



Evaluation of Wheat (*Triticum aestivum* L) Varieties for Leaf Rust and Yield Attributing Characters



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Abstract

The experiment was carried out to screen and evaluate commercial wheat varieties against leaf rust and grain yield at Agricultural Research Station, Baffa, Mansehra, Pakistan. The experimental location is considered favourable for development of leaf rust disease. Twenty wheat varieties including susceptible control Morocco showed variable response to leaf rust and no variety was found completely resistant to leaf rust. Three varieties (NARC-2011, Pirsabak-08 and Siran-2010) were moderately resistant (MR), 11 varieties (NARC-09, Punjab-11, Pirsabak-04, Pirsabak-05, Faisalabad-08, Pakistan-13, Pirsabak-15, Pukhtunkhwa-15, Shakaar-13, Pirsabak-13 and NIFA-Insaaf) were moderately susceptible (MS), 3 varieties (Millat-11, Lasani-08 and Atta Habib) showed medium response (M) while 3 varieties (Sehar-2006, Glaxy-2013 and Morocco) were susceptible (S) to leaf rust. The result of statistical analysis for yield attributing characters showed significant variations for number of grains per spike, 1000 grain weight (g), grain yield (tons/ha), biological yield (tons/ha) and Harvest Index (%). Number of grains per spike ranged from 41 to 67 showed by varieties Morocco and NARC-2011, 1000 grain weight from 32 to 61 grams by varieties Glaxy-2013 and Siran-2010, grain yield from 1.92 to 5.10 tons/hectares by varieties Sehar-2006 and NARC-2011, biological yield from 8.36 to 10.87 tons/hectares by varieties Morocco and Pakistan-13, and harvest index from 22.29 % to 49.22 % by varieties Morocco and NARC-2011. Screening results of wheat varieties revealed that the level of resistant to leaf rust is at risk due to possible evolution of rust pathogen in experimental location and the potential of grain yield of these varieties may be effected by leaf rust.

Keywords: Leaf rust; Wheat yield; Screening; Resistance; Evaluation

Abbreviations: RFLP: Restriction Fragment Length Polymorphism; SSR: Simple Sequence Repeats; RAPD: Random Amplified Polymorphic DNA; SNP: Single Nucleotide Polymorphism; RCBD: Randomized Complete Block Design; MR: Moderately Resistant, M: Medium; MS: Moderately Susceptible; S: Susceptible; CI: Coefficient of Infections; LSD: Least Significant Difference

Introduction

Wheat (*Triticum aestivum* L.) is one of the important cereal crop grown worldwide. It is originated in Mediterranean region and mainly used for grain food [1]. Major growing countries include United States of America (USA), China, India, Russia and Pakistan [2]. Wheat grains are high in protein content and contain iron, minerals, micronutrients and fibers [3]. Wheat is self pollinated crop with a chromosome number $2n=14$ [4].

Wheat is popular grain crop of temperate climate and due to high adoptability in diverse environmental regions, wheat production and area under cultivation is significantly increasing throughout the world [5]. Pakistan ranked sixth in terms of worldwide wheat production where area under wheat cultivation was 9.14 millions hectares in 2016 with production up to 26 millions tons [2]. Wheat is a Rabi season crop in Pakistan with a growing period from November to May. Sowing is usually done with a drill on a well prepared clay loam soil [6]. Wheat

is sensitive to drought, water logging and salinity condition, however some varieties can withstand under drought and saline condition [7].

Wheat is vulnerable to several diseases including rust, smut, powdery mildew and root rots [8]. Amongst other wheat diseases, rust is considered the most destructive disease which caused severe yield losses [9]. Wheat is attacked by two types of rust, leaf rust and stem rust. Leaf rust is more prevailing and pathogenic disease caused by fungi *Puccinia triticina* [10]. Worldwide up to 70% yield loss was reported due to leaf rust in susceptible cultivars of wheat [11]. Environmental factors play important role in spreading of rust disease and cause epidemics. In 1992, in Western Australia, an epidemic due to leaf rust caused 37 % yield losses [12] while in Pakistan in 1978, 10 % of yield losses (equivalent to 0.83 millions tons) were recorded in leaf rust susceptible cultivars of wheat [13].

