Int. J. Phytopathol. 10 (03) 2021. 215-224 DOI: 10.33687/phytopath.010.03.3649

Available Online at EScience Press
International Journal of Phytopathology
ISSN: 2312-9344 (Online), 2313-1241 (Print)
https://esciencepress.net/journals/phytopath

EFFICACY OF DIFFERENT FUNGICIDES FOR THE CONTROL OF RICE BLAST (*PYRICULARIA ORYZAE*) DISEASE UNDER FIELD CONDITIONS AT PAWE, NORTHWEST ETHIOPIA

Jemal T. Horo, Tesfaye Gudisa
Ethiopian Institute of Agricultural Research EIAR, Pawe Agricultural Research Center PARC, Ethiopia.

ARTICLE INFO

Article History
Received: July 23, 2021
Revised: September 07, 2021
Accepted: September 23, 2021

Keywords
Rice blast
Pyricularia oryzae
Cavara
Rice
Fungicide
Contaf Max 350 SC

ABSTRACT

Rice blast disease caused by *Pyricularia oryzae* Cavara is the most destructive rice disease worldwide. Among the disease management options, the use of a fungicide is suitable for immediate action and remained an exclusive management method in the continents like Africa where agricultural technologies are not well advanced. The present study aimed to evaluate the effectiveness of seven chemical fungicides viz., Amistar Xtra 280 SC, Artea 330 EC, Contaf Max 350 SC, Fungozeb 80 WP, Matco, Rex® Deo and Tilt 250 EC for the control of rice blast disease under field condition at Pawe, northwest Ethiopia. The result revealed that all the test fungicides have significantly suppressed the disease development with 28 – 70% suppression of panicle blast severity and 53 – 84 % suppression of neck blast severity compared to the control (Untreated plot). However, Contaf Max 350 SC had superior disease reduction by more than 80% and gave the maximum grain yield (5617.06 kg ha^{-1}) among the fungicides while the lowest yield was obtained from the control (4324.73 kg ha^{-1}) followed by Artea 330 EC (4639.35 kg ha^{-1}). Therefore, the present results suggest that twice application of Contaf Max 350 SC fungicide at 1 Lha^{-1} is effective for managing rice blast disease in Pawe and other places with a similar condition.

Corresponding Author: Jemal T. Horo
Email: tolajemal@gmail.com

INTRODUCTION

Rice (*Oryza sativa* L.) is a major food crop that is staple for more than half of the world population; accordingly, yields must be doubled by the next 30 years to sustain the nutritional need of the ever-expanding global population (Nalley *et al.*, 2016; Skamnioti and Gurr, 2009). Besides, the crop has been considered as a food security crop and tremendously expanding in many developing countries including Ethiopia (Ayele, 2012). However, its production has been hindered by both biotic and abiotic factors. Rice blast disease, caused by *Pyricularia oryzae* Cavara (teleomorph *Magnaporthe grisea* (Hebert) Barr), is one of the biotic factor and the most destructive of all rice diseases impeding rice production in more than 85 countries in the world (Katsantonis *et al.*, 2017; Shahriar *et al.*, 2020). The disease is responsible for approximately 30% of rice yield losses globally that would feed 60 million people (Nalley *et al.*, 2016). Thus, any reduction in rice blast disease would have a substantial contribution to food security and people's welfare.

Management of rice blast has been extensively investigated, where different disease management strategies have been examined. These include biological control (using antagonistic *Pseudomonas*, *Bacillus* (Wei *et al.*, 2020), *Trichoderma harzianum* (Chou *et al.*, 2020) and *Streptomyces* spp. (Law *et al.*, 2017), host resistance (using disease-resistant cultivars), cultural control (e.g.

reducing N fertilizers, using organic manure, using disease-free seed, etc.) (Abbas *et al.*, 2021), chemical control (i.e., application of either synthetic fungicides (Cruz *et al.*, 2019) or botanical fungicides (e.g. applying essential oils or extracts, neem seed extracts with antifungal properties) (Katsantonis *et al.*, 2017). Nowadays, rice blast disease management is more advanced and the integrated pest management (IPM) approach is mostly used for effective management in the countries with more advanced agricultural technologies such as Japan, China), the USA, and some European countries. Nevertheless, rice blast has never been eliminated from a region where rice is grown (Katsantonis *et al.*, 2017).

Among these management alternatives, the use of host resistance is believed to be the most effective and inexpensive method for farmers to control rice blast. However, the use of host resistance is hardly practiced in low-income countries due to the length of time and high initial budget requirement to develop resistant varieties (Lakew *et al.*, 2020; Zhou *et al.*, 2007). Most of the other management strategies are also preventive and do not work when rice disease epidemics occur in the field. On the other hand, fungicide application is the best option for immediate action, and thus, remains the dominant practice for controlling rice blast even in the countries with advanced disease management technologies (Todorova and Kozhuharova, 2010). In Africa, Asia, and South America, fungicide application seems to be the only option accessible to rice farmers for rice blast disease management because the other management technologies development and/or adoption are not advanced yet.

