

## Fungicidal Management of Sheath Rot (*Sarocladium oryzae*) Disease on Rice Production in Guyana and Assessment of Socio- Economic Benefits.

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### ABSTRACT

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Sheath rot caused by *Sarocladium oryzae* (Sawada), is a major disease of rice that can significantly reduce grain yield and quality, resulting in economic losses for farmers. This study evaluated the efficacy of selected fungicides for the management of sheath rot disease under field conditions in Guyana and also assessed the potential socio-economic benefits. Three field trials were conducted during the Spring and Autumn cropping seasons of 2022 and the Spring cropping season of 2024 at the Plant Pathology Department Experimental Area, Guyana Rice Development Board (GRDB), Rice Research Station (RRS), Burma. The experiments were established using a Randomized Complete Block Design (RCBD) with four replications per treatment. The rice variety GRDB 14 was grown under recommended agronomic practices, and fungicides were applied at their respective rates. Results from the three trials demonstrated that most fungicidal treatments reduced sheath rot disease severity and improved growth and yield parameters compared with untreated control. The most effective treatments were Top Cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300 g/ac, and the positive check, Fugi One at 300 ml/ac, which reduced disease severity by 68.00–76.00% relative to the untreated control. Other treatments also reduced disease severity by 31.99–48.00%. Yield responses were mostly positive across the trials, with increases ranging from 2.23–34.23% in Spring 2022, 8.69–90.98% in Autumn 2022, and 3.31–70.43% in Spring 2024 over the untreated control. The reduction in disease severity and some levels of increase in grain yield indicate that effective fungicide use can enhance rice productivity and profitability. In general, increased yields can improve the overall farm income, strengthen household livelihoods, and contribute slowly towards reduction of poverty leading to greater economic returns. Furthermore, improved productivity supports sustainable rice production, enhances food security, and allows for benefits to stakeholders throughout Guyana's rice value chain. Based on the consistent performance of Top Cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300 g/ac, and the positive check, Fugi One at 300 ml/ac are recommended for the management of sheath rot disease, particularly in areas where the disease is most prevalent.

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## INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops of the world, providing staple food for billions of people (Mandal et al., 2024). The rice crop is known to be susceptible to attacks by several bacterial, fungal, viral pathogens and other pests (Singh et al. 2019). In recent years, the sheath rot disease caused by *Sarocladium oryzae* (Sawada) Gams and Hawksworth (Sawada, 1922) has become a serious challenge to sustainable rice production (GRDB, 2025). This sheath rot disease is known to be present in most rice-growing countries and has become more prevalent in the wet season. The disease was first reported and described in Taiwan by Sawada (1922). The damage due to this disease has increased since the introduction of the photoperiod-insensitive modern rice varieties and changes in the climatic condition. Although there were reports on yield loss ranging from a few percent to as high as 20% (Ou, 1985), the disease, under favorable weather conditions during the crop growth period can cause substantial yield losses which can vary from 9.6- 85% (Pal et al., 2015; Mandal et al., 2024). The yield loss caused by *S. oryzae* implies that the disease could be a serious potential threat to rice production (Ou, 1985). Although sheath rot can be observed in the field as a single disease on rice sheath rot, more often, it has become part of a complex of grain and leaf sheath discoloration commonly observed on wet-season rice. Organisms involved in the grain and sheath rot complex are several; however, *Sarocladium oryzae* is just one of them (GRDB, 2025).

The typical symptoms of sheath rot (*S. oryzae*) disease mainly attack the uppermost leaf sheaths enclosing the young panicles. It appears on the rice plant as oblong, or irregular dark grey or brown color lesions on the leaf sheath covering the panicle or just below; and sometimes coalescing to prevent the emergence of panicle is common with the infection of the *Sarocladium oryzae* (Ou, 1985). Under severe infection, the panicle shows large number of partially emerged or totally compressed panicles and chaffy and/or discolored grains also (Thrimurthy et al., 1980).

In Guyana, sheath rot, *Sarocladium oryzae* is considered as one of the major rice diseases affecting the rice industry causing significant reduction in the yield and quality of paddy produced (Rajnandni and Tiwari, 2022; GRDB, 2025). Further, the use of the same fungicides continuously year after year can lead to resistant buildup of the *Sarocladium oryzae* pathogen (Mandal et al., 2024). This situation results in ineffective levels of control, reducing profitability and affects the socio-economic benefits expected to be derived by the rice farmers and other stakeholders in the rice industry. In view of this, the research project was put together in 2022 to 2024 to find the most effective fungicides for the management of the *S. oryzae* pathogen and to look at their influence on the growth and yield parameters, as well as to examine the socio-economic impacts.

## 2.0 MATERIALS AND METHOD

### 2.1 Field evaluation of fungicides against sheath rot (*Sarocladium oryzae*) disease

Two field trials were conducted in spring and autumn cropping seasons of 2022 and one in the spring cropping seasons of 2024 at Plant Pathology department experimental area at the GRDB, RRS, Burma in Guyana. The experiment was carried out using Randomized Complete Block Design (RCBD) with four replications per treatment. Each plot had a 15m<sup>2</sup> (3m x 5m) size with 1m plot-to-plot spacing. The soil type is front-land rice group and classified as Litchfield clay with the following characteristics: humic gley, very poorly drained, surface soil strongly acidic to neutral, thick and very dark grey, Low in P, Ca and K. The rice cultivar GRDB 14 was established using direct seed planting at a seed rate of 200 kg ha<sup>-1</sup>. Early season pest control and weed management follow the standard crop production practices as recommended and described by GRDB (GRDB 2009). Fertilizers were applied at a rate of N 120 P50 K0 kg/ha at the recommended timing (GRDB 2009).

### 2.2 Inoculation and application of treatments

Inoculation of experiment was done with spore suspension concentration of 10<sup>-5.5</sup> using a mixture of naturally existing sheath rot strains collected from diseased plantlets in the surrounding fields. The treatments were applied 7 days after inoculation. Individual treatments of the three new synthetic fungicide viz. Top Cop (Sulphur 50%, metallic copper equivalent 4.4%) at 100, 150 and 250 ml/ac., Onix (Carbendazim 12.50%, Propiconazole 12.50%) at 150, 250, 350 and 450 ml/ac., Curacarb (Carbendazim 50%) at 100, 150 and 250 g/ac., Tantor 25SC (Carbendazim 12.5%, Tebuconazole 12.5%) at 200 ml/ac., Tridium (Azoxystrobin 4.7% + Mancozeb 59.7% + Tebucuzonal 5.6% WG) at 350 g/ac., and Saaf (Mancozeb 63%, Carbendazim 12%) at 300g/ac. along with one positive checks, Fugi One (Isoprothiolane 40% SC) at 300 ml/ac. and an untreated control. Each individual treatment was keenly calculated, weight/measured out and applied as foliar spray two times at an interval of 7-10 days. The treatments were applied using a Cooper Pegler (CP3) manual operated knapsack sprayer with a built-in pressure relief valve at 55 and 65 Days After Sowing (DAS). The untreated control plots were sprayed with distilled water. During the treatment application uniform spray was ensured by covering both surfaces of entire plant with minute droplets of the solution.