There are several control measures for controlling wheat rust such as chemical application (as fungicides spray), cultural practices (crop rotation, seed dressing and removing disease debris etc) and use of resistant cultivars [14]. Genetic resistance is considered the most reliable and environmental friendly approach for controlling leaf rust. Various seedling and adult plant resistant genes are identified for leaf rust in wheat [15]. The resistance of seedling genes are not long lasting comparably to more durable adult plant resistant genes *Lr13* and *Lr34* [15]. Therefore development of wheat varieties with adult plant resistance are required to combat with the attack of pathogens and reduce yield losses caused by leaf rust [15]. For development of resistant varieties, the availability of variation and genetic diversity is the pre requisite. Genetic diversity of a genotype is usually assessed through field based morphological analysis or by molecular markers such as restriction fragment length polymorphism (RFLP), simple sequence repeats (SSR), random amplified polymorphic DNA (RAPD) and single nucleotide polymorphism (SNP) [16]. The Resistance of a variety with broad genetic background is usually less vulnerable to overcome by the attack of new races of pathogens [17]. For that reason, diverse resistant varieties should be developed to provide durable and long term resistance against rust disease.

With the evolution of new races of rust pathogen, the resistance of present wheat cultivars is at high risk so there is a strong need to screen and know the level of resistance of current cultivars against leaf rust. The objective of the present experiment is to screen the commercial wheat varieties for leaf rust and find out the yield potential and genetic diversity amongst them.

Material and Method

The experiment was conducted at Agricultural Research Station, Baffa, Mansehra. The experimental materials was comprised of 20 commercial wheat varieties including NARC-09, Sehar-2006, NARC-2011, Punjab-11, Millat-11, Pirsabak-04, Pirsabak-05, Lasani-08, Faisalabad-08, Pakistan-13, Pirsabak-08, Pirsabak-15, Pukhtunkhwa-15, Glaxy-2013, Shakaar-13, Pirsabak-13, Atta Habib, Siran-2010 and NIFA-Insaaf. Morocco variety was used as a control in the experiment. The experiment was laid out in randomized complete block design (RCBD) with 3 replications. Total four entries were sown per plot for each variety. Susceptible variety Morocco was planted after every four rows to ensure uniform distribution of infection. The experimental location is considered as hot spot for screening of wheat against leaf rust. Data was recorded on central two rows. Row length was kept 5 meter and row to row distance was 30 cm. Uniform cultural practices were carried out from sowing to harvesting. Disease scoring was done using modified cobbs scale [18] when susceptible variety Morocco attained 60 to 70 % disease severity. The coefficient of infection was calculated using the constant values for infection type such as R=0.1, MR=0.25, M=0.5, MS=0.75, S=1. Yield estimation data was recorded for number of grains per spike, 1000 grain weight (g), grain yield (tons/ha), biological yield (tons/ha) and Harvest Index (%). Statistical analysis for ANOVA was done through M-Stat-C program [19].

Results and Discussion

Results showed variable response of wheat varieties to leaf rust (Table 1) and significant variation for yield attributing parameters (Table 2).

Table 1: Response of twenty wheat varieties to leaf rust disease.

S.No.	Varieties	Disease reaction	Disease severity	Coefficient of infection (CI)
1	NARC-09	MS	50	37.5
2	Sehar-2006	S	80	80
3	NARC-2011	MR	10	2.5
4	Punjab-11	MS	60	45
5	Millat-11	M	60	30
6	Pirsabak-04	MS	50	37.5
7	Pirsabak-05	MS	40	30
8	Lasani-08	M	50	25
9	Faisalabad-08	MS	50	37.5
10	Pakistan-13	MS	10	7.5
11	Pirsabak-08	MR	20	5
12	Pirsabak-15	MS	50	37.5
13	Pukhtunkhwa-15	MS	70	52.5
14	Glaxy-2013	S	90	90
15	Shakaar-13	MS	30	22.5

16	Pirsabak-13	MS	60	45
17	Atta Habib	M	20	10
18	Siran-2010	MR	20	5
19	Morocco	S	100	100
20	NIFA-Insaaf	MS	30	22.5

Table 2: Mean performance of various yield parameters of wheat varieties.

