Pak. J. Bot., 42(3): 2029-2042, 2010.

VULNERABILITY OF PAKISTANI WHEAT (*TRITICUM AESTIVUM* L.) VARIETIES AGAINST STRIPE RUST UNDER RAIN-FED CLIMATE OF THE NORTHERN PUNJAB AND NWFP

SYED NADEEM AFZAL[1], M. I. HAQUE[*1], ABDUL RAUF[1], IFTIKHAR AHMAD[2] AND SYEDA SADIQA FIRDOUS[3]

[1]*Department of Plant Pathology, PMAS-Arid Agriculture University, Rawalpindi, Pakistan*
[2]*National Agricultural Research Centre, Islamabad, Pakistan*
[3]*Department of Botany, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.*

Abstract

Exploring resistance potential of commercial wheat varieties is imperative to combat against the escalating stripe rust dilemma in the wheat cultivated areas of the northern Punjab and NWFP. A two years field-based screening of 57 Pakistani commercial varieties to evaluate their potential against stripe rust was conducted during 2005-06 and 2006-07. The commercial varieties, Soorab-96 (barley), Tatara and GA-2002 were the only three that exhibited resistant response to stripe rust at all the WSRN sites during experimentation years. There were 5 cultivars viz., Pavon-76, Kohsar-93, Fakhr-e-Sarhad, Iqbal-2000 and Durum-97 that showed a combination of resistance and partial resistance responses at the six hot spots. Contrarily MH-97, Inquilab-91, Sindh-81, Zargoon, Faisalabad-83, Faisalabad-85, Kaghan-93, Kirin-95, Kohinoor-83, LU-26, Nowshera-96, Punjab-96, Sariab-92, Sarsabz, Tandojam-83, SH-2002, Pak-81, Bahawalpur-97, Rothas-90, Suleman-96, WL-711, Zardana, Abadgar-93, Watan-94, Moomal-2002 and Margalla-99 displayed susceptible reactions at all locations except Sialkot. The compiled field results exhibit that although the virulence frequency for some of the stripe rust resistance genes remained low, yet the presence of virulence against them is alarming under the circumstances when genetic base of resistance is stumpy in the presently cultivated varieties.

Introduction

Stripe rust caused by an obligate parasite *Puccinia striiformis* Westend. f. sp. *tritici* Eriks. (*Pst*), precincts wheat (*Triticum aestivum* L.) production throughout the world. This pathogen reportedly infects numerous wheat and barley cultivars as well as certain grass species (Stubbs, 1985). Stripe rust of wheat has been reported from more than 60 countries of the world and all the continents except Antarctica (Chen, 2005). Varieties often appear to lose their resistance due to cultivation in an area of its non-adaptability or change in virulence, which may either be due to appearance of a new race(s) or change in the composition of the existing races (Kilpatrick, 1975).

If a susceptible variety is under cultivation on large scale and weather turns favourable for the stripe rust pathogen, the yield losses can be unbearable (Aqil & Hussain, 2004). So far, four major stripe rust epidemics with intensity exceeding 20% have been reported during 1973 (35%), 1978 (55%), 1995 (37.5%) and 2003 (20%) while the stripe rust intensity has never gone below 8% in the country's history since 1950s (Ahmad, 2004). After the dawn of new millennium, the rust intensity is heading towards an epidemic situation with every passing year. During these epidemic years, the extensively cultivated resistant wheat cultivars Pirsabak-85, Pak-81 and Inquilab-91 possessing resistance genes *Yr7*, *Yr9* and *Yr27* were brutally attacked by the corresponding