### 2.3 Assessment of growth parameters, yield attributes, grain yield and Sheath rot disease incidence

The impact of treatments on growth parameters was assessed by measuring the plant height and counting the number of tillers per square meter at harvesting time. The yield attributes were derived by measuring the panicle length, counting the number of filled

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and unfilled grains per panicle, weighing the 1000-grain from 10 panicles harvested from each individual plots. The total grain yield was assessed after harvest by threshing and recording the weight and moisture from each plot. From the assessment of the sheath rot disease incidence, the lesion length was measured from five tagged plants from each plot and scoring was done using the International Rice Research Institute (IRRI), Standard Evaluation System (SES), 0 to 9 scale for sheath rot disease (IRRI INGER, 2013).

**2.4 Assessments of the socio-economic benefits**

The assessment of socio-economic benefits derived from this study was done by critically analyzing the data collected during the conduct of this research and by looking at percentage reduction in the percent disease severity and the percentage increase or decrease in overall grain yields compared with the untreated control and the most effective or better performing treatment. The percentage yield advantage and disease reduction were calculated to infer the economic gains and the possible socio-economic benefits expected expressed.

**2.5 Statistical analysis and computations**

The data obtained from various field experiments were analyzed using the RCBD statistical methods. The ANOVA and statistical significance were obtained using the Statistix 8.0 analytical software and graphs were derived using Microsoft Excel Software, Windows 10. The Percent Disease Severity (%DS) were calculated using this formula: % DS= [(Sum of all numerical ratings)/ (Total number of samples observed X Maximum rating)] \*100. Also, percent change in sheath rot disease severity and yield parameters over control were calculated using the following formula: Percent change= (T-C/C) \*100; Where C= Value of control, T= Value of treatment. The expected socio-economic benefits carefully analyzed and expressed.

**3.0 RESULTS**

**3.1 Effects of fungicides on sheath rot disease during 2022 and 2024**

In 2022 and 2024 seven fungicides [Top cop, Onix, Curacarb, Tantor, Tridium, Saaf, and Fugi One] were evaluated as foliar application against sheath rot disease under field conditions in three separate field trials. The initial percentage disease severity showed no significant differences among treatments (Table 1 and Table 2). At fourteen (14) days after the second set of fungicide treatment were applied, (insert comma) all fungicidal treatment showed significantly lower Sheath rot percent Disease Severity (% DS) (Table 1 and Table 2).

During 2022, plots treated with check Fugi One 300ml/ac demonstrated significantly lower sheath rot % DS (22.22%), followed by Top cop at 250ml/ac., Onix at 350 ml/ac., Curacarb 250ml/ac. (all recorded 27.78% DS, respectively) and then Saaf at 300 g/ac (33.33%). The untreated control recorded significantly highest sheath rot % DS (77.78%) (Table 1). During 2024, the untreated control treatment also recorded similar results with significantly highest % Sheath rot disease severity as compared to the other treatments (Table 2). Likewise, treatments with Top cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300g/ac, and positive check, Fugi One at 300ml/ac demonstrated significant reduction in the percent of sheath rot disease severity incidence as compared to the other treatments and the untreated control treatment in 2024 (Table 2).

**Table 1: Effect of fungicides on incidence of sheath rot (*S. oryzae*) disease during 2022**

Trt.	Treatment	Rates/ac.	* % Disease Severity*	
			+ Initial	++After
T1	Top cop	100ml	44.45 A	50.00 BC
T2	Top cop	150ml	44.45 A	50.00 BC
T3	Top cop	250ml	38.89 A	27.78 EF
T4	Onix	150ml	33.33 A	50.00 BC
T5	Onix	250ml	33.33 A	44.45 BCD
T6	Onix	350ml	33.33 A	27.78 EF
T7	Onix	450ml	38.89 A	55.56 B
T8	Curacarb	100ml	38.89 A	55.56 B
T9	Curacarb	150ml	38.89 A	38.89 CDE
T10	Curacarb	250ml	33.33 A	27.78 EF
T11	Tantor	200ml	33.33 A	50.00 BC
T12	Tridium	350g	38.89 A	55.56 B
T13	Saaf	300g	33.33 A	33.33 DEF
T14	Fugi One	300ml	33.33 A	22.22 F
T15	Control		38.89 A	77.78 A

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<b>Grand mean</b>		37.04	44.45
<b>SEM</b>		<b>6.82</b>	6.71
<b>CD (P=0.05)</b>		<b>13.76</b>	<b>13.55</b>
<b>CV (%)</b>		<b>26.03</b>	<b>21.36</b>

\* = average of four replications, + = Initial observation and first treatment applied; ++ = 14 days after second treatment applied; Means values in columns are followed by same superscript letter(s) and do not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

**Table 2: Effects of Fungicides treatment against Sheath Rot (*S. oryzae*) disease during 2024**

Trt.	Treatment	Rates/ac.	% Disease Severity*	
			+ Initial	++After
T1	Top cop	100ml	50.62 A	62.97 B
T2	Top cop	150ml	46.29 A	48.15 B
T3	Top cop	250ml	54.94 A	25.92 C
T4	Onix	150ml	37.04 A	59.26 B
T5	Onix	250ml	34.57 A	51.85 B
T6	Onix	350ml	55.56 A	29.63 C
T7	Onix	450ml	44.45 A	59.26 B
T8	Curacarb	100ml	38.27 A	55.56 B
T9	Curacarb	150ml	47.53 A	51.85 B
T10	Curacarb	250ml	56.79 A	29.63 C
T11	Tantor	200ml	49.38 A	51.85 B
T12	Tridium	350g	43.21 A	55.56 B
T13	Saaf	300g	41.98 A	29.63 C
T14	Fugi One	300ml	48.15 A	22.22 C
T15	Control		61.73 A	92.59 A
<b>Grand mean</b>			47.37	48.40
<b>SEM</b>			13.84	8.28
<b>CD (P=0.05)</b>			28.35	16.95
<b>CV (%)</b>			35.79	20.94

\* = average of four replications; + = Initial observation and first treatment applied; ++ = 14 days after second treatment applied; Means values in columns followed by same superscript letter(s) do not differ significantly at 95% confidence interval, according to Fisher's Least Significant Difference (LSD) procedure.

