



Original Research Article

Effectiveness of new fungicides and neem plant aqueous extract against brown spot disease of rice

Received 23 September, 2022

Revised 4 November, 2022

Accepted 18, November, 2022

Published 29 December, 2022

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Brown spot (BS) disease caused by *Bipolaris oryzae* has now become a major constraint in rice production globally. It could lead to yield loss of up to 6% at low severity level to total loss if left unmanaged. The present research was undertaken at GRDB, RRS, Burma, department of Plant Pathology experimental site in Guyana. The RCBD design with 4 replications used for each treatment. Nine fungicides at different rates, one plant aqueous extract of Neem (*Azadirachta indica*) at 15% concentration and a untreated control were evaluated under *in vivo* conditions during spring and autumn crop of 2020 and 2021. The results from the field evaluation showed 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%. 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 for the 2020 and 2021 trials. Further, these said treatments also demonstrated positive influence for plant growth, yield parameters and showed varying percent increase grain yields ranging from 0.36% to 29.30%. These treatments found to give superior control can be recommended as a protective treatment against the BS disease in BS disease prone areas.

Keywords: Rice Disease, Brown spot, *Bipolaris oryzae*, Neem plant aqueous extract, Fungicides.

INTRODUCTION

Like many countries of the world rice (*Oryza sativa* L.) is a major staple food crop (Surendhar et al., 2021) and

contribute more than 22% to Guyana agricultural gross domestic product (GDP) (GRDB, 2021). Guyana rice

cultivation area has grown to 92,000 ha. being double cropped annually with an average productivity of approximately 5.5 to 6.0 tons/ha (GRDB, 2021). The rice industry in Guyana is one of the most important agricultural industries which attracts more than US\$ 222 million annually. This industry supports more than 10% of the Guyanese population directly and indirectly. Rice is grown primarily within five administrative regions of Guyana (i.e., regions number 2, 3, 4, 5 and 6) and in these different geographical regions, the rice crop is known to suffer from many rice diseases (Ou, 1985; Chouhan and Kumar, 2022). Among them, brown spot (*Bipolaris oryzae*) is one of the major diseases affecting rice industry in Guyana. The brown spot disease can attack all the growth stages of the plant right from the nursery till the harvest of the crop (Ou, 1985). This disease if left unmanaged threaten the sustainable production and can cause great economic quality and capable of causing heavy yield losses, up to 6% at low to moderate level of severity, and 90% to complete yield loss, at moderate to high severity levels, depending upon the presence and full functioning of all components of the disease triangle (Imran et al., 2020). The brown spot (*Bipolaris oryzae*) is well known to students of plant pathology because of the 1942 epidemic that led to famine in Bengal Province of British India known as 'The Great Bengal Famine' (Surendhar et al., 2021). The pathogen *Bipolaris oryzae* is classified in the subdivision Deuteromycotina (imperfect fungi), class Deuteromycetes, order Moniliales, and family Dematiaceae and is the causal agent of brown spot disease of rice (Shabana et al., 2008). This disease was first observed as seedling blight that resulted in seedling mortality, perhaps due to heavy seedborne inoculum (Ou, 1985). Today, it is found 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 (Ou, 1985).

Many fungicides and plant extracts have been reported to be effective against brown spot disease, yet very little to no attempt have ever been made in Guyana to develop these as alternative management strategies for the control of brown spot disease (GRDB, 2021). In addition, there has been a dependency on a particular highly toxic and old fungicide for the control of the brown spot disease. This could lead to several problems such as pathogen resistance, overuse, failure to give adequate disease control. Therefore, there is a need to identify the new generation kind of fungicides and plant extracts that can be effectively used for the management of the brown spot disease in the event of an epidemic or a disastrous disease situation should arise. In Guyana an increase in incidence of brown spot disease have been observed in farmers' fields across the rice growing regions (GRDB 2021). 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, the research was conducted to evaluate available new novel fungicide molecules and plant

extract for the management of the rice brown spot disease.

MATERIALS AND METHODS

Isolation of brown spot pathogen

Rice plant leaves observed with typical brown spot disease symptoms were collected from the surrounding rice fields of GRDB, RRS, Burma for isolation of the pathogen. The similar method of isolation was follow as described in Persaud et al. (2019). The pathogen was identified by studying the characteristics of the colonies on potato dextrose agar (PDA) and by preparation of temporary slides for examination under the compound binocular microscope following the method described Agarwal et al. (1989) in a technical bulletin on seed borne disease and seed health testing of rice. The isolates were verified and confirmed as *B. oryzae* through pathogenicity test as described in Koch's postulates. The pure culture of the most virulent isolate was prepared and stored at 4°C for further use.

Preparation of neem plant aqueous extracts

Fresh and healthy stems and leaves of plants, *Azadirachta indica* (Neem) were collected from the Rice Research Station, Burma compound in Region 5 (Mahaica-Abary), Guyana and taken into the of Plant Pathology Department Laboratory, RRS, Burma for the aqueous extraction of the neem plant extracts. This was done following the procedure as described by Persaud et al. (2021).

The neem plant aqueous extract at the 1:1 w/v that constituted the 100% concentration was collected and stored in a sterile conical flask at 25-28°C for further use in the study.

Field evaluation of new generation fungicides and neem aqueous extracts against brown spot

Four field trials were conducted in spring and autumn cropping seasons of 2020 and 2021 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, weed management follow the standard crop production practices as recommended and described by GRDB. Fertilizers were applied at a rate of N₁₂₀ P₅₀ K₀ kg/ha at the recommended timing. Inoculation of experiment was done using a mixture of naturally existing brown spot strains collected from diseased plantlets from the surrounding fields and used as

a source of inoculum. The infected leaves with brown spot symptoms were prepared by chopping into small pieces, soaked for 24 hours, and spread over the entire experimental area at 7, 14, and 21 Days After Sown (DAS). Also, the conidial suspension with the most aggressive and virulent strain of the *B. oryzae* isolated and mass multiplied in the laboratory was adjusted to 1×10^6 conidia per mL and sprayed three times per week and twice per day as inoculum on the entire brown spot disease experimental area early morning before 7:00 a.m. and in the afternoon after 4:00 pm. The seedlings were sprayed with water early in the morning within 8 to 9 a.m. and afternoon after 4:30 p.m. three times per week to extend the leaf wetness period and maintain the humidity.

Application of treatment against brown spot disease under low land irrigated field conditions

Each treatment [*viz.* Rodazim 50SC (Carbendazim 50%) at 200 and 300 mL/ac., Amistar Xtra 28SC (Triazol, Estrobilurtina., Cyproconazol, Azoxystrobin) at 200 and 300 mL/ac., Saaf 75WP (Mancozem 63%, Carbendazim 12%) at 300, 500, 700 and 900 g/ac., Glory 75WG (Mancozeb + Azoxystrobin) at 1000g/ac., Antracol 70WP (Propineb) at 500g/ac., Tridium 70WG (Azoxystrobin 4.7% + Mancozeb 59.7% + Tebucuzonal 5.6% WG) at 350g/ac., Manzate Pro Stick(Mancozeb 70%) at 300 g/ac., Carbendazim 50SC(Carbendazim 50%) at 300 mL/ac. and Fugi One (Isoprothiolane 40% SC) at 300 mL/ac. along with Neem plant aqueous extract at 15% concentration] were carefully weighted and applied as foliar spray using Cooper Pegler (CP3) manual operated knapsack sprayer at 28 and 35 DAS. The plots that did not receive fungicides and plant aqueous extract serve as untreated control.

Measurement of lesion size, disease severity, growth, and yield parameters

The brown spot disease lesion length and disease intensity were recorded on 27 and 42 DAS by randomly tagging five plants per plot. The lesion length was measured by selecting 3rd and/or 4th leaf from the top of a randomly selected plant. Five lesions per leaf were selected for measuring the length. Percent Disease Severity was calculated based on the 1-9 scale of INGER, IRR (2002) using the following formula: $(\text{Mean disease score} / 9) \times 100$.

The growth parameters were taken by recording plant height and number of tillers per square meter at harvesting to assess the effect of treatments. The yield parameters such as panicle length, number of filled and unfilled grains, 1000-grain weight were recorded from 10 panicles harvested from each individual experimental unit. The yield per ha was computed after manually harvest and threshing of the samples. The weight and moisture taken from each plot harvested and recorded.

Data analysis

The data obtained from the four field trials conducted in

2020 and 2021 to assess the efficacy of fungicides and neem plant aqueous extract against brown spot disease (*B. oryzae*) were analyzed using analysis of variance (ANOVA) of the Randomized Complete Block Design (RCBD) and statistical significance derived using the analytical software, Statistix 8.0.

RESULTS

During 2020 and 2021 nine fungicides *viz.* Rodazim 50SC, Amistar Xtra 28SC, Saaf 75WP, Glory 75WG, Antracol 70WP, Tridium 70WG, Manzate Pro Stick, Carbendazim 50SC and Fugi One at varying rates, along with one botanical, neem plant aqueous extract, were evaluated against an untreated control for their effectiveness in managing the brown spot disease caused by *Bipolaris oryzae*.