[*]Corresponding author: Tel: +92-(51) 9290239 irfhaque@gmail.com
Phone: (+92 51) 9062243 Fax:(+92 51) 9290160

stripe rust virulent races that rendered the varieties susceptible (Khan & Mumtaz, 2004). Virulence for *Yr*9, which was widely deployed in bread wheat cultivars such as Seri82, Giza64 and Mexipak, spread rapidly throughout the Middle East region, Yemen and Ethiopia in the late 1980s (Wellings *et al.*, 2000). After the breakdown of *Yr*9 resistance gene in the final decade of the last century, several cultivars were released with the incorporation of resistance gene *Yr*27. One such important and very well known cultivar of the north-western Pakistan is Inquilab-91, which inspite of having potential to exhibit high yield in disease stress conditions (Afzal *et al.*, 2008) is highly vulnerable to stripe rust (Singh *et al.*, 2004). Wellings (2008) also confirmed *Pst* pathotype with virulence for the *Yr27* that arose as a single mutation derivative from the 'Jackie' pathotypes and is given the common name 'Jackie *Yr27*' pathotype. During 2004-05, stripe rust expressed its severity in the upper Punjab and NWFP thus posed a serious threat against sustainable wheat production. Due to prevalence of highly conducive environment for stripe rust development during April 2007 in Baluchistan, the stripe rust severity ranged from 5S-80S, 60S-80S, 5MS-80S, 5S-60S and traces to 80S in district Quetta, Mustung, Pishin, Loralai and Qilla Saifullah, respectively (Hussain Nasir, Personal communication).

Since, chemical control of rust is un-economical so cultivation of resistant varieties is of immense significance, however, presence of numerous races of each and the ever-transforming nature of the pathogens obscure breeding for rust resistance. During the years, many superior wheat cultivars have been developed with an exceptional degree of resistance to one or more rust diseases but the disease situation never remained static which thus emphasis that breeding of new strains of wheat resistant to rusts is an incessant process (Bariana *et al.,* 2007). Development and use of resistant cultivars possessing diverse and well characterized genes is integral for sustainable wheat production (Kaur *et al.,* 2008).

The stripe rust outbreaks in the past emphasizes to avoid monoculture of a single wheat variety on large scale besides signifies the importance of identifying stripe rust resistant wheat varieties and their cultivation according to different ecological zones of the country. Severe epidemics on wide scale could be avoided through use of durable resistance and diversification of resistance genes (Chen *et al.,* 2002). Monitoring of susceptible varieties to stripe rust is imperative so that new virulences with the potential to overcome resistance genes currently deployed in the wheat cultivars can be detected. An attempt has been made through the anticipated research to encompass information pertaining to the impact of stripe rust on commercially cultivated Pakistani wheat varieties through their response in terms of susceptibility under prevailing natural environmental conditions at hot spots in the Northern Punjab and NWFP.

Materials and Methods

To assess performance and response of commercial varieties against stripe rust in the Northern Punjab and NWFP, the wheat stripe rust nurseries (WSRNs) were established and frequently surveyed from 2nd week of February to the 1st week of April during 2006 and 2007. Data from all the nurseries was recorded thrice during the month of March, but was kept under regular observation from February till April of 2006 and 2007.

Establishment of WSRNs: The nurseries were established at six selected locations (Table 1) that serve as hot spots for development of stripe rust. Detail of WSRN, comprising of a universally susceptible wheat cultivar – Morocco as a check along with 57 commercial cultivars acquired from Crop Disease Research Program, NARC, Murree is given in Table 2.

Table 1. Location of the established wheat stripe rust nurseries.

Province	Location
Punjab	Pulses Research Station (PRS), Sahowali, Sialkot; PMAS – Arid Agriculture University (PMAS-AAUR), Rawalpindi; and National Agricultural Research Centre (NARC), Islamabad.
NWFP	Cereal Crop Research Institute (CCRI), Pirsabak, Nowshera; NWFP Agricultural University (AUP), Peshawar; and Nuclear Institute for Food and Agriculture (NIFA), Tarnab, Peshawar.

Stripe rust monitoring: Each entry of the nursery was planted in a single meter row length, 30 cm apart. Two rows of universally susceptible spreaders consisting of Local White and Morocco were planted around the nursery. In addition, a row of susceptible check (Morocco) was also raised at every 20th entry. At the entire field WSRNs locations, stripe rust severity was taken as percent of rust infection on wheat plants according to the modified Cobb's scale (Peterson *et al.*, 1948) and the field response scale referred to the infection type as described in Table 3 (Roelf *et al.*, 1992; Mcintosh *et al.*, 1995). The observation for severity and reaction were recorded together with severity first.