Therefore, it can be concluded that all these fungicidal treatment application expressed varying degrees of reduction in the percent sheath rot disease severity than those with the higher percent reduction of viz. Top cop at 250 ml/ac , Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300g/ac, and positive check, Fugi One at 300ml/ac which can be recommended to use for the management of the sheath rot disease.

### 3.2 Effects of treatments on growth and yield parameters during first (spring) crop 2022

According to the statistical analysis, there were no significant differences among 1000 grain weight, and grain yield (kg/ac. and bags/ac.) for each treatment against the untreated control. However, higher yields were seen from plots treated with Top Cop 100ml/ac & 150ml/ac; Onix 350ml/ac, Curacarb and Fugi-1 at 300ml/ac (Table 3). Treated plants with Fugi 1 (147.20), Top Cop 100ml/ac (143.60), & Onix were among the set that produced more filled grains per panicle samples against the control (134.03). Longer panicles were seen from plants treated with Top Cop at 100ml/ac (30.59), Onix 250ml/ac (25.89) and Curacarb 250ml/ac (25.90) against the untreated control (24.20). Taller plants were observed coming from the plot treated with Tantor at 200ml/ac (105.60cm) followed by Top Cop and Curacarb at 150ml/ac (105.07 and 104.00cm respectively). The mean plant height among all

the treatments is ~101cm is higher than the untreated control (98.37cm). More tillers/m<sup>2</sup> were observed from plants treated with Curacarb 150 and 250ml/ac (302.33, 305.67, respectively) against the control (260.00 tillers/m<sup>2</sup>) and the average among all the treatments was 274 tillers/m<sup>2</sup>(Table 3). No significant differences were observed when the grain yields (Kg/ha and bags/ac.) were examined for the spring crop 2022 (Table 3).

### 3.3 Effects of treatments on growth and yield parameters during second (autumn) crop 2022

Results revealed plants treated with Curacarb at 250ml/ac produced significantly longer panicles (25.08 cm) as compared to other treatments and control (23.52cm). The shorted panicles were seen from Tridium 350g/ac (23.48) and Saaf 300g/ac (23.45). All the other treatments showed no significant differences among each other for panicle length. Treatments with Onix at 250ml/ac (158.17) and Tridium 350g/ac (149.33) showed the highest number of filled grains compared against the untreated control (118.07), while Tantor (80.30) showed a significantly lower number of filled grains compared to all other treatments (Table 4). A significantly large number of unfilled grains (62.20/panicle) were harvested from panicles treated with Tantor at 200ml/ac, followed by treatments of Top Cop at 150g/ac (43.30/panicle) and control (42.33 grains/panicle). Those recording a significantly lower number of unfilled grains/panicle were Saaf at 300g/ac (21.20 grains), Onix at 350ml/ac (21.53 grains), against the untreated control (42.33 grains). Plants treated with Curacarb recorded the heaviest grains (27.90g per 1000 grains), followed by the untreated control weighing 26.36g. The average grain weight per 1000 grains were 24.84g for all treatments. Taller plants were observed from plots treated with Curacarb (104.07cm) and lowest plant height were from plants treated with Fugi 1 (93.85), while the untreated control had average plants height of 99.20cm (Table 4).

Another yield parameter examined during this trial is the number of tillers/m<sup>2</sup>. A total of 255.00 tillers/m<sup>2</sup> were obtained from plots treated with Top Cop at 250ml/ac, ranking the highest compared to the control which had a total of 147.67 tillers/m<sup>2</sup>. The lowest amount was seen for plants treated with Curacarb 150ml/ac (126. 33tillers/m<sup>2</sup>) (Table 4).

The recorded yield/treatment indicated that treatments with Top Cop at 250ml/ac was able to produce an equivalent of 3029.50 kg/ha or 19.26 bags/ac. This was significantly higher than all other treatments evaluated. This was followed by treatments with Curacarb at 250ml/ac which produced an equivalent of 2665.6 kg/ha or 16.95 bags/ac. Grain yield was lowest in plots treated with Tridium at 200 ml/ac (1724.10kg/ha ~ 10.96bags/ac) and the untreated control which produced only an equivalent of 1586.30 kg/ha or 10 .09bags/ac (Table 4).

In spring crop 2022, with exception of Curacarb 100ml/ac and Tantor 200ml/ac, there was an increase in mean grain yield for all treated plants over the control; while in autumn crop all of the treatments applied showed an increase in mean grain yields over the untreated control treatment (Table 3 and 4).

**Table 3: Efficacy of new fungicides against sheath rot (*S. oryzae*) on growth and yield parameters during spring crop, 2022**

Trt	Treatment	Rates/ac.	* <sup>2</sup> Panicle Length (cm)	* Filled grains/Panicle	*Unfilled grains/Panicle	* 1000 grain weight (g)	* <sup>1</sup> Plant Height (cm)	* Tillers/m <sup>2</sup>	* Kg/ha	* Bags/ac
T1	Top cop	100ml	30.59 A	143.60 A	24.367 A	24.33 A	103.63 ABC	258.33 AB	2930.50 A	18.64 A
T2	Top cop	150ml	24.60 B	129.33 AB	23.43 AB	27.27 A	105.07 AB	244.00 B	2553.30 A	16.24 A
T3	Top cop	250ml	25.36 AB	129.27 AB	26.00 A	24.43 A	97.17 CD	280.00 AB	3232.20 A	20.56 A
T4	Onix	150ml	24.83 B	144.53 A	24.30 A	25.33 A	101.93 ABCD	295.67 AB	2842.40 A	18.08A
T5	Onix	250ml	25.89 AB	142.63 A	22.03 AB	24.37 A	103.00 ABC	297.33 AB	2921.50 A	18.58 A
T6	Onix	350ml	25.52 AB	141.03 A	22.50 AB	26.17 A	95.97 D	254.67 AB	3122.40 A	19.85 A
T7	Onix	450ml	24.47 B	117.80 AB	15.53 BC	24.40 A	101.77 ABCD	299.00 AB	2461.70 A	15.65 A
T8	Curacarb	100ml	25.24 AB	130.93 AB	24.77 A	26.30 A	99.40 ABCD	258.67 AB	2364.20 A	15.03 A
T9	Curacarb	150ml	25.43 AB	133.17 AB	20.67 AB	26.07 A	104.00 AB	302.33 A	2615.60 A	16.63 A

