EVALUATION OF TRIAZOLE AND STROBILURIN FUNGICIDES AGAINST LEAF AND PANICLE BLAST OF RICE IN FARMER'S FIELD

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ABSTRACT

Blast disease of rice caused by the ascomycetes fungus *Magnaporthe grisea* poses a major threat to rice production from terai to hilly region of Nepal. Field trials were conducted in two successive years, 2021 and 2022 at Bharatpur-5, Chitwan in a farmer's field producing seed of Hardinath-1 variety with the main objective of finding the effective single and/or pre-mix formulation of triazole and strobilurin fungicides against rice blast that could be an alternative to tricyclazole. The trials were conducted in randomized complete block design with three replications and eight treatments viz. azoxystrobin 18.2% + difenoconazole 11.4% SC, propiconazole 13.9% + difenoconazole 13.9% EC, azoxystrobin 11% + tebuconazole 18.3% SC, azoxystrobin 23% SC, propiconazole 25% EC, difenoconazole 25% EC, tebuconazole 25%WDG and a control. The fungicides were applied during tillering and heading stage at the rate of 0.1%. All fungicides significantly reduced the leaf and panicle blast severity resulting in a higher yield. Among the tested fungicides, pre-mix formulation fungicide azoxystrobin 18.2% + difenoconazole 11.4% SC, propiconazole 13.9% + difenoconazole 13.9% EC and azoxystrobin 11% + tebuconazole 18.3% SC gave excellent performance with the lowest leaf and panicle blast severity and higher yield. Hence, these three fungicides could be used for the management of leaf and panicle blast disease for higher yield. However, controlling rice blast disease has become increasingly challenging due to the pathogens' capacity to adapt and evolve into new, more potent strains, making the management and control of this disease more difficult.

Key words : *Magnaporthe grisea*, management, severity, strobilurin, triazole

INTRODUCTION

Blast disease in rice caused by the ascomycetes fungus *Magnaporthe grisea* (Hebert) Barr is a destructive disease occurring worldwide from tropical to temperate region of rice growing area and causes severe damage every year (Kafle *et al.*, 2021; Kunova *et al.*, 2012). In Nepal, rice blast disease was recorded in 1966 for the first time and it was distributed from terai to hilly region (Sharma *et al.*, 2022). It poses major challenge to rice production in Nepal (Magar *et al.*, 2015). The blast fungus can attack all aboveground parts of the rice plant at all stages of growth (IRRI, 2023) although the leaves and the neck of the panicle are most commonly affected.

Depending on various factors like crop growth stage during infection, prevailing weather, cultural practices, inoculum pressure, and varietal susceptibility, the pathogen causes upto 80% yield loss (Groth, 2006). The rice blast can result in 10-20% yield reduction in susceptible varieties, however in severe cases, 80% yield loss may occur (Manandhar *et al.*, 1992). Manandhar *et al.* (1985) reported that 21 to 51 kg/ha grain yield loss in rice variety 'Sankharika" for 1% increase in neck blast. Similarly, 38.5 and 76.0 kg/ha grain yield loss were reported in the rice variety 'Masuli' and 'Radha-17', respectively, when there is 1% increase in neck blast (Chaudhary, 1999). There are several approaches recommended to farmers for the management of rice blast (Kunova *et al.*, 2014; Pak *et al.*, 2017), including use of resistant varieties, improved cultural practices, irrigation and nutrient management, however use of fungicides is still an effective and popular method for blast management in rice (Chen *et al.*, 2015; Kumar *et al.*, 2021; Pak *et al.*, 2017).

