



Official publication of Pakistan Phytopathological Society
Pakistan Journal of Phytopathology

ISSN: 1019-763X (Print), 2305-0284 (Online)

<http://www.pakps.com>



IMPACT OF FOLIAR APPLICATIONS OF DIFFERENT FUNGICIDES ON WHEAT STRIPE RUST EPIDEMICS AND GRAIN YIELD

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ABSTRACT

The stripe rust of wheat caused severe grain yield losses in Pakistan and all over the world. The present investigation involved two replicated experiments conducted in the research area of Bahuddin Zakariya University, Bahadur Sub campus Layyah during 2018-2019 and 2019 -2020 cropping seasons by following the Randomized Complete Block Design (RCBD). In both experiments, four different fungicides viz., Metiram @ 625g/ha; Sulphur @ 2500g/ha; Propiconazole @ 625ml/ha and Difenoconazole @ 375g/ha were evaluated to determine their impact on stripe rust severity and grain yield. Data on disease severity was recorded by using the modified Cobb scale whereas; the number of grains/spike and thousand-grain weight data were recorded after harvesting the crop. All four applied fungicides reduced the stripe rust severity as compared to control. However, maximum disease was controlled by Difenoconazole during both rating seasons 2018-19 (22.2%) and 2019-2020 (21.1%) followed by Propiconazole (21.6% & 20.5%), Sulphur (20.7% & 19.9%) and Metiram (20.1% & 19.4%). Grain yield was significantly increased with the foliar application of fungicides during both successive years. Maximum number of grains/spike (47 & 46.1) and 1000-grain weight (39.98 & 38.97 g) were recorded in first and second crop seasons respectively, with the application of Difenoconazole followed by Propiconazole, Sulphur and Metiram as compared to the control respectively. The present investigation could play an important role in controlling stripe rust epidemics and to enhance grain yield in central Asian countries.

Keywords: Fungicides, grain yield, management, stripe rust, wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a largely cultivated cereal crop all over the world after rice (27%) and maize (25%), it financially records 30% in the production of all cereal crops worldwide (Giraldo *et al.*, 2019). It is the main source of energy and protein for humans (Hazard *et al.*, 2020). Wheat is the most used food crop and source of nutrition for a country like Pakistan. All over the world nearly the total production of wheat is 600 million tons (MT) with a 2-5 million hectares area. The underdeveloped countries produce generally fifty

percent wheat all over the world (Hanson *et al.*, 2021). In Pakistan, it is cultivated on an area of 8.8 million hectares with annual production of 25.09 million tons (MT). Cool and temperate regions of the world, including Asia, Europe, the Middle East and Africa are most favourable to develop rust epidemics (Aboukhaddour *et al.*, 2020). The symptoms of wheat rust include the appearance of yellow uredia on the surface of the leaf in form of stripes or lines but rarely be seen on leaf sheath, stem and head (Ali *et al.*, 2020a).

Over the last 15 years in Central Asia, stripe rust of wheat has become a serious threat to grain production (Absattarova *et al.*, 2002; Sharma *et al.*, 2013). In Central and West Asia, stripe rust severity has increased from 2001 to 2010 as compared to the 1970-to-2010. In central Central Asi, the occurrence of four epidemics of stripe rust in the past six years 2009-2014, has

Submitted: April 04, 2022

Revised: June 05, 2022

Accepted for Publication: June 9, 2022

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increased the severity of rust (Sharma *et al.*, 2014). The stripe rust epidemics has resulted severe yield losses in the Central Asia. Previous investigation showed 10-90% yield losses occur due to the stripe rust epidemics (Dzhunusova *et al.*, 2009; Hussain *et al.*, 2017). As the cultivation of susceptible wheat varieties having low resistance to stripe rust is the main cause of epidemics in these regions (Sharma *et al.*, 2009), therefore various fungicides are widely used to control stripe rust, which is done without the knowing their capacity to control disease under field conditions (Atiq *et al.*, 2017; Razzaq *et al.*, 2018).