S.No.	Varieties	No. of grain / spike	1000 grain weight (g)	Grain Yield (Tons/ha)	Biological Yield (Tons/ha)	Harvest Index (%)
1	NARC-09	61 ABC	55 AB	4.23 ABC	9.90 CD	42.27 B
2	Sehar-2006	58 BC	42 DE	1.92 I	10.21 BCD	23.60 FG
3	NARC-2011	67 A	58 AB	5.10 A	10.36 ABC	49.22 A
4	Punjab-11	52 CD	48 BCD	3.76 CDE	10.78 AB	34.87 DE
5	Millat-11	63 AB	46 CD	3.93 CD	9.37 DE	41.94 BC
6	Pirsabak-04	49 CDE	51 BC	3.68 DE	9.52 CDE	38.65 CD
7	Pirsabak-05	53 BCD	49 BCD	4.06 BCD	10.67 AB	38.05 CD
8	Lasani-08	46 DE	44 DE	2.94 EFG	9.54 CDE	30.81 EF
9	Fisalabad-08	56 B	47 CD	3.82 CDE	10.12 BC	37.74 CD
10	Pakistan-13	54 BCD	52 ABC	4.47 AB	10.87 A	41.12 BC
11	Pirsabak-08	59 BC	45 DE	3.80 CDE	9.45 CDE	40.21 BCD
12	Pirsabak-15	62 AB	51 BC	4.35 ABC	10.37 ABC	41.94 BC
13	Pukhtunkhwa-15	48 CDE	43 DE	3.53 DE	10.58 AB	33.36 DEF
14	Glaxy-2013	43 DEF	32 F	2.32 EFG	9.10 DEF	25.49 FG
15	Shakaar-13	52 CD	47 CD	3.16 EF	9.84 CD	32.11 EF
16	Pirsabak-13	56 B	45 DE	3.76 CDE	9.42 CDE	39.91 CD
17	Atta Habib	61 ABC	53 ABC	4.43 ABC	10.76 AB	41.17 BC
18	Siran-2010	58 BC	61 A	4.27 BC	10.49 ABC	40.70 BCD
19	Morocco (control)	41 G	36 DEF	2.41 GH	8.36 G	22.29 I
20	NIFA-Insaaf	53 BCD	44 DE	3.45 DEF	9.95 CD	34.67 DE
LSD		10.43	9.8	3.12	7.21	2.65
CV		5.87	2.54	4.87	3.98	8.83

Leaf Rust

Due to mutation and genetic variation in leaf rust pathogen, the level of genetic resistance of current wheat cultivars are endangered which consequently affect their yield performance. Therefore it is very important to assess the extent of resistance in present commercial wheat varieties against leaf rust which will help in better understanding of disease scenario and pathogenic pressure for leaf rust in existing cultivars. In this experiment the screening of twenty commercial wheat varieties were performed for leaf rust at Agricultural Research Station, Baffa, Mansehra. As the experimental location is considered hot spot for leaf rust in wheat, therefore susceptible variety "Morocco" is used as a spreader of disease. Disease reaction was recorded according to modified cobbs scale and disease severity was recorded in percentage (Table 1). The coefficient of infection was calculated

using the constant values for infection type such as $R=0.1$, $MR=0.25$, $M=0.5$, $MS=0.75$, $S=1$.

Results indicated a distinct response of genotypes for leaf rust including moderately resistant (MR), medium (M), moderately susceptible (MS) and susceptible (S). The susceptible variety Morocco was used as a control. The disease severity on control was recorded 100% which represents the favourable environmental conditions for leaf rust at experimental location. Cultivar NARC-2011 was observed as moderately resistant with marginal (10%) disease severity. The coefficient of infection calculated at $MR=0.25$ level was 2.50 for this genotype. This good level of resistance represents the presence of possible resistance genes in this cultivar. Other varieties in MR category were Pirsabak-08 and Siran-2010 where 20% severity was recorded for leaf rust in both cultivars. The CI value for Pirsabak-08 and

Siran-2010 was measured as 5. The genetic level of resistance in these cultivars is sustainable and resistance breaking is low. Similar results were obtained by Arain et al. [20] where wheat genotypes/varieties were screened for leaf rust at six different experimental locations. In another study, 56 commercial wheat varieties were screened against spot blotch under controlled and field conditions [21]. The obtained results were consisted of MR, MS and S disease response and are accordance with the results of present experiment.

Medium (M) reaction type was found in three varieties viz Millat-11, Lasani-08 and Atta Habib. However, disease severity and level of resistance for these cultivars were different. The onset of disease was 20% in Atta Habib and 50 % and 60% for Lasani-08 and Millat-11 respectively. Similarly, the CI value was less (10%) for Atta Habib comparatively to Lasani-08 (25%) and Millat-11 (30%) (Table1). These cultivars showed average resistance level under hot spot environmental conditions and may perform well under climatic conditions less favourable for leaf rust. Rattu et al. [22] screened wheat varieties against leaf rust and virulence of leaf rust pathogen (*Puccinia triticinia*) was analysed in different wheat cultivars. Similarly, 64 advanced wheat lines/genotypes were evaluated for stem rust resistance and grain yield [23] and coefficient of infections (CI) were determined which are in agreement with the results of CI in present investigation.

