Research Article

Evaluation of Difenoconazole along with Macronutrients Spray for the Control of Brown Leaf Spot (*Bipolaris oryzae*) Disease in Rice (*Oryza sativa*) Crop

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Abstract | The study pertaining to the control of brown leaf spot (BLS) disease on rice crop by using different combinations of fungicide (difenoconazole) with various concentrations of sprayable formulations of macronutrients (NPK) was conducted during Kharif 2012 to 14 at Adaptive Research Farm, Gujranwala, Pakistan. The experiment was conducted on a promising basmati rice cultivars Super basmati in RCBD with three repeats. The spray of difenoconazole at rate of 315 $mlha^{-1}$ + 500gha^{-1} of NPK (20:20:20) significantly decreased incidence of BLS per leaf (9.31) and resulted in significant increase in 1000 grain weight (22.54 g) and yield (3.57 tha^{-1}) and gave an additional income of Rs.26305 ha^{-1} with benefit cost ratio of 11.31 compared with control. It is suggested that spray of difenoconazole and macro nutrients (NPK) at appropriate concentrations are handy to minimize incidence of BLS disease in rice crop.

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Introduction

Rice (*Oryza sativa* L.) is an important food crop in the developing countries and the staple food of more than half of the world's population. Worldwide, more than 3.5 billion people depend on rice for more than 20% of their daily calories intake (IRRI, 2012). Besides an important exportable item, it is staple food crop of Pakistan next to wheat. It accounts for 3.2 percent value addition in agriculture and 0.7 percent of GDP of the country. During the year 2014-15 rice was cultivated on an area of 2891 thousand hectares with total production 7005 thousand tons with an average yield of 2423 $kgha^{-1}$ (Anonymous, 2015). Rice yield in Pakistan is very low as compared to other rice growing countries of the world (Seebold et al., 2004). There are number of abiotic and biotic factors responsible for reduction of per hectare yield of rice crop in the country. Amongst the biotic factors, rice diseases, especially leaf spot fungal disease caused by *Bipolaris oryzae* is one of the serious diseases with widespread distribution and existence of its several physiological races (Chakrabarti, 2001; Asghar et al., 2007; Arshad et al., 2008). This disease has been reported in all rice growing areas in the world and is reported to reduce 6 to 90% yield in Asia (Singh and Singh, 2000; Aryal et al., 2016). There are indications that BLS is becoming more frequent and severe due to climate change (Savary et al., 2005; Barnwal et al., 2013).

In Pakistan, BSL has been reported both on fine and coarse varieties of rice. Symptoms of BLS appear on

leaves and glumes at the time of maturity of crop (Iqbal et al., 2015). Its pathogen penetrates in the rice husk causing spotting and discoloration of grains leading to reduced grain quality (Ou, 1985; Moletti et al., 1997). It also infects the coleoptile, leaves, leaf sheath, panicle, branches, glumes and spikelets (Webster and Gunnell, 1992) and causes significant yield losses. The pathogen can survive on infected rice stubbles, weeds, seeds and causes brown spot on subsequent rice crop (Ou, 1985; Moletti et al., 1996).

The high yield of rice crop can be achieved by high yielding varieties and better plant protection measures against pest and diseases (Srivastava et al., 2010). BLS can be controlled successfully through the foliar application of fungicides on rice crop (Singh et al. 1985). In the traditional rice growing area of Punjab (Pakistan), farmers mostly use difenaconazole fungicide for the control of BLS disease. Recently, the farmers reported that the spray of this fungicide alone does not provide complete or long lasting protection.

Keeping in view the devastating nature of BLS and importance of rice crop, the present study was planned to evaluate difenoconazole along with various concentrations of macronutrients to control BLS disease on rice crop and their effects on yield thereafter.

Materials and Methods

The study was designed to find the best combination of difenoconazole 250EC and various concentrations of spray able formulations of macronutrient (NPK) to control the BLS of rice in natural field conditions at Adaptive Research Farm Gujranwala, Pakistan during Kharif seasons 2012 to 2014. The nursery of rice cultivar Super Basmati was sown in the month of June. The land was prepared according to traditional agronomic practices of the area and 35 days old rice nursery was transplanted manually in well puddled soil. The plot size for each treatment was 6m×20m with plant to plant and row to row distance of 9 inches. Nitrogenous (N), phosphatic (P) and potassium (K) fertilizer was applied @ 140, 80 and 62 Kg ha^{-1} respectively. All P and K fertilizer was applied at the time of sowing while urea was applied in three equal splits. Weeds were controlled by Machete (butachlore) 60EC @ 2.00Lha^{-1}whereas Cartap 4G was used as insecticides @ 22.5 Kgha^{-1} when the pest insects reached at Economic Threshold level (ETL). Rice crop with various combinations of difenoconazole 250EC and concentrations of macronutrients (NPK) was sprayed when the crop reached at panicle emergence stage. The experiment was replicated thrice using Randomized Complete Block Design (RCBD) Treatments comprising following combinations of difenoconazole and various concentrations of NPK were tested:

T_1= (Control)
T_2 = Difenoconazole @ 315 mlha^{-1} + NPK (20:20:20) @500gha^{-1}
T_3 = Difenoconazole @ 315 mlha^{-1} + NPK (8:8:6) @500gha^{-1}
T_4 = NPK (20:20:20) @500mlha^{-1}
T_5 = Difenoconazole @ 315 mlha^{-1}
T_6 = NPK (8:8:6) @500gha^{-1}

The incidence of BLS was recorded by counting number of brown leaf spots on leaves before application of treatments and 20 days after the treatment. The intensity of disease was measured by using the scale given by Lenz et al. (2010) as shown in Figure 1. For this purpose, 30 leaves from each treatment were selected at random and brown spots on leaves were recorded. The 30 scored leaves were averaged to estimate intensity of disease. On maturity, the crop was harvested and threshed manually to record data of 1000-grains weight (g) and yield (tha^{-1}). The benefit cost ratio on the basis of total expenditures incurred and income received was also computed. Data were subjected to analysis of variance (ANOVA) and the differences among means were compared using Duncan's Multiple Range Test at 5% probability level (Steel et al., 1997).

Results and Discussion

The pre-treatment data given in Table 1 indicated that mean over seasons number of BLS per leaf was 7.32 to 8.75 before spray. A significant decrease in number of brown leaf spots per leaf i.e. 9.31, 11.80 and 12.69 was recorded in rice crop sprayed with T_2 (difenoconazole @315 mlha^{-1} + NPK (20:20:20) @500gha^{-1}), T_3 (difenoconazole @ 315 mlha^{-1} + NPK (8:8:6) @500gha^{-1}) and T_5 (difenoconazole @ 315 mlha^{-1}) treatments, respectively as compared to control (Table 2). However, maximum disease incidence (21.99 spots per leaf) was observed in control plot. Foliar sprays of phosphate and potassium can induce systemic protection against foliar pathogens (Reuveni and Reuveni, 1998).

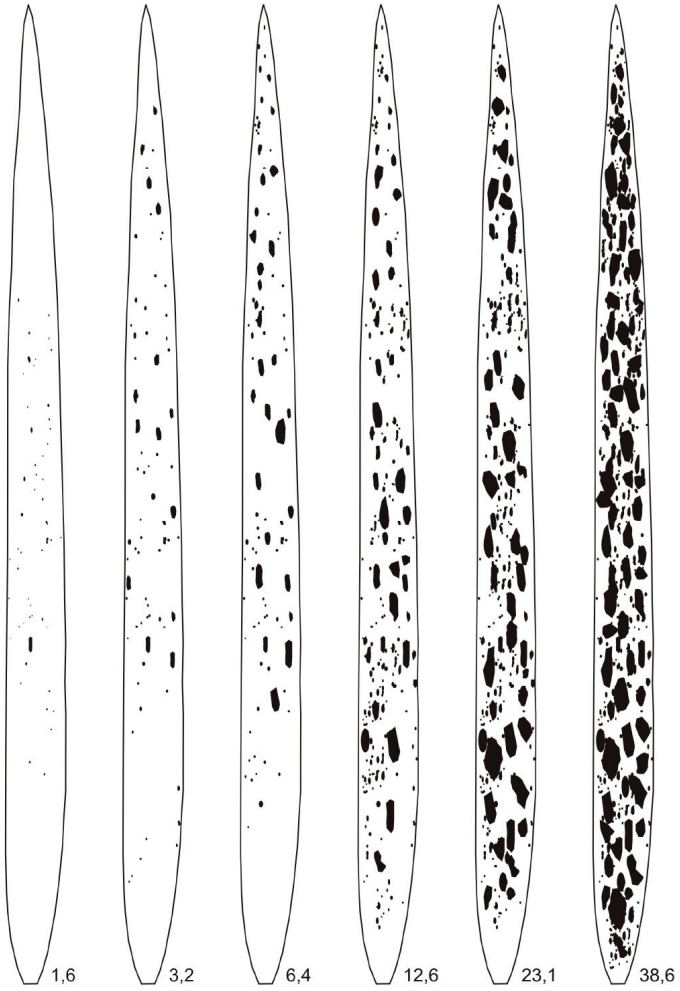

Figure1: *Diagrammatic scale for assessment of BLS severity in rice crop (taken from Lenz et al. 2010).*

