent accounting for 90% of the world production (IRRI, 2015). Sixty percent of world`s population were depending on rice for their half of the calorie intake (Deepmala, 2012). In Ethiopia, it is considered as "millennium crop", believing it ensures food security. Even though total rice production and area coverage have been increasing year to year since its recognition by government in 2005, rice productivity has stayed almost stagnant below three tones over the years, which is very low as compared to rice yield potential.

There are several factors that are limiting its productivity in the country. Rice disease, insect pests and weeds have been identified as leading constraints (Nigussie and Alemu, 2011). Rice sheath rot is a disease complex that can be caused by various fungal pathogens. Major pathogens associated with rice sheath rot are fungi such as *Sarocladium oryzae* and *Fusarium* species belonging to the *Fusarium fujikuroi* complex (Painkara, 2016). A variety of other pathogens have been associated with rice sheath rot. The various described sheath rot agents all cause very similar disease symptoms (Cottyn *et al*., 1996). This explains why there are practically no comprehensive studies mentioning the link between the presence and quantity of disease inoculum and yield loss (Mew and Gonzales, 2002). The unpredictable nature of the factors acting in the pathosystem explains why losses attributed to *Sarocladium oryzae* can be as variable as in the range of 20–85% (Sakthivel *et al*., 2002).

The disease is prevalent in all rice-growing areas in Ethiopia causing significant damage to rice crop. Sheath rot

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is now considered to be a major destructive disease which is common in rain-fed lowland rice ecosystems. The pathogen attacks flag leaf sheaths and grains and yield losses result mainly from poor panicle formation and exertion, spikelet sterility (80-100%), reduced grain filling, and losses in milling (Simon, 2016). Panicle exertion depends on the time of infection and severity of the disease. Under severe conditions, the panicle remains inside the leaf sheath (Naeimi *et al*., 2003). The booting stage of the rice plant is the most vulnerable stage for infection, causing maximum damage (Nasu, 2004). While emerging from the infected sheath, the young panicles are affected, increasing the number of chaffy, discolored, and shriveled grains and reducing the weight and number of healthy grains. Yield loss incurred by sheath rot infection was found to be as high as 85% (Bigirimana *et al.*, 2015). Caused yield losses are variable from 10 to 85%, depending on the pathosystem conditions (Sakthivel, 2001).

According to 2007/2008 E.C production year rice disease survey, rice sheath rot is found to be one of the most serious diseases which bring significant yield loss on the popular cultivar of X-Jigina at different sub-districts of the Fogera, Dera and Libo kemkem districts. The assessment shows that the disease prevalence, incidence and severity in the above areas range 100, 47 and 44 %, respectively. Still there were no reports regarding the occurrence and its management in Ethiopia for which is caused by *Sarocladium oryzae* in the country.

Use of fungicides is an option to manage rice sheath rot disease, in which an integration of cultural practices with chemical control is the most effective. Therefore, this study was conducted to evaluate fungicides efficacy against rice sheath rot *disease* at rain fed low land rice growing areas of the country and recommend it to be included in the rice package.

MATERIALS AND METHODS

Description of the study area: The study was conducted in low land rice ecosystem under rain fed condition at Fogera National Rice Research and Training Center (FNRRTC), South Gondar zone of Ethiopia, located 565 Km far from the capital city of Addis Ababa and about 55 Km north of Bahir Dar, the capital city of Amhara regional state. Geographically the experimental site is located at latitude of 11° 58′ N and longitude of 37° 41′ E with an altitude of 1819 meter above sea level and it receives average annual rainfall of 1230 mm. Mean minimum and maximum temperature of the area is 12 and 28^{0}C, respectively. The soil is brown clay (vertisol) which is rich in underground water (Getahun, 2015).

Experimental design and treatments: The treatments were arranged using randomized complete block design with three replications. The plot size was 3 meters with 2.4 meter (7.2 m^2) and the block size was 25.6 meter with 11 meters (281.6 m^2). A spacing of 0.5 meter and 1 meter was used between plots and blocks, respectively. In this experiment nine treatments were evaluated, of which four were seed dressing fungicides while the other four were foliar fungicides and one control check. Randomization was held independently for each replication by which treatments were assigned completely at random as described by Gomez and Gomez (1984) and Poduska (2008).

The seed dressing fungicides were carboxin+ thiram + imidacloprid, imidacloprid + tebuconazol, thiamethoxam 20% + metalaxyl- 20 % + ifenoconazol 2% and imidaclopride 250 gm/kg + 200 gm/kg. On the other hand, epoxiconazole + thiophanate-methyl, mancozeb + metalaxyl WP, tebuconazole, and mancozeb 80% WP were applied through foliar spray (Table 1).