Despite the vast demand for fungicide for the control of rice blast disease globally, the number of available effective fungicide's active ingredients is limited. Naik *et al.* (2012) have tested ten common active ingredients (i.e., dithane, carbendazim, propiconazole, mancozeb, wettable sulfur, thiophanate methyl, benomyl, ediphenphos, kitazine, and tricyclazole) for their efficacy against rice blast in India and reported that only ediphenphos, kitazine, and tricyclazole were effective for rice blast control, and only tricyclazole increased crop yield (Naik *et al.*, 2012). In Ethiopia, however, investigations in this regard were limited so far notwithstanding the current changes in the rice disease pressure. This might be because the crop has a short history in the country (Ayele, 2012; Alemu *et al.*, 2018) and had no severe disease problem up to recent. Currently, rice diseases have been increasing both in prevalence and intensity in the country with rice blast being the most severe (Zeleke *et al.*, 2019). Therefore, this study was initiated to identify fungicides with effective active ingredient(s) for the control of rice blast disease.

MATERIALS AND METHODS

Site description

The experiment was conducted at Pawe research center of Ethiopian Institute of Agricultural Research (EIAR) from June to October during 2017 and 2018. Pawe Agricultural Research Center (PARC) is located $11^{0}19$\` N and $36^{0}24$\` E at a height of 1120 meters above sea level (m.a.s.l.). The center receives an average rainfall of 1586 mm with mean monthly minimum and maximum temperature of 16.5 ^{0}C and 32.7 ^{0}C, respectively. The area has been experienced high rice blast disease pressure in the country due to the prevailing high relative humidity which more than 75%, and other suitable weather conditions and cropping systems for the development of the disease.

Fungicide materials

Chemical fungicides used in this study comprised of seven (7) registered fungicides in Ethiopia for the control of different diseases on various crops. Six of these fungicides (Amistar Xtra 280 SC, Artea 330 EC, Fungozeb 80 WP, Matco, Rex® Duo, and Tilt 250 EC) were purchased from Gojam Berenda agrochemical trading while another fungicide (Contaf Max 350 SC) was obtained from Chemtex private limited company.

Treatments, experimental design, and procedures

Eight treatments consisting of seven fungicides and one negative check (untreated plot) were evaluated under natural infection of rice blast pathogen at field conditions of upland rice ecosystem at PARC for the control of blast disease. For all treatments, Getachew rice variety, which is susceptible to blast disease, was seeded on June 17 and 15 during 2017 and 2018 cropping seasons, respectively, in RCBD design with three replications. The plot size was 2.4 m * 3 m, and blocks, plots and rows were spaced by 1.5 m, 1 m and 0.2 m, respectively, giving rise to a total experimental area of 314.4 m^2 (12 m length * 26.2 m width).

Fungicide application

The test fungicides were applied using a lever-operated knapsack sprayer at the first appearance of disease symptoms (i.e., August 23 in 2017 and August 02 in 2018) and then repeated once after 14 days following the manufacturer's recommendation rate for each fungicide (Table 1). In this case, the second time application was applied at the booting stage of the rice plant in both seasons (i.e., August 23 in 2017 and August 02 in 2018).

Table 1. Fungicide's trade name, active ingredients, application rate ha^{-1}, and sources in Ethiopia.

SN	Trade name	Common names (Active ingredients)	Application rate ha^{-1}	Source (Registrant)[a]
1	Amistar Xtra 280 SC	Azoxystrobin 200 gm/lt + Cyproconazole 80 gm/lt	0.5 L	6
2	Artea 330 EC	Propiconazole + Cyproconazole	0.5 L	6
3	Contaf Max 350 SC	Hexaconazole 50 + Tricyclazole 300 gm/lt	1 L	2
4	Fungozeb 80 WP	Mancozeb	2.5 Kg	15
5	Matco	Metalaxyl 8% + mancozeb 64%WP	2.5 Kg	22
6	Rex® Duo	Epoxiconazole + Thiophanate- methyl	0.5 L	29
7	Tilt 250 EC	Propiconazole	1 L	6

[a]2 = Chemtex P.L.C., 6 = Adami-Tulu Pesticides Processing Factory, Ato Kassahun, 15 = Belayne Kinde Importer, 22 = Arysta Life Science Mauritius Ltd., and 29 = BASF Trade Representative Office. The table is modified from MoANR (2019).

Disease assessment

Panicle blast severity and neck blast severity were assessed 20 days after heading using a standard evaluation system for rice blast described by IRRI (IRRI, 2013).

Panicle blast severity (PBS)

Based on the number of panicles with each scale, compute panicle blast severity (PBS) as follows:

$$PBS = \frac{(10 \times N1) + (20 \times N3) + (40 \times N5) + (70 \times N7) + (100 \times N9)}{Total\ No. of\ Panicles\ Observed}$$

Where N_1-N_9 are the number of panicles with score 1-9. At growth stage: 8 (20-25 days after heading).