Results and Discussion

Occurrence of stripe rust: The disease was observed in the first week of March 2006 on Morocco in WRSN established at Nowshera followed by Rawalpindi in the second week of March 2006. Heavy and above-average rain showers together with lower than average minimum and maximum temperatures recorded during February and March 2007 contributed significantly to the occurrence of stripe rust.

Due to prevalence of conducive environmental conditions, expression of stripe rust was much earlier in the WRSN established at Nowshera as the disease was detected in the third week of February 2007, while at Rawalpindi during the 1st week of March 2007. At all the WRSN sites, Morocco was the first that expressed susceptibility to stripe rust during both the years.

The results revealed that the intensity of disease infection during 2006-07 was higher as compared to 2005-06. This severity may be attributed to the relative dry weather which prevailed during 2005-06. More rainfalls during 2006-07 favored disease intensity in almost all the commercial varieties. The results are in line with the work done by TeBest *et al*., (2008) who reported that intensity of stripe rust is favored by a model with temperature, humidity and rainfall.

Wheat varietals response to stripe rust: The susceptible cultivar Morocco and Kohistan-97 were the only two cultivars that responded with 80S-90S and 10R-5R reaction, respectively, during 2005-06 and 2006-07 at the WRSN established at Sialkot. No disease was expressed by any other commercial variety at this site during these years. The commercial varieties, Soorab-96 (barley), Tatara (*Yr3*) and GA-2002 were the only three that exhibited resistant response to stripe rust at all the WSRN sites during these two experimentation years (Table 4). The resistant expression of Soorab-96 and GA-2002 is in line with the findings of Rattu *et al*., (2007). There were also 5 cultivars viz-a-viz Pavon-76, Kohsar-93, Fakhr-e-Sarhad, Iqbal-2000 and Durum-97, which showed a combination of resistance and partial resistance responses (Table 4) at the six hot spots.

Among the commercial wheat cultivars included in the nurseries, MH-97, Inquilab-91, Sindh-81, Zargoon, Faisalabad-83, Faisalabad-85, Kaghan-93, Kirin-95, Kohinoor-83, LU-26, Nowshera-96, Punjab-96, Sariab-92, Sarsabz, Tandojam-83, SH-2002, Pak-81, Bahawalpur-97, Rothas-90, Suleman-96, WL-711, Zardana, Abadgar-93, Watan-94, Moomal-2002 and Margalla-99 exhibited susceptible reactions at all locations except at Sialkot (Table 4). Contrarily, Kohistan-97, Punjab-85, Bakhtawar-93, Blue Silver and Chakwal-86 bestowed mix response from resistant to partial resistant and even susceptible reactions at the WSRNs during 2005-06 and 2006-07. Chakwal-86 was the single variety that presented MRMS type reaction at all the WSRN sites during these years (Table 5).

Table 4 exposes 8 wheat commercial varieties viz., Kohistan-97, Bakhtawar-93, Chakwal-86, Parwaz-94, Pasban-90, Pirsabak-85, Bahawalpur-2000 and Manthar-3 as completely resistant to stripe rust only at the WSRN site in Peshawar (AUP) and Sialkot (PRS) during 2005-06 and 2006-07.

Field data illustrated that majority of the *Yr* resistance genes showed susceptible reaction at all WSRN locations and expressed 5–100S yellow rust reaction in Morocco, Inquilab-91 (*Yr*27), Bakhtawar-93 (*Yr*9+), Wafaq-01 (*Yr*9) and MH-97 during both the years (Table-5) but exhibited immune reaction at Sialkot. However, Bakhtawar-93 offered 20-30MS at AAUR, 30MRMS-40S at NARC, 20S at CCRI and 50MSS-50S at NIFA during 2005-06 and 2006-07, respectively (Table-5). No susceptibility for this variety was observed during these years at AUP. Wafaq-01 showed 20S at UAAR and NARC, while 40MS at CCRI and 30S at NIFA whereas MH-97 revealed 30-80S response at the WRSN sites during 2005-06 and 2006-07 (Table 5).