Experimental procedures: The experimental site was ploughed four times and precise leveling was done. Infected seed with rice sheath rot pathogen was used as a spreader row which could be a source of inoculums for the disease occurrence. The X-Jigina rice cultivar was used and the recommended seed rate by which the experiment conducted was 80 kilogram per hectare from which 58 grams was used for each plot. Furthermore, 60.5 kilogram per hectare nitrogen, phosphorus and sulfur (NPS with grade of 19N-38P-7 S) fertilizer and 130 kilogram per hectare recommended urea fertilizer rates were applied. All plots were received 43.56 gram of Nitrogen, phosphorus and sulfur (NPS with grade of 19N-38P-7S) and 93.6 gram of urea fertilizer rates per plot.

The seed was dressed with fungicides one week before sowing. It was thoroughly dressed with the seed through adding an ample amount of water to coat it well. Foliar fungicides were applied at booting stage of the crop, once a season as per the recommended dose. All agronomic management practices were kept the same for each treatment except fungicides application which were the target to know their variation in efficacy.

Data collection and statistical analysis: Pre-treatment disease incidence and severity data of rice sheath rot were recorded at regular weekly intervals from ten randomly selected plants in each plot and the degree of infection occurred in each treatment were visually scored and averaged to obtain the mean of the ten selected plants, similarly for each plot. Days to emergency, days to heading, plant height, panicle length, number of spikes per plant, number of fertile tillers per plant, number of filled grains per panicle, number of unfilled grains per panicle, thousand grain weight, grain yield, grain moisture content data were taken.

Moreover, in disease data, disease incidence and severity were scored in both pre and post application of treatments. Four times of scoring was made so as to have confidence in the efficacy of fungicides evaluation. Disease intensity was recorded at maturity of the crop in 0-9 scales by following the procedure of standard evaluation system of International Rice Research Institute (IRRI, 2009).

The collected data were analyzed by the using 9.0 version Statistical Analysis Software (SAS) and mean separation was done at 5% least significant difference. The analysis of variance was employed for the analysis of treatments variation in terms of sheath rot control among variables.

RESULTS AND DISCUSSION

The result of analysis of variance showed that there was high significance difference among seed dressing and foliar fungicides in terms of disease incidence and severity. In addition to it, treatments had shown significant variation

Table 1: List of applied fungicides, dose and their method of application

Code	Trade name	Active ingredient name	Method of application	Recommended rates per hectare
T1	Proseed Plus 63 WS	Carboxin+ Thiram + Imidacloprid	Seed treatment	200 gm/100kg seed
T2	Rex® Duo	Epoxiconazole +thiophanate- methyl	Foliar	0.5 L+ 200 Lt water
T3	Joint 246 FS	Imidacloprid + Tebuconazol	Seed treatment	200 ml/100kg seed
T4	Mancolaxyl 72 % WP	Mancozeb + metalaxy WP	Foliar	3.5 L + 550 L water
T5	Natura 250 EW	Tebuconazole	Foliar	0.5 L+ 250 Lt water
T6	Apron Star 42 WS	Thiamethoxam 20% + metalaxyl- 20 % + ifenoconazol 2%	Seed treatment	200 gm/100kg seed
T7	Indofil M-45	Mancozeb 80% WP	Foliar	2 kg + 750 Lt water
T8	Imidalm T 450 WS	Imidaclopride 250 gm/kg	Seed treatment	100 gm/100kg seed
T9	Untreated check			

T1: Treatment one, T2: Treatment two, T3: Treatment three, T4: Treatment four, T5: Treatment five, T6: Treatment six, T7: Treatment seven, T8: Treatment eight, T9: Treatment nine

Table 2: The effect of seed dressing and foliar fungicides on the rice sheath rot diseases