Currently, forty different products of fungicides have been documented for the management of stripe rust disease. Among these, most of the chemicals are in the quinone outside inhibitor (QoI; strobilurin) and demethylation inhibitors (DMI; triazole) class (Chen and Kang, 2017). Pyraclostrobin registered as Headline and Propiconazole registered as Tilt has been used for more than 20 years (Chen, 2014). Combine application of propiconazole and azoxystrobin has become the best choice for the growers to control stripe rust of wheat since chemicals consist of two modes of action by combining the DMI and QoI chemicals. Hence, the main objective of the present investigation was to evaluate the efficiency of different fungicides for controlling stripe rust epidemics and their impact on grain yield.

MATERIALS AND METHODS

The present study was conducted to determine the

Table 1. Name of fungicides used for the management of stripe rust of wheat

Sr. No.	Treatments	Scientific name	Common name	Concentration	Company name
1	T ₁	Metiram	Polyram DF	@625g /ha	Swat agro chemical
2	T ₂	Sulphur	Sulphur	@2500g/ha	Evyol group
3	T ₃	Propiconazole	Tilt	625ml/ha	Syngenta
4	T ₄	Difenoconazole	Score	375g/ha	Syngenta
5	T ₅	Control	-	-	-

Data recording: Disease assessment was recorded on both consecutive seasons (2018-2019 and 2019 -2020) at GS 49-59 and GS 75-77 (medium to late milky stage) by rating the disease severity (%) on flag leaves of each plot using the modified Cobb scale (Peterson *et al.*, 1948). To record the yield data, each plot was divided into different sections (3x2 m) and a wire frame was used for data recording by using the method proposed by Ali *et al.*, (2019a). The crop was harvested at maturity when its colour changed to yellow from green. Mini-thresher was used to harvest the crop and it was cleaned

efficiency of different foliar fungicides to control stripe rust of wheat in the field Area of B.Z.U. Bahadur Sub-Campus Layyah during the 2018-2019 and 2019-2020 cropping seasons. Two spreader rows of Morocco were sown around each side of the experimental material to prevent the fungicide drift. Four different fungicides (Table 1) registered for stripe rust were applied either in single applications at GS 16-19 (unfolded six to nine leaves) and (GS) 49-59 (first awns visible to emergence of spike completed) or in 2-3 applications at GS 16-19 and GS 49-59, respectively. Fungicides were applied using a knapsack sprayer at 160 kPa fitted with 3.5 psi cone nozzles and water volumes of approximately 300 L hac⁻¹ after the emergence of disease symptoms (Figure 1). The single variety SH-2 was cultivated each year on the 26th of November 2018-2019 and 2019 -2020 cropping seasons by following the Randomized Complete Block Design (RCBD) with three replications (Figure 2). After 1st irrigation, the recommended dose of urea of 2.5 bags/ha was manually broadcasted and after 2nd irrigation, weeds were controlled by spraying suitable herbicides *viz.*, imazamethabenz, fenoxaprop-P-ethyl and mesosulfuron-methyl with the help of a knapsack sprayer with T-Jet/Flat Fan nozzle. The field was irrigated three times with 19-acre inches during the growing season. Before applying fungicides plots were set for each fungicide. Fungicides were sprayed when disease just appeared in the field compared to the control.

manually. After cleaning, the parameters recorded were stripe rust disease control (%), the number of grains/spike and 1000 grain weight (g).

STATISTICAL ANALYSIS

Data recorded during the current research work was analyzed statistically by using the statistical software Minitab ver.20. Analysis of variance (ANOVA) was performed to evaluate the effects of treatments. To test the effect of each fungicide, their means were compared by using the leaf significant difference test at a 5% level of significance (Steel *et al.*, 1997).