Effects of fungicides and neem plant aqueous extract on brown spot disease during 2020

In spring crop 2020 before first treatment applied lower lesion length was observed for plants treated with Saaf 75 WP at 300 mL/ac. (0.32 cm), and higher lesion length for plants with Manzate Pro Stick TM (40 cm). No significant difference was observed among all other treatments (Table 1). Likewise, almost similar results were recorded in the autumn crop 2020 when this trial was repeated. There was no significant difference among treatment for initial lesion length and percent disease incidence when compared before treatment applied (Table 1).

The data collected 7 days after second treatment applied during spring crop 2020 showed, that plot treated with Amistar Xtra 28 SC at 300 mL/ac. (0.40 cm), Saaf 75 WP at 300, 500 and 900 g/ac. (0.39, 0.40, 0.37 cm), Manzate Pro Stick TM and Carbendazim 50 SC recorded significantly smaller lesions (0.38 cm each, respectively), and saw a slower rate of lesion progression after second treatment when compared to the untreated control (0.70 cm) during that season (Table 1).

Likewise, during the autumn crop 2020 the treatment with Rodazim 50 SC 300 mL/ac. and Saaf 75 WP 900g/ac. recorded the smallest lesion length 7 days after second treatment applied; followed by Saaf 75 WP 500g/ac., Carbendazim 50 SC 300mL/ac., then Amistar Xtra 28 SC 200mL/ac., Saaf 75 WP 300g/ac., Manzate Pro Stick TM 300g/ac., and Neem plant aqueous extract at 15% concentration. The control treatment with distilled water recorded longer lesion length (0.63 cm) than all other treatment (Table 1). Also, the positive check Fugi One recorded significantly lower percent disease severity (40.48%), followed by Saaf 75 WP 300 g/ac. (23.82%) and 500 g/ac. (28.57%), respectively, Glory 75 WG at 600 g/ac. (33.34%), Manzate Pro Stick TM 300g/ac. (28.57%), Carbendazim 50 SC 300mL/ac. (23.82%) and Neem plant aqueous extracts (23.81%) as compared to the untreated control treatment (Figure 1). All other treatments were

Table 1. Effects of new fungicides and neem plant aqueous extract against brown spot (*B. oryzae*) disease under field condition-2020

Trt.	Treatment	Rate	*Spring, 2020				*Autumn, 2020			
			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	Rodazim 50 SC	200mL/ac.	0.37 AB	0.41 BC	63.89 A	58.34 BC	0.38 A	0.55 ABCD	36.11 A	41.67 A
T2	Rodazim 50 SC	300mL/ac.	0.35 AB	0.40 BC	61.11 A	55.56 BCD	0.34 A	0.39 F	36.11 A	38.89 A
T3	Amistar Xtra 28 SC	200mL/ac.	0.37AB	0.40 C	58.33 A	55.56 BCD	0.39 A	0.46 DEF	33.33 A	38.89 A
T4	Amistar Xtra 28 SC	300mL/ac.	0.33 AB	0.49 B	61.12 A	61.12 B	0.39 A	0.67 A	36.11 A	44.45 A
T5	Saaf 75 WP	300g/ac.	0.32 B	0.39 C	58.34 A	52.78 BCD	0.37 A	0.46 DEF	33.33 A	36.11 A
T6	Saaf 75 WP	500g/ac.	0.37 AB	0.40 C	63.89 A	50.00 CD	0.34 A	0.42 EF	33.33 A	33.34 AB
T7	Saaf 75 WP	700g/ac.	0.40 AB	0.42 BC	63.89 A	58.34 BC	0.36 A	0.56 ABCD	33.33 A	41.67 A
T8	Saaf 75 WP	900g/ac.	0.35 AB	0.37 C	58.34 A	58.34 BC	0.37 A	0.40 F	33.33 A	41.67 A
T9	Glory 75 WG	1000g/ac.	0.39 AB	0.42 BC	58.34 A	47.22 D	0.36 A	0.59 ABC	36.11 A	30.56 AB
T10	Antracol 70WP	500g/ac.	0.36 AB	0.41 BC	61.12 A	58.34 BC	0.35 A	0.54 BCDE	33.33 A	41.67 A
T11	Tradium	350g/ac.	0.35 AB	0.41 BC	63.89 A	55.56 BCD	0.39 A	0.56 ABCD	33.33 A	38.89 A
T12	Manzate Pro Stick TM	300g/ac.	0.40 A	0.38 C	63.89 A	50.00 CD	0.37 A	0.49 CDEF	36.11 A	33.34 AB
T13	Carbendazim 50SC	300mL/ac.	0.35 AB	0.38 C	63.89 A	52.78 BCD	0.38 A	0.42 EF	33.33 A	36.11 A
T14	Fugi One (Check)	300mL/ac.	0.38 AB	0.41 BC	66.67 A	50.00 CD	0.38 A	0.60 ABC	38.89 A	19.45 B
T15	Neem aqueous Extract	15%	+	+	+	+	0.39 A	0.44 DEF	38.89 A	44.45 A
T16	Distilled water (Control)		0.38 AB	0.70 A	61.12 A	72.23 A	0.36 A	0.63 AB	36.11 A	44.45 A
	Grand mean		0.36	0.42	61.86	55.74	0.37	0.51	35.07	37.85
	SEm ±		0.04	0.04	5.87	5.32	0.06	0.06	2.79	6.97
	CD (P = 0.05)		0.09	0.09	11.84	10.74	0.12	0.13	5.63	14.04
	CV (%)		16.80	14.40	13.42	13.50	22.41	17.60	11.26	26.05

*Average of four replications; ¹Average from three tag plants per each replications; ²Data collected before first treatment applied; ³Data collected 7 days after second treatment applied; += Treatment was not applied during that season.

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.

similar for reduction in percent disease severity (Table 1 and Figure 1).

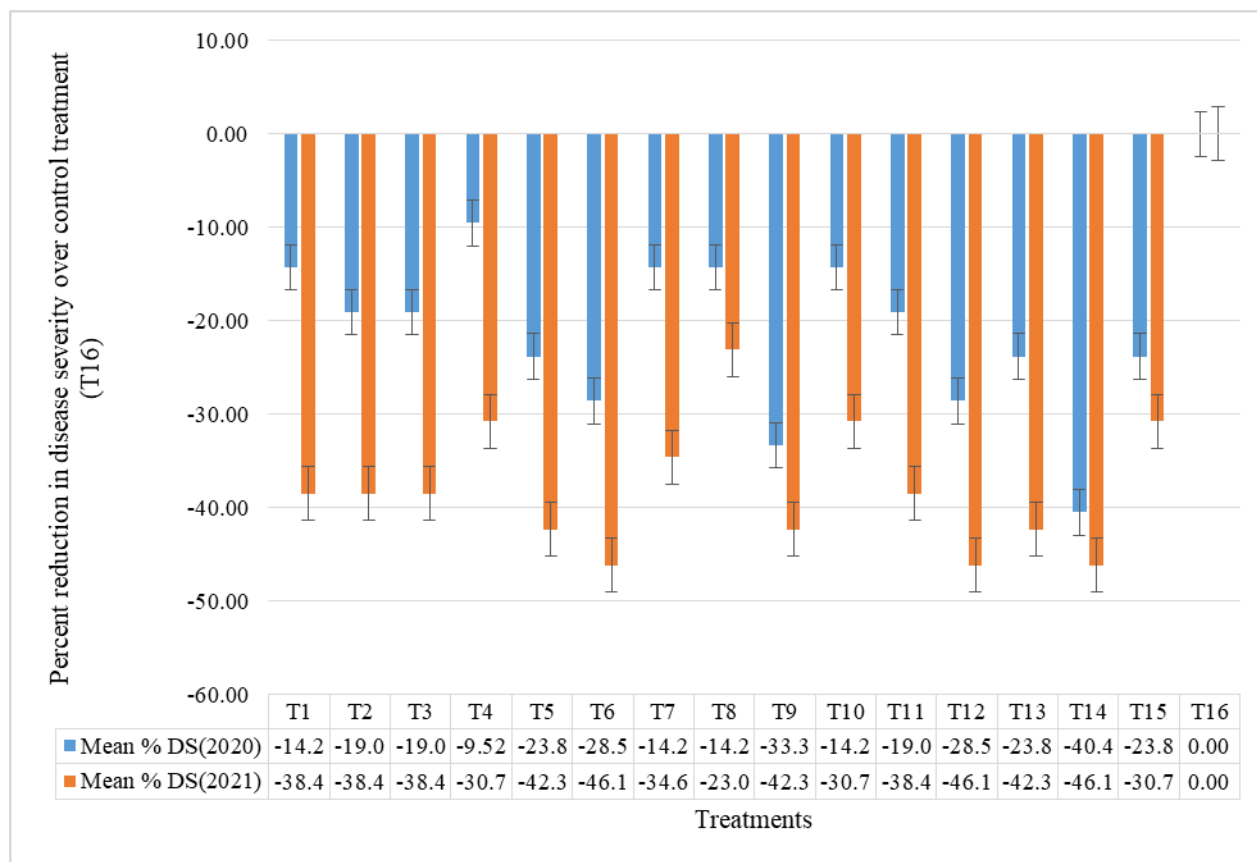
Effects of fungicides and neem plant aqueous extract on brown spot disease during 2021

Field trial conducted in spring 2021 recorded significantly lower lesion length for plants treated with Manzate Pro Stick TM (0.33 cm) and Saaf 75

WP smaller lesion length was observed among all other treatments except plants treated with the check Fugi One (0.63 cm) and the untreated control (0.74 cm) which recorded longer lesion lengths. There was no significant difference among treatments for initial lesion length when compared before treatment applied (Table 2).

