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MANAGEMENT OF YELLOW RUST (*PUCCINIA STRIIFORMIS*. WEST) OF WHEAT AND ITS IMPACT ON YIELD UNDER JAMMU SUB-TROPICS OF INDIA

RAYEES A. AHANGER*, VISHAL GUPTA, HILAL A. BHAT AND NISAR A. DAR
Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu - 191121 (J and K), INDIA
e-mail: rayees.ahanger87@gmail.com

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***Corresponding author**

ABSTRACT
The experiment was conducted during 2009-10 at the Research Farm of SKUAST-J.Foliar application of fungicideQuadris proved most effective in reducing the Final Rust Severity (FRS) in all the varieties viz., PBW-343 (15.00%), RSP-561 (5.67%), PBW-550 (9.67%) and Agra local (16.33%). Seed treatment by Raxil also resulted in significant decrease in the disease severity in all the varieties tested.Qadris also proved more effective in increasing the yield susceptible varieties Agra local (45.83%) and PBW-343 (42.56%) as compared to moderately resistant varieties, RSP-561 (27.93%) and PBW-550 (31.64%).

INTRODUCTION

Wheat (*Triticumaestivum* L.) is the world's most extensively grown cereal crop and is staple food for over 10 billion people. In India, wheat (*Triticumaestivum*L.) is the second most important cereal crop next to rice. It is cultivated over an area of 29.9 million hectare with present production of 93.90 million tones and projected demand of 100 millions tones by 2030 AD (Sharma, 2011). In Jammu and Kashmir wheat is grown over an area of 278.30 thousand hectares with a production and productivity of 4959 thousand quintals and 17.82 qha^{-1}, respectively (Anonymous, 2008). Aquino *et al*. (2002) and Singh, *et al*. (2004) reported that rust diseases of wheat cause significant damage throughout the world, however, yellow rust caused by *Pucciniastriiformis* West. f.sp. *tritici* is a major threat to global wheat production, resulting both in yield losses and downgrading the grain quality. Yellow rust has caused heavy losses in the different parts of the world and is also a future threat for global wheat production (Coram *et al*., 2008). In most wheat-producing areas, yield losses caused by yellow rust have ranged from 10 to 70 per cent depending on susceptibility of the cultivar, earliness of the initial infection, rate of disease development, and duration of disease (Chen, 2005). Extreme yield losses of 87 to 94 per cent occurred in susceptible varieties and up to 27-54 per cent in partially resistant cultivars in Australia in 2007-2008 (Jayasena *et al*., 2009). Variety resistance is ultimately the best option for managing stripe rust in the long term (Kolmer, 1995). However, medium term growers planting moderately susceptible varieties are reliant on the use of fungicides either at sowing (in furrow on fertiliser or seed treatments) or in crop (application of foliar fungicides), or a combination of both options (Simpfendorfer and Taylor, 2011). The development of new pathotypes of the stripe rust fungus, which reduce the resistance of selected commercial varieties can also make fungicide intervention necessary (Simpfendorfer and Taylor, 2011). The yellow rust is well controlled by many of the azoles and strobilurin fungicides which also increases the yield and grain quality (Lockley and Clark, 2005).Timely application of newly identified fungicides Tilt (propiconazole), Quadris (azoxystrobin), Stratego (propiconazole + trifloxystrobin), Headline (strobilurin), and Quilt (azoxystrobin + propiconazole) restricts the spread of stripe rust (Chen, 2005). Quadris, a broad spectrum fungicide with the active ingredient azoxystrobin is a xylem systemic fungicide that can move to new growth in wheat and effectively controls the major foliar diseases on wheat like stripe rust, leaf rust and septoria leaf blotch (Bartlett *et al*. 2002). Strobilurins provide excellent control of stripe rust and are most effective when applied before infection and if stripe rust is already present, it is better to use the triazoles (Eddy, 2009).

During cropping season of 2010-11, the stripe rust appeared in severe form in almost all the wheat growing areas of Jammu region of Jammu and Kashmir state of India, wherein, wheat was grown over an area of 239 thousand hectares with a production and productivity of 465.33 thousand tones and 19.47q ha-1, respectively (Anonymous, 2011). Further, variation in climatic conditions had led to a breakdown of disease resistance in mega wheat variety PBW-343 as well as out-breaks of new pathotypes, which caused a significant loss

to the production of wheat. To prevent the excessive use of fungicides, a single spray of each fungicide at a single dose was adapted on the four commonly grown varieties of Jammu to assess and evaluate the most effective fungicide and the most effective interaction between the fungicides and varieties for the management of yellow rust of wheat.

MATERIALS AND METHODS

The field experiment was laid out in factorial randomized block design during 2009-2010 crop season. Wheat varieties PBW-343, RSP-561, PBW-550 and Agra local were used for testing five fungicides *viz*., propioconazole (Tilt 25EC), tebuconazole (Folicur 250EC), triademefon (Bayletion 25% WP), tebuconazole (Raxil 2% WP) and azoxystrobin-22.9% (Quadris 2.08SC) at 0.1 per cent concentration. The fungicide tebuconazole (Raxil 2% DS) was used as seed treatment @ 0.1%. Single spray of respective fungicides was done in first week of Feb. after the appearance of symptoms. Observations regarding disease severity in each treatment and yield/plot were recorded. Disease severity was recorded on the basis modified Cobb's scale (Peterson *et al*., 1948)

Area under rust progress curve (AURPC)

The area under rust progress curve was estimated by using the formula adapted by Pandey*et al*. (1989)

AURPC = D (1/2 ($Y_1 + Y_k$) + ($Y_2 + Y_3 +$ ..... Y_k), where Y_1, Y_2..... Y_k are K disease scorings at a constant interval of D-days.

Grain yield and test weight

Observation regarding yield per plot in varieties PBW-343, PBW-550, RSP-561 and Agra local were recorded in treated (protected) and untreated (unprotected) plots. The varieties in different plots were individually harvested, threshed and the cleaned seeds were weighed.

The per cent increase in yield was ascertained as fallows

$$\text{Per cent increase in yield} = \frac{b-c}{c} \times 100$$

Where,

b = estimate of yield obtained in protected plot.

c = estimate of yield obtained in unprotected plot.

Similarly, the test weight of 1000 seeds of each plot was recorded. Data was statistically analyzed by using OP software.

RESULTS AND DISCUSSION

Field evaluation of various fungicides with different varieties of wheat revealed that Agra local showed maximum Final Rust Severity (FRS) of 57.67 per cent, whereas, RSP-561 exhibited minimum FRS of 21.33 per cent in untreated checks. Seed treatment with Raxil reduced disease severity by55.39, 20.52, 32.58 and 56.05 in PBW-343, RSP-561, PBW-550 and Agra local, respectively (Table 1). Foliar application of fungicides revealed that Quadris was most effective in reducing FRS in all the varieties followed by Folicur, Tilt and Bayleton. The AURPC indicated a significant decrease in yellow rust on different varieties with fungicides as compared to the control. McIntosh (2012) reported aoxystrobin and propiconazole as most effective fungicides in the management of yellow rust of wheat. Seed treatmenthelps to break the green bridge, clears out rust lurking in the crop until early spring and thereby delayed the start of an epidemic. Cheer *et al*. (1990) also reported that seed treatment with fungicides (triadimenol/

Table 1: Effect of seed treatment with tebuconazole (Raxil 2% DS @ 0.1%) on the severity of yellow rust in wheat, during 2009-10

Variety	Disease Severity (%)				Yield (q/ hectare)			Increase in yield over control (%)
	Control	Seed treatment	Mean ± S.E.(m)	Per cent disease reduction	Control	Seed treatment	Mean	
PBW-343	56.00 (48.45)	34.33 (35.91)	45.20 ± 10.8 (42.18)	55.39	33.64	36.61	35.12	8.84
RSP-561	21.33 (27.46)	17.37 (24.58)	19.35 ± 1.98 (26.02)	20.52	39.74	42.11	40.92	5.96
PBW-550	33.33 (35.10)	25.00 (29.94)	29.16 ± 4.16 32.52)	32.58	37.52	40.28	38.90	7.35
Agra-Local	56.67 (48.83)	35.17 (36.32)	45.90± 10.80 (42.57)	56.05	28.09	32.55	30.32	15.89
Mean	41.83 ± 4.87 (39.96)	27.96 ±4.22 (31.54)			34.75	37.89		9.04
C.D. (p=0.05)	Variety	Chemical	Variety x Chemical	Variety	Chemical	Variety x Chemical		
	3.13	2.18	N.S		4.19	2.15	N.S.	

Table 2: Effect of foliar application of various fungicides on final rust severity in different varieties of wheat, during 2009-10

Variety	Final Rust Severity Control	Bayleton	Tilt	Folicur	Quadris	Mean ± S.E.(m)
PBW-343	56.00 (48.45)	31.67 (34.13)	22.33 (28.17)	18.33 (25.30)	15.00 (22.59)	28.67 ± 4.11 (31.73)
RSP-561	21.33 (27.46)	13.00 (21.01)	8.33 (16.59)	6.00 (14.09)	5.67 (13.72)	10.87 ± 1.66 (18.57)
PBW-550	33.33 (35.10)	23.67 (28.98)	17.33 (24.34)	10.67 (19.05)	9.67 (18.07)	18.93 ± 2.71 (25.11)
Agra local	56.67 (48.83)	30.00 (32.99)	24.67 (29.69)	22.33 (28.19)	16.33 (23.77)	30.00 ± 3.97 (32.69)
Mean ± S.E. (m)	41.83 ± 4.87 (39.96)	24.58 ± 2.82 (29.28)	18.17 ± 2.20 (24.70)	14.33 ± 1.99 (21.65)	11.67 ± 1.50 (19.54)	
C.D. (p=0.05)	Variety 2.633	Chemical 2.944	Variety x chemical N.S.			

Table 3: Effect of foliar application of various fungicides on AURPC in different varieties of wheat, during 2009-10

Variety	AURPC					
	Control	Bayleton	Tilt	Folicur	Quadris	Mean
PBW-343	2687.78	1188.89	717.10	453.78	410.00	1091.51
RSP-561	941.00	236.67	108.67	80.00	41.17	281.50
PBW-550	830.00	678.63	452.00	205.44	111.70	455.56
Agra Local	2777.67	1352.07	794.11	320.00	466.49	1142.07
Mean	1809.11	864.07	517.97	264.81	257.34	

C. D. Variety Chemical Variety x Chemical; (p = 0.05) 23.04 25.76 51.52

Table 4: Effect of foliar application of various fungicides on yield of different varieties of wheat, during 2009-10

Variety	Yield (q/ ha)						Percent increase over control			
	Control	Bayleton	Tilt	Folicur	Quadris	Mean	Bayleton	Tilt	Folicur	Quadris
PBW-343	33.64	39.74	43.96	44.62	47.95	41.98 ± 1.72	18.14	30.68	32.65	42.56
RSP-561	39.74	45.73	47.17	47.84	50.84	46.27 ± 1.08	15.07	18.70	20.39	27.93
PBW-550	37.52	42.96	44.07	45.51	49.39	43.89 ± 1.53	14.50	17.45	21.30	31.64
Agra local	28.09	35.30	36.74	37.74	40.96	35.77 ± 1.23	25.67	30.82	34.37	45.83
Mean ± SEm	34.75 ± 3.25	40.93 ± 3.68	43.23 ± 3.81	43.68 ± 3.87	47.29 ± 3.81		17.80	24.43	25.71	36.09
C.D.	Variety	Chemical	Variety × Chemical							
(p = 0.05)	2.86	3.22	N.S.							

Table 5: Effect of seed treatment with tebuconazole (Raxil 2% DS) and foliar application of various fungicides on test weight of wheat, during 2009-10

Variety	Control	Seed treatment	Bayleton	Tilt	Folicur	Quadris	Mean
PBW-343	39.46	40.86	41.35	41.37	42.40	42.76	41.40
RSP-561	40.63	42.05	42.21	42.57	42.68	44.31	42.41
PBW-550	39.72	41.18	41.34	41.59	41.90	43.20	41.49
Agra local	36.92	38.42	38.45	38.70	38.99	40.64	38.67
Mean	39.17	40.63	40.84	41.06	41.49	42.73	
C.D.	Variety	Chemical	Variety x Chemical				
(p = 0.05)	1.11	1.36	N.S.				

fuberidazole) effective in controlling early infection by yellow rust (*P. striiformis*). TheYellow rust cause yield loss by reducing the kernel weight and quality deterioration (Afzal *et al.*, 2008). Increase in yield to the extent of 15.89, 8.84, 7.35 and 5.96 per cent was recorded in Agra local, PBW-343, PBW-550 and RSP-561, respectively, by seed treatment with tebuconazole. Yadav*et al*. (2004) reported that seed treatment with triadimefon at 2.5 g kg^{-1} seed was effective in reducing disease severity and increase the yield.The application of chemicals reduced the Final Rust Severity (FRS) in all the varieties. Quadris proved to be most effective in reducing the Final Rust Severity (FRS) and limited the disease progress followed by Folicur, Tilt and Bayleton. In susceptible varieties, PBW-343 and Agra local, the severity kept on increasing and reached to 56.00 and 56.67 per cent, respectively (Table 2).

In the treated varieties by Quadris and Folicur, AURPC was checked to a greater extent as compared to Tilt and Bayleton (Table 3). Hamm and Eggers (2008) reported that AURPC was significantly reduced by Quadris, Tilt and Folicur. All the chemicals increased the yield with greater increase in susceptible varieties (Table 4). Singh (1999) reported that fungicides (mancozeb and propiconazole) were effective in controlling the yellow rust leading to an increase in grain yield to the extent of 25.8 to 11.1 per cent, with the increase higher in wheat cultivar HD 2329 than HD 2285. Quadris proved most effective in increasing the yield of all the varieties with highest of 45.83 per cent in Agra local, followed by PBW-343 (42.56%), PBW-550 (31.64%) and RSP-561 (27.93%). Hamm and Eggers (2008) reported that application of Quadris was most effective followed by Folicur and Tilt in increasing the seed yield. The effectiveness of Quadris could be because it causes hormonal change in wheat leading to increasing grain yield due to delayed senescence and water conserving effects.Gindrat*et al*. (2002) reported that under a moderate or high disease pressure, yield increases were higher after a strobilurin) than after a triazole fungicide application. Tewari and Zewde (2000) reported highest yield increase of 72.34 per cent when Folicur was applied @ 0.025%, followed by Tilt (59.57%) @ 0.1% and Bayleton (53.90%).Among the untreated varieties highest test weight (40.63g) was recorded in RSP-561 followed by, PBW-550 (39.72g), PBW-343 (39.46g) and Agra local (36.92g). Afzal*et al*. (2008) reported variation in test weights of different cultivars having different levels of resistance against the *P. striiformis*. . Application of chemicals increased the test weight with Quadris being most effective followed by Folicur, Tilt, Bayleton and seed treatment with Raxil (Table 5). Among the various treatments used highest test weight of 44.31g was recorded in RSP-561 by the application of Quadris and lowest in Agra local (40.64g) by seed treatment with Raxil. Tewari and Zewde (2000) also reported highest test weight when Folicur was applied to the crop. Dofe *et al*. (2003) also observed the per cent increase in 1000 grain weight compared to the control (9.79%) when the crop was sprayed with mancozeb at 10 days intervals.Wiik and Ewaldz(2009) also noticed increase in 1000 grain weight with fungicidal treatments.

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