Several fungicides including triazole and strobilurin have been registered in Nepal to control various plant diseases (Plant Quarantine and Pesticide Management Centre, 2019). Various researchers have reported the use of single and/or mixed formulation of triazole and strobilurin fungicides against rice blast (Ahmad *et al.*, 2020; Ghazanfar *et al.*, 2009; Kongcharoen *et al.*, 2020; Kunova *et al.*, 2012; Mustafa *et al.*, 2013). Systemic fungicides like triazole and strobilurin should be used judiciously for the control of blast as they pose the risk of development of resistance in pathogens (Chen *et al.*, 2015). Tricyclazole is one of the most common recommended and frequently used fungicides to control blast disease (Mohiddin *et al.*, 2021; Moktan *et al.*, 2021), however, resistance to blast pathogen has been reported from all round the world (Bezerra *et al.*, 2021; Zhang *et al.*, 2006; Zhang *et al.*, 2009). So, it is necessary to find out the effective fungicides as alternative to tricyclazole. The present study was carried out to identify potential single and/or mixed formulation of triazole and strobilurin fungicides that could be used as alternative to tricyclazole for blast disease management.

MATERIALS AND METHODS

Field experiments were carried out in 2021 and 2022 in a progressive farmer's field continuously cultivating rice for seed production at Bharatpur-5, Chitwan, Nepal. The trials were conducted in randomized complete block design with 8 treatments and 3 replications. The treatments consisted of single and mixed formulation of triazole and strobilurin fungicides (Table 1). The foundation seed of Hardinath-1 was purchased from Unnat Beej Bridhi Krishak Samuha, a cooperative seed producing and processing company located in Bharatpur, Chitwan. Twenty-five days old seedlings were transplanted in a puddled field at the spacing of 20 cm × 20 cm on 3rd week of July. The plot size measuring 3 m × 3 m were marked and 10 plants excluding border plants were randomly selected and tagged in each plot. All the cultural practices like weeding, irrigation, fertilizer application were done as recommended. Treatments were applied at 30 days after transplanting (DAT) and 60 DAT. The leaf blast severity was recorded 3 times using 0 - 9 rating scale given by International Rice Research Institute (IRRI, 2013) after 7 days of 1st spray at 7 days interval and panicle blast severity was recorded only once using 0 - 9 rating scale given by International Rice Research Institute (IRRI, 2013) after 20 days of 2nd spray (milk stage). The leaf blast severity was calculated by the formula given by Magar *et al.* (2015) and panicle blast severity was calculated by formula given by IRRI (2013).

$$\text{Leaf blast severity (LBS)} = \frac{\text{Sum of all rating}}{\text{Total number of observation x highest rating in the rating scale}} \text{ x } 100$$

$$\text{Panicle blast severity (PBS)} = \frac{(10 \text{ x N1}) + (20 \text{ x N3}) + (40 + \text{N5}) + (70 + \text{N7}) + (100 \text{ x N9})}{\text{Total number of panicles observed}}$$

where,

N1 - N9 = Number of panicles with rating from 1 to 9.

Harvesting was done from 1 m^2 area in the centre of plot and the yield was converted to kg/ha, and its moisture content was measured. The yield of grain at standard moisture (12%) was calculated by a formula given by Timsina *et al.* (2023).

$$\text{Grain yield} = \frac{\text{Harvest yield x (100 – Harvest moisture)}}{\text{(100 – Standard moisture)}} \text{ x } 100$$

The collected data entered into the Microsoft excel 2010 program and the variables were statistically analyzed using ANOVA with the help of R studio (R Core Team., 2022). Leaf blast and panicle blast severity were statistically analyzed after performing arcsine transformation as suggested by Gomez and Gomez (1984) and treatment mean were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance. Results of the statistical analyses are presented in table and graph below.

Table 1. Treatment details

Treatments	Fungicide	Group	Mode of action	Dose
T1	Azoxystrobin 18.2% + Difenoconazole 11.4% SC	Triazole + Strobilurin	Respiration inhibitors + Sterol biosynthesis inhibitors	1 ml/l water
T2	Propiconazole 13.9% + Difenoconazole 13.9% EC	Triazole + Strobilurin	Sterol biosynthesis inhibitors+ Sterol biosynthesis inhibitors	1 ml/l water
T3	Azoxystrobin 11% + Tebuconazole 18.3% SC	Triazole + Strobilurin	Respiration inhibitors + Sterol biosynthesis inhibitors	1 ml/l water
T4	Azoxystrobin 23% SC	Strobilurin	Respiration inhibitors	1 ml/l water
T5	Propiconazole 25% EC	Triazole	Sterol biosynthesis inhibitors	1 ml/l water
T6	Difenoconazole 25% EC	Triazole	Sterol biosynthesis inhibitors	1 ml/l water
T7	Tebuconazole 25%WDG	Triazole	Sterol biosynthesis inhibitors	1 g/l water
T8	Control (water spray)			