Treatments	PH	PL	TPP	SPP	TGW	GY	DI	DS
Proseed plus 63 WS	79.77	17.83	4.96	9.8	28.77	4.02481^{a}	16.44^{de}	12.01^{f}
Rex® Duo	74.36	17.56	4.70	9.4	28.24	3.13085^{bc}	33.33^{ab}	32.73^{b}
Joint 246 FS	79.86	18.23	5.73	9.5	29.92	3.97978^{ab}	18.50^{cde}	17.59^{e}
Mancolaxyle 72% WP	79.40	17.93	4.90	10.1	27.97	3.29156^{abc}	24.50^{bcd}	22.68^{d}
Natura 250 EW	74.03	16.90	5.53	9.3	27.94	2.70119^{c}	41.50^{a}	39.13^{a}
Apron star 42 WS	76.16	17.40	5.43	9.26	29.60	3.4039^{abc}	20.44^{cde}	16.84^{e}
Indofil M-45	75.13	18.16	5.30	9.8	28.78	3.00916^{c}	24.83^{bcd}	21.67^{d}
ImidalmT 450 WS	77.60	18.53	4.93	9.43	29.82	3.94371^{ab}	11.02^{e}	8.69^{g}
Untreated check	76.63	18.40	5.17	10.3	27.70	2.87170^{c}	27.06^{bc}	25.82^{c}
Grand mean	76.99	17.88	5.18	9.65	28.74	3.3733	24.18	21.90
LSD (5%)	5.75	1.09	0.98	0.98	1.77	882.55	10.58	2.49
CV(%)	6.42	5.23	16.33	8.78	5.29	22.45	37.57	9.78
p-value	0.24	0.06	0.50	0.27	0.08	0.01	0.0003	0.0001

Note: PH: plant height (cm), PL: Plant length (cm), TPP: Number of tillers per plant, SPP: Number of spikelet per panicle, TGW: Thousand grain weight (gram), GY: Grain yield in ton/ha, DI: Disease incidence percentage, DS: Disease severity percentage, LSD: Least significant difference at 5% significance level, CV: Coefficient of variation in percent

Table 3: The analysis of variance in terms of different variables mean squares with the interaction of inputs across year

SV	DF	PH	PL	TPP	SPP	TGW	GY	DI	DS
Block	2	20.67	1.77	0.09	9.70	4.71	745678.84	528.58	55.72
Year	1	897.92^{**}	92.3^{**}	142.11^{**}	45.92^{**}	544.54^{**}	475387.31^{ns}	54.12^{ns}	21.18^{**}
Treatment	8	31.53^{ns}	1.64^{*}	0.69^{ns}	0.8^{ns}	4.40^{ns}	1514989.57^{*}	503.76^{**}	560.27^{**}
Year * Trt	8	31.11^{ns}	0.52^{ns}	0.61^{ns}	1.15^{ns}	2.51^{ns}	46778.46^{ns}	10.47^{ns}	1.42^{ns}
Error	34	22.82	0.95	0.74	0.61	2.27	598689.31	99.53	5.34

Note: * = significant at $p<0.05$, ** = significant at $p<0.01$, SV = source of variation, DF = degree of freedom, PH = plant height(cm), PL= panicle length(cm), TPP = number of tillers per plant, SPP = number of spikelet per panicle, TGW = thousand grain weight, GY = grain yield, DI = disease incidence, DS = disease severity, Trt = treatment

Table 4: Partial budget analysis and marginal rate of return of fungicides (CIMMYT, 1988)

Inputs	GY (kg/ha) = A	AGY kg/ha (A*0.9)=B	CPR (ETB)=C	GFB Birr/ha (B*C)=D	TVIC /Ha=E	NB Birr/Ha ((B*C)-E)=F	CNB Birr/Ha (F-control)=G	CTVIC Birr/Ha (E-control)=H	MRR=I
Proseed plus 63 WS	4.02481	3.62233	11.00	39845.62	383.5	39462.12	11032.29	383.5	2877
Rex® Duo	3.13085	2.81777	11.00	30995.42	1550	29445.42	1015.59	1550	66
Joint 246 FS	3.97978	3.58180	11.00	39399.82	383.5	39016.32	10586.49	383.5	2760
Mancolaxyle 72% WP	3.29156	2.96240	11.00	32586.44	2710	29876.44	1446.61	2710	53
Natura 250 EW	2.70119	2.43107	11.00	26741.78	1020	25721.78	-2708.05	1020	-265
Apron star 42 WS	3.4039	3.06351	11.00	33698.61	390	33308.61	4878.78	390	1251
Indofil M-45	3.00916	2.70824	11.00	29790.68	1990	27800.68	-629.15	1990	-32
ImidalmT 450 WS	3.94371	3.54934	11.00	39042.73	320	38722.73	10292.90	320	3217
Untreated check	2.8717	2.58453	11.00	28429.83	0	28429.83	0.00	0	0.00