Figure 1. Foliar Applications of different fungicides with the help of knapsack sprayer to control stripe rust infection on SH-2 wheat variety



Figure 2. Cultivation of a wheat variety SH-2 in the Research Area of College of Agriculture, B.Z.U. Bahadur Sub-Campus Layyah season 2018-2019 whereas, 21.6% in the second crop season 2019-2020. Similarly, propiconazole controlled the disease severity 21.6% in first crop season and 20.5% in second growing season. The sulphur controlled the disease severity by 20.7% in the first crop season and 19.9 % in the second crop season followed by metiram as compared to the control as indicated in the Figure3.

RESULTS

Effect of fungicides on disease control (%) of stripe rust: Application of all treatments showed statistically significant results to control stripe rust of wheat during both crop seasons 2018-2019 and 2019-2020. Among all fungicides, difenoconazole proved the most effective in controlling stripe rust epidemics. Difenoconazole controlled the disease by 22.2 % in the first crop

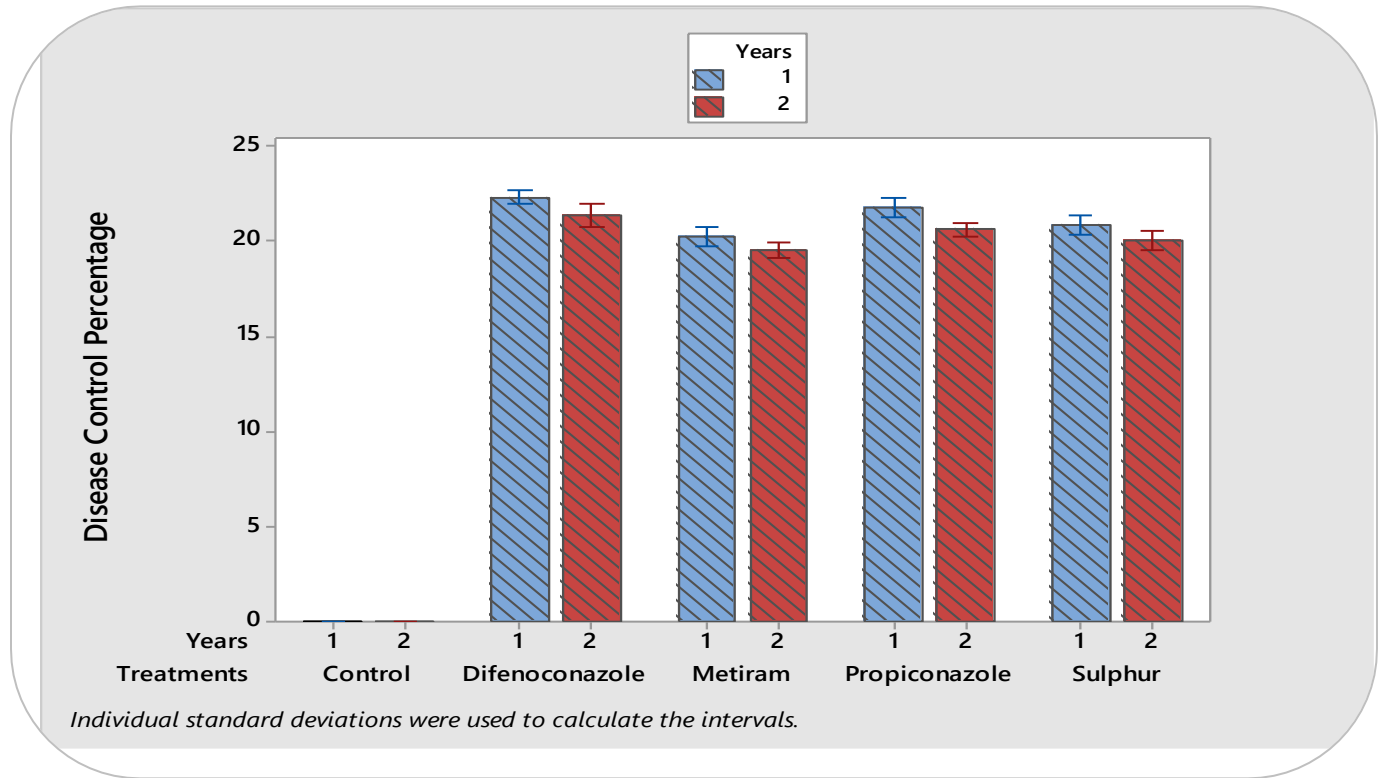


Figure 3. Impact of different fungicides to control stripe rust (%) during crop growing years 1 (2018-2019) and 2 (2019-2020)

Efficacy of different fungicides on number of grains/spike against stripe rust: In both years (2018-2019 and 2019-2020), significant effect of all fungicides was recorded on the number of grains/spike. With the application of Difenoconazole maximum number of grains/spike (47 & 46.1) were recorded in the first and