RESULTS AND DISCUSSION

Leaf blast severity differed highly significantly ($p \leq 0.01$) among the treatments in 2021 and 2022 (Table 2). Overall, the lowest leaf blast severity was observed in azoxystrobin 11% + tebuconazole 18.3% SC (20.14 ± 2.49) treated plot followed by azoxystrobin 18.2% + difenoconazole 11.4% SC (20.59 ± 1.54), propiconazole 13.9% + difenoconazole 13.9% EC (21.12 ± 2.19) and azoxystrobin 23% SC (24.95 ± 1.68) which were at par.

Highly significant difference ($p \leq 0.01$) was observed among various fungicides in panicle blast severity in both years (Table 3). Overall, propiconazole 13.9% + difenoconazole 13.9% EC significantly reduced the panicle blast severity (15.17 ± 0.73) which was at par with azoxystrobin 18.2% + difenoconazole 11.4% SC (15.83 ± 0.73) followed by azoxystrobin 11% + tebuconazole 18.3% SC (16.50 ± 0.76) and azoxystrobin 23% SC (17.00 ± 0.87). The control plot recorded the highest leaf and panicle blast severity which was significantly higher than other fungicides.

Yield of rice also differed significantly (p ≤0.01) among various fungicides in 2021 and 2022 (Fig. 1). Overall, highest yield was recorded in azoxystrobin 18.2% + difenoconazole 11.4% SC treated plot (3385.2 kg/ha) which was at par with propiconazole 13.9% + difenoconazole 13.9% EC (3273.2 kg/ha). Similarly, azoxystrobin 11% + tebuconazole 18.3% SC and azoxystrobin 23% SC had similar effect on yield. The lowest yield was recorded in control plot which was significantly lower than any other treatment.

Table 2. Effect of fungicide on leaf blast severity

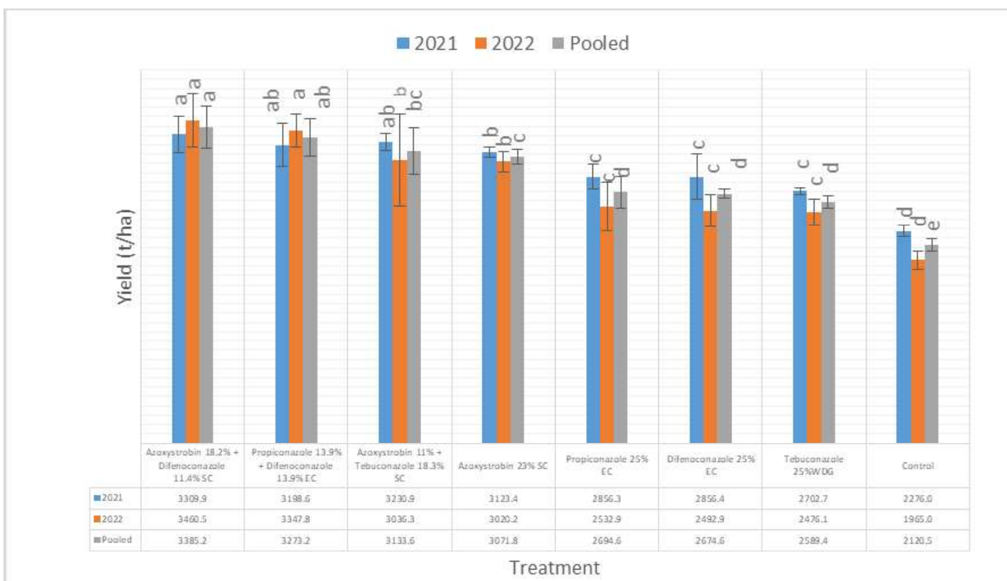
Treatment	Leaf Blast Severity (%)		
	2021	**2022**	**Pooled mean**
Azoxystrobin 11% + Tebuconazole 18.3% SC	$20.38^{cd} \pm 1.31$ (26.81)	$19.90^{d} \pm 4.03$ (26.28)	$20.14^{c} \pm 2.49$ (26.58)
Azoxystrobin 18.2% + Difenoconazole 11.4% SC	$19.24^{d} \pm 2.21$ (25.95)	$21.94^{cd} \pm 2.21$ (27.87)	$20.59^{c} \pm 1.54$ (26.96)
Propiconazole 13.9% + Difenoconazole 13.9% EC	$19.50^{d} \pm 1.83$ (26.15)	$22.73^{cd} \pm 3.57$ (28.35)	$21.12^{c} \pm 2.19$ (27.03)
Azoxystrobin 23% SC	$23.15^{bcd} \pm 1.55$ (28.73)	$26.75^{bcd} \pm 3.19$ (31.07)	$24.95^{bc} \pm 1.68$ (29.94)
Propiconazole 25% EC	$26.99^{bc} \pm 2.67$ (31.25)	$31.81^{bc} \pm 2.92$ (34.29)	$29.40^{b} \pm 1.81$ (32.81)
Difenoconazole 25% EC	$29.48^{b} \pm 3.12$ (32.81)	$33.75^{b} \pm 2.37$ (35.49)	$31.62^{b} \pm 2.49$ (34.18)
Tebuconazole 25%WDG	$30.93^{b} \pm 3.62$ (33.71)	$33.06^{b} \pm 3.89$ (35.03)	$31.99^{b} \pm 3.38$ (34.38)
Control	$49.57^{a} \pm 3.27$ (44.75)	$54.80^{a} \pm 3.39$ (47.77)	$52.19^{a} \pm 2.97$ (46.26)
Mean	27.41	30.59	28.00
CV (%)	14.59	17.47	12.55
F-test	**	**	**