Table 1: *BLS per leaf on rice crop before spray of difenoconazole and macronutrients.*

Treatments	2012	2013	2014	Mean
T1: Control	1.64	5.17	16.10	7.64
T2: Difenoconazole @ 315 ml ha^{-1}+NPK (20:20:20) @ 500 g ha^{-1}	1.81	5.73	16.40	7.98
T3: Difenoconazole @ 315 ml ha^{-1}+NPK (8:8:6) @500 g ha^{-1})	1.85	5.60	18.80	8.75
T4: NPK (20:20:20) @500 g ha^{-1}	1.69	5.10	15.17	7.32
T5: Difenoconazole @ 315 ml ha^{-1}	1.65	5.27	17.10	8.01
T6: NPK (8:8:6) @ 500 g ha^{-1}	1.64	6.03	15.93	7.87

Nas and Fin (2012) reported that P and K are most consistent and effective in minimizing disease incidence. Though P and K application can reduce diseases and improve plant health (Perrenoud, 1990), yet disease cannot be controlled completely by the use of fertilizers alone. Mustafa et al. (2013) and Iqbal et al. (2015) reported reduction in disease incidence by the spray of difenoconazole. However, in many cases periodic applications of fungicides is suggested for economic control of diseases (Reuveni and Reuveni, 1998).

Table 2: *BLS per leaf on rice crop after spray of difenoconazole and macronutrients.*

Treatments	2012	2013	2014	Mean
T1: Control	18.13 a	18.33 a	29.50 a	21.99a
T2: Difenoconazole @ 315 ml ha^{-1} +NPK (20:20:20) @500 gha^{-1}	6.77 e	3.67 c	17.50 b	09.31d
T3: Difenoconazole @ 315 ml/ha+NPK (8:8:6) @500 g ha^{-1})	10.67 d	4.33 c	20.40 b	11.80 cd
T4: NPK (20:20:20) @ 500 g ha^{-1}	13.68 c	15.67 b	26.30 a	18.55 b
T5: Difenoconazole @ 315 ml ha^{-1}	11.43 d	5.67 c	20.97 b	12.69 c
T6: NPK (8:8:6) @500 g ha^{-1}	16.60 b	16.00 ab	28.13 a	20.24 ab
$LSD_{0.05}$	1.456	2.608	4.657	3.119

Statistical analysis ($P<0.05$) depicted significant decrease in 1000-grain weight of rice crop not sprayed with fungicide or NPK (control). However, maximum 1000-grain weight of 22.54g and 22.09g was observed when crop was sprayed with T_2 (difenoconazole @ 315 $mlha^{-1}$+NPK (20:20:20) @500gha^{-1}) and T_3 (difenoconazole @ 315 $mlha^{-1}$+NPK (8:8:6) @500gha^{-1}), respectively (Table 3). Rice crop that was sprayed with T2 (difenoconazole @ 315 mlha-1+NPK (20:20:20) @ 500gha-1) attained maximum yield (3.57 tha-1) followed by T3 (difenoconazole @ 315 mlha-1+NPK (8:8:6) @500gha-1) (3.50tha-1) and T5 (difenoconazole @ 315 mlha-1) (3.46tha-1) (Table 4). However, yield was significantly reduced in control. Paddy yield was also improved after management of disease (Singh et al., 2007). According to Iqbal et al. (2015) the use of difenoconazole for the economic control of BLS of rice can be recommended. Mustafa et al. (2013) had also reported reduction in disease incidence in rice crop by the foliar application of difenoconazole which led to an increase in rice yield thereafter. Tuli et al. (2017) found that difenoconazole was effective in reducing the incidence of BLS and blast diseases at flowering, milking, dough and maturity stages of rice crop. Qudsia et al. (2017) demonstrated that six fungicides including difeno-

conazole control the brown leaf spot significantly as compared to Control.

Table 3: *Effect of difenoconazole and macronutrients on 1000- grain weight (g) of rice crop.*

Treatments	2012	2013	2014	Mean
T1: Control	17.33 a	17.75 d	17.44 c	17.51 b
T2: Difenoconazole @ 315 ml ha^{-1}+NPK (20:20:20) @ 500 g ha^{-1}	19.68 a	24.39 a	23.55 a	22.54 a
T3: Difenoconazole @ 315 ml ha^{-1}+NPK (8:8:6) @500g ha^{-1})	19.44 a	23.64 ab	23.19 a	22.09 a
T4: NPK (20:20:20) @500 g ha^{-1}	18.91 a	19.53 c	18.64 b	19.03 b
T5: Difenoconazole @ 315 ml ha^{-1}	19.66 a	22.99 b	22.87 a	21.84 a
T6: NPK (8:8:6) @ 500 g ha^{-1}	18.74 a	18.68 cd	18.10 bc	18.51 b
$LSD_{0.05}$	4.368	1.036	0.989	2.249

Economic analysis computed on the basis of grain yield revealed that rice crop sprayed with T_2 (difenoconazole @ 315 $mlha^{-1}$ + NPK (20:20:20) @ 500gha^{-1}) gave the highest additional income (Rs. 26305ha^{-1}) followed by T_3 (difenoconazole @ 315 $mlha^{-1}$ + NPK (8:8:6) @ 500gha^{-1}(Rs.22869 ha^{-1}) and T_5 (difenoconazole @ 315 $mlha^{-1}$ (Rs.18323ha^{-1}) as given in Table 5. Additional expenditure over check was the highest (Rs.2259 ha^{-1}) in T_2 (difenoconazole @ 315 $mlha^{-1}$ + NPK (20:20:20) @ 500gha^{-1}) as compared to other combinations. Maximum benefit cost ratio (11.31) was gained with T_2 (difenoconazole @ 315 $mlha^{-1}$ + NPK (20:20:20) @500gha^{-1}). This highest benefit cost ratio is due to less disease incidence which ultimately resulted in high yield as compared to other treatments.

Table 4: *Effect of difenoconazole and macronutrients on yield of rice crop (t ha^{-1}).*

Treatments	2012	2013	2014	Mean
T1: Control	3.03 e	3.57 b	2.66 c	3.09 c
T2: Difenoconazole @ 315 ml ha^{-1} +NPK (20:20:20) @500g ha^{-1}	3.57 a	3.96 a	3.18 a	3.57 a
T3: Difenoconazole @ 315 ml ha^{-1} +NPK (8:8:6) @500 g ha^{-1})	3.46 b	3.89 a	3.15 a	3.50 a
T4: NPK (20:20:20) @500 g ha^{-1}	3.38 c	3.66 b	2.86 b	3.30 b
T5: Difenoconazole @ 315 ml ha^{-1}	3.43 bc	3.84 a	3.12 a	3.46 a
T6: NPK (8:8:6) @500 g ha^{-1}	3.26 d	3.63 b	2.76 bc	3.21 b
$LSD_{0.05}$	0.062	0.168	0.167	0.107

Conclusions and Recommendations

Difenoconazole alone and in combination with different sprayable formulations of macronutrients (NPK) reduces the BLS incidence in rice crop. Combinations comprising difenoconazole @ 315 $mlha^{-1}$ + NPK (20:20:20) @ 500gha^{-1} were found appropriate for the control of BLS in transplanted rice in addition to most economical.

Authors's Contribution

Dr. Muhammad Asghar conceived the idea and designed the experiment while Dr. Mirza Muhammad Qadeer Baig collected the data. Dr. Muhammad Asghar and Dr. Mirza Muhammad Qadeer Baig wrote the research paper. Sanaullah Chaudhary performed statistical analysis of the data. Dr. Muhammad Anjum Ali facilitated the research study.

Table 5: *Economic comparison of different combinations of Difenoconazole and macronutrients.*

Treatments	Yield (Kg ha^{-1})	Yield increase over check (Kg ha^{-1})	Additional income over check (Rs.ha^{-1})	Additional expenditure over check (Rs.ha^{-1})	Net Income or Additional benefit (Rs.ha^{-1})	BCR
T1: Control	3087	0	0	0	0	-
T2: Difenoconazole @ 315 ml ha^{-1}+NPK (20:20:20) @500 g ha^{-1}	3570	483	26305	2259	24046	11.31
T3:Difenoconazole @ 315 ml ha^{-1}+NPK (8:8:6) @500g ha^{-1})	3500	413	22869	2154	20715	10.29
T4: NPK (20:20:20) @500 g ha^{-1}	3300	213	10859	1125	9734	9.32
T5: Difenoconazole @ 315 ml ha^{-1}	3427	340	18323	1934	16389	9.14
T6: NPK (8:8:6) @500 g ha^{-1}	3213	127	6199	1020	5179	5.74

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