Neck blast severity (NBS)

Neck blast severity was assessed as mass evaluation of panicle blast incidence counting only the number of panicles with lesions covering completely around the neck or lower part of the panicle axis (symptom type 7-9 in table 2 and table 3). Besides disease data, agronomic data such as number of tillers, plant height (cm), panicle length (cm), number of seed per panicle, thousand seed weight (g), and grain yield (kg ha^{-1}) were collected based on the standard evaluation system for rice (IRRI, 2013).

The relative yield gain, percent PBS and NBS reduction in reference to the untreated plot (control) were computed by the following formulas and presented in graph;

$$\text{Relative yield gain (\%)} = \frac{(\text{Yield of treated plot} - \text{Yield of untreated plot})}{\text{Yield of treated plot}} \times 100$$

$$\text{Percent PBS reduction (\%)} = \frac{(\text{PBS of untreated plot} - \text{PBS of treated plot})}{\text{PBS of untreated plot}} \times 100$$

$$\text{Percent PBS reduction (\%)} = \frac{(\text{PBS of untreated plot} - \text{PBS of treated plot})}{\text{PBS of untreated plot}} \times 100$$

Table 2. Standard procedure used for recording rice panicle blast disease.

Scale	Symptom
0	No visible lesion or observed lesions on only a few pedicels.
1	Lesions on several pedicels or secondary branches.
3	Lesions on a few primary branches or the middle part of panicle axis.
5	Lesion partially around the base or the uppermost internode or lower part of panicle axis near the base.
7	Lesion completely around panicle base or uppermost internode or panicle axis near base with more than 30% of filled grains.
9	Lesion completely around panicle base or uppermost internode or the panicle axis near the base with less than 30% of filled grains.

Source: IRRI (2013).

Table 3. Procedures used for recording neck blast severity.

Scale	Incidence of infected panicles with symptom type 7-9
0	No disease observed
1	Less than 5%
3	5-10%
5	11-25%
7	26-50%
9	More than 50%

Source: modified from IRRI (2013).

Data analysis

The data were arranged on Microsoft Excel and analyzed in R software (R Core Team, 2021). The disease data were transformed by ArcSin before data analysis. One-way analysis of variance (ANOVA) were used to determine the level of significant difference among chemical fungicides. Since the treatment effects on grain yield, PBS and NBS were significantly varied over the seasons and the fungicide x season interaction was non-significant for grain yield and PBS, separate analysis was done for each year. The means were compared using Duncan's multiple range test (DMRT) at 5% probability level.

RESULTS

Effect of fungicides application on rice blast disease severity

In 2017, the application of all fungicides has significantly reduced the PBS and NBS compared to the control with no significant variation among the fungicides at 5% probability level. The PBS was ranged from 14.3 – 19.7% with the mean of 15.4% while the NBS was ranged from 13.6 – 41.2% with the mean of 17.4% (Table 4, 5).

In 2018, means of fungicides were significantly varied for PBS and NBS with the range of 13.8 – 29.3% (20.9%, mean) and 18.9 – 45.7% (28.3%, mean), respectively. The lowest PBS was recorded on the plot treated with Contaf Max 350 SC (13.8%) and significantly different from that of recorded on the plot treated with the rest of test fungicides while the highest PBS was recorded on the untreated plot (29.3%) followed by Tilt 250 EC (25.7%). On the other hand, the lowest and statistically similar NBS was recorded on the plot treated with Contaf Max 350 SC (18.9%), Amistar Xtra 280 SC (19.2%) and Rex® Duo (19.5%). The highest NBS was recorded on the untreated plot (45.7%) followed by Tilt (37.1%) (Table 6).

Overall mean of the two-year data showed that fungicides were significantly varied for PBS and NBS with the lowest severity recorded on the plot treated with Contaf Max 350 SC followed by Rex® Duo and Amistar Xtra 280 SC (Table 7). The untreated plot demonstrated the highest PBS (24.5%) and statistically significantly different from that of the plot treated with all fungicides except Tilt 250 EC (20.0%). Similarly, the lowest NBS was recorded on the plot treated with Contaf Max 350 SC (16.2%) followed by Rex® Duo (16.5%) while the highest NBS was recorded on the untreated plot (43.4%) followed by Tilt 250 EC (26.1%) and Matco (24.6%).

Table 4. Summary of analysis of variance mean squares for the effect of fungicides on agronomic, yield, and disease parameters at Pawe, northwest Ethiopia.

SOV	df	NTM	PH	PL	NSPP	TSW	GY	PBS	NBS
Season (S)	1	16.33	6009.93***	60.30***	38.88***	159.14***	113294781.53***	455.10***	2220.88***
Fungicides (F)	7	3.79	36.16	1.26	0.71	5.79	889791.22*	82.21**	1045.51***
F x S	7	4.412	49.78	1.18	0.47	3.13	194637.75	36.52	165.70*
Error	30	4.04	28.27	2.38	0.95	2.82	363922.68	20.32	51.05
Mean		7.98	115.49	21.47	9.07	28.59	4970.84	9.75	16.87
CV (%)		25.21	4.6	7.17	10.73	5.86	12.13	46.21	42.36

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05, SOV = Source of variation, df = Degree of freedom, NTM = Number of tillers at maturity stage, PH = Plant height (cm), PL = Panicle length (cm), NSPP = Number of seed per panicle, TSW = Thousand seed weight (g), GY = Grain yield ($kgha^{-1}$), PBS = Panicle blast severity (%), NBS = Neck blast severity (%), and CV = Coefficient of variation.

Table 5. Effect of different fungicides on rice blast disease and rice crop yield and yield component parameters, during 2017.

Fungicide	NTM	PH	PL	NSPP	TSW	GY	PBS	NBS
Tilt 250 EC	8	105	19.8	91	26.5	3577.6±550	14.3±0.8^b	15.2±1.6^b
Amistar Xtra 280 SC	10	105.3	20.8	93	26.7	3279±177	14.8±1.2^b	14.9±1.3^b
Control	9	98.8	20.2	93	25.9	2818.7±261	19.7±1.9^a	41.2±0.6^a
Artea 330 EC	8	100.3	19.3	82	26.5	3273±291	15.1±0.8^b	13.6±0.0^b
Fungozeb 80 WP	8	106.7	20.5	90	25.5	3677±511	14.3±0.8^b	13.6±0.0^b
Rex® Duo	8	100.6	20.5	87	26.8	3540.7±455	16.2±1.3^b	13.6±0.0^b
Matco	9	111	21	97	27.7	3511.8±187	14.3±0.8^b	13.6±0.0^b
Contaf Max 350 SC	10	106.7	20.7	99	28.5	3798.7±478	14.3±0.8^b	13.6±0.0^b
Mean	9	104.3	20.4	92	26.8	3434.5	15.4	17.4
CV (%)	26.7	4.4	6.5	10.2	5.9	13.5	12.3	7.2
Signif. (P<0.05)							*	***

Means followed by the same letter in the same column are not statistically different by Duncan's Multiple Range test (DMRT) at 5%.
Signif. codes: '***' 0.001 '*' 0.05, GY = Grain yield ($Kgha^{-1}$), PBS = Panicle blast severity (%), NBS = Neck blast severity (%), and CV = Coefficient of variation.

Table 6. Effect of different fungicides on rice blast disease and rice crop yield and yield component parameters, during 2018.

Fungicide	NTM	PH	PL	NSPP	TSW	GY	PBS	NBS
Tilt 250 EC	6	128.6	23.3	109	28.8	6302±127[bc]	25.7±5.4[ab]	37.1±8.2[ab]
Amistar Xtra 280 SC	6	125.1	22.1	110	31.8	6625.5±176[bc]	19.5±0.6[bc]	19.2±0.3[c]
Control	7	128.5	22	108	28.2	5830.8±294[c]	29.3±4.3[a]	45.7±0.4[a]
Artea 330 EC	8	121.5	21.9	106	32	6005.7±128[c]	19.8±0.5[bc]	25.1±5.7[bc]
Fungozeb 80 WP	7	128.7	22.9	107	30.5	6410.1±471[bc]	19.5±0.6[bc]	25.1±4.8[bc]
Rex® Duo	9	131.9	23.9	104	31	6988.5±371[ab]	19.2±0.3[bc]	19.5±0.3[c]
Matco	6	126.3	22.4	108	29.5	6458±423b[c]	20.7±0.0[bc]	35.6±1.1[ab]
Contaf Max 350 SC	9	122.7	22.2	110	31.5	7436.5±53[a]	13.8±1[c]	18.9±0.0[c]
Mean	7	126.7	22.6	108	30.4	6507.2	20.9	28.3
CV (%)	22.5	3.8	7.1	9.2	6	6.4	19.7	22.6
Signif. (P<0.05)						*	*	***

Means followed by the same letter in the same column are not statistically different by Duncan's Multiple Range test (DMRT) at 5%.
Signif. codes: '***' 0.001 '*' 0.05, GY = Grain yield ($Kgha^{-1}$), PBS = Panicle blast severity (%), NBS = Neck blast severity (%), and CV = Coefficient of variation.

Table 7. Effect of different fungicides on rice blast disease and rice crop yield and yield component parameters, overall mean of the two years.