Values with same letters in a column are not significantly different at 5% level of significance by DMRT; **: Significant at 1% level of significance; CV: Coefficient of variation; Figures after ± indicate standard error and figures in parentheses indicate arcsine transformation values.

Table 3. Effect of fungicide on panicle blast severity

Treatment	Panicle Blast Severity		
	2021	2022	Pooled mean
Propiconazole 13.9% + Difenoconazole 13.9% EC	14.33^{d} ± 1.33 (22.21)	16.00^{d} ± 0.58 (23.57)	15.17^{d} ± 0.73 (22.91)
Azoxystrobin 18.2% + Difenoconazole 11.4% SC	16.67^{cd} ± 1.20 (24.07)	15.00^{d} ± 0.58 (22.78)	15.83^{d} ± 0.73 (23.44)
Azoxystrobin 11% + Tebuconazole 18.3% SC	15.33^{cd} ± 0.88 (23.04)	17.67^{d} ± 1.20 (24.83)	16.50^{d} ± 0.76 (23.96)
Azoxystrobin 23% SC	15.67^{cd} ± 1.20 (23.29)	18.33^{d} ± 0.67 (25.35)	17.00^{d} ± 0.87 (24.34)
Propiconazole 25% EC	20.67^{bc} ± 1.33 (27.02)	24.00^{c} ± 2.00 (29.39)	22.33^{c} ± 1.45 (28.18)
Difenoconazole 25% EC	24.00^{b} ± 2.52 (29.27)	27.33^{bc} ± 1.76 (31.50)	25.67^{bc} ± 2.13 (30.40)
Tebuconazole 25%WDG	26.33^{b} ± 2.33 (30.83)	31.00^{b} ± 2.52 (33.80)	28.67^{b} ± 0.17 (32.37)
Control	41.33^{a} ± 4.37 (39.98)	47.00^{a} ± 1.53 (43.28)	44.17^{a} ± 2.95 (41.64)
Mean	21.79	24.54	23.17
CV (%)	16.55	11.08	10.61
F-test	**	**	**

Values with same letters in a column are not significantly different at 5% level of significance by DMRT; **: Significant at 1% level of significance; CV: Coefficient of variation; Figures after ± indicate standard error and figures in parentheses indicate arcsine transformation values.



Same letter in each coloured bar is not significantly different at 5% level of significance by DMRT.

Fig. 1. Effect of fungicides on yield (kg/ha) of rice.

The single and pre-mix formulation of triazole and strobilurin fungicides were effective in reducing leaf and panicle blast and increasing yield as compared to control. Based on the results, the pre-mix formulation viz. azoxystrobin 18.2% + difenoconazole 11.4% SC, propiconazole 13.9% + difenoconazole 13.9% EC and azoxystrobin 11% + tebuconazole 18.3% SC gave best performance while other single formulation fungicides viz. azoxystrobin 23% SC, propiconazole 25% EC, difenoconazole 25% EC and tebuconazole 25%WDG were also found to be effective in terms of lower disease severity and higher yield. The higher yield in the fungicide treated plot can be due to the efficacy of fungicides to check the growth of pathogen. Application of fungicide at tillering stage to control leaf blast and heading stage to control panicle blast are usually recommended. The results of this experiment were in accordance to the findings of various researchers.

A fungicide application at heading stage can be effective in controlling the panicle blast (Groth, 2006). To effectively manage leaf blast, it is recommended to apply chemical fungicides when lesions become visible on rice leaves which is followed by additional spraying on the second and third day. On the other hand, for controlling panicle blast, it is advisable to spray chemical fungicides prior to reaching the 25% panicle initiation stage (NurulNahar *et al.*, 2020).

As per the guidelines provided by the Department of Agriculture and Rural Affairs of Jiangsu Province regarding pest occurrence and control technologies during the rice heading stage, the recommended timeframe for effectively managing panicle blast is from the panicle opening/heading stage to the full heading stage. Currently, pesticide spraying is the primary method employed for controlling panicle blast (Ma *et al.*, 2023).

The research carried out in Chitwan, Nepal revealed that the most effective method for controlling disease (with 87.03% and 79.62% reduction in leaf and neck blast, respectively), achieving the highest grain yield (4.23 t/ha), and improving yield by 56.09% compared to the control, involved the application of tricyclazole 22% + hexaconazole 3% SC three times at weekly intervals starting from the booting stage (Magar *et al.*, 2015).

Mustafa *et al.* (2013) evaluated nine fungicides including the triazole and strobilurin group against the rice blast and reported that azoxystrobin + difenoconazole, followed by difenoconazole resulted in lowest rice blast incidence (6.63% and 10.16% respectively) and azoxystrobin + difenoconazole was found to be superior in terms of higher yield. Ghazanfar *et al.* (2009) reported the effectiveness of propiconazole + difenoconazole, propiconazole, and difenoconazole in reducing the leaf and neck blast. Ahmad *et al.* (2020) showed that the application of azoxystrobin + tebuconazole, and azoxystrobin + difenoconazole significantly reduce rice blast. Kongcharoen *et al.* (2020) reported that the strobilurin fungicide, azoxystrobin, and the mixed triazole fungicides, propiconazole + difenoconazole and fluopyram + tebuconazole had greater potential to reduce the incidence of rice blast. The effectiveness of single and/or mixed formulation of triazole and strobilurin fungicides against rice blast were demonstrated by Chen *et al.* (2015); Groth (2006); Kunova *et al.* (2014); Ogoshi *et al.* (2018), Pak *et al.* (2017); Pandey (2016); Mohiddin *et al.* (2021); Moktan *et al.* (2021).

CONCLUSIONS

The experiment conducted to find out the effective triazole and strobilurin fungicides revealed that the pre-mix as well as single formulation of triazole and strobilurin fungicides significantly controlled leaf and panicle blast and increased grain yield. The pre-mix formulation fungicide azoxystrobin 18.2% + difenoconazole 11.4% SC, propiconazole 13.9% + difenoconazole 13.9% EC and azoxystrobin 11% + tebuconazole 18.3% SC performed superior in terms of lower leaf blast, lower panicle blast severity with higher yield. So, these three fungicides can be recommended to control leaf and panicle blast for higher yield.

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