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<b>T10</b>	Curacarb	250ml	25.97 AB	135.53 AB	23.33 AB	26.30 A	103.13 ABC	305.67 A	3066.60 A	19.50 A
<b>T11</b>	Tantor	200ml	24.78 B	133.07 AB	25.20 A	25.50 A	105.60 A	249.00 AB	2167.20 A	13.78 A
<b>T12</b>	Tridium	350g	24.19 B	122.43 AB	26.47 A	25.57 A	100.73 ABCD	283.67 AB	2557.00 A	16.260A
<b>T13</b>	Saaf	300g	24.82 B	102.80 B	21.20 AB	24.97 A	103.03 ABC	255.67 AB	2670.70 A	16.98 A
<b>T14</b>	Fug I	300ml	25.13 AB	147.20 A	11.28 C	26.90 A	100.63 ABCD	270.00 AB	3216.30 A	20.46 A
<b>T15</b>	Control		24.20 B	134.03 AB	21.60 AB	25.40 A	98.37 BCD	260.00 AB	2408.00 A	15.31 A
<b>Grand mean</b>			25.40	132.49	22.18	25.55	101.56	274.27	2742.00	17.44
<b>SEM</b>			2.76	16.76	4.04	2.03	3.32	28.41	606.56	3.86
<b>CD (P=0.05)</b>			5.66	34.34	8.28	4.16	6.81	58.20	1242.50	7.90
<b>CV (%)</b>			13.32	15.5	22.31	9.73	4.01	12.69	27.09	27.09

\*= average of four replication; <sup>1</sup>= Average from ten plants per each replication; <sup>2</sup>=Average from ten panicle per each replication, Means values in columns followed by same superscript letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

**Table 4: Efficacy of new fungicides against sheath rot (*S. oryzae*) on growth and yield parameters during autumn crop, 2022**

Trt	Treatment	Rates/ac.	<sup>2</sup> Panicle Length (cm)	*Filled grains/Panicle	*Unfilled grains/Panicle	*1000 grain weight (g)	<sup>1</sup> Plant Height (cm)	*Tillers/m <sup>2</sup>	*Kg/ha	*Bags/ac
<b>T1</b>	Top cop	100ml	23.88 AB	130.87 AB	25.57 B	23.73 BC	102.43 AB	185.67 AB	2415.90 ABC	15.36 ABC
<b>T2</b>	Top cop	150ml	24.54 AB	142.80 AB	43.30 AB	25.27 ABC	101.47 AB	187.67 AB	2571.80 ABC	16.36 ABC
<b>T3</b>	Top cop	250ml	25.00 AB	133.30 AB	27.23 B	24.80 ABC	96.33 AB	255.00 A	3029.50 A	19.26 A
<b>T4</b>	Onix	150ml	23.91 AB	137.57 AB	30.10 AB	23.67 BC	96.90 AB	138.33 B	2203.30 BCD	14.01 BCD
<b>T5</b>	Onix	250ml	24.60 AB	158.17 A	33.93 AB	22.57 C	98.43 AB	166.33 AB	2117.70 BCD	13.47 BCD
<b>T6</b>	Onix	350ml	24.36 AB	141.17 AB	21.53 B	25.97 ABC	100.90 AB	231.67 AB	2498.20 ABC	15.89 ABC
<b>T7</b>	Onix	450ml	24.89 AB	133.23 AB	28.10 B	25.13 ABC	100.83 AB	138.33 B	2500.80 ABC	15.90 ABC
<b>T8</b>	Curacarb	100ml	24.26 AB	128.40 AB	39.07 AB	23.67 BC	99.13 AB	203.67 AB	2391.80 ABC	15.21 ABC
<b>T9</b>	Curacarb	150ml	24.42 AB	126.80 AB	32.60 AB	24.57 ABC	104.07 A	126.33 B	2187.10 BCD	13.91 BCD
<b>T10</b>	Curacarb	250ml	25.08 A	125.00 AB	26.37 B	27.90 A	96.20 AB	179.67 AB	2665.60 AB	16.95 AB
<b>T11</b>	Tantor	200ml	23.97 AB	80.30 C	62.20 A	25.933 ABC	97.27 AB	221.67 AB	1983.90 CD	12.62 CD
<b>T12</b>	Tridium	350g	23.48 B	149.33 AB	30.10 AB	23.133 BC	97.10 AB	154.33 AB	1724.10 D	10.96 D
<b>T13</b>	Saaf	300g	23.45 B	117.83 B	21.57 B	24.77 ABC	96.80 AB	187.67 AB	2126.40 BCD	13.52 BCD

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<b>T14</b>	Fug 1	300ml	24.28 AB	135.27 AB	30.73 AB	25.33 ABC	93.73 B	173.67 AB	2492.90 ABC	15.86 ABC
<b>T15</b>	Control		23.52 AB	118.07 B	42.33 AB	26.27 AB	99.20 AB	147.67 AB	1586.30 D	10.09 D
<b>Grand mean</b>			24.242	130.54	32.98	24.85	98.72	179.84	2299.70	14.62
<b>SEM</b>			0.766	17.46	16.18	1.72	4.69	54.48	318.34	2.03
<b>CD (P=0.05)</b>			1.57	35.77	33.15	3.52	9.61	111.59	652.09	4.15
<b>CV (%)</b>			3.87	16.38	60.09	8.47	5.82	37.10	16.95	16.96

\* = average of four replications; <sup>1</sup> = Average from ten plants per each replication; <sup>2</sup> = Average from ten panicles per each replication. Means values in columns followed by same superscript letter(s) do not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

**3.4 Effects of treatments on growth and yield parameters during first (spring) crop 2024**

According to the statistical analysis, there were no significant differences among treatments for panicle length (cm) and filled grains per panicle for each treatment compared against the untreated control (Table 5). In terms of unfilled grains per panicle Onix 150ml/ac (49.63), Top Cop 100ml/ac (41.33), and the untreated control (39.33) recorded significant higher number of unfilled grains per panicle as compared to the other treatments (Table 5). Top Cop 250ml/ac (23.43) followed by Top Cop 150ml/ac (25.90) recorded significantly lower 1,000 grain weight as compared to the untreated control and the other treatments (Table 5). Onix 150ml/ac (109.40cm) recorded the significant shortest plant height while treatment with Top Cop 100ml/ac was observed with the tallest height (116.83cm). There were no significant differences between the other treatments for plant height (Table 5). Treatment with positive check Fugl-One 300ml/ac (176.00), Tridium 350 g/ac, (162.67) and Top Cop 100ml/ac (164.00) expressed the significantly lower number of tillers per meter square as compared to the other treatments, while treatment with Top Cop 250ml/ac (245.33) expressed the highest number of tillers per meter square (Table 5).

Treatment with Curacarb 250ml/ac (4695.40 kg/ha) recorded the significantly highest grain yield (kg/ha) followed by Saaf 300g/ac (4302.50 kg/ha), Top Cop 250ml/ac (4178.50.80 kg/ha) and Fugl-one 300ml/ac (4096.60 kg/ha) are among the treatments with the highest grain yield over the untreated control (2755.10 kg/ha) (Table 5).