Note: GY: grain yield, AGY: Adjusted grain yield, CPR (ETB): current price of rice in Ethiopian birr, GFB: gross farm get benefit, TVIC/Ha: total variable input cost per hectare, NB Birr/Ha: net benefit in birr per hectare, CNB Birr/Ha: change in net benefit in birr per hectare, CTVIC Birr/Ha: change in total variable input cost in birr hectare, MRR: marginal rate of return (%)

on grain yield and panicle length of the crop. It clearly revealed that application of various form of application fungicides had different control for the sheath rot disease. Plots that were treated with Proseed plus 63 WS (carboxin+ thiram + imidacloprid), Joint 246 FS (imidacloprid + tebuconazol) and ImidalmT 450 WS (imidaclopride 250 gm/kg) fungicides gave the best grain yield, since they effectively inhibited the disease progress. Sharma *et al.* (2013) also reported that the fungicides at different concentration effectively inhibited spore germination, germ tube elongation, mycelial growth and sporulation of *Sarocladium oryzae.*

The lowest disease incidence was recorded on imidalm T 450 WS (Imidaclopride 250 gm/kg), proseed plus 63 WS (Carboxin+ Thiram + Imidacloprid) and joint 246 FS (Imidacloprid + Tebuconazol) fungicides treated seeds

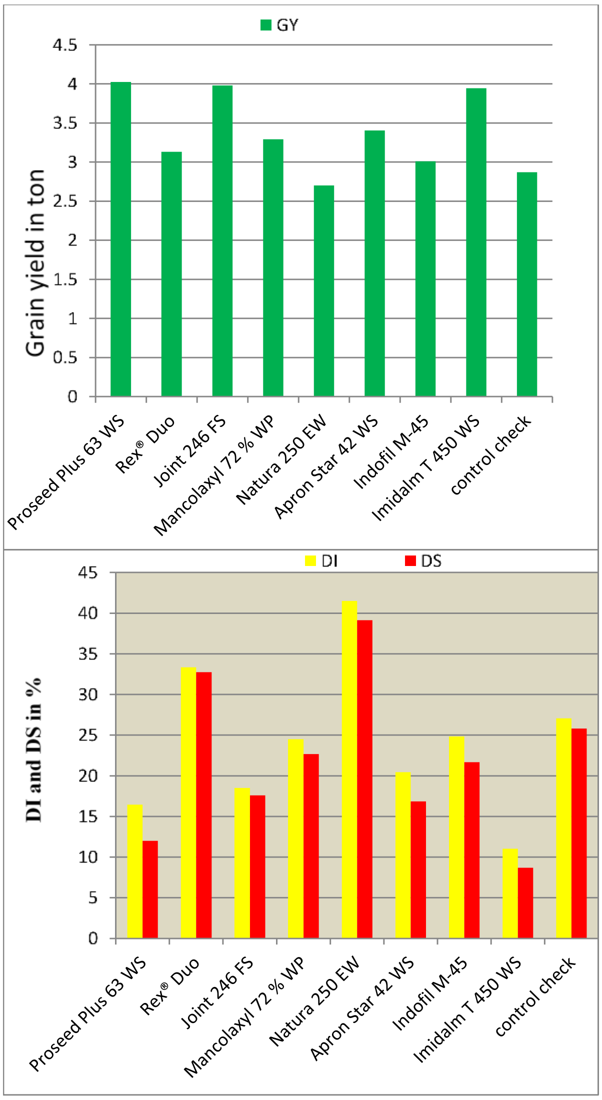

Fig. 1: Effect of fungicides (seed dressing and foliar application) on grain yield (kg/ha) and sheath rot severity and incidence in percent: DI: Disease incidence in percent, DS: Disease severity in percent, GY: Grain yield in ton/ha

sowed plots, which had 11.02, 16.44 and 18.5 %, respectively. Similarly, the lowest disease severity was recorded on imidalm T 450 WS (imidaclopride 250 gm/kg), proseed plus 63 WS (carboxin+ thiram + imidacloprid) and apron Star 42 WS (thiamethoxam 20% + metalaxyl- 20 % + ifenoconazol 2%) fungicides treated seeds sowed plots, which were 8.69, 12.01 and 16.84%, respectively (Table 2).

On the other hand, joint 246 FS (imidacloprid + tebuconazol), imidalm T 450 WS (imidaclopride 250 gm/kg) and apron Star 42 WS (thiamethoxam 20% + metalaxyl- 20 % + ifenoconazol 2%) gave the highest thousand grain weight (29.92, 29.82 and 29.60 gram), respectively (Table 2). This implies that the grain quality which was obtained from them was excellent. The same result was proved by Painkra (2016) under the in-vivo conditions revealed that all fungicides significantly reduced the disease intensity over control and increased the grain yield of rice.