Fungicide	NTM	PH	PL	NSPP	TSW	GY	PBS	NBS
Tilt 250 EC	7	116.8	21.5	100	27.7	4939.9±660[abc]	20.0±3.5[ab]	26.1±6.2[b]
Amistar Xtra 280 SC	8	115.2	21.5	102	29.3	4952.3±757[abc]	17.1±1.2[bc]	17.0±1.1[d]
Control	8	113.6	21.1	101	27	4324.7±696[c]	24.5±3[a]	43.4±1.1[a]
Artea 330 EC	8	110.9	20.6	94	29.3	4639.4±627[bc]	17.5±1.1[bc]	19.3±3.6[cd]
Fungozeb 80 WP	7	117.7	21.7	98	28	5043.9±686[abc]	16.9±1.2[bc]	19.3±3.4[cd]
Rex® Duo	8	116.6	22.2	96	28.9	5264.6±814[ab]	17.7±0.9[bc]	16.5±1.3[d]
Matco	8	118.6	21.7	102	28.6	4984.9±691[abc]	17.5±1.5[bc]	24.6±4.9[bc]
Contaf Max 350 SC	9	114.7	21.5	105	30	5617.1±842[a]	14.1±0.6[c]	16.2±1.2[d]
Mean	8	115.5	21.5	100	28.6	4970.8	18.2	22.8
CV (%)	25.2	4.6	7.17	10.73	5.86	12.13	46.21	42.36
Signif. (P<0.05)	ns	ns	Ns	ns	ns	*	**	***

Means followed by the same letter in the same column are not statistically different by Duncan's Multiple Range test (DMRT) at 5%.
Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05, GY = Grain yield ($Kgha^{-1}$), PBS = Panicle blast severity (%), NBS = Neck blast severity (%), and CV = Coefficient of variation.

Accordingly, the fungicides' percent panicle blast severity suppression was ranged from 11.1 – 51.5% and percent neck blast severity suppression was ranged from 18.9 – 67% compared to the control (untreated plot) (Figure 1-3).

Effect of fungicides application on rice grain yield

The analysis of variance revealed that the means of fungicides were significantly varied (P < 0.05) for grain yield while there was no variation among treatment for number of tillers, plant height, panicle length, number of seed per panicle and thousand seed weight both during 2017 and 2018 cropping seasons (Table 5-7).

In 2017, application of Contaf Max 350 SC resulted in the highest grain yield (3798.7 kg ha^{-1}) followed by Fungozeb 80 WP (3677.6 kg ha^{-1}) (Table 5). Again, in 2018, Contaf Max 350 SC fungicide application gave the highest grain yield (7436.5 kg ha^{-1}) followed by Rex® Duo (6988.5 kg ha^{-1}) (Table 6). The lowest grain yield was harvested from the untreated plot both in 2017 (2818.7 kg ha^{-1}) and 2018 (5830.8 kg ha^{-1}). As reflected in table 7, the highest overall mean of grain yield was obtained in Contaf Max 350 SC (5617.1 kg ha^{-1}) followed by Rex® Duo (5264.6 kg ha^{-1}) and Fungozeb 80 WP (5043.9 kg ha^{-1}) while the lowest (4324.7 kg ha^{-1}) was obtained in control (untreated plot).

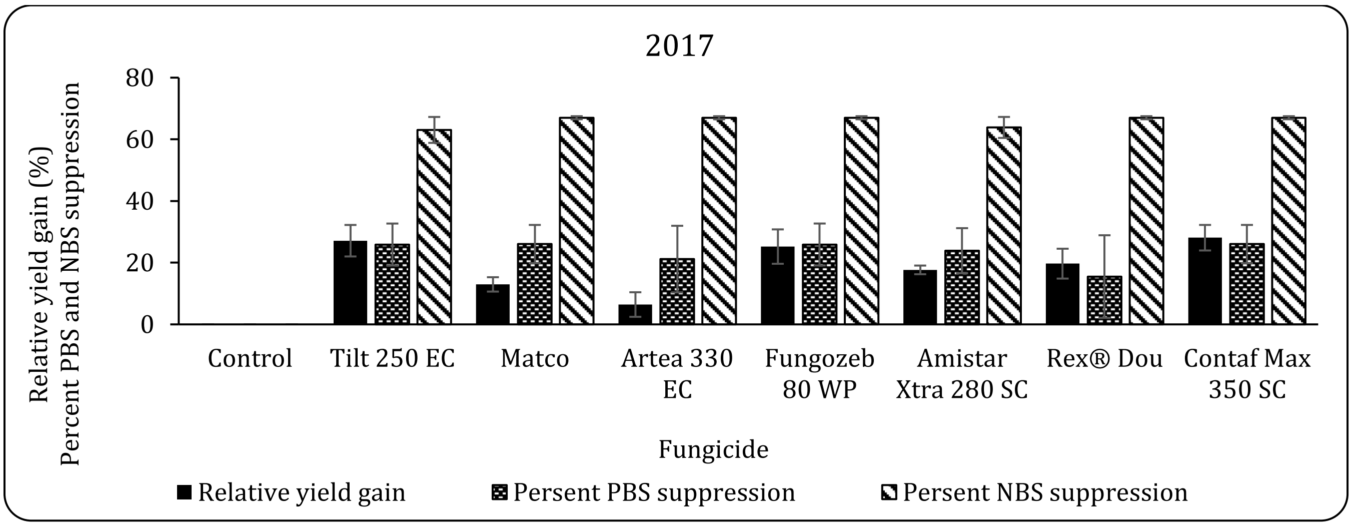

Figure 1. Percent blast severity suppression and relative yield gain by different fungicides application on rice, during 2017 cropping season.