In general, results from the 3 separate field trials showed that most of the fungicidal treatments had positive impacts in terms of the growth and yield parameter as well as higher overall mean grain yields (Table 3, 4 and 5) over the untreated control. Likewise, similar results were seen in the reduction of the SR disease severity percentage. Treatment applied such as Top cop at 250ml/ac., Onix at 350 ml/ac., Curacarb 250ml/ac., Saaf at 300 g/ac. and Fugl One 300ml/ac (check) demonstrated significantly lower sheath rot % DS, and likewise showed positive impacts in terms of the growth and yield parameter as well as higher overall mean grain yields (Table 3, 4 and 5). Therefore, treatments with these six fungicides viz. Top cop at 250ml/ac., Onix at 350 ml/ac., Curacarb 250ml/ac., Saaf at 300 g/ac and Fugl One 300ml/ac can be recommended firstly, a protective treatment for the management of Sheath rot disease at their respective recommended rates especially in SR disease prone area.

**Table 5: Efficacy of new fungicides against sheath rot (*S. oryzae*) on plant growth, yield parameters and grain yields during first crop 2024**

Trt	Treatment	Rates/ac.	* <sup>2</sup> Panicle Length (cm)	* Filled grains/ Panicle	*Unfilled grains/ Panicle	* 1000 grain weight (g)	* <sup>1</sup> Plant Height (cm)	* Tillers/ m <sup>2</sup>	* Kg/ha	* Bags/ac
<b>T1</b>	Top cop	100ml	27.18 A	121.33 A	41.33 AB	28.13 ABC	116.83 A	164.00 B	3534.9 BCDEF	22.48 BCDEF
<b>T2</b>	Top cop	150ml	27.75 A	128.33 A	20.33 DE	25.90 CD	112.40 AB	190.67 AB	2846.2 EF	18.10 EF
<b>T3</b>	Top cop	250ml	28.31 A	121.70 A	21.13 DE	23.43 D	115.70 AB	245.33 A	4178.5 AB	26.57 AB
<b>T4</b>	Onix	150ml	27.15 A	105.17 A	49.63 A	29.00 ABC	109.40 B	201.33 AB	2858.7 EF	18.18 EF

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<b>T5</b>	Onix	250ml	26.85 A	133.40 A	16.47 E	29.03 ABC	114.73 AB	216.00 AB	3267.5 CDEF	20.78 CDEF
<b>T6</b>	Onix	350ml	27.73 A	114.57 A	25.43 BCDE	29.27 AB	112.27 AB	213.33 AB	4075.3 ABC	25.92 ABC
<b>T7</b>	Onix	450ml	27.74 A	121.00 A	19.23 DE	27.73 BC	115.13 AB	182.67 AB	3077.2 DEF	19.57 DEF
<b>T8</b>	Curacarb	100ml	27.46 A	124.23 A	36.60 ABCD	31.13 A	115.27 AB	193.33 AB	3164.4 DEF	20.12 DEF
<b>T9</b>	Curacarb	150ml	28.25 A	127.87 A	34.18 ABCDE	28.57 ABC	114.20 AB	200.00 AB	3699.9 BCDE	23.53 BCDE
<b>T10</b>	Curacarb	250ml	28.73 A	128.07 A	21.47 CDE	27.33 BC	113.97 AB	217.33 AB	4695.4 A	29.86 A
<b>T11</b>	Tantor	200ml	27.88 A	137.10 A	26.13 BCDE	26.83 BC	114.80 AB	184.00 AB	3833.3 ABCD	24.38 ABCD
<b>T12</b>	Tridium	350g	27.66 A	117.27 A	20.53 DE	28.37 ABC	112.00 AB	162.67 B	3597.6 BCDEF	22.88 BCDEF
<b>T13</b>	Saaf	300g	27.64 A	121.83 A	22.40 CDE	28.00 ABC	112.50 AB	205.33 AB	4302.5 AB	27.36 AB
<b>T14</b>	Fug 1	300ml	27.52 A	125.90 A	25.00 BCDE	28.93 ABC	113.23 AB	185.33 AB	4096.6 ABC	26.05 ABC
<b>T15</b>	Control		27.92 A	98.13 A	39.33 ABC	26.87 BC	111.43 AB	176.00 B	2755.1 F	17.52 F
<b>Grand mean</b>			27.72	121.73	27.95	27.90	113.59	195.82	3598.90	22.89
<b>SEM</b>			0.95	19.96	8.76	1.61	3.34	30.77	435.62	2.77
<b>CD (P=0.05)</b>			1.95	40.89	17.94	3.30	6.85	63.03	892.32	5.68
<b>CV (%)</b>			4.21	20.08	38.38	7.08	3.60	19.24	14.82	14.83

\* = average of four replications; <sup>1</sup>= Average from ten plants per each replication; <sup>2</sup>=Average from ten panicle per each replication, Means values in columns followed by same superscript letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

### 3.5 Assessments of the socio-economic benefits

The results of this study indicate significant socio-economic benefits associated with the application of fungicides for the effective management of rice sheath rot disease. Socio-economic benefits can be used to identify vulnerable groups of rice farmers and include local experiences encountered in sustaining local rice economies and communities. Socioeconomic standing is seen as a measure of people's combined economic and social status and is positively associated with better health, education, income, and occupation (Baker,2026). Key to farmers and the thrust for successful rice production, is selecting best practice centering on treatments that impact upon the quality of rice as a staple food and overall human well-being, spanning nutrition and health as well as local production and economic growth.

The superior-performing treatments, namely Top Cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300 g/ac, and the positive check, Fugi One at 300 ml/ac, demonstrated substantial reductions in sheath rot disease severity, ranging from 68.00% to 76.00% compared with the untreated control. The remaining fungicidal treatments also provided meaningful disease suppression, reducing disease severity by 31.99% to 48.00% relative to the untreated control treatment (Figure 1). These findings demonstrate the effectiveness of fungicide applications in reducing disease pressure and protecting rice crops from significant production losses.