On the same fashion, seed dressing fungicides had direct effect on the plant panicle length since the pathogen mainly infects the upper most flag leaf sheaths that enclose the emerging young panicle during the boot stage and causes empty head. In a net shell, seed dressing fungicides were by far better than foliar ones since the pathogen is seed born and can be transmitted by infected crop residue. This realizes that these fungicides had controlled the pathogen which can be available in the soil and on the seed. Furthermore, the pre sowing treatments were effective in the enhancement of plant height due to the fact that it inhibits through clogging the panicle exertion. Similarly, Ramabadran and Velazhahan (1990) confirmed that seed treatment with seed dressing fungicides improved seed germination.

As shown in the above (Figure1) the lowest grain yield was recorded from the untreated pot, indofil and mancolaxyl sprayed plots. Thus, grain yield is directly proportional with sheath rot disease severity. When the severity increased the yield becomes decreased and vice versa. However, there were some restrictions that the disease affects the plant flag leaf and leaf sheath, it may not necessarily true. This is due to the fact that, the disease record was mostly undertaken from panicle initiation to flowering crop stages and the fungicides were applied early in the incidence of it. As the figure trend revealed that fungicides efficacy was varied in sheath rot disease incidence and severity. All seed treatment fungicides controlled by far better than the foliar applied treatments. This clearly stated that the disease is seed borne and most likely transmitted via the seed.

Economic analysis: As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the rewarding treatments. Yield from experimental plots was adjusted downward by 10% for management and plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment (CIMMYT, 1988).

The partial budget analysis includes only production costs that vary across treatments while common costs for all treatments were excluded. Average market grain price of rice (14 ETB per kg) and labor valued at ETB 50 per person day were used. The result of the partial budget analysis is described in (Table 4). The economic analysis revealed that the highest net benefit of (birr 39462.12 ha^{-1}) was obtained from the application of proseed plus 63 WS followed by joint 246 FS and imidalm T 450 WS seed dressing fungicides. As the marginal rate of return showed that when we invest one birr on imidalm T 450 WS, Proseed Plus 63 WS and Joint 246 FS to control sheath rot, we will get one birr + extra 3217, 2877 and 2760 %, respectively, whereas natura 250 EW and indofil M-45 have provided negative rate of return which were -265 and -32 %, respectively (Table 4).

The change in total variable inputs cost (total variable input cost minus the control check) was highest in Mancolaxyle 72% WP, Indofil M-45 and Rex® Duo inputs which was 2710, 1990 and 1550 ETB per hectare, respectively. On the contrary, proseed plus63 WS (11,032.29 ETB ha^{-1}), joint 246 FS (10,586.49 ETB ha^{-1}) and imidalm T 450 WS (10,292.90 ETB ha^{-1}**)** showed highest change in net benefit (net benefit minus the control check). Change in net benefit implies that the benefit or profit that we obtain after we recover the application cost of fungicides to control rice sheath rot diseases. Whereas, natura 250 EW and indofil M-45 were provided the lowest change in net benefit (-2708.05 and -629.15 ETB ha^{-1}), respectively. It showed that with the application of them we lost an extra 2708.05 and 629.15 ETB ha^{-1}. On the other hand, the untreated plot has provided better yield than the above foliar fungicides as shown in the table below.

Conclusion and recommendation: In conclusion, the experiment result showed that three seed dressing fungicides were the most effective in the control of rice sheath rot diseases. It is clear from the efficacy of fungicides that the highest yields were recorded in Proseed plus 63 WS (carboxin+ thiram + imidacloprid), Joint 246 FS (imidacloprid + tebuconazol) and ImidalmT 450 WS (imidaclopride 250 gm/kg) fungicides treated seeds sowed plots (4.02481, 3.97978 and 3.94371-ton ha^{-1} respectively). However, the partial budget analysis proved that ImidalmT 450 WS (imidaclopride 250 gm/kg) was the most promising seed treatment fungicide in terms of disease severity, incidence, and change in net benefit as well as marginal rate of return.

Seed treatment fungicides are by far better than foliar ones since the rice sheath rot disease is most likely transmitted by infected seed and crop residue. In other words, the above most effective fungicides are ideal for the aquatic organisms as compared with the foliar applied fungicides, because of their time of application early in the season at the absence of stand water.

Therefore, based on the economic analysis, fungicides efficacy and the grain yield obtained, ImidalmT 450 WS (imidacloprid 250 gm/kg), Proseed plus 63 WS (carboxin+ thiram + imidacloprid) and Joint 246 FS (imidacloprid + tebuconazol) fungicides are recommended for the management of rice sheath rot disease at the dose of specified in table 1. But, sustainable productivity with eco-friendly to the environment can be achieved by the use of integrated disease management.

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