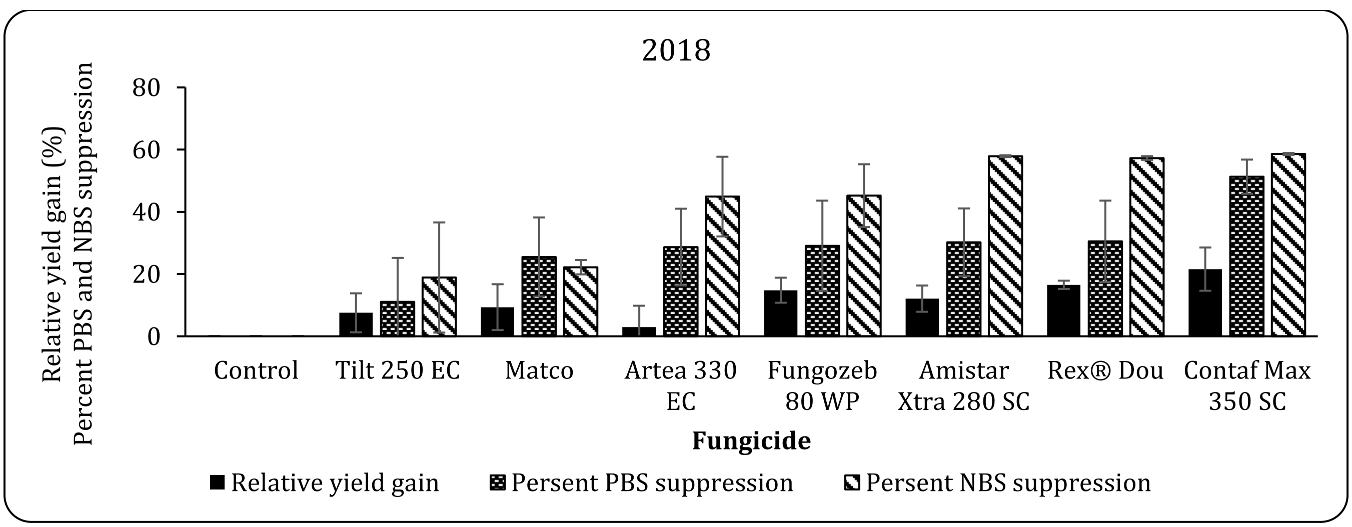

Figure 2. Percent blast severity suppression and relative yield gain by different fungicides application on rice, during 2018 cropping season.

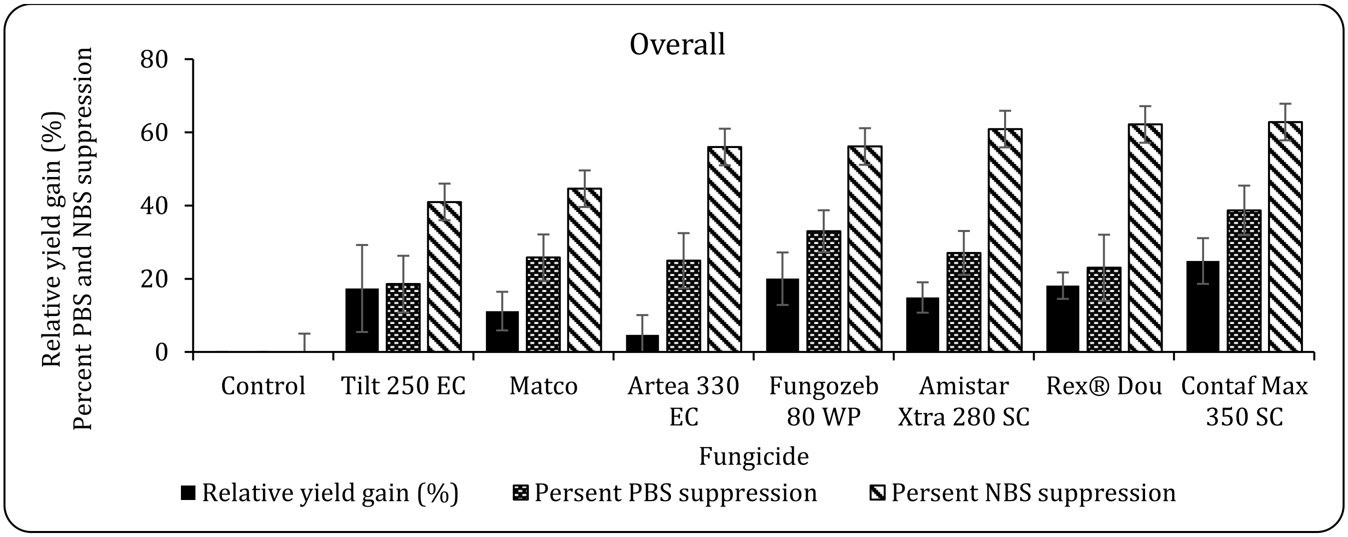

Figure 3. Percent blast severity suppression and relative yield gain by different fungicides application on rice, overall mean of the two years.