second crop seasons respectively, over control. Similarly, maximum numbers of grains per spike were recorded by Propiconazole (45.2 & 44.3) during the 2018-2019 and 2019-2020 cropping seasons respectively, followed by Sulphur, Metiram as compared to the control (Figure 4).

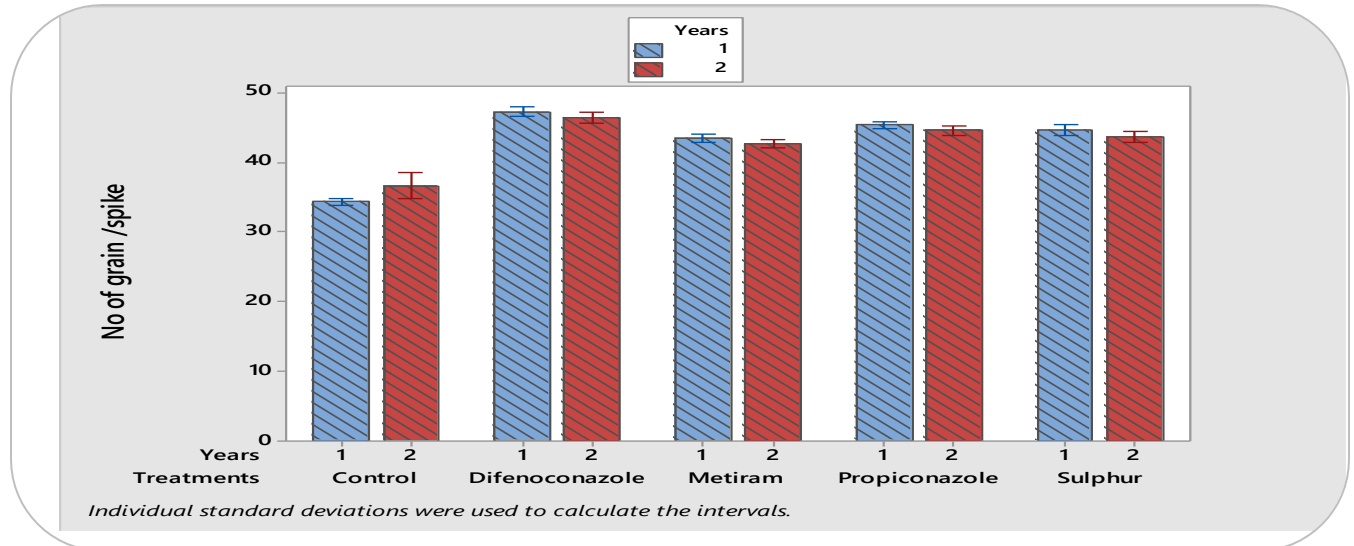


Figure 4. Impact of different fungicides on number of grain/spike against stripe rust epidemics during two crop seasons 1 (2018-2019) and 2 (2019-2020)

Efficacy of different fungicides on 1000-grain weight against stripe rust: A significant impact of each fungicide was recorded on 1000-grain weight against stripe rust epidemics in each trial during both rating seasons. Among all fungicides, Difenconazole proved the most effective in controlling stripe rust of wheat and increasing the 1000-grain weight. With the application

of Difenconazole, maximum 1000-grain weights (39.98 & 38.97 g) were recorded in the first crop season 2018-2019 and second crop season 2019-2020, respectively. Similarly, Propiconazole increase the 1000 grain weight up to 38.37 g in the first crop season and 37.37g in the second growing season followed by Sulphur and Metiram as compared to the control (Figure 5).

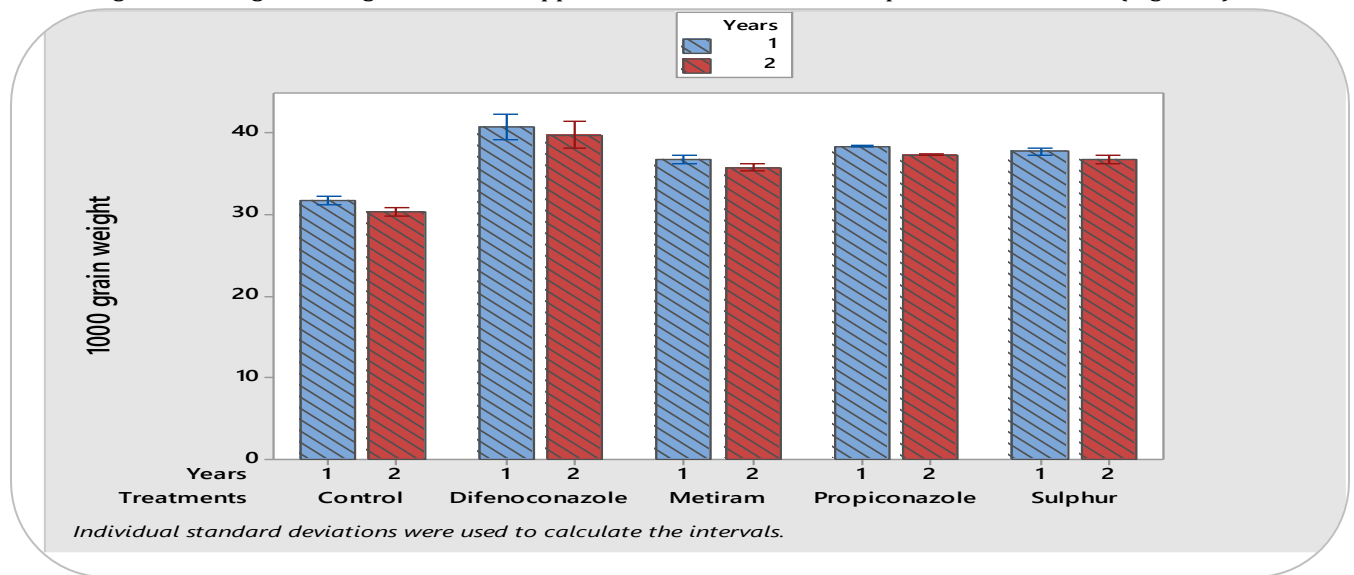


Figure 5. Impact of different fungicides on 1000-grain weight against stripe rust epidemics during two crop seasons 1 (2018-2019) and 2 (2019-2020)

DISCUSSION

The application of all fungicides effectively controlled the stripe rust severity (%) under field conditions. However, a large proportion of grain yield reductions could be attributed to the decreases in thousand kernel weight (TKW). The magnitudes of thousand kernel weight and grain yield observed in the current investigation were similar to recent published research from the neighbouring state of South and West Asia (Al-Maarroof *et al.*, 2014; Ali *et al.*, 2019b; Karaman *et al.*, 2014). The current study exhibited that difenoconazole significantly reduced disease severity and increased the grain yield and thousand grain weights as compared to other fungicides and control. All fungicides showed a great response in controlling wheat rust if they are applied before the disease infects upper leaves. In these results, Difenoconazole fungicide proved to be most significant for controlling wheat rust. Efficiency and the fungicide applied on time are the key to controlling wheat rust. Nevertheless, the use of fungicides is expensive which a problem is for poor farmers (Ali *et al.*, 2021).

Recent studies indicated that the impact of foliar rusts on wheat quality and plant development depends on the level of genotype resistance, yield potential and onset of disease (Herrera-Foessel *et al.*, 2006; Cruppe *et al.*, 2021; Motta-Romero *et al.*, 2021). Ash and Brown (1990) exhibited that an early outbreak of disease percentage had a larger effect on grain yield as compared to the late epidemics. Thousand-grain weight and total grain yield were most affected in the plots of susceptible genotype. Yield losses reduced in crops with a higher level of durable resistance at the adult plant stage (Yirga *et al.*, 2021). According to Pathan and Park (2006) durable resistance in the genotypes is most effective reducing yield losses due to stripe rust and leaf rust infection. Genotypes with low levels of durable resistance experienced 15-25% yield losses as compared to 45-55% losses in susceptible genotypes. Early disease outbreaks, initiating before the onset of durable resistance at the adult plant stage, however, can produce significant yield losses in genotypes with resistant-to-moderate adult plant reactions and seedling susceptibility (Zhou *et al.*, 2022). When yield losses are low or stripe rust epidemics appear late in season, grain yield losses in moderately susceptible genotypes would be expected to be small (Ash and Brown, 1990).

Foliar application of fungicides significantly reduced the wheat grain yield losses caused by stripe rust pathogen. However, the time of fungicide application and their interaction effect is significant in controlling disease severity. In the case of the SH-2 variety, the application of Difenoconazole and Propiconazole produced significantly higher grain yield over Metiram and Sulphur. Application of Difenoconazole produced the highest grain and thousand-grain weight which was significantly superior to the rest of the treatments. Similarly, the application of foliar Difenoconazole nearly had the same effect as other fungicides in increasing the grain yield of wheat; this difference was not statistically significant. However, there was a significant difference between unsprayed control and foliar application of Difenoconazole. Tilt has a systemic mode of action with protective and curative functions with more fungal growth inhibiting rather than fungicidal properties.

Most of the cultivated wheat varieties in central Asian countries are susceptible to stripe rust races (Sharma *et al.*, 2013, Ali *et al.*, 2020b) and the growers manage the disease severity primarily through foliar application of fungicides. Generally, 41% grain yield increases due to disease protection by fungicide application therefore the wheat growers can greatly benefit from crop protection measures. Furthermore, fungicide application increased the thousand-grain weight, number of grains/spike and also improves the quality of straw which is widely used as animal feed in developing countries (Javaid *et al.*, 2018). Current study also clearly demonstrated a difference in yield increase with the foliar application of appropriate fungicides. The response of moderately susceptible variety SH-2 to fungicide application resulted in maximum increase in grain yield even at the hot spot of stripe rust.

CONCLUSION

Application of all fungicides proved most effective for controlling stripe rust severity and increasing grain yield. Difenoconazole significantly reduced stripe rust severity (22.2% & 21.1%) and increased the number of grains/spike (47 & 46.1) and 1000 grain-weight (39.98 & 38.97 g) compared to follow by Propiconazole, Sulphur and Metiram for two successive years 2018-2019 and 2019 -2020, respectively . Applications of these fungicides were recommended for wheat growers to be used for the management of disease severity and

increasing grain yield in central Asian countries.

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Contribution of Authors:

Yasir Ali	: Designed the experiment and wrote the manuscript
Tatheer Abbas	: Performed the experiments
Hafiz M. Aatif	: Edit the manuscript
Salman Ahmad	: Review the manuscript
Azhar A. Khan	: Analyzed the data
Ch. M. S. Hanif	: Prepared figures and help in performing experiment