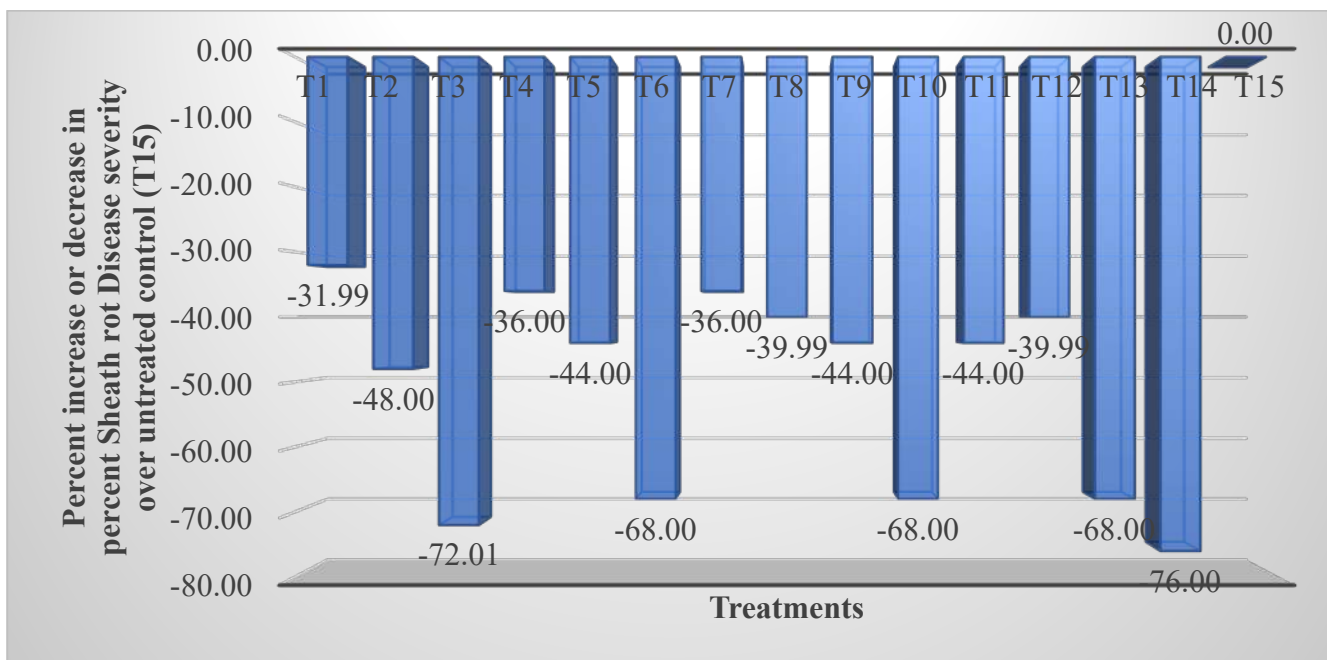


Figure 1: Percentage increase or decrease in mean percent sheath rot disease severity over the control (T15).

The reduction in disease severity translated into improved grain yields across the different cropping seasons. During the Spring Crop 2022, all fungicidal treatments except Curacarb at 100 ml/ac and Tantor at 200 ml/ac increased mean grain yields compared with the untreated control, with gains ranging from 2.23% to 34.23% (Figure 2). In the Autumn Crop 2022, all fungicide treatments resulted in yield increases ranging from 8.69% to 90.98% over the untreated control (Figure 2).

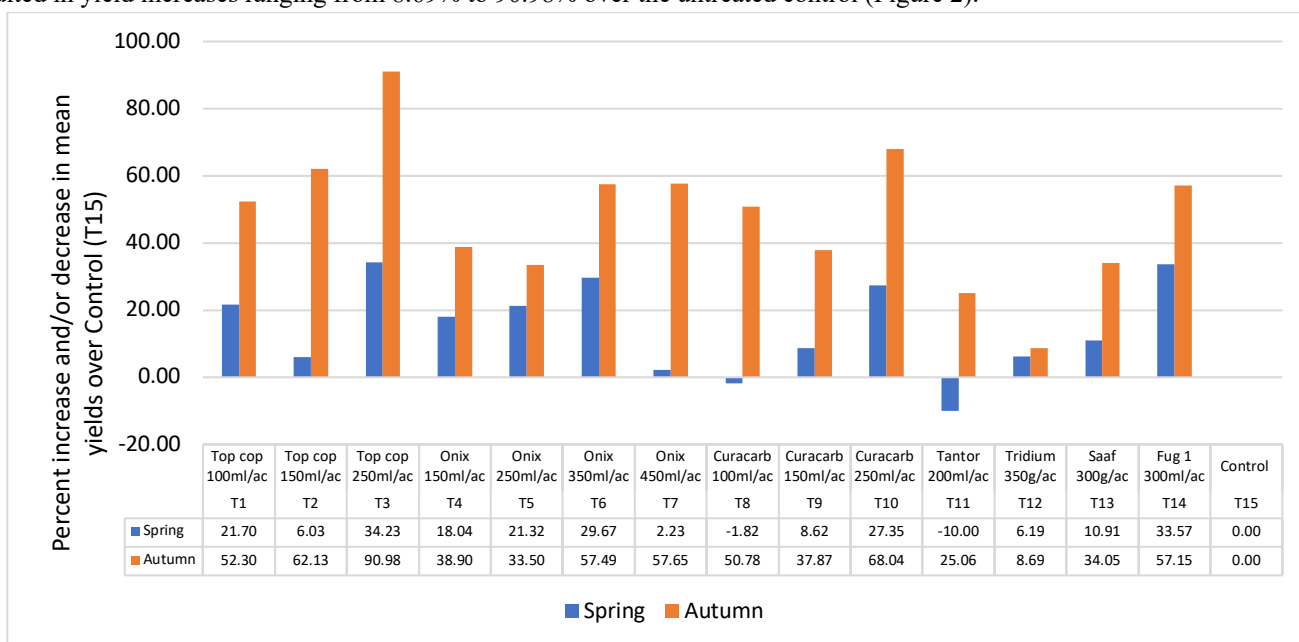


Figure 2: Percentage increase or decrease in mean grain weight (kg/ha.) over the control (T15)

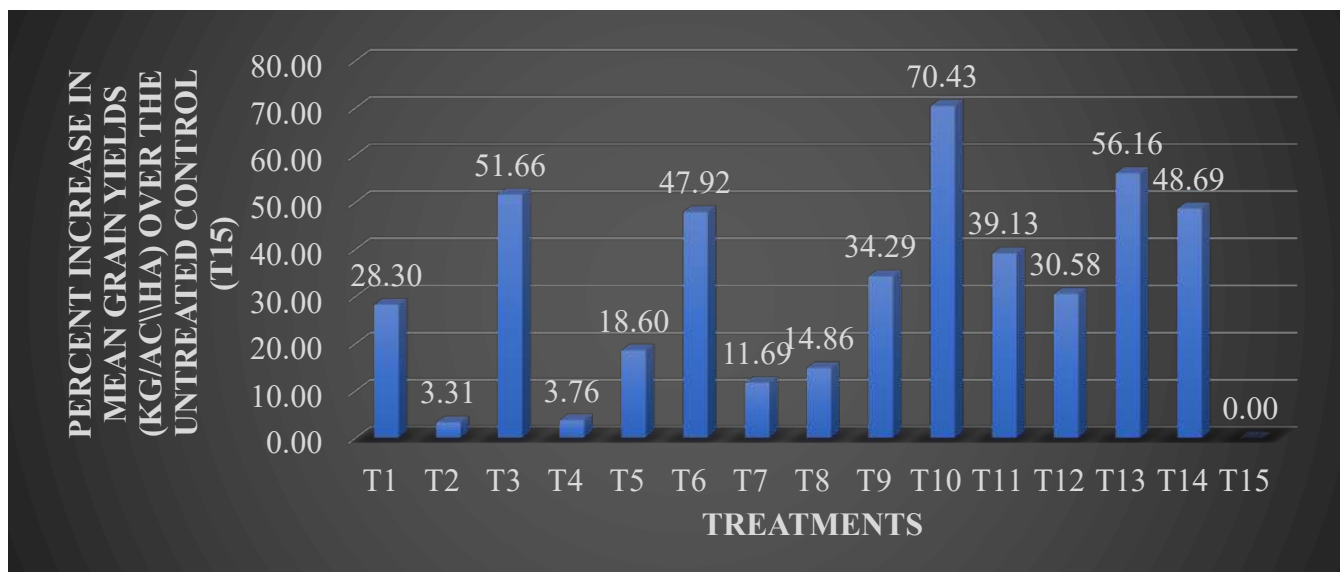


Figure 3: Percentage increase or decrease in mean grain weight (kg/ha.) over the control (T15).

Similarly, the First Crop 2024 trial showed that all fungicide-treated plots produced higher grain yields than the untreated control, with percentage increases ranging from 3.31% to 70.43% (Figure 3). These yield improvements highlight the potential of fungicide-based disease management to enhance rice productivity under local production conditions.

From a socio-economic perspective, the observed reductions in disease severity and corresponding increases in grain yield can generate substantial benefits for rice farmers and the wider rice industry. Higher yields result in greater quantities of marketable paddy, which can significantly improve farm income and profitability. Increased profitability enables farmers to better meet production costs, reinvest in their farming operations, adopt improved technologies, and strengthen the overall resilience and sustainability of their rice production. In addition, improved financial returns can enhance farmers' access to essential services such as education, healthcare, housing, transportation, and other household necessities, thereby contributing to improved standards of living for farming families and rural communities.

The economic benefits generated through increased productivity can also play an important role in poverty reduction of the more than 10% of the Guyanese population who directly and indirectly involved in rice production. For many rice-producing households, rice cultivation represents a primary source of income. Therefore, reductions in yield losses caused by sheath rot disease can help stabilize their earnings, reduce vulnerability to economic shocks, and improve household financial security. Increased farm revenues can create opportunities for employment, stimulate local business activities, and support economic growth within rice-producing communities. Such outcomes are particularly important in rural areas where agriculture remains a major driver of livelihoods and socio-economic development.

At the industry level, increased rice production can contribute positively to the growth and competitiveness of Guyana's rice sector. Higher yields can enhance the availability of rice for both domestic consumption and export markets, thereby strengthening foreign exchange earnings and supporting national economic development. Improved productivity can also benefit other stakeholders within the rice value chain, including seed suppliers, agrochemical distributors, machinery operators, millers, transport providers, exporters, and agricultural service providers, creating multiplier effects throughout the economy.

Furthermore, effective management of sheath rot disease contributes to sustainable food production and food security. By reducing disease-related losses and improving crop productivity, farmers will be able to produce more rice from the same cultivated area, thereby increasing production efficiency and promoting more sustainable use of agricultural resources. Increased and stable rice production helps ensure a reliable supply of this staple commodity for local and international markets, supporting food availability and food security. Improved productivity and profitability also encourage farmers to remain engaged in rice cultivation, helping to sustain agricultural production systems and rural livelihoods over the long term.

Overall, the findings of this study suggest that the adoption of effective fungicide management strategies for sheath rot disease can provide considerable socio-economic benefits through increased productivity, improved profitability, enhanced living standards, poverty reduction, strengthened food security, and sustainable growth of the rice industry. These benefits extend beyond individual farmers to their families, rural communities, and the broader network of stakeholders involved in Guyana's rice sector, thereby contributing to national agricultural and economic development.

#### 4.0 DISCUSSION

The results of the present study demonstrated that fungicidal applications significantly reduced sheath rot (SR) disease severity caused by *Sarocladium oryzae* and improved growth and yield parameters of rice across three cropping seasons (2022–2024). The consistent reduction in disease severity observed among fungicide-treated plots compared with the untreated control confirms the importance of chemical disease management in minimizing the impact of sheath rot under field conditions. These findings are consistent with previous reports that identified sheath rot as an increasingly important rice disease capable of causing substantial quantitative and qualitative yield losses when left unmanaged (Bigirimana et al., 2015; Mehta et al., 2025). Studies have reported yield losses ranging from approximately 10% to more than 80% depending on disease severity, environmental conditions, cultivar susceptibility, and management practices (Bigirimana et al., 2015; Sharma et al., 2013; Mehta et al., 2025).

Among the fungicides evaluated, Top Cop (Sulphur 50% + metallic copper equivalent 4.4%), Onix (Carbendazim 12.5% + Propiconazole 12.5%), Curacarb (Carbendazim 50% at 100, 150, and 250 g/ac), Saaf (Mancozeb 63% + Carbendazim 12%), and the positive check Fugi One (Isoprothiolane 40% SC) consistently provided superior disease control, reducing sheath rot severity by 68–76% compared with the untreated control. The superior performance of these treatments can be explained by their complementary modes of action, including multi-site activity, sterol biosynthesis inhibition, and disruption of fungal metabolic processes. For example, Top Cop (Sulphur 50%, metallic copper equivalent 4.4%) are copper-based protectant fungicides, which act through multi-site activity by denaturing proteins, disrupting enzyme systems and causing membrane leakage in fungal cells. Because of their multi-site action, copper compounds are generally considered low risk for resistance development and provide broad-spectrum protective activity against foliar pathogens (Lamichhane et al., 2018). Similarly, Saaf (Mancozeb 63%, Carbendazim 12%) as a pre-mix fungicide formulation combines two different active ingredients to provide both curative and protective action, which contributed to its consistent disease suppression and yield improvement. However, resistance development to Carbendazim has been widely reported in several fungal pathogens (Mochizuki and Ohki, 2012), highlighting the importance of mixture partners such as mancozeb in sustaining efficacy (Brent & Hollomon, 2007). Likewise, Onix (Carbendazim 12.50%, Propiconazole 12.50%) and Fugi One (Isoprothiolane 40% SC) are widely used in rice disease management due to their systemic movement, curative action, and relatively strong efficacy against sheath rot and other sheath-associated pathogens (Kongcharoen et al., 2020; Mehta et al., 2025). Their strong performance in this study aligns with reports Mehta et al., (2025) who indicate that fungicides can reduce sheath-related diseases by more than 60% under field conditions.

Similarly, Tuli et al., (2017) conducted an experiment by evaluating new 9 fungicides molecules and in a separate study Balgude et al., (2019) screened 7 modern broad-spectrum fungicides against major rice disease including sheath rot disease. These researchers reported that all fungicides were effective in reducing the incidence of the major rice diseases at flowering, milking, dough and maturity stages and resulted in higher yield.

Likewise, Kindo and Tiwari, (2015) study the efficacy of several fungicide against sheath rot under field conditions. These researchers also reported that treatment with Hexaconazole 5 SC (Contaf) treatment followed by Tebuconazole 250 EC (Folicur), Carbendazim 50% WP (Bavistin), Propiconazole 25 EC (Tilt), Saaf [Carbendazim 12% + Mancozeb 63%] and Mancozeb 75% WP (Dithane M-45) treatment significantly reduced the sheath rot intensity and increased the grain yield which is in full agreement with the findings of this present study.

Further, the findings of the present study also concur with previous studies that reported significant reductions in sheath rot incidence and severity following the application of fungicides with protective and systemic modes of action (Naveenkumar & Mohanpriya, 2017; Sharma et al., 2013; Rajnandni and Tiwari, 2022). Similarly, Mandal et al. (2024) reported that effective fungicide treatments achieved more than 70% disease control and substantially improved rice yields under field conditions. The comparable performance of the best-performing treatments in the present study suggests that several fungicide options are available for effective sheath rot management, allowing flexibility in disease management programs and supporting fungicide resistance management strategies through product rotation (Mandal et al., 2024).

The reduction in disease severity was accompanied by improvements in plant growth, yield components, and grain yield. This relationship is expected because sheath rot infection interferes with panicle emergence, grain filling, and overall plant physiological processes, resulting in increased sterility, chaffiness, and reduced grain weight (Bigirimana et al., 2015). The higher grain yields recorded in fungicide-treated plots therefore reflect the protection of reproductive structures and the maintenance of photosynthetic capacity during critical growth stages. Similar observations were reported by Mehta et al. (2025), who found that fungicide-protected rice plots had significantly lower disease severity and higher grain weight than untreated plots. Their study further demonstrated a strong relationship between disease severity and yield loss, confirming that effective disease suppression directly contributes to improved crop productivity.

The yield increases observed in the present study, ranging from 2.23% to 90.98% over the untreated control depending on season and treatment, demonstrate the substantial economic value of effective sheath rot management. Increased grain production translates directly into greater marketable yield and improved farm profitability. Such benefits are particularly important in rice-dependent

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farming systems where disease outbreaks can significantly affect household income and livelihood security. Previous studies have similarly emphasized that effective disease management strategies are critical for reducing production risks and improving economic returns to farmers (Bigirimana et al., 2015; Mehta et al., 2025).

Beyond farm-level productivity gains, the findings have broader socio-economic implications for Guyana's rice industry. Increased yields resulting from improved disease management can contribute to higher household incomes, improved living standards, and enhanced livelihood opportunities for rice-farming families. Greater profitability may enable farmers to reinvest in production, adopt improved technologies, and increase farm resilience. Furthermore, increased rice production contributes to food security by enhancing the availability and stability of rice supplies for domestic consumption and export markets. As rice remains one of the world's most important staple foods, sustainable increases in productivity are essential for supporting food security and rural development (Bigirimana et al., 2015).

The consistent performance of Top Cop, Onix, Curacarb, Saaf, and Fugi One across multiple cropping seasons suggests that these fungicides can serve as valuable components of integrated disease management programs for sheath rot in Guyana and other places where rice is being cultivated under similar conditions. While fungicide application remains an important management tool, the findings also highlight the importance of integrated disease management (IDM) since the sole reliance on fungicides may increase selection pressure and long-term resistance risk, particularly for site-specific fungicides. Therefore, long-term disease management should also incorporate complementary approaches such as the use of healthy seed, balanced fertilization, proper crop husbandry, and the deployment of resistant or moderately resistant cultivars where available (Bigirimana et al., 2015; Mehta et al., 2025). Such integrated approaches can enhance disease control, reduce reliance on fungicides, and contribute to the sustainability of rice production systems.

Overall, the findings of this study demonstrate and confirm that Top Cop, Onix, Curacarb, Saaf, and Fugi One are effective fungicidal management of sheath rot disease and can substantially reduce disease severity, improve grain yield, increase economic profitability, strengthen food security and social conditions. The recommended fungicides therefore provide practical and economically viable options for managing sheath rot disease in Guyana's rice production systems, particularly in areas prone to severe disease outbreaks.

### 5.0 CONCLUSION AND RECOMMENDATION

The results obtained from three field trials conducted during the Spring and Autumn cropping seasons of 2022 and the Spring cropping season of 2024 clearly demonstrated the effectiveness of fungicidal treatments in managing rice sheath rot (SR) disease caused by *Sarocladium oryzae*. Across all trials, fungicide-treated plants consistently exhibited lower disease severity than the untreated control, confirming the importance of fungicidal intervention in reducing disease pressure and protecting rice productivity. Among the treatments evaluated, Top Cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, and Saaf at 300 g/ac consistently provided the highest levels of disease control and performed comparably to the positive check, Fugi One at 300 ml/ac. These treatments significantly reduced sheath rot disease severity while positively influencing plant growth, yield components, and overall grain yield. Their consistent performance across multiple cropping seasons highlights their potential as reliable management options for sheath rot disease, particularly in areas where the disease is prevalent.

The reductions in disease severity were accompanied by increased grain yields, demonstrating the socio-economic value of effective disease management. Higher productivity can improve farm profitability, strengthen household incomes, and contribute to improved livelihoods and the social environments in which rice-farming families exist, including healthcare, nutrition, and a better quality of life. In addition, increased rice production supports food security and provides benefits to stakeholders throughout Guyana's rice value chain.

Overall, the findings indicate that Top Cop at 250 ml/ac, Onix at 350 ml/ac, Curacarb at 250 ml/ac, Saaf at 300 g/ac and positive check, Fugi One at 300 ml/ac are effective fungicidal options for the management of sheath rot disease and can be recommended for use in Guyana's rice production systems, particularly in areas prone to severe disease outbreaks.

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## AUTHOR'S CONTRIBUTIONS

Rajendra Persaud designed and executed the study, analyzed the data and drafted the paper. Vashti Singh provided valuable information and perspectives on the socio-economic approach. All authors assisted with data analysis and interpretation, literature review and editing support, technical advice, and read, and agreed with the content of the manuscript.

## DISCLOSURE STATEMENT

### Data Availability

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding authors.

### Ethical Standards

The authors declare that the current research did not involve human participants or animals as test materials.

### Funding

The authors have no relevant financial or non-financial interests to disclose.

### Conflict of Interest

The authors declare that there is no potential conflict of interest to report.

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