The variety Blue Silver (*Yr6+YrA*), which demonstrated susceptibility at four WSRN sites, expressed resistance at Peshawar (AUP) during 2005-06 while showed partial resistance in 2006-07. Likewise, Soghat-90 (*Yr6+Yr7*) offered susceptibility at all the nursery sites excluding Sialkot but remained partially resistant at Peshawar (AUP) during 2005-06 and 2006-07. Mehran-89 (*Yr9*) and AS-2002 showed all types of reactions including resistance, partial as well as susceptible responses at various locations during the experimentation years.

There were few commercial varieties in the trials like Punjab-85 at Islamabad, Shahkar-95 at Rawalpindi while Shaheen-94 and Auqab-2000 at Peshawar that showed resistance or partial resistance during 2005-06 but expressed susceptibility in the following year. This suggests that virulence was not present or if present, was not effective enough to overcome resistance. In the following year resistance seems to collapse and this short term resistance failure led to a boom-and-bust syndrome (Kilpatrick, 1975).

Among the wheat rust resistance breeding programs, few achievements have, however, been seen for some years as 1BL.1RS wheat-rye translocation (Zeller, 1973), linked with *Yr9, Lr26, Sr31* and *PM8* remained effective throughout the wheat world till 1999. Presently, this translation is available in a number of high yielding wheat cultivars, including Faisalabad-85 and Pak-81. Although virulence is prevailing to *Yr9* at the NWFP, however, some cultivars like Anmol-91, Zarlashta and Wafaq-01, known to possess *Yr9,* showed resistant response during 2005-06 at Peshawar (AUP) but exhibited susceptibility at the same site during 2006-07 (Table 4).

The commercial varieties in Pakistan that encompass the range between MRMS to MSS type reaction might eventually express susceptibility after appearance of virulence. The genes, *Yr6, Yr7* and *Yr9* are the most frequently encountered stripe rust resistance gene either alone or in a blend with other *Yr* genes, present in the commercial Pakistani wheat varieties while Inquilab-91 possesses *Yr27* resistance gene. The commercial cultivars SH-2002 and Bakhtawar that were found resistant to the race group collection of 2003-04 (Ahmad & Kazi, 2005) proved a contrary situation when tested under this study during 2005-06 and 2006-07. SH-2002 and Bakhtawar-93 was found resistant at Sialkot and Peshawar (AUP), respectively during the experimentation years, while expressed susceptibility at other WSRNs. The commercial cultivar Marvi-2000 is worth to be mentioned here as it showed resistant response (Rattu *et al.*, 2007) and also expressed no disease reaction at WSRN Sialkot (2005-06 and 2006-07), Rawalpindi and Islamabad during 2005-06. The variety Marvi-2000 exhibited TR to 10MS type disease reaction at Rawalpindi and Islamabad, respectively during the following year and a susceptible type reaction ranging from 10-40S at the WRSN sites in the NWFP during both the experimentation years (Table 5). This is indicative of the fact that stripe rust pathotypes have the potential to overcome resistance with time and accordingly have rendered the variety susceptible, which was considered to be resistant earlier on.

The unwavering race composition could be due to few wheat varieties that are extensively cultivated over the years with similar genetic background as the previous wheat breeding programs have not generally been concerned with the resistance to stripe rust. After the dawn of new millennium, the race composition has become a complex due to introduction of a number of wheat cultivars such as SH-2002, Bahawalpur-2000, Bahkhar-2002, Marvi-2000, AS-2002, Iqbal-2000, Auqab-2000, Moomal-2002, Zarlashata, GA-2002, Wafaq-01 and Manthar.