Though the grain yield obtained from Tilt 250 EC (4939.91 kg ha^{-1}) and Amistar Xtra 280 SC (4952.25 kg ha^{-1}) were lower than the average grain yield (4970.84 kg ha^{-1}), they were not significantly different from the obtained from the plot treated with Contaf Max 350 SC and other test fungicides except Artea 330 EC and control. Nevertheless, the relative yield gains due to the application of fungicides ranged from 3 – 28.1% with the maximum yield gain in Contaf Max 350 SC, Rex® Duo and Fungozeb 80 WP fungicides application (Figure 1-3).

DISCUSSION

Even though the use of pesticide for pest management is considered as the last resort, it has remained dependable in developing countries due to its quick response once the disease appeared in the field coupled with the lack or less advancement of other management options of the disease (Todorova and Kozhuharova, 2010). In early years, copper and mercury compounds were recommended against blast but were found not suitable because of phytotoxicity and mammalian toxicity (Kumar *et al.*, 2013). Chemical fungicides with isoprothiolane, probenazole, pyroquilon, and tricyclazole active ingredient(s) are generally considered effective for the control of rice blast. However, their level of effectiveness to suppress rice blast disease development differ (Kumar *et al.*, 2013).

In this study, seven fungicides were tested for the control of rice blast under field conditions of the upland rice ecosystem at Pawe, northwest Ethiopia. The result revealed that all the test fungicides have significantly reduced blast disease severity as compared to the control, except Tilt 250 EC in the case of panicle blast severity (Table 6-7). However, Contaf Max 350 SC fungicide that constitutes hexaconazole 50 and tricyclazole 300g/l SC active ingredients were superior among the test fungicides in suppressing rice blast disease development. It exhibited the highest percent of neck blast reduction (>60%) and resulted in the highest grain yield (5617.06 Kgha^{-1}) with up to 28% yield gain over the control. Rex® Dou was the second most effective fungicide though the yield harvested from the plot treated with it was lesser by 352 Kg than that of harvested from the plot treated with Contaf Max 350 SC. Fungozeb 80 WP and Amistar Xtra 280 SC fungicides were also effective in disease reduction and gave a yield that was statistically similar to that of Rex® Dou and can be considered as an alternative fungicide for the management of rice blast in the absence of Contaf Max 350 SC. However, fungicides with single active ingredient and contact type, for instance, Tilt 250 EC and Matco were found less effective for the management rice blast disease in the present study. Similarly, Moktan *et al.* (2021) have reported that all tested fungicides effectively reduced leaf blast but tricyclazole was superiorly effective and resulted in the highest grain yield. Gohel and Chauhan (2015) have tested the integrated management of leaf and neck blast disease using fungicides (tricyclazole, iprobenfos, and mancozeb), bio-agent (*Pseudomonas flourescens* 2x10^{8}

CFU/g), and botanicals (*Azadirachta indica* leaf extract 10% and *Ocimum sanctum* leaf extract 10%), and proved that tricyclazole was significantly superior over the rest of the treatments for controlling rice blast disease and increasing the yield. The other scholars had also tested the efficacy of fungicides with active ingredient combinations and reported tricyclazole 22% + Hexaconazole 3% SC (0.2%) as the most effective treatment for the control rice blast (Magar *et al.*, 2015).

The disease severity through the two examination seasons were significantly different with almost two-fold higher in 2018 than that of in 2017. This could be related to several factors such as late occurrence of the disease in 2017 (August 23), soil fertility level and other edaphic and micro-climate conditions. In 2017, the plant height, number of seed per panicle, thousand seed weight and grain yield recorded were lesser compared to that of 2018 when there is less disease pressure, suggesting that there was low soil fertility. Nevertheless, the efficacy of test fungicides exhibited similar trend in both seasons. Therefore, the present results suggest that twice application of Contaf Max 350 SC fungicide at the rate of 1 Lha^{-1} is effective for the management of rice blast disease in Pawe and other places with a similar condition.

ACKNOWLEDGMENT

The authors would like to thank the Ethiopian Institute of Agricultural Research /EIAR/ and Chemtex P.L.C for the provision of financial support (Code: 21-07) and chemical fungicide (Contaf Max 350 SC), respectively.

REFERENCES

Abbas, R. N., A. Iqbal, M. A. Iqbal, O. M. Ali, R. Ahmed, R. Ijaz, A. Hadifa and B. J. Bethune. 2021. Weed-Free durations and fertilization regimes boost nutrient uptake and paddy yield of direct-seeded fine rice (*Oryza sativa* L.). Agronomy, 11: 2448.

Alemu, D., A. Tesfaye, A. Assaye, D. Addis, T. Tadesse and J. Thompson. 2018. A historical analysis of rice commercialisation in Ethiopia: The case of the Fogera Plain.

Ayele, A. 2012. Rice Extension Approaches and Extension Packages in Ethiopia. In: F. Reda, D. Alemu, S. Kiyoshi and A. Kirub (eds.), Backing Rice Extention Rightly. EIAR/ FRG II. Addis Ababa, Ethiopia.

Chou, C., N. Castilla, B. Hadi, T. Tanaka, S. Chiba and I. Sato. 2020. Rice blast management in Cambodian rice fields using *Trichoderma harzianum* and a resistant variety. Crop Protection, 135: 104864.

Cruz, C. D., F. M. Santana, T. C. Todd, J. L. Maciel, J. Kiyuna, D. F. Baldelomar, A. P. Cruz, D. Lau, C. S. Seixas and A. C. Goulart. 2019. Multi-environment assessment of fungicide performance for managing wheat head blast (WHB) in Brazil and Bolivia. Tropical Plant Pathology, 44: 183-91.

Gohel, N. and H. Chauhan. 2015. Integrated management of leaf and neck blast disease of rice caused by *Pyricularia oryzae*. African Journal of Agricultural Research, 10: 2038-40.

IRRI. 2013. Standard Evaluation System (SES) for Rice. Manila, Philippines.

Katsantonis, D., K. Kadoglidou, C. Dramalis and P. Puigdollers. 2017. Rice blast forecasting models and their practical value: A review. Phytopathologia Mediterranea, 56: 187-216.

Kumar, M. P., D. S. Gowda, R. Moudgal, N. K. Kumar, K. P. Gowda and K. Vishwanath. 2013. Impact of fungicides on rice production in India. In, Fungicides-showcases of integrated plant disease management from around the world.

Lakew, T., Y. Fukuta and R. Ishikawa. 2020. Genetic study of diversity and blast resistance in Ethiopian rice cultivars adapted to different ecosystems. Breeding science, 70: 18198-204.

Law, J. W.-F., H.-L. Ser, T. M. Khan, L.-H. Chuah, P. Pusparajah, K.-G. Chan, B.-H. Goh and L.-H. Lee. 2017. The potential of *Streptomyces* as biocontrol agents against the rice blast fungus, *Magnaporthe oryzae* (*Pyricularia oryzae*). Frontiers in microbiology, 8: 1-10.

Magar, P. B., B. Acharya and B. Pandey. 2015. Use of chemical fungicides for the management of rice blast (*Pyricularia grisea*) disease at Jyotinagar, Chitwan, Nepal. International Journal of Applied Sciences and Biotechnology, 3: 474-78.

Moktan, R., A. Aryal, S. Karki, A. K. Devkota, B. Acharya, D. Joshi and K. Aryal. 2021. Evaluation of different chemical fungicides against rice blast in field conditions. Journal of Agriculture and Natural Resources, 4: 295-302.

Naik, G., G. Naik, B. Naik and K. Naik. 2012. Fungicidal management of leaf blast disease in rice. Global Journal Bioscience and Biotechnology, 1: 18-21.

Nalley, L., F. Tsiboe, A. Durand-Morat, A. Shew and G.

Thoma. 2016. Economic and environmental impact of rice blast pathogen (*Magnaporthe oryzae*) alleviation in the United States. PLoS One, 11: e0167295.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. https://www.r-project.org/

Shahriar, S. A., A. A. Imtiaz, M. B. Hossain, A. Husna and M. N. K. Eaty. 2020. Rice Blast Disease. Annual Research and Review in Biology, 35: 50-64.

Skamnioti, P. and S. J. Gurr. 2009. Against the grain: Safeguarding rice from rice blast disease. Trends in biotechnology, 27: 141-50.

Todorova, S. and L. Kozhuharova. 2010. Characteristics and antimicrobial activity of *Bacillus subtilis* strains isolated from soil. World Journal of Microbiology and Biotechnology, 26: 1207-16.

Wei, Y., L. Li, W. Hu, H. Ju, M. Zhang, Q. Qin, S. Zhang and G. Li. 2020. Suppression of rice blast by bacterial strains isolated from cultivated soda saline-sodic soils. International Journal of Environmental Research and Public Health, 17: 5248-57.

Zeleke, T., M. Birhan and W. Ambachew. 2019. Survey and identification of rice diseases in South Gondar Zone, Amhara Region, Ethiopia. Journal of Agriculture and Crops, 5: 123-31.

Zhou, E., Y. Jia, P. Singh, J. C. Correll and F. N. Lee. 2007. Instability of the *Magnaporthe oryzae* avirulence gene AVR-Pita alters virulence. Fungal Genetics and biology, 44: 1024-34.

CONFLICT OF INTEREST

We, the authors would like to declare that there is no conflict of interest regarding the publication of this article

AUTHORS CONTRIBUTIONS

Jemal T. Horo did roposal writing, data analysis, first draft writing and editing; Tesfaye Gudisa conducted the experiment, performed data collection and manuscript editing.