Almost similar results were obtained during the autumn season 2021 as the trial was repeated

(Table 2). All treatments [viz.-Rodazim 50 SC 200 and 300mL/ac., Amistar Xtra 28 SC 200 and 300mL/ac., Saaf 75 WP 300, 500, 700 and 900g/ac., Glory 75 WG 1000 g/ac., Antracol 70WP 500g/ac., Tradium 350 g/ac., Manzate Pro Stick TM300g/ac., Carbendazim 50SC 300mL/ac., Fugi One (Check) 300mL/ac., and plant aqueous extracts of Neem 15%] recorded significantly smaller lesions length ranging from 0.38 cm to 0.55 cm and saw a slower



Notes: T1- Rodazim 50 SC 200mL/ac., T2- Rodazim 50 SC 300mL/ac., T3- Amistar Xtra 28 SC 200mL/ac., T4- Amistar Xtra 28 SC 300mL/ac., T5- Saaf 75 WP 300g/ac., T6- Saaf 75 WP 500g/ac., T7- Saaf 75 WP 700g/ac., T8- Saaf 75 WP 900g/ac., T9- Glory 75 WG 1,000g/ac., T10- Antracol 70WP 500g/ac., T11- Tridium 350 g/ac., T12- Manzate Pro Stick TM 300g/ac., T13- Carbendazim 50SC 300mL/ac., T14- Fugii One (Check) 300mL/ac., T15- Neem Extract 15%, T16- Distilled water (Control)

Figure 1: Percentage reduction in mean percent disease severity over control treatment (T16) for 2020 and 2021 trials.

rate of lesion progression 7 days after second treatment applied when compared to the untreated control (0.76 cm) during that season (Table 2).

All the fungicidal treatments and the treatment with the Neem plant aqueous extract showed varying levels of reduction in the mean percent BS severity levels when compared to the control treatments in 2020 and 2021, with higher reductions in percent BS severity levels observed and recorded in 2021 (Figure 1 and Figure 2). These treatment *viz.*-Rodazim 50 SC at 200 and 300mL/ac. at both rates demonstrated a 38.46% reduction in mean BS percent disease severity incidence, respectively when compared to the untreated control. Likewise, Amistar Xtra 28 SC at 200 and 300mL/ac. showed a 38.46% and 30.76% reduction, respectively, Saaf 75 WP at 300 (42.31%), 500 (46.14%), 700 (34.61%) and 900g/ac. (23.06%), Glory 75 WG at 1000 g/ac. (42.31%), Antracol 70WP at 500g/ac. (30.76%), Tridium 350 g/ac. (38.46%), Manzate Pro Stick TM at 300g/ac. (46.14%), Carbendazim 50SC at 300mL/ac. (42.31%), Fugii One (Check) at 300mL/ac. (46.14%), and Neem plant aqueous extracts at 15% demonstrated 30.76% reduction in brown spot disease percent disease severity

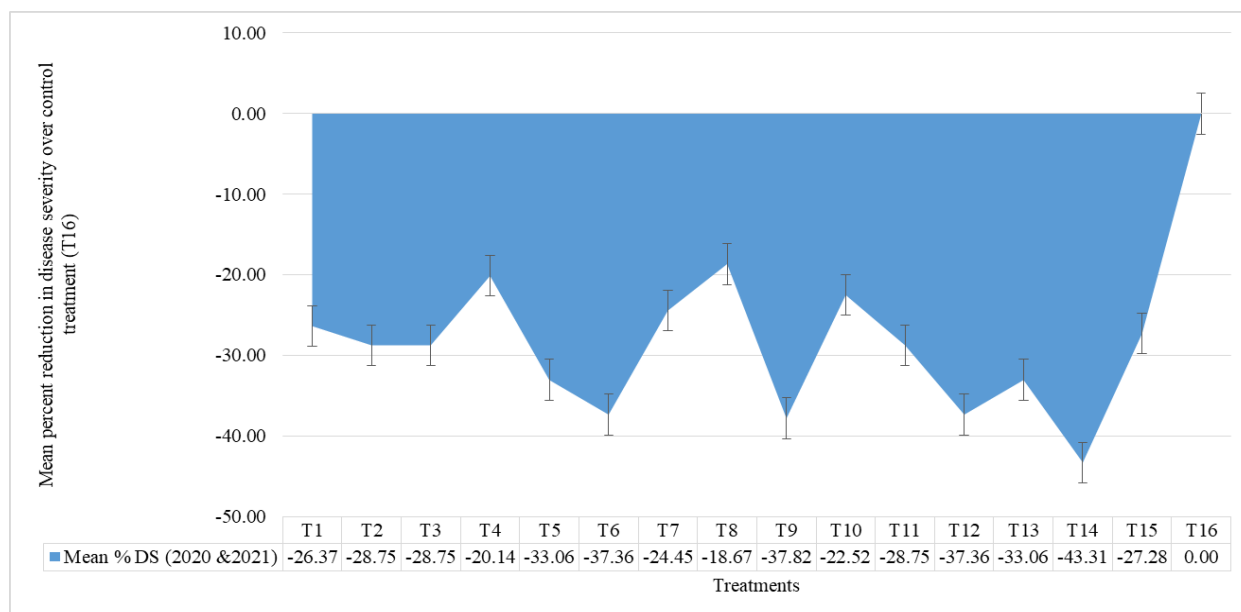
incidence over the untreated control treatment during the screening experiment in 2021 (Figure 1).

In general, these treatments *viz.* Rodazim 50 SC at 200 mL/ac. showed an overall percent BS severity reduction of 26.37% and the 300 mL/ac. 28.75%, respectively when compared to the untreated control for 2020 and 2021 trials (Figure 2). Likewise, Amistar Xtra 28 SC at 200 g/ac. showed a 28.75%; Saaf 75 WP at 300 g/ac. (33.06%) and 500 g/ac. (37.36%), respectively; Antracol 70WP at 500g/ac. a 22.52%; Glory WG at 1000 g/ac. a 37.82%; Tridium 70WG at 350 g/ac. a 28.75%; Manzate Pro Stick TM at 300 g/ac. a 37.36%; Carbendazim 50SC at 300 mL/ac. a 33.30%. Additionally, the positive check Fugii One at 300 mL/ac. showed a 43.31% reduction in the overall mean percent reduction in BS disease severity levels as compared to the overall mean percent disease severity in the untreated controls for the 2020 and 2021 trials (Figure 2). Similarly, the Neem plant aqueous extracts at 15 % concentration revealed smaller BS lesion length (Table 1 and 2) and an overall reduction of 27.28% BS disease severity when compared to the untreated control (Figure 2).

Table 2. Effects of Neem plant aqueous extract and new fungicides against brown spot (*B. oryzae*) disease under field condition-2021

Trt.	Treatment	Rate	*Spring, 2021		*Autumn, 2021		2021 Disease Severity (%)	
			¹ Lesion Length (cm)		¹ Lesion Length (cm)		² Before	³ After
			² Before	³ After	² Before	³ After		
T1	Rodazim 50 SC	200mL/ac.	0.28 A	0.45 BC	0.41 ABC	0.53 BC	25.00 AB	44.44 CD
T2	Rodazim 50 SC	300mL/ac.	0.39 A	0.38 BC	0.37 ABC	0.52 BC	30.55 A	44.44 CD
T3	Amistar Xtra 28 SC	200mL/ac.	0.43 A	0.49 ABC	0.44 ABC	0.48 BC	25.00 AB	44.44 CD
T4	Amistar Xtra 28 SC	300mL/ac.	0.30 A	0.50 ABC	0.45 ABC	0.52 BC	30.55 A	50.00 BC
T5	Saaf 75 WP	300g/ac.	0.38 A	0.39 BC	0.42 ABC	0.55 B	25.00 AB	41.66 CD
T6	Saaf 75 WP	500g/ac.	0.38 A	0.56 ABC	0.38 ABC	0.50 BC	27.78 AB	38.89 D
T7	Saaf 75 WP	700g/ac.	0.35 A	0.54 ABC	0.40 ABC	0.50 BC	27.78 AB	47.22 BCD
T8	Saaf 75 WP	900g/ac.	0.38 A	0.35 C	0.51 A	0.51 BC	27.78 AB	55.56 B
T9	Glory 75 WG	1000g/ac.	0.39 A	0.40 BC	0.41 ABC	0.44 BC	25.00 AB	41.66 CD
T10	Antracol 70WP	500g/ac.	0.31 A	0.38 BC	0.36 BC	0.38 C	25.00 AB	50.00 BC
T11	Tradium	350g/ac.	0.31 A	0.46 BC	0.39 ABC	0.43 BC	25.00 AB	44.44 CD
T12	Manzate Pro Stick TM	300g/ac.	0.27 A	0.33 C	0.45 ABC	0.49 BC	22.22 B	38.89 D
T13	Carbendazim 50SC	300mL/ac.	0.30 A	0.40 BC	0.41 ABC	0.55 B	27.78 AB	41.66 CD
T14	Fugi One (Check)	300mL/ac.	0.32 A	0.63 AB	0.33 C	0.48 BC	25.00 AB	38.89 D
T15	Neem aqueous Extract	15%	0.30 A	0.49 ABC	0.48 AB	0.43 BC	25.00 AB	50.00 BC
T16	Distilled water (Control)		0.42 A	0.74 A	0.41 ABC	0.76 A	25.00 AB	72.21 A
	Grand mean		0.34	0.47	0.41	0.50	26.21	46.53
	SEm ±		0.10	0.14	0.07	0.08	3.90	5.14
	CD (P = 0.05)		0.20	0.27	0.14	0.16	7.85	10.35
	CV (%)		40.48	40.89	24.37	22.91	21.03	15.62

*Average of four replications; ¹Average from three tag plants per each replications; 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



Notes: T1- Rodazim 50 SC 200mL/ac., T2- Rodazim 50 SC 300mL/ac., T3- Amistar Xtra 28 SC 200mL/ac., T4- Amistar Xtra 28 SC 300mL/ac., T5- Saaf 75 WP 300g/ac., T6- Saaf 75 WP 500g/ac., T7- Saaf 75 WP 700g/ac., T8- Saaf 75 WP 900g/ac., T9- Glory 75 WG 1,000g/ac., T10- Antracol 70WP 500g/ac., T11- Tradium 350 g/ac., T12- Manzate Pro Stick TM 300g/ac., T13- Carbendazim 50SC 300mL/ac., T14- Fugi One (Check) 300mL/ac., T15- Neem aqueous Extract 15%, T16- Distilled water (Control)

Figure 2: Overall percentage reduction in mean percent disease severity over control treatment (T16) for all trials executed in 2020 and 2021.

Table 3. Efficacy of plant aqueous extract and new fungicides against brown spot (*B. oryzae*) on growth and yield parameters during spring crop, 2020

Trt.	Treatment	Rate/ ac.	*Growth parameters			*Yield parameters		
			¹ Av. plant height (cm)	Av. Tiller/m ²	² Panicle length (cm)	Av. No. of grains/panicle		1000- grain weight (grams)
						Filled	Unfilled	
T1	Rodazim 50 SC	200mL/ac.	114.50 AB	288.00 A	26.62 B	131.00 A	32.00 AB	26.03 ABC
T2	Rodazim 50 SC	300mL/ac.	118.75 A	272.00 AB	27.27 AB	139.00 A	32.00 AB	24.07 BC
T3	Amistar Xtra 28 SC	200mL/ac.	113.52 AB	296.00 A	27.59 AB	151.00 A	28.00 B	28.20 ABC
T4	Amistar Xtra 28 SC	300mL/ac.	114.75 AB	288.00 A	27.25 AB	143.00 A	31.00 AB	27.30 ABC
T5	Saaf 75 WP	300g/ac.	116.12 AB	256.00 AB	27.50 AB	143.00 A	29.00 B	27.45 ABC
T6	Saaf 75 WP	500g/ac.	116.04 AB	284.00 AB	27.57 AB	139.00 A	37.00 AB	26.83 ABC
T7	Saaf 75 WP	700g/ac.	117.17 AB	276.00 AB	28.04 A	142.00 A	34.00 AB	28.80 AB
T8	Saaf 75 WP	900g/ac.	115.33 AB	260.00 AB	27.12 AB	132.00 A	34.00 AB	28.38 ABC
T9	Glory 75 WG	1000g/ac.	115.46 AB	272.00 AB	27.36 AB	128.00 A	28.00 B	29.58 A
T10	Antracol 70WP	500g/ac.	117.17 AB	276.00 AB	27.62 AB	140.00 A	31.00 AB	27.85 ABC
T11	Tradium	350g/ac.	118.50 A	264.00 AB	26.82 AB	143.00 A	30.00 B	28.25 ABC
T12	Manzate Pro Stick TM	300g/ac.	113.98 AB	268.00 AB	27.74 AB	129.00 A	41.00 A	27.33 ABC
T13	Carbendazim 50SC	300mL/ac.	115.79 AB	252.00 B	27.67 AB	131.00 A	33.00 AB	26.28 ABC
T14	Fugi One (Check)	300mL/ac.	111.87 B	284.00 AB	27.51 AB	129.00 A	34.00 AB	23.60 C
T15	Control (Distill water)	-	117.46 A	264.00 AB	27.00 AB	135.00 A	32.00 AB	28.10 ABC
	Grand mean		115.76	272.00	27.38	137.00	32.00	27.20
	SEm ±		-	-	0.48	95.27	38.07	1.72
	CD (P = 0.05)		0.82	0.47	0.22	0.30	0.13	0.80
	CV (%)		3.26	9.40	3.50	13.90	23.53	12.66

* = average of three replication; 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) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure

Effects of fungicide on growth parameters during spring crop 2020

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/m², panicle length, filled and unfilled grains per panicle and 1000 grain weight. Treatments with Rodazim at 300mL/ac., Tridium 70WG and the untreated control all recorded significantly taller plants as compared to their counterparts, 118.75, 118.50 and 117.46 cm, respectively. Treatments with Fugi One yielded significantly shorter plants than all other treatments (111.87cm), while no significant difference was observed among the remaining treatments. Tillers/m² ranged from 296 in plants treated with Amistar Xtra at 200 mL/ac. to 252 tillers/m² in treatments with Carbendazim. Other treatments which produced a larger number of tillers were Rodazim at 200mL/ac. (288.00 tillers/m²), and Amistar Xtra at 300mL/ac. (288.00tillers/m²). The difference in length of panicles amongst treatments had minimum variation, while treatments with Saaf at 700g/ac. produced significantly longer panicles (28.04cm) and those treated with Rodazim at 200mL/ac. were significantly shorter (26.62cm), there was no other significant difference among treatments in this regard. No significant difference was observed among treatments for influence on filled grains per panicle during this season, however there was

some variation in the number of unfilled grains per panicle among treatments (Table 3). Treatments with Manzate produced the largest number of unfilled grains per panicle (41.00), this was significantly greater than all other treatments; while treatments with Amistar Xtra at 200mL/ac., Saaf at 300g/ac., Glory at 1000g/ac. and Tridium 70WG produced significantly smaller number of unfilled grains per panicle (28.00, 29.00, 28.00 and 30.00 unfilled grains, respectively). Variability was also observed among treatments in the weight of 1,000 grains, treatments with Glory (1,000mL/ac.) was observed to have significantly heavier grains (29.58), followed by Saaf (700g/ac.) 28.80g; while treatments with Rodazim (300mL/ac.) and Fugi One had significantly lesser weight (24.07 and 23.60g, respectively) (Table 3).

Effects of fungicide on growth parameters during autumn crop 2020

An evaluation was conducted to determine whether the growth and yield parameters were influenced by the application of fungicides for the management of brown spot disease. Based on the data recorded it was determined that, treatment with Antracol at 500g/ac. produced the longest panicles (34.34cm), however there was no significant difference in panicle length among any of the other treatments under study (Table 4). Similarly, there was very little statistical difference with regards to the number of

Table 4. Efficacy of aqueous plant extract and new fungicides against brown spot (*B. oryzae*) on growth and yield parameters during autumn crop, 2020

Trt.	Treatment	Rate/ ac.	*Growth parameters			*Yield parameters		
			¹ Av. plant height (cm)	Av. Tiller/ m ²	² Panicle length(cm)	Av. No. of grains/ panicle		1,000- grain weight (grams)
						Filled	Unfilled	
T1	Rodazim 50 SC	200mL/ac.	113.08 AB	202.00 ABC	28.12 B	136.00 A	15.00 ABC	24.70 ABCDE
T2	Rodazim 50 SC	300mL/ac.	113.08 AB	210.00 AB	28.12 B	126.00 A	11.00 BCD	22.13 DE
T3	Amistar Xtra 28 SC	200mL/ac.	110.45 ABC	190.00 BCD	27.48 B	131.00 A	10.00 CD	29.32 A
T4	Amistar Xtra 28 SC	300mL/ac.	108.75 BC	205.00 AB	27.91 B	92.00 B	8.00 D	20.33 E
T5	Saaf 75 WP	300g/ac.	112.40 AB	201.00 ABC	27.32 B	132.00 A	12.00 BCD	28.05 ABC
T6	Saaf 75 WP	500g/ac.	114.00 A	219.00 A	26.91 B	112.00 AB	12.00 BCD	26.80 ABCD
T7	Saaf 75 WP	700g/ac.	114.05 A	195.00 BCD	28.20 B	133.00 A	14.00 ABC	22.15 DE
T8	Saaf 75 WP	900g/ac.	109.47 ABC	202.00 ABC	28.04 B	131.00 A	14.00 ABC	28.35 AB
T9	Glory 75 WG	1000g/ac.	113.17 AB	207.00 AB	27.49 B	124.00 A	15.00 AB	29.35 A
T10	Antracol 70WP	500g/ac.	109.57 ABC	197.00 BCD	34.34 A	127.00 A	14.00 ABC	21.53 DE
T11	Tradium	350g/ac.	110.45 ABC	200.00 ABCD	26.81 B	132.00 A	14.00 ABC	23.33 BCDE
T12	Manzate Pro Stick TM	300g/ac.	109.42 ABC	203.00 ABC	27.38 B	111.00 AB	10.00 CD	23.88 BCDE
T13	Carbendazim 50SC	300mL/ac.	107.58 C	201.00 ABC	28.46 B	131.00 A	19.00 A	23.63 BCDE
T14	Fugi One (Check)	300mL/ac.	111.50 ABC	194.00 BCD	26.09 B	129.00 A	16.00 AB	22.80 CDE
T15	Neem aqueous extract	15%	108.83 BC	183.00 CD	27.79 B	131.00 A	12.00 BCD	29.48 A
T16	Control (Distill water)	-	110.33 ABC	180.00 D	27.40 B	113.00 AB	14.00 ABC	27.58 ABC
Grand mean			111.01	199.00	27.99	124.00	13.00	25.21
SEm ±			1.69	7.21	2.34	129.80	25.92	2.66
CD (P = 0.05)			4.82	20.53	4.71	261.44	52.21	5.35
CV (%)			3.05	7.24	11.82	14.76	28.17	14.90

*= average of four replication; 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) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure

Table 5. Efficacy of aqueous plant extract and new fungicides against brown spot (*B. oryzae*) on growth and yield parameters during spring crop, 2021

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	Rodazim 50 SC	200mL/ac.	24.74 E	142.00 AB	41.00 BC	26.10 ABC	122.75 A	251.00 A
T2	Rodazim 50 SC	300mL/ac.	25.93 A	152.00 A	49.00 ABC	25.18 BC	100.60 B	261.00 A
T3	Amistar Xtra 28 SC	200mL/ac.	25.31 ABCDE	127.00 AB	45.00 ABC	26.73 AB	99.93 B	255.00 A
T4	Amistar Xtra 28 SC	300mL/ac.	25.79 ABC	152.00 A	49.00 ABC	25.05 BC	97.67 B	279.00 A
T5	Saaf 75 WP	300g/ac.	25.14 BCDE	156.00 A	45.00 ABC	24.80 C	100.15 B	247.00 A
T6	Saaf 75 WP	500g/ac.	25.13 CDE	161.00 A	38.00 C	25.25 BC	100.20 B	253.00 A
T7	Saaf 75 WP	700g/ac.	25.05 CDE	141.00 AB	44.00 ABC	26.48 ABC	100.08 B	223.00 A
T8	Saaf 75 WP	900g/ac.	25.57 ABCD	144.00 AB	48.00 ABC	25.75 ABC	101.22 B	256.00 A
T9	Glory 75 WG	1000g/ac.	25.33 ABCDE	132.00 AB	54.00 A	26.33 ABC	99.92 B	260.00 A
T10	Antracol 70 WP	500g/ac.	26.01 A	144.00 AB	44.00 ABC	25.40 BC	100.92 B	258.00 A
T11	Tradium	350g/ac.	25.91 AB	140.00 AB	46.00 ABC	26.23 ABC	101.65 B	278.00 A
T12	Manzate Pro Stick	300g/ac.	25.53 ABCD	155.00 A	52.00 AB	25.50 BC	102.73 B	255.00 A
T13	Carbendazim 50 SC	300mL/ac.	24.98 DE	112.00 B	41.00 ABC	25.73 ABC	100.40 B	244.00 A
T14	Fugi One	300mL/ac.	25.30 ABCDE	130 AB	40.00 BC	27.25 A	103.00 B	244.00 A
T15	Neem aqueous extract	15%	25.63 ABCD	146.00 AB	42.00 ABC	25.18 BC	101.63 B	270.00 A
T16	Control		25.05 CDE	133.00 AB	43.00 ABC	26.00 ABC	98.65 B	222.00 A
Grand mean			25.40	142.00	45.00	25.81	101.97	251.63
SEM			0.38	19.55	6.36	0.84	7.88	41.76
CD (P=0.05)			0.78	39.38	12.81	1.70	15.86	84.11
CV (%)			2.14	19.53	19.94	4.62	10.92	23.47

*= average of four replication; 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) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

filled grains per panicle, all treatments apart from Amistar Xtra at 300mL/ac. (with 92.00 grains per panicle) yielded more than 110.00 grains per panicle (Table 4). Unfilled grains per panicle ranged from 19m in treatment with Carbendazim to 8 in treatments with Amistar Xtra at 300mL/ac. All other treatments besides Manzate and Amistar Xtra at 200mL/ac. produced more than 10 unfilled grains per panicle (Table 4).

The heaviest set of 1,000 grains came from plants treated with Amistar Xtra at 200g/ac. (29.32g), Glory at 1,000g/ac. (29.35g), Neem aqueous extract (29.48g) and Saaf at 900g/ac. (28.35g), while plants subjected to other treatments such as Amistar Xtra at 300g/ac., Saaf at 700g/ac., Antracol at 500g/ac. and Rodazim at 300mL/ac. weighed significantly lower 1,000 grain weight (20.33, 22.15, 21.53 and 22.13g, respectively) (Table 4). With respect to plant height and tillers/m², treatments with Saaf at 500g/ac. and Rodazim at 300mL/ac. had the tallest plants with the most tillers/m² (114cm, 219 tillers/m² and 119.8 cm, 210 tillers/m², respectively). Treatments with Glory, Amistar Xtra at 300g/ac., Manzate, Saaf at 300 and 900g/ac., Carbendazim and Tridium 70WG all recorded 200 and more tillers/m², while the untreated control produced significantly lower number of tillers/m² (180) (Table 4).

Effects of fungicide on growth and yield parameters during spring crop 2021

Data for spring crop 2021 collected and analyzed using statistix 8 revealed that treatments with Antracol at 500g/ac. and Rodazim at 300mL/ac. resulted in the longest panicles, 26.01cm and 25.93cm, respectively; followed by treatments with Tridium 70 WG at 350 g/ac. and Amistar Xtra at 300 mL/ac. (25.91cm and 25.79cm, respectively) (Table 5). Treatments with Saaf at 500g and 700g/ac., Carbendazim 300mL/ac., Rodazim 200mL/ ac. and the untreated control produced some of the shortest panicles within this trial (25.13, 25.05, 24.98, 24.74 and 25.05cm, respectively). The number of filled grains per panicle ranged from 161.00 in treatments with Saaf at 500g/ac. to 112.00 grains per panicle in treatments with Carbendazim. Other treatments with significantly larger number of grains per panicles included Saaf at 300g/ac., Amistar Xtra at 300mL/ac., Rodazim at 200mL/ac. and Manzate at 300g/ac. which produced 156.00, 152.00, 152.00 and 155.00 grains per panicle, respectively (Table 5). Treatments with Glory and Manzate produced significantly larger number of unfilled grains as compared to all other treatments (54.00 and 52.00, respectively); while treatments with Fugi One and Saaf at 500g/ac. yielded the least number of unfilled grains per panicle (40.00 and 38.00, respectively). The heaviest grain weight per 1,000 grains was obtained from grains treated with Fugi One (27.28g), this was followed by treatment with Amistar Xtra at 200mL/ac. (26.73g) and Saaf at 700mL/ac. (26.48g) (Table 5).

Significantly taller plants were produced by plants treated with Rodazim at 200mL/ac., there was no significant difference in plant height among any of the other

treatments inclusive of the control treatment. Likewise, there was no significant difference among treatments in the number of tillers produced per m² (Table 5).

Effects of fungicide on growth and yield parameters during autumn crop 2021

In the autumn crop of 2021, when the lengths of panicles were examined, it was observed that the untreated control recorded significantly longer panicles (25.23 cm), while treatment with Carbendazim produced the shortest (23.72 cm). There was no significant difference in panicle length among other tested treatments (Table 6). Likewise, no significant difference was recorded among treatments for the number of filled grains per panicle. In terms of unfilled grains per panicle, the untreated control was observed to have produced the largest number in this regard (46.00), other treatments producing significantly larger number of unfilled grains per panicle included Rodazim at 200mL/ac. and Saaf at 300g/ac. (41.00 grains), Fugi One and Rodazim at 300mL/ac. (40.00 grains). Treatment with Rodazim at 200mL/ac. however produced the heaviest 1,000 grain weight (25.15g), while treatment with Antracol produced the lightest (23.50g), no significant difference was observed among other treatments regarding this character (Table 6).

The height of ten plants within each treatment were measured and there was found to be no significant difference among treatments in relation to plant height (Table 6). Treatments with the largest number of tillers/m² were Amistar Xtra at 300mL/ac. (282.00) and Carbendazim (273.00), these were closely followed by Tridium (271.00) and Amistar Xtra at 200mL/ac. (266.00), while treatments with Saaf at 300g/ac. and Neem plant aqueous extract produced the least number of tillers/m², 205.00 and 201.00, respectively (Table 6).

Effects of fungicide on grain yield during 1st and 2nd Crop 2020

The average yield obtained from plants treated with the various fungicides in the first crop of 2020 ranged from 5881.6kg/ha in plants treated with Tridium 70WG to 4125.6kg/ha in treatments with Fugi One (Table 7). There was no significant difference among any other treatments in the grain yield obtained during this trial (Table 7). While in the second crop of 2020 average yield ranged from 6330.9Kg/ha in plants treated with Saaf at 700g/ac. to 5027.5 Kg/ha in treatments with Fugi One. Other treatments which yielded on the higher scale were Glory at 1,000g/ac. (6236.1 Kg/ha), Rodazim at 200mL/ac. (6207.3Kg/ha), Amistar Xtra at 200g/ac. (6159.5 Kg/ha), Saaf at 500g/ac. (5950.6Kg/ha) and 15% Neem aqueous extract (5909.5Kg/ha) (Table 7).

Treatment with Tridium 70WG showed a small percent (3.12 to 3.45 %) increase in the overall grain yield when compared to the untreated control treatments (Figure 2) in both first and second crop 2020; while treatment with

Table 6. Efficacy of aqueous plant extract and new fungicides against brown spot (*B. oryzae*) on growth and yield parameters during autumn crop, 2021

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	Rodazim 50 SC	200mL/ac.	24.46 AB	140.00 A	40.00 AB	25.15 A	104.73 A	242.00 ABCD
T2	Rodazim 50 SC	300mL/ac.	24.20 AB	150.00 A	29.00 B	24.65 AB	104.67 A	215.00 BCD
T3	Amistar Xtra 28 SC	200mL/ac.	24.02 AB	142.00 A	41.00 AB	24.03 AB	105.23 A	266.00 AB
T4	Amistar Xtra 28 SC	300mL/ac.	24.92 AB	169.00 A	29.00 B	23.85 AB	103.75 A	282.00 A
T5	Saaf 75 WP	300g/ac.	24.54 AB	149.00 A	41.00 AB	24.35 AB	105.72 A	205.00 CD
T6	Saaf 75 WP	500g/ac.	24.30 AB	143.00 A	31.00 AB	24.23 AB	105.18 A	244.00 ABCD
T7	Saaf 75 WP	700g/ac.	24.44 AB	158.00 A	29.00 B	23.88 AB	104.08 A	244.00 ABCD
T8	Saaf 75 WP	900g/ac.	24.48 AB	164.00 A	31.00 AB	24.73 AB	106.73 A	235.00 ABCD
T9	Glory 75 WG	1000g/ac.	24.16 AB	151.00 A	35.00 AB	24.32 AB	105.08 A	236.00 ABCD
T10	Antracol 70 WP	500g/ac.	24.59 AB	144.00 A	30.00 B	23.50 B	106.63 A	242.00 ABCD
T11	Tradium	350g/ac.	24.57 AB	161.00 A	27.00 B	23.65 AB	105.80 A	271.00 AB
T12	Manzate Pro Stick	300g/ac.	24.49 AB	146.00 A	34.00 AB	23.90 AB	105.67 A	234.00 ABCD
T13	Carbendazim 50 SC	300mL/ac.	23.72 B	147.0 A	30.00 B	24.73 AB	106.27 A	273.00 A
T14	Fugi One	300mL/ac.	24.52 AB	155.00 A	40.00 AB	23.83 AB	106.60 A	259.00 ABC
T15	Neem aqueous extrac.ts	15%	24.42 AB	146.00 A	28.00 B	24.38 AB	105.80 A	201.00 D
T16	Control		25.23 A	146.00 A	46.00 A	24.48 AB	105.17 A	230.00 ABCD
	Grand mean		24.44	150.00	34.00	24.23	105.49	242.00
	SEM		0.74	17.27	7.47	0.78	1.66	28.16
	CD (P=0.05)		1.50	34.78	15.04	1.58	3.34	56.71
	CV (%)		4.30	16.22	31.39	4.58	2.22	16.45

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

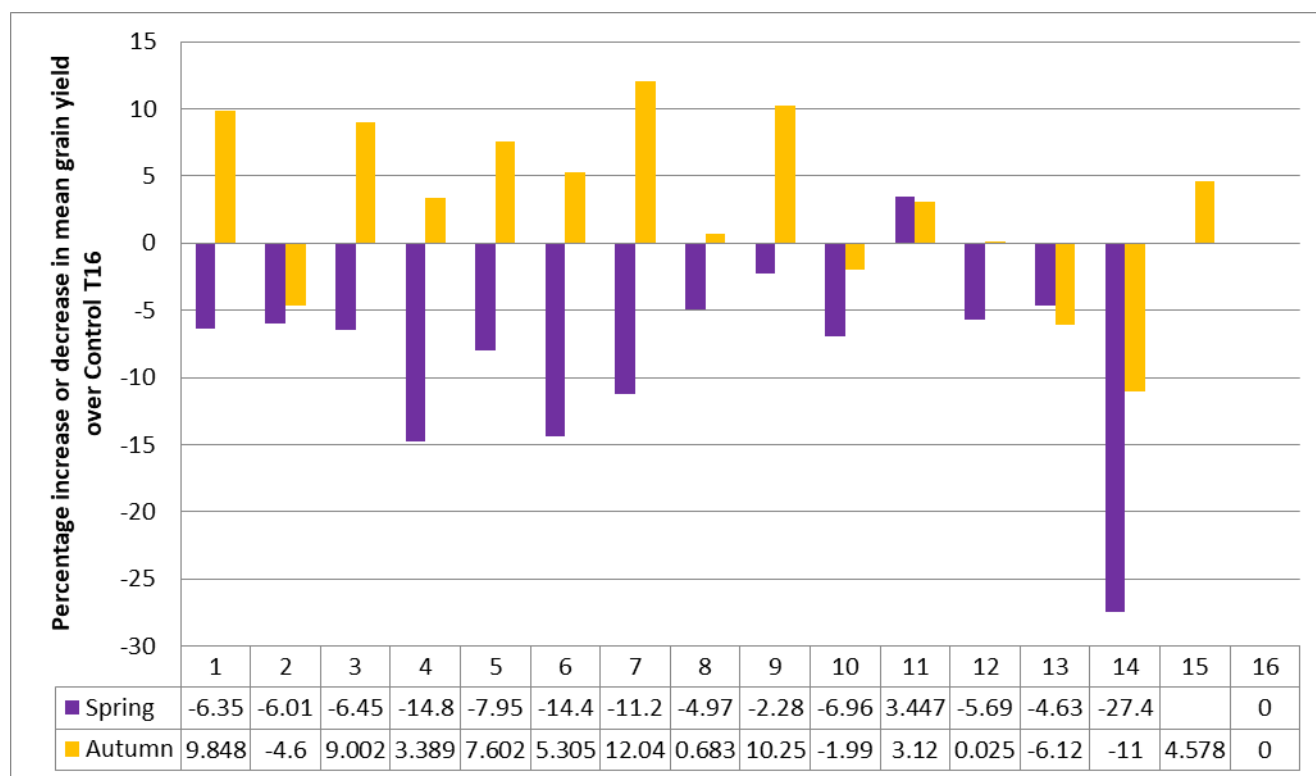
Means values in columns followed by same superscript letter(s) are not differ significantly at 95% confidence interval according to Fisher's Least Significant Difference (LSD) procedure.

Table 7: Effects of aqueous plant extract and fungicides against brown spot (*B. oryzae*) on yield during first and second crop 2020

Trt	Treatment	Rates/ac.	Grain Yield			
			*First Crop 2020		* Second Crop 2020	
			Kg/ha	Bags/ac.	Kg/ha	140 lbs. Bags/ac.
T1	Rodazim 50 SC	200mL/ac.	5324.4 AB	33.86 AB	6207.3 AB	39.48 AB
T2	Rodazim 50 SC	300mL/ac.	5084.2 AB	32.33 AB	5390.9 BCD	34.30 BCD
T3	Amistar Xtra 28 SC	200mL/ac.	5318.8 AB	33.83 AB	6159.5 ABC	39.18 ABC
T4	Amistar Xtra 28 SC	300mL/ac.	4846.4 AB	30.82 AB	5842.3 ABCD	37.15 ABCD
T5	Saaf 75 WP	300g/ac.	5233.4 AB	33.28 AB	6080.4 ABC	38.70 ABC
T6	Saaf 75 WP	500g/ac.	4866.3 AB	30.95 AB	5950.6 ABC	37.85 ABC
T7	Saaf 75 WP	700g/ac.	5049.1 AB	32.11 AB	6330.9 A	40.25 A
T8	Saaf 75 WP	900g/ac.	5188.8 AB	33.00 AB	5689.4 ABCD	36.15 ABCD
T9	Glory 75 WG	1000g/ac.	5555.8 AB	35.34 AB	6230.1 AB	39.6 AB
T10	Antracol 70WP	500g/ac.	5290.0 AB	33.64 AB	5538.5 ABCD	35.23 ABCD
T11	Tradium	350g/ac.	5881.6 A	37.41 A	5827.1 ABCD	37.08 ABCD
T12	Manzate Pro Stick TM	300g/ac.	5361.9 AB	34.09 AB	5652.2 ABCD	35.95 ABCD
T13	Carbendazim 50SC	300mL/ac.	5422.2 AB	34.48 AB	5304.9 CD	33.75 CD
T14	Fugi One (Check)	300mL/ac.	4125.6 B	26.23 B	5027.5 D	32.00 D
T15	Neem aqueous extrac.t	15%	-	-	5909.5 ABC	37.60 ABC
T16	Distilled water (Control)		5685.6 AB	36.15 AB	5650.8 ABCD	35.95 ABCD
	Grand mean		5215.60	33.17	5799.50	36.89
	SEm ±		-	-	21.43	0.01
	CD (P = 0.05)		21.43	0.01	0.01	21.42
	CV (%)		0.0056	21.42	10.47	10.48

* = average of four 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



Notes: T1- Rodazim 50 SC 200mL/ac., T2- Rodazim 50 SC 300mL/ac., T3- Amistar Xtra 28 SC 200mL/ac., T4- Amistar Xtra 28 SC 300mL/ac., T5- Saaf 75 WP 300g/ac., T6- Saaf 75 WP 500g/ac., T7- Saaf 75 WP 700g/ac., T8- Saaf 75 WP 900g/ac., T9- Glory 75 WG 1,000g/ac., T10- Antracol 70WP 500g/ac., T11- Tradium 350 g/ac., T12- Manzate Pro Stick TM 300g/ac., T13- Carbendazim 50SC 300mL/ac., T14- Fugii One (Check) 300mL/ac., T15- Neem aqueous extract 15%, T16- Distilled water (Control)

Figure 3: Percentage increase or decrease in mean grain weight (kg/ha.) over the control (T16)-2020

Rodazim 50 SC 200mL/ac., Amistar Xtra 28 SC 200 and 300 mL/ac., all 4 rates of Saaf 75 WP (i.e., 300, 500, 700 and 900 g/ac.); Manzate Pro Stick TM 300g/ac., and medicinal plant aqueous extract Neem (15%) also showed some level of increase in the overall grain yield during the second crop 2020 ranging from 0.68 % to 12.04% (Table 7; Figure 3).

Effects of fungicide on grain yield during spring and autumn crop 2021

The average yield per plot during spring crop 2021 ranged between 6593.50 kg/ha (41.93 bags/ac.) in plants treated with Amistar Xtra at 200mL/ac. to treatments with Saaf at 500g/ac. (4977.00 kg/ha or 31.66 bags/ac.) (Table 8). Grain yield was highest from plants treated with Saaf at 900g/ac., producing 6564.10 kg/ha (41.70 bags/ac.) followed by treatments with Amistar Xtra at 200mL/ac., Carbendazim, Manzate and Rodazim at 300mL/ac. with 6432.60 kg/ha (40.90 bags/ac.), 5864.3.00 kg/ha (37.30 bags/ac.) and 5836.80 kg/ha (37.10 bags/ac.), respectively. Those on the lower end of the production scale were Fugii One, Neem aqueous extract, Antracol and Amistar Xtra at 300mL/ac. with 5527.00 kg/ha (35.20 bags/ac.), 5491.00 kg/ha (34.90 bags/ac.), 5448.70 kg/ha (34.70 bags /ac.)

and 5260.20 kg/ha (33.50 bags/ac.), respectively (Table 8).

In the spring crop 2021 almost, all treatments showed a positive increase in grain yield ranging from 4.14% in Manzate Pro Stick TM at 300g/ac. to 29.30% in Amistar Xtra 28 SC 200mL/ac. except Saaf 75 WP 500g/ac. which recorded a 2.38% reduction in grain yield over the untreated control treatment (Figure 3) which was not significant different from each other (Table 8). Treatment with viz. Rodazim 50 SC 200mL/ac., Rodazim 50 SC 300mL/ac., Amistar Xtra 28 SC 200mL/ac., Saaf 75 WP 900g/ac., Glory 75 WG 1,000g/ac., Manzate Pro Stick TM 300g/ac. and Carbendazim 50SC 300mL/ac. showed 0.36 to 14.29 percent increase in the overall mean grain yield when compared to the untreated control treatments (Figure 3) in second crop 2021 evaluation; while the other treatment recorded a reduction in mean grain yield when compared to the untreated control treatment ranging from 0.49 to 8.41 percent (Figure 4; Table 8).

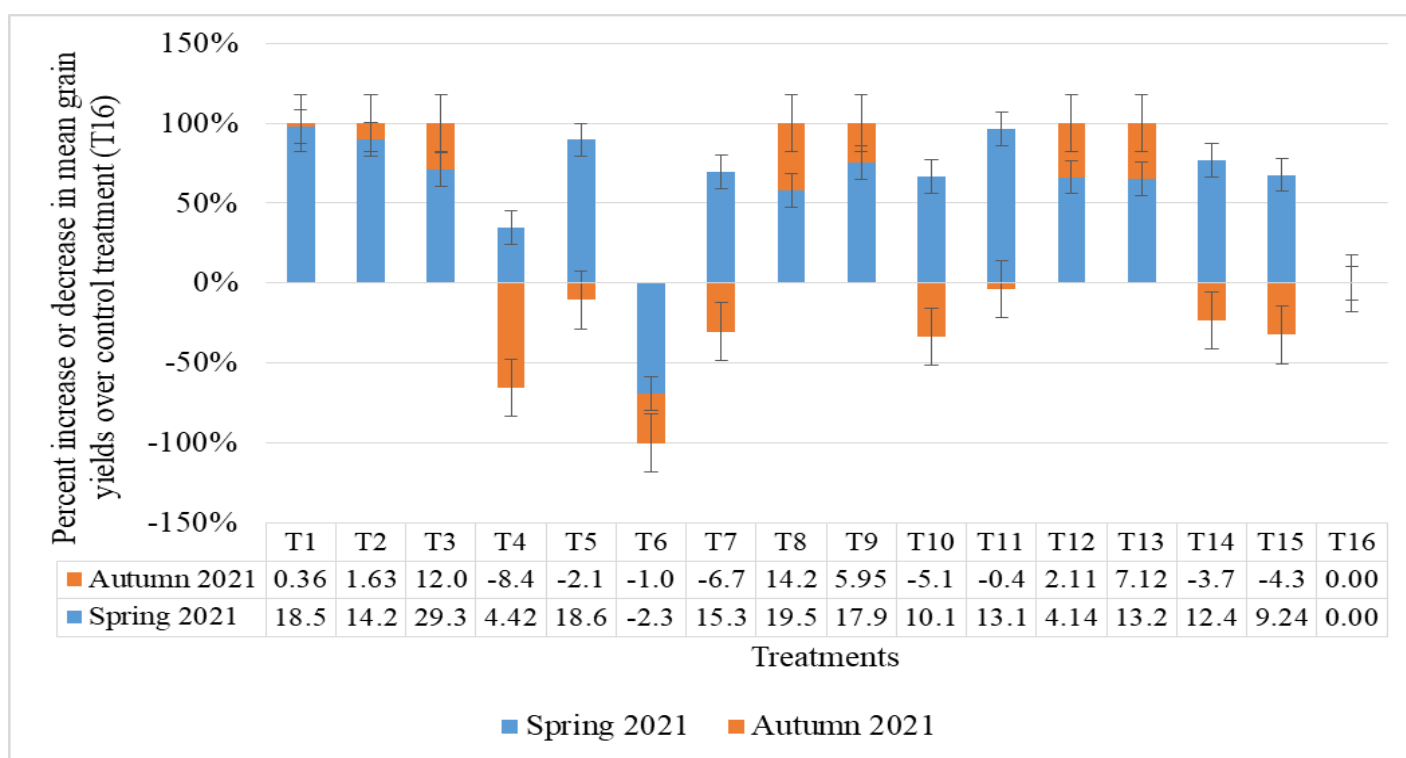
In general, the current study conducted during the spring and autumn crop of 2020 and 2021 showed that plant treated with these fungicides viz. Rodazim 50 SC, Amistar Xtra 28 SC, Saaf 75 WP, Antracol 70WP, Glory 75WG, Tridium 70WG, Manzate Pro Stick TM, Carbendazim 50SC and Fugii One (Check) along with the Neem plant

Table 8. Effects of aqueous plant extract and fungicides against brown spot (*B. oryzae*) on yield during spring and autumn crop 2021

Trt.	Treatments	Rates	*Spring, 2021		*Autumn, 2021	
			Kg/ha	Bags/ac.	Kg/ha	Bags/ac.
T1	Rodazim 50 SC	200mL/ac.	6045.60 AB	38.45 AB	5763.80 ABC	36.70 ABC
T2	Rodazim 50 SC	300mL/ac.	5823.20 ABCD	37.04 ABCD	5836.80 ABC	37.10 ABC
T3	Amistar Xtra 28 SC	200mL/ac.	6593.50 A	41.93 A	6432.60 AB	40.90 AB
T4	Amistar Xtra 28 SC	300mL/ac.	5324.90 BCD	33.86 BCD	5260.20 C	33.50 C
T5	Saaf 75 WP	300g/ac.	6048.90 AB	38.47 AB	5618.90 ABC	35.70 ABC
T6	Saaf 75 WP	500g/ac.	4977.70 D	31.66 D	5682.20 ABC	36.20 ABC
T7	Saaf 75 WP	700g/ac.	5882.20 ABC	37.41 ABC	5358.60 C	34.10 C
T8	Saaf 75 WP	900g/ac.	6095.30 AB	38.77 AB	6564.10 A	41.70 A
T9	Glory 75 WG	1000g/ac.	6015.10 AB	38.26 AB	6084.90 ABC	38.70 ABC
T10	Antracol 70 WP	500g/ac.	5618.40 BCD	35.73 BCD	5448.70 BC	34.70 BC
T11	Tradium	350g/ac.	5769.80 ABCD	36.69 ABCD	5715.00 ABC	36.40 ABC
T12	Manzate Pro Stick	300g/ac.	5310.60 BCD	33.77 BCD	5864.30 ABC	37.30 ABC
T13	Carbendazim 50 SC	300mL/ac.	5775.00 ABCD	36.73 ABCD	6152.20 ABC	39.10 ABC
T14	Fugi One	300mL/ac.	5733.50 ABCD	36.46 ABCD	5527.10 BC	35.20 BC
T15	Neem aqueous extrac.ts	15%	5570.70 BCD	35.43 BCD	5491.00 BC	34.90 BC
T16	Control		5099.30 CD	32.43 CD	5743.40 ABC	36.50 ABC
Grand mean			5730.20	36.44	5784.00	36.78
SEM			448.67	2.85	513.46	3.27
CD (P=0.05)			903.67	5.75	1034.20	6.58
CV (%)			11.07	11.07	12.55	12.56

* = average of four 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.



Notes: T1- Rodazim 50 SC 200mL/ac., T2- Rodazim 50 SC 300mL/ac., T3- Amistar Xtra 28 SC 200mL/ac., T4- Amistar Xtra 28 SC 300mL/ac., T5- Saaf 75 WP 300g/ac., T6- Saaf 75 WP 500g/ac., T7- Saaf 75 WP 700g/ac., T8- Saaf 75 WP 900g/ac., T9-Glory 75 WG 1,000g/ac., T10- Antracol 70WP 500g/ac., T11- Tradium 350 g/ac., T12- Manzate Pro Stick TM 300g/ac., T13-Carbendazim 50SC 300mL/ac., T14- Fugi One (Check) 300mL/ac., T15-Neem aqueous Extract 15%, T16- Distilled water (Control)

Figure 4: Percentage increase or decrease in mean grain weight (kg/ha.) over the control (T16)-2021

aqueous extracts recorded smaller lesion length and to reduce the percent disease severity significantly with slower progress of the rice brown spot disease development. Thus, provide effective control of the BS disease by their application when compared to untreated control (Table 1 and 2; Figure 1).

Further, these said treatments not only demonstrated a reduction in the brown spot disease severity but also some showed a positive influence in terms of rice plant growth, yield parameters and fluctuating levels overall grain yields (Tables 3,4,5,6,7 and 8; Figure 2 and 3).

DISCUSSION

Brown spot of rice is caused by fungus, *Bipolaris oryzae* is one of the deadliest diseases of rice. Many strategies are available for management of the BS disease, but the instability of the pathogen threaten the rice crop (Shamim and Singh, 2017). The present research demonstrated the effects of the use of new fungicides and neem plant aqueous extract for management of the brown spot disease under low land irrigated rice field conditions under Guyanese agricultural settings. The present research found plots treated with Rodazim 50 SC (Carbendazim 50%) at 200-300 mL/ac., Amistar Xtra 28 SC (Triazol, Estrobilurtina., Cyproconazol, Azoxystrobin) at 200-300 g/ac., Saaf 75 WP (Mancozem 63%, Carbendazim 12%) at 300-500 g/ac., Antracol 70WP (Propineb) at 500g/ac., Glory 75WG (Mancozeb + Azoxystrobin) at 1,000 g/ac., Tridium 70WG (Azoxystrobin 4.7% + Mancozeb 59.7% + Tebucuzonal 5.6% WG) at 350 g/ac., Manzate Pro Stick TM (Mancozeb 70%) at 300 g/ac., Carbendazim 50SC (Carbendazim 50%) at 300 mL/ac. and Check Fugi One (Isoprothiolane 40% SC) at 300 mL/ac. along with the Neem (*Azadirachta indica*) plant aqueous extracts at 15 % concentration to demonstrated significant reduction in mean brown spot disease severity levels in the 2020 and 2021 trials ranging from 9.52% to 46.10% when compared to the untreated control. Further, these said treatment not only expressed reduction in the brown spot disease severity but also showed favorable influence in terms of rice plant growth parameter, yield parameter and fluctuating increase in the overall grain yields for the different ranging from 0.36% to 29.30% when compared to the untreated control over the trials conducted in 2020 and 2021. Similar findings were reported by Parajuli et al. (2022) and Kumar et al. (2017) when the Efficacy of several fungicide combinations was evaluated against the brown spot pathogen in field and laboratory condition. Kumar et al. (2017) states that the foliar spray with Propiconazole @ 1mL/l demonstrated a significant reduction in disease severity by 37.26% and increase in the grain yield up to 55.49%. Likewise, Monisha et al. (2019) tested twelve fungicides and found Hexaconazole 5% EC and Tebuconazole 25% + Trifloxystrobin 50% WP and Zineb 68% + Hexaconazole 25% WG to be effective in controlling brown spot disease (*B. oryzae*) at 50 and 100 ppm

concentration compared control under laboratory and field condition.

In another study conducted by Hossain et al. (2011) found a marked reduction of Brown spot and Narrow brown spot disease incidence when rice plant treated with Bion (benzothiodiazole), Amistar (azoxystrobin) and Tilt (propiconazole) @ 50 mg/L, 1 mL/L and 1 mL/L, respectively and a significant increase in the number of grains per panicle and number of filled, healthy grains per panicle. Also, these treatments [viz. Bion (benzothiodiazole), Amistar (azoxystrobin) and Tilt (propiconazole) @ 50 mg/L, 1 mL/L and 1 mL/L] demonstrated higher grain yield (increased by 25.87, 32.17 and 26.76%, respectively) over the untreated control. Similarly, Sunder et al. (2010) evaluated six different fungicides and 10 botanicals against brown leaf spot disease of rice and reported similar findings to this present study. The researchers found propiconazole (1 mL/l) and hexaconazole (2 mL/l) along with the botanical Neemazal (3 mL/l) and Wanis (5 mL/l) to be most effective in reducing brown leaf spot severity along with significant increase in grain yield of rice. In addition, Chouhan and Kumar (2022) evaluated nine phytoextracts against *Bipolaris oryzae* (causal agent of brown leaf spot disease of rice) also reported that neem aqueous extract at 30% concentration reduce the mycelium growth of *B. oryzae* by 84.85% when compared to the control. Further, Amadioha (2002) report similar findings to this present study. The researcher demonstrated that the extract of *Azadirachta indica* (Neem) were effective in reducing the radial growth of *Bipolaris oryzae* (teleomorph: *Cochliobolus miyabeanus*) in culture and in checking the spread of brown spot disease in rice *in vivo*. The treatment with the neem plant extract also reported to give comparable control as the treatment with carbendazim (Bavistin) at 0.1% a.i and have the potential for control of rice brown spot disease under field condition.

Also, Iwuagwu, (2020) found *Azadirachta indica* (Neem plant aqueous extract), to inhibit the growth of *B. oryzae* by 81.02% under *in vitro*. Comparable findings were reported by Harish et al. (2008), Gupta et al. (2013), Nazifa et al. (2021), Parajuli et al. (2022). The Neem tree (*Azadirachta indica*) is popular for its pharmacological, microbicidal, insecticidal, nematicidal and other such important attributes. It is also rich in various phytochemicals such as alkaloids, steroids, flavonoids, terpenoids, fatty acids, and carbohydrates. These phytochemicals along with the presence of azadirachtin and nimbin is likely to be responsible for the fungicidal potential of the neem tree extracts (Kumar et al., 2016, Saleem et al., 2018).

CONCLUSION

It can be concluded from this research that treatments with Rodazim 50 SC at 200-300 mL/ac., Amistar Xtra 28 SC at 200-300 g/ac., Saaf 75 WP at 300-500 g/ac., Antracol 70WP at 500g/ac., Glory WG at 1000 g/ac., Tridium 70WG at 350

g/ac., Manzate Pro Stick TM at 300 g/ac., Carbendazim 50SC at 300 mL/ac. and Fugui One (Check) at 300 mL/ac., along with the Neem (*Azadirachta indica*) plant aqueous extracts at 15 % concentration significantly restrict the lesion growth, thus lowering the rate of brown spot development and overall mean disease severity incidence (by greater than 20.14% to 43.31%) and also demonstrated a varying increases in the overall grain yield (fluctuate by 0.36% to 29.30%) for these treatments. Therefore, the use of the phytoextracts of Neem plant (*A. indica*) can be recommended as the *first line approach* as a protective treatment for the management of brown spot disease, since it can be more safe, eco-friendly, cost-effective economically and biodegradable. Then, the fungicides found to be effective at their respective recommended rates can be recommended as the *second* option for the management of the brown spot disease especially in disease prone areas.

Author's contributions

First author Rajendra Persaud design and carried out the experiments, analyzed the data and wrote the manuscript. All other authors provide technical advice, assisted with editing, moral support, read agree with the content of the manuscript.

ACKNOWLEDGEMENTS

The authors are thankful to Guyana Rice Development Board (GRDB) for providing them with the necessary funding and laboratory facility to conduct this research work at the GRDB, Rice Research Station, Burma in Guyana. Also thankful for assistance received from staffs of the department, Ms. D.McGowan, Ms. J. Gilkes, Mr. A. Casey and workers assisted in one way or another with the execution of these experiments.

Disclosure statement

There is no potential conflict of interest to declare.

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