Majority of cultivars in present experiment were found moderately susceptible (MS) to leaf rust. This shows the pathogenic pressure and possible evolution of new races of *Puccinia triticina* L. in experimental region which highlighted an urgent need for evolutionary and pathogenicity study of wheat rust pathogen in this area. Wheat varieties which showed MS response were NARC-09, Punjab-11, Pirsabak-04, Pirsabak-05, Faisalabad-08, Pakistan-13, Pirsabak-15, Pukhtunkhwa-15, Shakaar-13, Pirsabak-13 and NIFA-Insaaf. The disease severity

and coefficient of infection for NARC-09 were found 50 and 37.50, for Punjab-11 were 60 and 45, for Pirsabak-04 were 50 and 37.50, for Pirsabak-05 were 40 and 30, for Faisalabad-08 were 50 and 37.50, for Pakistan-13 were 10 and 7.50, for Pirsabak-15 were 50 and 37.50, for Pukhtunkhwa-15 were 70 and 52.50, for Shakaar-13 were 30 and 22.50, for Pirsabak-13 were 60 and 45 and for NIFA-Insaaf were 30 and 22.50 respectively. The results of field screening of 29 wheat varieties to stripe rust by Ehsan-ul-haq et al. [24] are similar as obtained in this experiment. Like wise, in another investigation, 42 Egyptian wheat varieties were screened for leaf rust resistance [25]. The results obtained in current study are in line with the results obtained by Draz et al. [25].

Two varieties Sehar-2006 and Glaxy-2013 were recorded susceptible to leaf rust. Both these varieties were severely infected with rust disease. The infection severity in Sehar-2006 was 80% while Glaxy-2013 showed 90% of rust infection and showed similar response like susceptible control (Morocco) where 100 % severity was reported for leaf rust. Overall, no variety was found completely (100%) resistant to leaf rust in this experiment. NARC-2011 showed good level of resistance followed by Pisabak-08 and Siran-2010. The durable resistance of these varieties may be used for future breeding program against leaf rust in wheat genotypes. Similar results of wheat screening were reported by Arora et al. [26], Abdul et al. [27], Arain et al. [20], Cheruiyot et al. [23] and Fayyaz et al. [28].

Yield Parameters

The analysis of variance for twenty wheat varieties revealed significant variation for grain yield related parameters (Table 3). The mean comparison and least significant difference (LSD) at 0.05 level for number of grain per spike, 1000 grain weight (g), grain yield (tons/ha), biological yield (tons/ha) and harvest index (%) are given in Table 2.

Table 3: Analysis of variance for yield and related parameters in twenty wheat varieties.

Source of variation	D.F	No. of grain / spike	1000 grain weight (g)	Grain Yield (Tons/ha)	Biological Yield (Tons/ha)	Harvest Index (%)
Replications	2	3.218	1.436	3.875	3.641	1.56
Genotypes	19	198.548	38.417	183.651	265.764	187.438
Error	41	4.982	0.987	5.984	7.238	3.674
Total	62	4426.343	921.436	3546.198	3134.786	843.986

Number of grain per spike is one of the important yield parameter. Healthy and robust grains in each spike of genotypes contribute to the overall yield. Highly significant variation was recorded for grain/spike amongst tested wheat varieties. Grain/spike ranged from 41 to 67. Maximum number of grains were observed in NARC-2011 (67 grains/spike) followed by Millat-11 and Pirsabak-15 where 63 and 62 number of grains were recoded respectively (Table 2). Other cultivars with optimum number of grains were NARC-09 and Atta Habib which on the average produced 61 grains per spike. Conversely, genotype with

minimum number of grain was susceptible variety Morocco. Grain average per spike was less (41) in Morocco which may be the cause of disease susceptibility or the over all genetic potential of this variety. On the other hand, majority of cultivars produced optimal (above 50) grains/spike in this experiment. Jamil et al. [29] recorded similar results for number of grains per spike in an experiment which assessed the genetic variability in sixty wheat genotypes. Similarly, the findings of Masood et al. [30] and Carew et al. [31] are in accordance with present results.

Grain weight is the integral parameter of overall yield and differs from genotype to genotype. In present experiment, grain weight of wheat varieties showed significant variation. The highest grain weight was recorded by Siran-2010 variety where 1000 randomly selected grains weighted 61 grams (Table 2). NARC-2011 was the second highest in terms of grain weight which showed 58 grams for 1000 seeds. On the other hand, minimum grain weight (32 gram) was reported in Glaxy-2013. Susceptible Morocco variety was also recorded with poor grain weight (36 gram/1000 grains). The given data of grain weight reflects the overall genetic potential of experimental genotypes which may or may not be directly related with disease conditions. Similar results were obtained by Ehdai and Waines [32] Cheruiyot et al. [23] and Draz et al. [25].

Yield is the most desirable and important parameter of crop plant. Grain yield vary from genotype to genotype due to genetic variation of crop plant. Being quantitative character, yield is greatly effected by genotype-environment interactions. Final grain yield depends on genetic potential of a genotype against biotic and a-biotic stresses and overall performance of individual plant.

In this experiment, grain yield of wheat varieties showed significant variation (Table 2). The variation in yield reflects the genetic diversity of cultivars. Grain yield ranged from 1.92 to 5.10 tons per hectare (Table 2). Variety NARC-2011 produced maximum yield (5.10 tons/ha) followed by Pakistan-13 (4.47 tons/ha) and Atta Habib (4.43 tons/ha). On the other hand, wheat varieties Sehar-2006, Glaxy-2013 and Morocco were found with poor grain yield of 1.92 tons/ha, 2.32 tons/ha and 2.41 tons/ha respectively. Overall, cultivar NARC-2011 performed well in the experiment in terms of disease resistance and grain yield. NARC-2011 showed moderately resistant (MR) response against leaf rust and produced high yield up to 5.10 tons/ha. Other wheat cultivars which were MR to leaf rust was found sub optimal for grain yield. Majority of rust susceptible varieties showed low grain yield which represents that susceptibility to biological stress may be the cause of less yield in these varieties.

Similar results of grain yield analysis was reported in 42 Egyptian wheat varieties screened against leaf rust resistance [25]. Similarly, Cheruiyot et al. [23] analysed grain yield of 64 wheat genotypes along with screening and evaluation of genotypes for stem rust resistance. The results of yield analysis in present study are in line with the results of Jamil et al. [29], Masood et al. [30] and Ehdai and Waines [32].

Biological yield is also an essential part of overall yield which helps in accurate estimation of grain yield. Significant variation were recorded for biological yield amongst wheat genotypes. The differences in biological yield are due to genetic variation of cultivars. Biological yield ranged from 8.36 to 10.87 tons per hectare (Table 2). Pakistan-13 showed maximum biological yield (10.87 tons/ha) followed by cultivar Punjab-11 which produced 10.78 tons biological yield per hectare. On the average, cultivars

produced biological yield from 9 to 10 tons/ha. In contrast, Morocco (control) was recorded with minimum biological yield (8.36 tons/ha) followed by Glaxy-2013 (9.10 tons/ha) as shown in Table 2. In this experiment the lowest biological yield was recorded in rust susceptible wheat varieties which indicates that leaf rust in wheat could be the cause of low biological yield in susceptible cultivars. The given results are in great lines with the findings of Cheema et al. [33] and Masood et al. [30].

Harvest Index is calculated by the formula yield/biological yield x 100 and is essential for estimation between grain yield and biological yield. The variation in harvest indices of experimental genotypes are because of genetic potential for grain and biological yield. Harvest index ranged from 22.29 % to 49.22 % (Table 2). The highest harvest index was observed in genotype NARC-2011 (49.22 %). Other genotypes with high harvest indices were NARC-09 (42.27 %), Millat-11 (41.94 %), Pirsabak-15 (41.94 %) and Atta Habib (41.17 %). Conversely, Morocco and Glaxy-2013 varieties were recorded with minimum harvest indices 22.29 % and 25.49 % respectively. Varieties with high harvest indices produced more grain yield and performed well in the experiment. Similar results were reported by Jamil et al. [29], Cheema et al. [33] and Carew et al. [31].

Conclusion

From the screening of wheat varieties against leaf rust in hot spot experimental location, it is concluded that wheat varieties NARC-2011, Pirsabak-08 and Siran-2010 were moderately resistant to leaf rust and produced sub optimal yield while Sehar-2006 and Glaxy-2013 were susceptible to leaf rust and performed poor in this experiment. Majority of wheat varieties were found moderately susceptible to wheat rust which could be due to possible evolution of new races of rust pathogen and favourable environmental conditions to leaf rust in Baffa, Mansehra.

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