An unnamed slow rusting gene in combination with *Lr46* is responsible for the Pavon-76 slow rusting resistance (Singh *et al.*, 1998), is currently believed to possess durable resistance (Singh & Rajaram, 1994). Although the adult plant genes *Yr29* present in cultivar Pavon-76 showed MS type reaction only at Rawalpindi and Islamabad, it might still have relative level of resistance compared with other susceptible varieties cultivated in Pakistan. It can, therefore, still be used as a potential cultivar and the responses are expected to provide adequate crop protection. It can, therefore, be concluded that few of the varieties still have potential to be used as a source of resistant germplasm against the stripe rust disease. However, we should not solely rely upon Inquilab-91 as it has shown greater susceptibility than the previous years (Afzal *et al.*, 2008).

The key to control cereal rusts is to use resistant cultivars (Johnson, 1981). The cultivars remain resistant to rust for five or a bit more years depending upon the agronomic lifespan, when a lively breeding program subsists. Some varieties fell to rust as soon as they are cultivated. Most of such cases are attributed to the failure that happen due to inadequate knowledge about the prevailing virulences in the pathogen population. In some instances, mutations or possibly recombination in existing virulences render the wheat crop susceptible.

A quest for hunting new and efficient sources of stripe rust resistance genes is imperative to tangle the alteration in the host-pathogen interaction. In Pakistan, *Yr27* was not widely used in commercial wheat cultivars and due to this reason Inquilab-91 survived for the longest period in the major stripe rust zone of the Northern Punjab and NWFP till 2003-04. These previously resistance genes now lack sufficient protection against prevailing stripe rust pathotypes in the northern areas of Pakistan. Nonreplacement of these cultivars by the ones with more effective genes would endanger the golden grains harvest in an ample quantity.

The epidemics that witnessed during 1977-78 and 1992-93 cautions that stripe rust could be a serious threat for wheat in Pakistan whenever the pre-requisites of disease triangle is accomplished. Production losses associated with the disease (Afzal *et al.*, 2008) and non-affording of high input costs due to the repeated fungicidal application necessitate the development of sustainable control measures against stripe rust. Under the present growing circumstances of predominantly dry-land wheat production coupled with uncertain rainfall, breeding for resistant cultivars is emphasized which will offer the most reliable and cost-effective channel for controlling stripe rust. Effective breeding approach, therefore, strongly relies upon the understanding of genetic variation in both host and pathogen. Effective disease control approach further necessitates an epidemiological understanding of the pathogen. This includes the potential of stripe rust pathogen to persist during non-crop season and disease occurrence probability in different wheat-cultivated areas of the Northern Punjab and NWFP. The same will have a restraining influence on the release of cultivars that are susceptible in hot spot areas, which will be an important aspect in selection of a cultivar by the farmers.

References

Afzal, S.N., M.I. Haque, M.S. Ahmedani, A. Rauf, M. Ahmad, S.S. Firdous, A.R. Rattu and I. Ahmad. 2008. Impact of stripe rust on kernel weight of wheat varieties sown in rainfed areas of Pakistan. *Pak. J. Bot*., 40(2): 923-929.

Ahmad, I. 2004. Wheat Rust Scenario 2003-2004. In: *Multimedia Presentation during Second Regional Yellow Rust Conference for Central & West Asia and North Africa*, 22-26 March 2004, Islamabad, Pakistan, pp. 18.

Ahmad, I. and A.M. Kazi. 2005. Evaluation and incorporation of new genetic diversity in Pakistani wheats for stripe (yellow) rust resistance. *2nd Annual Progress Report, ALP, PARC, Islamabad*.

Aqil, M.K. and M. Hussain. 2004. Combining yellow rust resistance with high yield in bread wheat. In: *Abstracts, Second Regional Yellow Rust Conference for Central & West Asia & North Africa*, 22-26 March 2004, Islamabad, Pakistan, pp. 28.

Bariana, H. S., H. Maih, G. N. Brown, N. Willey and A. Lehmensiek. 2007. Molecular mapping of durable rust resistance in wheat and its implecation in breeding. In: *Wheat production in stressed environment*, (Eds.): H.T. Buck *et al.*, Springer Netherlands. pp. 723-728.

Chen, X.M. 2005. Epidemiology and control of stripe rust (*P. striiformis* f. sp. *tritici*) on wheat. *Can. J. Plant Pathol*., 27: 314-337.

Chen, X.M., M. Moore, E.A. Milus, D.L. Long, R.F. Line, D. Marshall and L. Jackson. 2002. Wheat stripe rust epidemics and races of *Puccinia striiformis* f. sp. *tritici* in the United States in 2000. *Plant Dis*., APS 2002. 86(1): 39-46.

Hussain, N. 2007. Plant Pathologist, A.R.I. Sariab, Quetta. *Tour report of wheat rust position in uplands of Balochistan*. 19-25 April, 2007. Personal Communication.

Johnson, R. 1981. Durable resistance, definition of genetic control and attainment in plant breeding. *Phytopathol*., 71:567-568.

Kaur, S., U. K. Bansal, R. Khanna and R. G. Saini. 2008. Research note: Genetics of leaf and stripe rust resistance in a bread wheat cultivar Tonichi. *Journal of Genetics*, 87(2):191-194.

Khan, M.A. and H. Mumtaz. 2004. Combining yellow rust resistance with high yield in grain wheat. In: Abstracts, *Second Regional Yellow Rust Conference for Central & West Asia and North Africa*, 22-26 March 2004, Islamabad, Pakistan, pp. 28.

Kilpatrick, R.A. 1975. New wheat cultivars and longevity of the rust resistance, 1971-75. United States Department of Agriculture, Agricultural Research Service. NE64. Washington, DC.

McIntosh, R. A., C. R. Wellings and R. F. Park. 1995. *Wheat rusts: An atlas of resistance genes*. CSIRO Publ., East Melborne, Victoria, Australia.

Peterson, R. F., A. B. Campbell and A. E. Hannah. 1948. A diagrammatic scale for estimating rust intensity of leaves and stem of cereals. *Can J. Res. Sect*. C, 26:496-500.

Rattu, A. R., M. A. Akhtar, M. Fayyaz and M. Bashir. 2007. *Report on screening of wheats against yellow rust and leaf rusts under NUWYT and NWDSN and wheat rust situation in Pakistran*. CDRP, IPEP, NARC, PARC, Islamabad, Pakistan, pp. 1-59.

Roelfs, A. P., R. P. Singh and E. E. Saari. 1992. *Rust Diseases of Wheat: Concepts and Methods of Disease Management*. Mexico, D.F.: CIMMYT. 81 Pages.

Singh, R. P., A. Mujeeb-Kazi and J. Huerta-Espino. 1998. *Lr*46: a gene conferring slow-rusting resistance to leaf rust in wheat. *Phytopathol*., 88(9): 890-894.

Singh, R. P., E. Duveiller and J. Huerta-Espino. 2004a. Virulence to yellow rust resistance gene *Yr*27: A threat to stable wheat production in Asia. In: Abstracts, *Second Regional Yellow Rust Conference for Central & West Asia and North Africa*, 22-26 March 2004, Islamabad, Pakistan, pp. 16.

Singh, R.P. and S. Rajaram. 1994. Genetics of adult plant resistance to stripe rust in ten spring bread wheat. *Euphytica*, 72:1-7.

Stubbs, R.W. 1985. Stripe rust. In: *Cereal rusts*. Vol. II. *Disease, distribution, epidemiology, and control*. (Eds.): A.P. Roelfs and W.R. Bushnell. Academic Press, Inc., New York. pp. 61-101.

TeBest**,** D. E., N.D. Paveley, M.W. Shaw and F. van den Bosch. 2008. Disease–weather relationships for Powdery Mildew and yellow rust on winter wheat. *Phytopathol*., 98(5): 609-617.

Wellings, C.R. 2008. Stripe rust pathotypes ‘Jackie Yr27’ detected for the first time. Plant Breeding Institute, Unv. of Sydney. *Cereal Rust Report*, 6(8): pp. 1-3.

Wellings, C.R., R.P. