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Research Article

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Evaluate the Efficacy of Different Dose of New Synthetic and Botanical Fungicides Against Brown Spot (*Bipoloris Oryzae*) Disease of Rice Under Field Condition

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ABSTRACT

Bipolaris oryzae is the causal agent of rice brown spot disease and is responsible for significant economic losses. In order to control this disease, three new synthetics fungicide viz. Top Cop (Sulphur 50%, metallic copper equivalent 4.4%), Droxide (Cupric hydroxide), and Onix (Carbendazim 12.50%, Propoconozole 12.50%), and one botanical fungicide viz. Sporan (Rosemary oil 16%, Clove oil 10%, Thyme oil 10%, Peppermint oil 2%), at varying rates were along with two positive checks, Saaf (Mancozem 63%, Carbendazim 12%) at 300g/ac. and Fugi One (Isoprothiolane 40% SC) at 300 ml/ac. and a untreated control were evaluated for their effectiveness in managing the brown spot disease. The experiment was conducted under field conditions within the Plant Pathology experimental area at the Rice Research Station, Burma during first and second crop of 2022 and 2023. The experimental design used is an RCBD with 4 replications. Results for the 4 seasons of trials showed that treatments with Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, Onix at 250ml/ac demonstrated consistent superior levels of control and reduction in brown spot disease severity when compared to the untreated control similar to the two (2) positive fungicidal checks, Saaf 300g/ac and Fugi One at 300 ml/ac. under field conditions. Also, the said treatments demonstrated positive influence in terms of plant growth, yield parameters and overall grain yields were reported. Therefore, these four (4) new fungicides viz. Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, Onix at 250ml/ac. can be recommended for the management of brown spot disease.

Keywords: Rice, Brown Spot Disease, Synthetic and Botanical Fungicides, Control

Introduction

Brown spot (*Bipolaris oryzae*) is well known to researchers of Plant pPathology because of the 1942 epidemic that led to famine in Bengal Province of British India known as 'The Great Bengal Famine'[1,2]. This disease was first observed as seedling blight that resulted in seedling mortality, perhaps due to heavy seedborne inocula [3]. Due to the development and introduction of new high yielding rice varieties, the crop suffers from several fungal diseases of which brown spot (Bipolaris oryzae) appears in more severe form in the last few years, with more than 45% yield lost reported when there are no plant protection methods practices in the rice crop [2]. Today, brown spot disease of rice is distributed worldwide wherever rice is grown. However, it is more prevalent in upland and lowland rice fields that are deficient in nitrogen or has any nutritional deficiency particularly N, P and K which creates unfavorable conditions for rice cultivation [4,5]. Many strategies for the management of brown spot disease have studied and documented by thousands of researchers. However, the best-known strategy to manage the disease is the use of resistant varieties. The use of resistant varieties in disease management is found to be safe, efficient, and cost-effective

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for controlling many of the major rice diseases but due the lack of resistant varieties for brown spot disease farmers mostly prefers the use of synthetic chemicals and this found to be the most effective management strategy for preventing brown spot disease, and found to be highly recommended method and widely used throughout the world [6-8].

Brown spot has been reported to have a widespread distribution in all rice-growing areas of the world [3]. In Guyana an increase in incidence of brown spot disease have been observed within the various rice growing regions [9]. Therefore, finding ways to minimize losses due to brown spot disease can immediately improve the household food security of resource-poor rice farmers. In view of this, this research project was conducted to evaluate four novel molecules along with two positive checks and a untreated control for the management of the rice brown spot disease in Guyana.

Materials and Method

Field Evaluation of Synthetic and Botanical Fungicides Against Brown Spot Disease

Four field trials were conducted in spring and autumn cropping seasons of 2022 and 2023 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 replication per treatment. Each plot had a 15m2 (3m x 5m) size with 1m plot-to-plot spacing. The soil type is front-land rice group and classified as Litchfield clay (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-1. Early season pest control and weed management follow the standard crop production practices as recommended and described by GRDB [10]. Fertilizers were applied at a rate of N 120 P50 K0 kg/ha at the recommended timing [10].

Inoculation and Application of Treatments

Inoculation of experiment was done with spore suspension concentration of 105 using a mixture of naturally existing brown spot strains collected from diseased plantlets from the surrounding fields. The treatments were applied 7 days after inoculation. Individual treatments of the three new synthetics fungicide viz. Top Cop (Sulphur 50%, metallic copper equivalent 4.4%) at 100, 150 and 250 ml/ac., Droxide (Cupric hydroxide) at 150, 250 and 350 g/ac., and Onix (Carbendazim 12.50%, Propoconozole 12.50%) at 150, 250 350 and 450 ml/ac., and one botanical fungicide viz. Sporan (Rosemary oil 16%, Clove oil 10%, Thyme oil 10%, Peppermint oil 2%), at 300, 600 and 900 ml/ac., along with two positive checks, Saaf (Mancozem 63%, Carbendazim 12%) at 300g/ac. and Fugi One (Isoprothiolane 40% SC) at 300 ml/ac. and a 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 surface of entire plant with minute droplets of the solution.

Assessment of Growth Parameters, Yield Attributes, Grain Yield and Brown Spot 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 and unfilled grains per panicle, weight 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 brown spot disease incidence the lesion length was measured from five tagged plants from each plot, as well as scoring was done using the International Rice Research Institute (IRRI), Standard Evaluation System (SES), 0 to 9 scale for Brown Spot disease [11].

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 formular: %DS= [(Sum of all numerical ratings)/ (Total number of samples observed X Maximum rating)] *100. Also, percent change in brown spot 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.

Results

Effects of Synthetic and Botanical Fungicides on Brown Spot Disease

During 2022 and 2023 cropping seasons four new fungicides (Table i), at varying dose rates (Table 1), were evaluated against two positive checks, Saaf at 300g/ac. and Fugi One at 300 ml/ac. and a untreated control for their effectiveness in managing the brown spot disease caused by *Bipolaris oryzae*.

Table i: List of Fungicides Under Evaluation Against Bs Disease

Trade names	Formulation	Group	AI
Top Cop	Flowable	Sulphur and Copper based	Sulphur 50%, metallic copper equivalent 4.4%
Droxide	WP	Copper based	Cupric hydroxide
Sporan	EC	Botanical Fungicide	Rosemary oil 16%, Clove oil 10%, Thyme oil 10%, Peppermint oil 2%
Onix	25SC	Benzimidazole + Triazole	Carbendazim 12.50%, Propoconozole 12.50%
Saaf	75WP	Ditiocarbamate + Benizidazole	Mancozem 63%, Carbendazim 12%
Fugi-One	40% SC	Isoprothiolane	Isoprothiolane 40% SC

Field Trials Results for Lesion length and Percent Disease Severity (%DS) - 2022 Cropping Seasons

In spring 2022 from the field trial significantly lower lesion length for plants treated with Onix at 450ml/ac (0.39 cm) were

recorded, while the higher lesion length was for plants in the control treated plots (0.98cm) (Table 1). Significantly shorter length was also observed among all other treatments including those treated with the check Fugi-one (0.43 cm), when compared to untreated control. There was no significant difference among treatment for initial lesion length (Table 1).

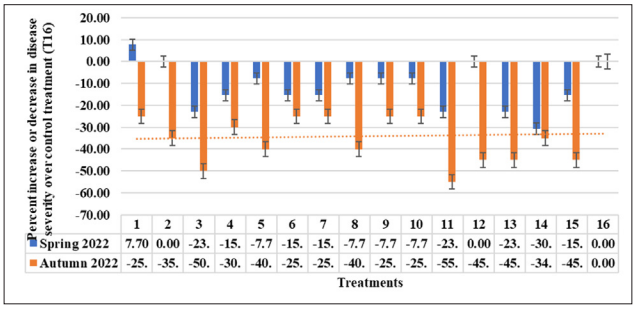
Table 1: Effects of New Fungicides Against Brown Spot (B. oryzae) Disease Under Field Condition 2022

Trt.	Treatment	Rate	*Spring, 2022		*Autumn, 2022		2022 Disease Severity (%)	
			[1]Lesion Length (cm)		[1]Lesion Length (cm)			
			[2]Before	[3]After	[2]Before	[3]After	[2]Before	[3]After
T1	Top Cop	100ml/ac	0.44 A	0.44 BC	0.54 A	0.50 BC	38.89 A	41.66 B
T2	Top Cop	150ml/ac	0.43 A	0.48 BC	0.49 AB	0.59 BC	36.11 AB	36.11 BCD
T3	Top Cop	250ml/ac	0.52 A	0.42 BC	0.39 BC	0.57 BC	27.78 AB	27.78 CD
T4	Droxide	150g/ac	0.47 A	0.49 BC	0.43 ABC	0.49 BC	30.55 AB	38.89 BC
T5	Droxide	250g/ac	0.44 A	0.42 BC	0.47 ABC	0.43 BC	33.33 AB	33.33 BCD
T6	Droxide	350g/ac	0.38 A	0.52 BC	0.33 C	0.48 BC	30.55 AB	41.66 B
T7	Sporan	300ml/ac	0.37 A	0.44 BC	0.43 ABC	0.48 BC	30.55 AB	41.66 B
T8	Sporan	600ml/ac	0.33 A	0.57 BC	0.44 ABC	0.48 BC	33.33 AB	33.33 BCD
T9	Sporan	900ml/ac	0.46 A	0.49 BC	0.37 BC	0.41 C	33.33 AB	41.67 B
T10	Onix	150ml/ac	0.39 A	0.48 BC	0.54 A	0.64 B	33.33 AB	41.67 B
T11	Onix	250ml/ac	0.40 A	0.48 BC	0.48 ABC	0.46 BC	27.78 AB	25.00 D
T12	Onix	450ml/ac	0.34 A	0.39 C	0.39 BC	0.50 BC	36.11 AB	30.55 BCD
T13	Onix	350ml/ac	0.41 A	0.42 BC	0.40 ABC	0.46 BC	27.78 AB	30.55 BCD
T14	Saaf	300g/ac	0.34 A	0.58 BC	0.51 AB	0.57 BC	25.00 B	36.12 BCD
T15	Fugi-one	300ml/ac	0.35 A	0.43 BC	0.42 ABC	0.58 BC	30.55 AB	30.55 BCD
T16	Control		0.43 A	0.98 A	0.39 BC	0.93 A	36.11 AB	55.56 A
Grand mean			0.41	0.50	0.44	0.53	31.94	23.53
SEm ±			0.10	0.09	0.07	0.10	6.07	6.09
CD (P = 0.05)			0.20	0.19	0.14	0.19	12.23	12.28
CV (%)			34.56	26.35	23.16	25.56	26.88	36.63

*Average of four replications; 1Average from three tag plants per each replication; 2Data collected before first treatment applied; 3Data collected 7 days after second treatment applied; 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.

Almost similar results were obtained during the autumn season 2022 as the trial was repeated (Table 1). All treatments [viz.- Top Cop 100ml/ac., Top Cop 150ml/ac., Top Cop 250ml/ac., Droxide 150g/ac., Droxide 250g/ac., Droxide 350g/ac., Sporan 300ml/ac., Sporan 600ml/ac., Sporan 900ml/ac., Onix 150ml/ac., Onix 250ml/ac., Onix 450ml/ac., Onix 350ml/ac., including the two positive checks, Saaf 300g/ac., Fugi-one 300ml/ac.] recorded significantly smaller lesions ranging from 0.41 cm to 0.64 cm and saw a slower rate of lesion progression after second treatment applied when compared to the untreated control (0.93 cm) during that autumn season (second crop) of 2022 (Table 1).

Except for treatment with Top Cop 100 and 150ml/ac., and Onix 450ml/ac., with did either showed higher BS DS% or no reduction when compared to the untreated control, all the other treatments demonstrated reductions in percentage disease severity incidence ranging from 7.7% to 30.7% in spring 2022 and higher percentage reduction in BS % DS in autumn crop 2022 ranging from 25.0% to 55.0% (Table 1 and Figure 1).



Notes: T1- Top Cop 100ml/ac., T2-Top Cop 150ml/ac., T3- Top Cop 250ml/ac., T4- Droxide 150g/ac., T5- Droxide 250g/ac., T6- Droxide 350g/ac., T7- Sporan 300ml/ac., T8- Sporan 600ml/ac., T9- Sporan 900ml/ac., T10- Onix 150ml/ac., T11- Onix 250ml/ac., T12- Onix 450ml/ac., T13- Onix 350ml/ac., T14- Saaf 300g/ac., T15- Fugione (check) 300ml/ac, T16 Control.

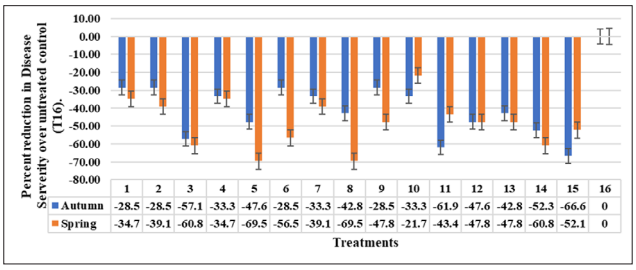
Figure 1: Percentage Reduction in Mean Percent Disease Severity Over Control Treatment (T15).

Field Trials Results for Lesion Length and Percent Disease Severity (%Ds) - 2023 Cropping Seasons

In spring crop 2023 significantly lower lesion lengths were recorded for plants treated with Onix at 250 and 350ml/ac (0.26 and 0.33cm, respectively) and Top Cop at 250ml/ac (0.26 cm), followed by Sporan at 600ml/ac (0.28 cm), Droxide at 250g/

ac (0.30 cm), and the positive check, Saaf at 300g/ac (0.31 cm). Significantly shorter length was also observed among all other treatments including those treated with the check Fugi-one (0.29 cm), when compared to the untreated control (Table 2). There was no significant difference among treatment for initial lesion length. Additionally, no significant difference was observed in terms of % DS before treatment application (Table 2). However, the % DS collected 7 days after second treatment applied revealed that the plants treated with Onix at 350ml/ac., Top Cop at 250ml/ac., Sporan at 600ml/ac., Droxide at 250g/ac., along with the two positive check Saaf at 300g/ac Fugi-one at 300 ml/ac. demonstrated significantly lower % DS compared to the other treatments and untreated control (Table 2).

Similar results were observed from the results of the autumn season of 2023 as the trial was repeated (Table 2). Plants treated with Onix at 250ml/ac had lower lesion length (0.29). Other treatments such as Sporan at 600ml/ac., Top Cop 250ml/ac., and the two positive checks, (Saaf 300g/ac., Fugi-one 300ml/ac.) recorded significantly smaller lesions within the treated plants, ranging from 0.31 cm to 0.33 cm and saw a slower rate of lesion progression after second treatment applied when compared to the untreated control (0.93 cm) during autumn season (Table 2). Like in the spring crop of 2023, there is no significant difference in the %DS before treatment application during the autumn crop of 2023 except Droxide at 250g/ac. which recorded significantly higher %DS (24.99%). Like in the spring 2023, the results for %DS was recorded in the autumn crop 2023 and the similar treatments viz. Onix at 350ml/ac., Top Cop at 250ml/ac., Droxide at 250g/ac., along with the two positive checks, Saaf at 300g/ac Fugi-one at 300 ml/ac., demonstrated lower %DS as compared to the other treatments and untreated control (Table 2).



Notes: T1- Top Cop 100ml/ac., T2-Top Cop 150ml/ac., T3- Top Cop 250ml/ac., T4- Droxide 150g/ac., T5- Droxide 250g/ac., T6- Droxide 350g/ac., T7- Sporan 300ml/ac., T8- Sporan 600ml/ac., T9- Sporan 900ml/ac., T10- Onix 150ml/ac., T11- Onix 250ml/ac., T12- Onix 450ml/ac., T13- Onix 350ml/ac., T14- Saaf 300g/ac., T15- Fugione (check) 300ml/ac, T16 Control.

Figure 2: Percentage Reduction in Mean Percent Disease Severity Over Control Treatment (T15).

All the other fungicidal treatments demonstrated reductions in percentage disease severity incidence ranging from 21.7% to 69.5% in spring 2023 and higher percentage reduction in BS % DS in autumn crop 2023 ranging from 28.50% to 66.6% (Figure 2).

Table 2: Effects of New Fungicides Against Brown Spot (B. oryzae) Disease Under Field Condition 2023

Trt.	Treatment	Rate	*Spring, 2023		*Spring 2023,		*Autumn, 2023		*Autumn 2023,	
			[1]Lesion Length (cm)		Disease Severity (%)		[1]Lesion Length (cm)		Disease Severity (%)	
			[2]Before	[3]After	[2]Before	[3]After	[2]Before	[3]After	[2]Before	[3]After
T1	Top Cop	100ml/ac	0.27 ABC	0.43 BC	22.22 A	41.67 BC	0.44 A	0.44 BCD	22.22 B	41.66 B
T2	Top Cop	150ml/ac	0.25 BC	0.43 BC	22.22 A	38.89 CD	0.43 A	0.43 BCDE	22.22 B	41.67 B
T3	Top Cop	250ml/ac	0.20 C	0.26 F	16.67 A	25.00 FG	0.42 A	0.33 DEF	22.22 B	25.00 DE
T4	Droxide	150g/ac	0.26 BC	0.36 BCDEF	16.67 A	41.66BC	0.33 A	0.40 CDEF	22.22 B	38.89 BC
T5	Droxide	250g/ac	0.23 BC	0.30 DEF	16.67 A	19.44 G	0.28 A	0.32 DEF	24.99 A	30.55 BCDE
T6	Droxide	350g/ac	0.27 ABC	0.40 BCD	16.67 A	27.78 EFG	0.37 A	0.54 B	22.22 B	41.66 B
T7	Sporan	300ml/ac	0.26 BC	0.48 B	13.89 A	38.89 CD	0.41 A	0.48 BC	22.22 B	38.89 BC
T8	Sporan	600ml/ac	0.28 ABC	0.28 EF	16.67 A	19.44 G	0.35 A	0.32 DEF	22.22 B	33.33 BCD
T9	Sporan	900ml/ac	0.33 AB	0.39 BCDE	16.67 A	33.33 CDEF	0.40 A	0.38 CDEF	22.22 B	41.67 B
T10	Onix	150ml/ac	0.27 BC	0.48 B	16.67 A	50.00 B	0.37 A	0.38 CDEF	22.22 B	38.89 BC
T11	Onix	250ml/ac	0.22 C	0.26 F	13.89 A	36.11 CDE	0.36 A	0.29 F	22.22 B	22.22 DE
T12	Onix	450ml/ac	0.28 ABC	0.36 BCDEF	16.67 A	33.33 CDEF	0.42 A	0.35 DEF	22.22 B	30.55 BCDE
T13	Onix	350ml/ac	0.22 C	0.33 CDEF	16.67 A	33.33 CDEF	0.29 A	0.39 CDEF	22.22 B	33.33 BCD

T14	Saaf	300g/ac	0.22 C	0.31 CDEF	16.67 A	25.00 FG	0.43 A	0.31 EF	22.22 B	27.78 CDE
T15	Fugi-one	300ml/ac	0.25 BC	0.29 DEF	13.89 A	30.55 DEF	0.39 A	0.31 EF	22.22 B	19.44 E
T16	Control		0.36 A	0.89 A	16.67 A	63.89 A	0.44 A	0.78 A	22.22 B	58.34 A
Grand mean			0.26	0.39	16.84	34.89	0.38	0.40	22.394	35.24
SEm ±			0.05	0.06	4.98	5.13	0.08	0.06	0.98	6.68
CD (P = 0.05)			0.09	0.12	10.03	10.33	0.17	0.13	1.98	13.49
CV (%)			26.12	20.78	41.82	20.80	31.00	21.89	6.20	26.88

*Average of four replications; [1]Average from three tag plants per each replication; [2]Data collected before first treatment applied; [3]Data collected 7 days after second treatment applied; 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.

Effects of Fungicide on Growth and Yield Parameters - 2022 Cropping Seasons

To determine whether the use of the fungicides under evaluation had any influence on growth and yield parameters of rice, several parameters were evaluated, these included plant height, tillers/m^2, panicle length, filled and unfilled grains per panicle and 1000 grain weight.

Data for spring crop 2022 retrieved and analyzed using statistix 8 revealed that treatments with Onix at 450ml/ac resulted in the longest panicles, 25.52cm; while treatments with Onix at 350ml/ac, and Sporan at 300 ml/ac produced some of the shortest panicles within this trial (23.05 and 24.00cm, respectively). The number of filled grains per panicle ranged from 127.05 in treatments with Sporran at 300ml/ac to 91.42 grains per panicle in treatments with Droxide at 350g/ac. Other treatments with significantly larger panicles included Onix at 150ml/ac, Top Cop at 100ml/ac, Top Cop at 250ml/ac, Onix at 150ml/, Droxide at 150g/ac, untreated control, positive check, Saaf at 300g/ac and Droxide at 250ml/ac which produced 112.80, 108.97, 108.40, 108.03, 106.02, 101.95 and 100.60 grains per panicle, respectively (Table 3). Treatments with Sporan at 600ml/ac and 300ml/ac produced significantly larger number of unfilled grains as compared to control (28.15 and 25.73, respectively); while treatments with Droxide at 350ml and Sporan at 900ml yielded the least number of unfilled grains per panicle (16.60 and 13.53, respectively). The heaviest grain weight per 1000 grains was obtained from grains treated with Onix at 250ml/ac (29.73g), this was followed by treatment with Fugi-one 300ml/ac (29.25g) and Onix at 350ml/ac (28.73g) (Table 3).

There was no significant difference in plant height among any of the other treatments inclusive of the untreated control treatment. However, there were significant differences among treatments in the number of tillers produced per m^2 (Table 3). Treatment with Saaf at 300g/ac recorded the highest tiller count (285.00), followed by treatment with Droxide at 150g/ac (277.00), while treatment with Top Cop and Onix both at 150ml/ac recorded the lowest tiller per meter (200.00 and 196.00, respectively).

In the autumn crop of 2022, when the lengths of panicles were examined, it was observed that treatments with Onix at 350ml/ac and Droxide at 150g/ac produced significantly longer panicles (26.48 cm and 26.39 cm), while treatment with Sporan at 600ml/ac produced the shortest (24.78 cm). There was no significant difference in panicle length among other tested treatments (Table 4). Droxide at 150g/ac recorded significantly higher filled grain per panicle (94.70) followed by Top Cop at 150ml/ac (92.73), Sporan at 600ml/ac and Saaf at 300ml/ac recorded the lowest filled grain per panicle count (78.35 and 78.10, respectively). In terms of unfilled grains per panicle, treatment with Onix at 150ml/ac was observed to have produced the largest number in this regard (21.80), other treatments producing significantly larger number of unfilled grains per panicle included Droxide at 150g/ac, Droxide at 250g/ac and Sporan at 600ml/ac (16.93, 14.58 and 14.00, respectively). There are no significant differences among the other treatments as it relates to unfilled grains per panicle. There were no significant differences observed in 1,000 grain weight among various treatments (Table 4). The height of ten plants within each treatment were measured and there was significant difference among treatments in relation to plant height (Table 4). Droxide at 150g/ac recorded the tallest plants (106.13cm) with Droxide 350ml/ac and Onix at 150ml/ac recording the shortest plant height (97.50 and 97.03, respectively). Treatments with the largest number of tillers/m2 were Sporan at 900ml/ac (298.00) and Onix at 150ml/ac (294.00), while treatments with Sporan at 300ml/ac and Onix at 250ml/ac produced the least number of tillers/m^2, 204.00 and 198.00, respectively (Table 4).

Table 3: Efficacy of New Fungicides Against Brown Spot (B. oryzae) on Growth and Yield Parameters During Spring Crop, 2022

Trt.	Treatments	Rates	[2]Panicle Length (cm)	Filled grains/ Panicle	Unfilled grains/ Panicle	1000 grain weight(g)	[1]Plant Height (cm)	Tillers/ m^2
T1	Top Cop	100ml/ac	24.88 AB	108.97 AB	21.98 ABCD	27.40 AB	95.50 A	213.00 BCD
T2	Top Cop	150ml/ac	24.17 ABC	95.97 B	22.70 ABCD	26.28 AB	96.90 A	200.00 D
T3	Top Cop	250ml/ac	24.28 ABC	108.40 AB	21.53 BCD	24.03 AB	94.45 A	219.00 BCD
T4	Droxide	150g/ac	25.30 AB	106.30 AB	23.13 ABC	28.26 A	95.60 A	277.00 AB
T5	Droxide	250g/ac	24.55 AB	100.60 AB	19.78 BCDE	27.73 AB	97.40 A	229.00 ABCD
T6	Droxide	350g/ac	24.25 ABC	91.42 B	16.60 DE	28.20 AB	96.50 A	220.00 ABCD
T7	Sporan	300ml/ac	24.00 BC	127.05 A	25.73 AB	27.73 AB	96.50 A	227.00 ABCD
T8	Sporan	600ml/ac	24.91 AB	94.40 B	28.15 A	26.35 AB	95.05 A	209.00 CD
T9	Sporan	900ml/ac	24.77 AB	94.70 B	13.53 E	28.40 A	96.33 A	213.00 BCD
T10	Onix	150ml/ac	24.20 ABC	108.03 AB	19.43 BCDE	26.10 AB	97.78 A	196.00 D
T11	Onix	250ml/ac	24.46 ABC	95.63 B	19.08 CDE	29.73 A	96.08 A	231.00 ABCD
T12	Onix	450ml/ac	25.52 A	112.80 AB	18.88 CDE	28.73 A	95.20 A	217.00 BCD
T13	Onix	350ml/ac	23.05 C	95.05 B	18.08 CDE	28.35 A	94.63 A	257.00 ABCD
T14	Saaf	300g/ac	24.59 AB	101.95 AB	21.20 BCD	26.00 AB	93.80 A	285.00 A
T15	Fugi- one	300ml/ac	24.55 AB	92.92 B	23.40 ABC	29.25 A	96.73 A	214.00 BCD
T16	Control		25.21 AB	106.02 AB	19.08 CDE	28.30 A	97.38 A	273.00 ABC
Grand mean			24.54	102.51	20.74	27.55	95.99	230.00
SEM			0.74	15.13	3.21	2.09	2.09	32.55
CD (P=0.05)			1.50	30.47	6.47	4.21	4.21	65.56
CV (%)			4.28	20.87	21.88	10.72	3.09	20.01

* = average of four replications; [1]= Average from ten plants per each replication; [2]=Average from ten panicle 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.

Table 4: Efficacy of New Fungicides Against Brown Spot (B. oryzae) on Growth and Yield Parameters During Autumn Crop, 2022

Trt.	Treatments	Rates	[2]Panicle Length (cm)	Filled grains/ Panicle	Unfilled grains/ Panicle	1000 grain weight(g)	[1]Plant Height (cm)	Tillers/ m^2
T1	Top Cop	100ml/ac	25.42 AB	88.20 ABC	10.28 B	29.48 A	100.03 AB	301.25 A
T2	Top Cop	150ml/ac	25.26 AB	92.73 AB	8.75 B	28.70 A	101.03 AB	262.25 AB
T3	Top Cop	250ml/ac	25.36 AB	91.50 ABC	8.18 B	28.48 A	102.17 AB	280.25 AB
T4	Droxide	150g/ac	26.39 A	94.70 A	16.93 B	28.95 A	106.13 A	245.75 AB
T5	Droxide	250g/ac	25.07 AB	80.48 BC	14.00 AB	30.15 A	104.78 AB	254.25 AB
T6	Droxide	350g/ac	25.77 AB	88.13 ABC	12.50 B	28.75 A	97.50 AB	228.25 B
T7	Sporan	300ml/ac	25.39 AB	81.68 ABC	9.40 B	29.40 A	103.63 AB	228.75 B
T8	Sporan	600ml/ac	24.77 B	78.35 C	14.00 AB	27.80 A	104.03 AB	272.75 AB
T9	Sporan	900ml/ac	25.82 AB	91.38 ABC	10.03 B	28.65 A	99.25 AB	298.25 AB
T10	Onix	150ml/ac	25.84 AB	83.63 ABC	21.80 A	28.95 A	97.03 B	294.25 AB
T11	Onix	250ml/ac	25.70 AB	92.43 AB	9.45 B	28.90 A	102.92 AB	272.75 AB
T12	Onix	450ml/ac	25.39 AB	83.45 ABC	9.20 B	29.15 A	104.15 AB	290.50 AB
T13	Onix	350ml/ac	26.48 A	87.33 ABC	10.53 B	30.60 A	101.50 AB	278.50 AB

T14	Saaf	300g/ac	25.51 AB	78.10 C	9.98 B	28.80 A	102.53 AB	283.25 AB
T15	Fugi-one	300ml/ac	25.38 AB	83.33 ABC	8.58 B	29.95 A	99.75 AB	270.50 AB
T16	Control		26.09 AB	81.37 ABC	11.96 B	27.80 A	102.55	263.00 AB
Grand mean			25.60	86.05	11.63	29.03	101.81	270.28
SEM			0.75	6.78	4.39	1.55	4.02	35.85
CD (P=0.05)			1.52	13.66	8.84	3.11	8.11	72.21
CV (%)			4.17	11.15	53.34	7.53	7.53	18.76

* = average of four replications; [1]= Average from ten plants per each replication; [2]=Average from ten panicle 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.

Effects of Fungicide on Growth and Yield Parameters - 2023 Cropping Seasons

Data for spring crop 2023 retrieved and analyzed revealed that treatments with Onix at 150ml/ac, Sporan at 600ml/ac and Droxide 250g/ac produced slightly longer panicles (27.77, 27.46 and 27.36 cm, respectively). While treatment with Droxide at 350ml/ac produced the shortest (25.72 cm). However, there was no significant difference in panicle length among all tested treatments (Table 5). The number of filled grains per panicle ranged from 118.33 in treatments with Onix at 150ml/ac to 88.33 grains per panicle in treatments with Sporan 300ml/ac. Treatments with Droxide at 350ml/ac and Sporan 600ml/ac produced significantly larger number of unfilled grains as compared to untreated control (36.05 and 34.95, respectively); while treatments with Top Cop at 250ml yielded the least number of unfilled grains per panicle (15.60). The heaviest grain weight per 1,000 grains was obtained from grains treated with Top Cop at 250ml/ac (30.25g), this was followed by treatment with Top Cop 100ml/ac (29.16g) and Sporan at 300ml/ac (29.10g) (Table 5). There was no significant difference in plant height among any of the other treatments inclusive of the control treatment. There were no significant differences among treatments in the number of tillers produced per m2 (Table 5). However, plants Treated with Onix at 150g/ac recorded the highest tiller count (297.00), followed by Treatment with Droxide at 250g/ac (296.00), while treatment with positive check, Fugi One at 300ml/ac and Top Cop at 250ml/ac recorded the lowest tiller per meter (253.00 and 258.00, respectively) (Table 5).

In the autumn crop of 2023, when the lengths of panicles and filled grains per panicle were examined, it was observed that there was no significant difference in panicle length and filled grains per panicle among treatments tested (Table 6). In terms of unfilled grains per panicle, treatment with Droxide at 350g/ac (10.93), recorded significantly lower number of unfilled grains per panicle while the highest number were recorded by Onix at 450ml/ac (19.10). There were no significant differences among the other treatments as it relates to unfilled grains per panicle (Table 6). There were no significant differences observed in 1,000 grain weight among various treatments except plants treated with Onix at 150ml/ac which recorded the highest weight 28.74g and Onix at 250ml/ac had the least weight at 26.95. (Table 6).

The height of ten plants within each treatment were measured in relation to plant height (Table 6). Top Cop at 250ml/ac recorded the significantly tallest plants (102.40cm) while Saaf 350ml/ac and recording the shortest plant height (96.38). Treatments with the significantly largest number of tillers/m2 were Top Cop at 150ml/ac (318.00) while treatments with Onix at 350ml/ac produced the least number of tillers/m2, (179.00) (Table 6).

Table 5: Efficacy of New Fungicides Against Brown Spot (B. oryzae) on Growth and Yield Parameters During Spring Crop, 2023

Trt.	Treatments	Rates	[2]Panicle Length (cm)	Filled grains/ Panicle	Unfilled grains/ Panicle	1000 grain weight(g)	[1]Plant Height (cm)	Tillers/ m^2
T1	Top Cop	100ml/ac	26.42 A	94.23 BC	31.13 AB	29.16 AB	99.53 A	272.00 AB
T2	Top Cop	150ml/ac	26.52 A	113.43 AB	25.33 BC	28.85 AB	96.00 A	288.00 AB
T3	Top Cop	250ml/ac	26.95 A	104.28 ABC	15.60 C	30.25 A	98.20 A	258.00 AB
T4	Droxide	150g/ac	26.76 A	96.05 BC	24.88 BC	28.99 B	97.02 A	272.00 AB
T5	Droxide	250g/ac	27.46 A	107.53 ABC	28.30 ABC	28.29 AB	99.63 A	296.00 A
T6	Droxide	350g/ac	25.72 A	91.48 C	36.05 AB	27.69 B	99.68 A	275.00 AB
T7	Sporan	300ml/ac	25.93 A	88.93 C	31.15 AB	29.10 AB	96.47 A	269.00 AB
T8	Sporan	600ml/ac	27.36 A	97.82 ABC	34.95 AB	28.64 AB	99.70 A	274.00 AB
T9	Sporan	900ml/ac	26.67 A	107.00 ABC	34.20 AB	28.12 AB	98.30 A	274.00 AB
T10	Onix	150ml/ac	27.77 A	118.33 A	27.83 ABC	26.90 B	97.05 A	297.00 A
T11	Onix	250ml/ac	26.25 A	94.32 BC	25.50 BC	28.60 AB	98.25 A	276.00 AB

T12	Onix	450ml/ac	26.71 A	95.10 BC	31.33 AB	28.35 AB	98.92 A	275.00 AB
T13	Onix	350ml/ac	27.09 A	98.95 ABC	28.55 ABC	28.38 AB	100.07 A	279.00 AB
T14	Saaf	300g/ac	26.08 A	107.75 ABC	30.80 AB	28.82 AB	98.52 A	261.00 AB
T15	Fugi- one	300ml/ac	26.34 A	109.72 ABC	27.13 ABC	27.66 B	98.55 A	253.00 B
T16	Control		26.60 A	103.25 ABC	40.43 A	28.44 AB	97.45 A	289.00 AB
Grand mean			26.67	101.76	29.57	28.52	98.33	275.50
SEM±			1.06	10.78	6.79	1.23	2.1	19.60
CD (P=0.05)			2.14	21.70	13.67	2.51	4.24	39.47
CV (%)			5.65	14.98	32.45	6.19	3.03	10.06

* = average of four replications; 1= Average from ten plants per each replication; 2=Average from ten panicle 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.

Table 6: Efficacy of New Fungicides Against Brown Spot (B. oryzae) on Growth and Yield Parameters During Autumn Crop, 2023

Trt.	Treatments	Rates	[2]Panicle Length (cm)	Filled grains/ Panicle	Unfilled grains/ Panicle	1000 grain weight(g)	[1]Plant Height (cm)	Tillers/ m^2
T1	Top Cop	100ml/ac	25.92 A	103.88 A	14.95 ABC	28.07 AB	101.83 AB	225.00 BC
T2	Top Cop	150ml/ac	25.96 A	106.65 A	12.93 ABC	28.20 AB	101.92 AB	318.00 A
T3	Top Cop	250ml/ac	26.41 A	103.72 A	15.45 ABC	27.51 AB	102.40 A	243.00 ABC
T4	Droxide	150g/ac	26.61 A	101.20 A	13.58 ABC	27.47 AB	99.75 AB	233.00 ABC
T5	Droxide	250g/ac	25.69 A	99.42 A	12.66 ABC	28.54 AB	97.33 AB	275.00 AB
T6	Droxide	350g/ac	26.43 A	111.15 A	10.93 C	27.07 AB	100.10 AB	219.00 BC
T7	Sporan	300ml/ac	25.87 A	98.65 A	15.35 ABC	28.14 AB	99.40 AB	208.00 BC
T8	Sporan	600ml/ac	25.71 A	95.35 A	15.03 ABC	27.67 AB	101.05 AB	268.00 ABC
T9	Sporan	900ml/ac	26.33 A	103.03 A	12.90 ABC	28.22 AB	101.05 AB	268.00 ABC
T10	Onix	150ml/ac	26.05 A	103.12 A	12.23 BC	28.74 A	97.22 AB	237.00 ABC
T11	Onix	250ml/ac	25.92 A	102.60 A	15.38 ABC	26.95 B	101.67 AB	224.00 BC
T12	Onix	450ml/ac	26.92 A	103.08 A	19.10 A	28.01 AB	99.75 AB	216.00 BC
T13	Onix	350ml/ac	26.49 A	105.18 A	14.75 ABC	28.33 AB	99.85 AB	179.00 C
T14	Saaf	300g/ac	26.42 A	97.95 A	15.45 ABC	28.23 AB	96.38 B	226.00 BC
T15	Fugi-one	300ml/ac	26.38 A	102.78 A	13.35 ABC	27.74 AB	98.80 AB	182.00 C
T16	Control		27.17 A	108.55 A	18.17 AB	27.70 AB	98.58 AB	245.00 ABC
Grand mean			26.27	102.89	14.51	27.91	99.82	235.38
SEM±			0.81	9.27	3.28	0.86	2.98	45.49
CD (P=0.05)			1.64	18.67	6.60	1.73	6.01	91.63
CV (%)			4.39	12.74	31.93	4.36	4.23	27.33

* = average of four replications; [1]= Average from ten plants per each replication; [2]=Average from ten panicle 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.

Table 7: Effects of Fungicides Against Brown Spot (b. oryzae) on Yield During Spring and Autumn Crop 2022

Trt.	Treatments	Rates	*Spring, 2022		*Autumn, 2022	
			Kg/ha	Bags/ac	Kg/ha	Bags/ac
T1	Top Cop	100ml/ac	3710.20 A	23.60 A	3757.3 BCD	23.89 BCD
T2	Top Cop	150ml/ac	3075.50 ABC	19.56 ABC	3891.2 ABCD	24.75 ABCD
T3	Top Cop	250ml/ac	3541.90 AB	22.53 AB	4196.5 A	26.69 A
T4	Droxide	150g/ac	2732.8 BC	17.38 BC	3939.9 ABCD	25.06 ABC
T5	Droxide	250g/ac	2688.4 BC	17.10 BC	3863.6 ABCD	24.57 ABCD

T6	Droxide	350g/ac	3612.6 AB	22.97 AB	3793.4 ABCD	24.12 ABCD
T7	Sporan	300ml/ac	2449.50 C	15.58 C	3919.1 ABC	24.92 ABC
T8	Sporan	600ml/ac	3225.5 ABC	20.50 ABC	4093.9 AB	26.04 AB
T9	Sporan	900ml/ac	3151.8 ABC	20.05 ABC	3889.0 ABCD	24.73 ABCD
T10	Onix	150ml/ac	2894.8 ABC	18.41 ABC	3723.1 BCD	23.89 BCD
T11	Onix	250ml/ac	3612.6 ABC	22.97 AB	4017.1 ABC	25.49 ABC
T12	Onix	450ml/ac	3541.8 AB	22.53 AB	3828.6 ABCD	24.35 ABCD
T13	Onix	350ml/ac	3479.30 AB	22.13 AB	4008.6 ABC	25.49 ABC
T14	Saaf	300g/ac	3129.20 ABC	19.90 ABC	3629.2 CD	23.08 CD
T15	Fugi- One	300ml/ac	2792.00 ABC	17.76 ABC	3794.0 ABCD	24.13 ABCD
T16	Control		3273.5 ABC	20.82 ABC	3468.2 D	22.06
Grand mean			3181.7	20.24	3863.3	24.57
SEM			480.49	3.06	217.95	1.39
CD (P=0.05)			967.75	6.15	438.94	2.79
CV (%)			21.36	21.35	7.98	7.98

* = average of four 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.

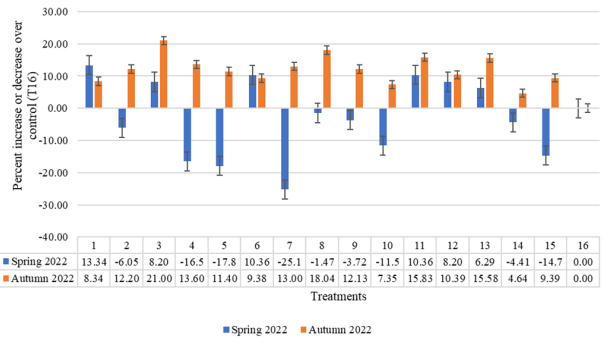
Effects of Fungicide on Grain Yield During Spring (1st) and Autumn (2nd) Crop 2022

The average yield per plot during spring crop 2022 ranged between 3710.20 kg/ha (23bags/ac) in plants treated with Top Cop at 100ml to treatments with Sporan at 300ml/ac (2449.50 kg/ha or 15.58bags/ac). Other treatments which yielded in par with Top Cop included Onix at 250ml/ac (3612.6 kg/ha or 23.60 bags/ac), Droxide at 350g/ac (3612.60 kg/ha), Top Cop at 250ml/ac (3541.90 kg/ha), Onix at 450ml/ac (3541.8kg/ha) and Onix 350ml/ac (3479.30kg/ha) Those on the significantly lower end of the production scale were Fugi One, Droxide at 150g and 250g/ac and Sporan at 300ml/ac with 2792.00kg/ha or 17.76 bags/ac, 2732.80kg/ha or 17.83 bags/ac, 2688.4kg/ha or 17.10 bags/ac and 2449.50kg/ha or 15.58 bags/ac respectively (Table 7). In the autumn crop 2022 the average yield per plot ranged between 4196.5 kg/ha or 26.69 bags/ac in plants treated with Top Cop at 250ml/ac to Control 3468.20 or 22.06 bags/ac.

In the spring crop 2022 treatments with Top Cop 100 and 250 ml/ac., Droxide 350g/ac., Onix 250, 350 and 450ml/ac., showed a positive increase in grain yield ranging from 8.20% to 13.34% as compared to the untreated control (Figure 3); while in the autumn crop 2022 all the fungicidal treatments showed higher percent increase in the overall mean grain yield when compared to the untreated control treatments with the increase ranges from 4.64% to 21% (Figure 3, Table 7).

Effects of Fungicide on Grain Yield During Spring (1st) and Autumn (2nd) Crop 2023

There was a significant difference between the treatments during spring 2023, the highest yielding came from plants treated with the two positive check, Fugi One at a rate of 300ml/ac yielding 4470.70kg/ha (28.43 bags/ac) and Saaf at 300g/ac 4314.00/ha (27.43 bags/ac). Other treatments which yielded in par with Fugi One included Droxide at 250g/ac (4185.80 kg/ha or 26.62 bags/ac), Top Cop at 250ml/ac (4116.60 kg/ha or 26.18 bags/ac) (Table 8).



Notes: T1- Top Cop 100ml/ac., T2-Top Cop 150ml/ac., T3- Top Cop 250ml/ac., T4- Droxide 150g/ac., T5- Droxide 250g/ac., T6- Droxide 350g/ac., T7- Sporan 300ml/ac., T8- Sporan 600ml/ac., T9- Sporan 900ml/ac., T10- Onix 150ml/ac., T11- Onix 250ml/ac., T12- Onix 450ml/ac., T13- Onix 350ml/ac., T14- Saaf 300g/ac., T15- Fugione (check) 300ml/ac, T16 Control.

Figure 3: Percentage Increase or Decrease in Mean Grain Weight (kg/ha.) Over the Control (T16)

Those on the significantly lower end of the production scale were Sporan at 900ml/ac and 300ml/ac (2975. 20 kg/ha or 18.92 bags/ac and 2946.30 kg/ha or 18.74 bags/ac respectively) (Table 8). In the autumn crop of 2023, there was a significant difference between the treatments, the highest yielding came from plants treated with Droxide at rate of 250g/ac yielding 2898.40 kg/ha (18.44 bags/ac and Onix at 250ml/ac 2849.20 kg/ha (18.12 bags/ac). Those on the significantly lower end of the production scale were Onix at 350ml/ac with 2316.80 kg/ha (14.74 bags/ac) and Sporan at 900ml/ac yielding 2321.40 kg/ha (14.76 bags/ac) (Table 8).

Table 8: Effects of Fungicides Against Brown Spot (b. Oryzae) on Yield During Spring and Autumn Crop 2023

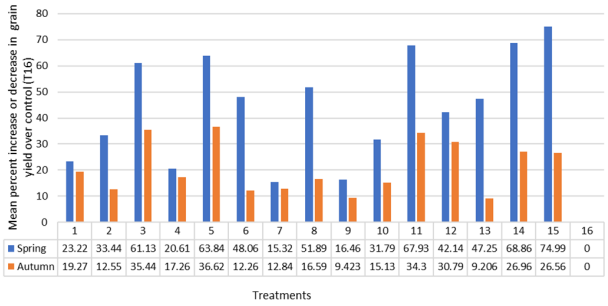
Trt.	Treatments	Rates	*Spring, 2022		*Autumn, 2022	
			Kg/ha	Bags/ac	Kg/ha	Bags/ac
T1	Top Cop	100ml/ac	3148.10 EFGH	20.02 EFGH	2530.40 ABCD	16.09 ABCD
T2	Top Cop	150ml/ac	3409.00 CDEFG	21.68 CDEFG	2387.80 BCD	15.18 BCD
T3	Top Cop	250ml/ac	4116.60 ABCD	26.18 ABCD	2873.40 AB	18.27 AB
T4	Droxide	150g/ac	3081.40 FGH	19.60 FGH	2487.70 ABCD	15.82 ABCD
T5	Droxide	250g/ac	4185.80 ABC	26.62 ABC	2898.40 A	18.44 A
T6	Droxide	350g/ac	3782.70 ABCDEF	24.06 ABCDEF	2381.50 BCD	15.15 BCD
T7	Sporan	300ml/ac	2946.30 GH	18.74 GH	2393.90 ABCD	15.23 ABCD
T8	Sporan	600ml/ac	3880.50 ABCDE	24.68 ABCDE	2473.50 ABCD	15.73 ABCD
T9	Sporan	900ml/ac	2975.20 GH	18.92 GH	2321.40 CD	14.76 CD
T10	Onix	150ml/ac	3367.00 DEFG	21.41 DEFG	2442.50 ABCD	15.53 ABCD
T11	Onix	250ml/ac	4290.40 AB	27.28 AB	2849.20 AB	18.12 AB
T12	Onix	450ml/ac	3631.40 BCDEFG	23.10 BCDEFG	2774.80 ABC	17.65 ABC
T13	Onix	350ml/ac	3761.90 ABCDEF	23.92 ABCDEF	2316.80 CD	14.74 CD
T14	Saaf	300g/ac	4314.00 AB	27.44 AB	2693.40 ABC	17.13 ABC
T15	Fugi- One	300ml/ac	4470.70 A	28.43 A	2684.90 ABC	17.08 ABC
T16	Control		2554.80 H	16.25 H	2121.50 D	13.49 D
Grand mean			3619.70	23.02	2539.40	16.15
SEM±			387.97	2.47	252.37	1.61
CD (P=0.05)			781.42	4.97	508.29	3.23
CV (%)			15.16	15.16	14.05	14.06

* = average of four 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.

In the spring crop 2023 treatments with Top Fugi One at 300 ml/ac., Saaf at 300g/ac., Onix 250, 350 and 450ml/ac., showed a higher positive increase in grain yield ranging from 15.32% to 74.99% as compared to the untreated control (Figure 9); while in the autumn crop of 2023 all the fungicidal treatments also showed an percent increase in the overall mean grain yield when compared to the untreated control treatments with the increase ranges from 9.206% to 36.62% (Figure 4, Table 8).

In general, the current study conducted during the cropping seasons in 2022 and 2023 demonstrated plant treated with all these four (4) new fungicides viz. Top Cop, Droxide, Sporan, and Onix at varying rates,, and the two(2) positive checks, Saaf and Fugi One recorded smaller brown spot(BS) disease lesion length and found to significantly reduce the percent disease severity and observed with slower progress of the development of the rice brown spot disease and provide effective control of this disease by their application when compared to untreated control (Table 1 and 2 ; Figure 1 and 2).

Further, these said treatments not only demonstrated a reduction in the brown spot disease incidence but also some showed a positive influence in terms of plant growth, yield parameters and overall grain yields (Table 3,4,5,6,7,8 and Figure 3 and 4). Therefore, treatments with these four (4) new fungicides viz. Top Cop 250ml/ac, Droxide 250g/ac, Sporan 600ml/ac, Onix 250ml/ac, along with the two (2) positive Saaf 300g/ac and Fugi One at 300 ml/ac can be recommended firstly as a protective treatment for the management of brown spot disease at their respective recommended rates especially in disease prone areas



Notes: T1- Top Cop 100ml/ac., T2-Top Cop 150ml/ac., T3- Top Cop 250ml/ac., T4- Droxide 150g/ac., T5- Droxide 250g/ac., T6- Droxide 350g/ac., T7- Sporan 300ml/ac., T8- Sporan 600ml/ac., T9- Sporan 900ml/ac., T10- Onix 150ml/ac., T11- Onix 250ml/ac., T12- Onix 450ml/ac., T13- Onix 350ml/ac., T14- Saaf 300g/ac., T15- Fugione (check) 300ml/ac, T16 Control.

Figure 4: Percentage Increase or Decrease in Mean Grain Weight (Kg/ha.) Over the Control (T16)

Discussion

Rice (**Oryza sativa L.**) has been regarded as one of the most important cereal crops and a major food grain contributor to the

total world food grain basket [12]. Brown spot of rice is a fungal disease caused by Bipolaris oryzae, which is found to be a major problem capable of causing significant losses both in quality and quantity if no control actions is taken [13]. This present study examined the efficacy of three new synthetics fungicide viz. Top Cop (Sulphur 50%, metallic copper equivalent 4.4%) at 100, 150 and 250 ml/ac., Droxide (Cupric hydroxide) at 150, 250 and 350 g/ac., and Onix (Carbendazim 12.50%, Propoconozole 12.50%) at 150, 250 350 and 450 ml/ac., and one botanical fungicide viz. Sporan (Rosemary oil 16%, Clove oil 10%, Thyme oil 10%, Peppermint oil 2%), at 300, 600 and 900 ml/ac., along with two positive checks, Saaf (Mancozem 63%, Carbendazim 12%) at 300g/ac. and Fugi One (Isoprothiolane 40% SC) at 300 ml/ac. and a untreated control over the spring (first) and autumn (second) cropping seasons of 2022 and 2023. Results obtained from these series of screening trials showed that treatment with these four (4) new fungicides viz. Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, and Onix at 250ml/ac, demonstrated superior control of the brown spot disease under field conditions when compared to the other treatments and the untreated control. Likewise, the two (2) positive, Saaf 300g/ac and Fugi One at 300 ml/ac also demonstrated equally similar levels of control like those treatments. Similar studies were conducted by many other researchers utilizing different fungicides combinations and yielded similar results. For instant, Hossain et al. evaluated the Efficacy of Bion (benzothiodiazole), Amistar (azoxystrobin) and Tilt (propiconazole) for controlling Brown spot of rice on cv. BR11 (Mukta) [14]. The researchers reported that Bion, Amistar and Tilt @ 50 mg/L, 1 ml/L and 1 ml/L, respectively were sprayed resulted in marked reduction of Brown spot and and significantly increased number of grains/panicles, resulted in 25.87, 32.17 and 26.76% higher grain yield, respectively over the untreated control when sprayed at tillering stage. Likewise, Kumar et al. evaluated several fungicides against brown spot disease. From this research they found that foliar spray (FS) with Tilt (propiconazole) @ 1ml/liter led to a significant reduction in disease severity (37.26%), as well as showed significant increase in the grain yield (55.49 %) and its components compared to the untreated control [15]. Ranjan et al. evaluated the efficacy of sveral selected different fungicides i.e. Difenoconazole 25% EC, Isoprothiolane 40% EC, Kasugamycin 3% SL, Kitazin 48% EC, Propineb 70% WP, Tebuconazole 25.9% EC and Thifluzamide 24% SC that was available fungicides in the market were assess against brown leaf spot of rice. Results indicate that Difenoconazole 25% EC (0.5 ml/l) and Tebuconazole 25.9% EC (1.5 ml/l) proved most effective in reducing brown spot disease severity with significant increase in grain yield of rice as compare to control [2]. Similarly, Barúa et al. evaluated several mixtures of fungicides and reported that all treatments with fungicides decreased rice brown spot incidence significantly and increased yield compared with non-sprayed control [16]. Shaheen et al. reported that the application of combination of propiconazole and thiophanate methyl showed significant reduction in disease incidence percent as compared to solo applications [6]. The reduction in disease incidence percent in all application methods suggested that these synthetic fungicides could be used against BLS of rice. Additionally, conducted a comparative review on effect of chemicals Fungicides like: pro-piconazole, Carbendazim, Mancozeb, Hexaconazole, Cabendazim, Bion, Amistar, Tilt etc [13]. on the diseases brown spot of rice reported diverse performance with each products showing varying levels of control of the brown spot disease under field conditions. Gupta et al. reported that timely application propiconazole can significantly reduce the brown disease severity and resulted in an increased in the grain yield as compared to controls [12]. Further, Lore et al. studied the efficacy of some new fungicide formulations namely kresoxim methyl 40% + hexaconazole 8% (RIL-068/F1 48 WG), hexaconazole (RIL-01/F1 75 WG), propiconazole (Tilt 25 EC), hexaconazole (Contaf 5 EC), tricyclazole (Beam 75WP), and carbendazim 12% + mancozeb 63% (Saaf 75WP) against brown spot (B. oryzae) under field conditions [17]. The researchers found Kresoxim methyl 40% + hexaconazole 8% @ 0.1% to be the most effective fungicide against brown spot disease compared to untreated checks. Similarly, Shrestha et al. evaluated three different chemical fungicides; SAAF® (Carbendazim 12% + Mancozeb 63%), Tilt® (Propiconazole 25 EC) & Bavistin® (Carbendazim 50% W.P.) at three different doses and reported that Tilt® at the rate of 2 ml/lit water showed significantly lowest AUDPC value (373.7) followed by SAAF® at 2 gm/lit (374.9) compared to the untreated control [18]. Likewise, Nargave et al. evaluated several fungicides against brown spot disease and reported that all treatments involving fungicides significantly reduced the incidence of rice brown spot under field condition and increased crop yield when compared to the control group [19]. Also, Chouhan et al. reported that, foliar spray of propiconazole @ 0.1% was found most effective in controlling the BS disease upto 63.24 per cent followed by pyraclostrobin + epoxyconazole (50.07%) under field conditions [20].

Further, Sunder et al. evaluated several botanicals against brown spot disease, amongst botanicals, Neemazal (3 ml/l) and Wanis (5 ml/l) provided about 26% reduction of brown leaf spot [21]. Likewise, Persaud et al. evaluated one botanical and several fungicides at different rates against brown spot disease under field conditions [22]. The results indicate that Rodazim 50 SC (Carbendazim 50%) at 300 mL/ac., Amistar Xtra 28 SC (Triazol, Estrobilurtina., Cyproconazol, Azoxystrobin) at 200 g/ac. and Tridium 70WG (Azoxystrobin 4.7% + Mancozeb 59.7% + Tebucuzonal 5.6% WG) at 350 g/ac. showed an overall reduction in BS disease severity of 28.75%; Saaf 75 WP (Mancozem 63%, Carbendazim 12%) at 300 g/ac. (33.06%) and 500 g/ac. (37.36%), respectively; Antracol 70WP at 500g/ac. a 22.52%; Glory WG (Mancozeb + Azoxystrobin) at 1000 g/ac. a 37.82%; Manzate Pro Stick TM (Mancozeb 70%) at 300 g/ac. a 37.36%; Carbendazim 50SC (Carbendazim 50%) at 300 mL/ac. a 33.30% and the positive check Fugi One (Isoprothiolane 40% SC) at 300 mL/ac. a 43.31%. Further, the Neem (Azadirachta indica) plant aqueous extracts at 15 % concentration demonstrated a 27.28% reduction in the overall average BS disease severity as compared to the untreated controls. Similarly, the results of this study also found that the botanical fungicide viz. Sporan (Rosemary oil 16%, Clove oil 10%, Thyme oil 10%, Peppermint oil 2%) at 600 ml/ac. was equally effective in controlling the brown spot disease as the positive checks, Saaf 300g/ac and Fugi One at 300 ml/ac. Additionally, this present study is also in agreed with the findings of many of these researcher since these present better preforming treatments viz. Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, Onix at 250ml/ac. not only demonstrated superior control of the brown spot disease compared to the untreated control but also showed positive influences plant growth, yield parameters and overall grain yields.

Conclusion and Recommendation

It is clear from these four (4) seasons of field trials conducted during 2022 and 2023 that all plants treated with these four (4) new fungicides viz. Top Cop, Droxide, Sporan, and Onix, at varying rates, showed smaller BS disease lesion length and found to significantly reduce the percent disease severity when compared to untreated control. The better preforming treatments were Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, Onix at 250ml/ac. These four treatments produce similar level of control of the BS disease when compared with the two (2) positive fungicidal checks, Saaf 300g/ac and Fugi One at 300 ml/ac. Also encouraging influence in terms of plant growth, yield parameters and overall grain yields were reported. Therefore, treatments with these four (4) new fungicides viz. Top Cop at 250ml/ac, Droxide at 250g/ac, Sporan at 600ml/ac, Onix at 250ml/ac. can be recommended for the management of brown spot disease.

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Author's Contributions

Rajendra Persaud designed and executed the study analyzed the data and drafted the paper. All other authors assist 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.

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

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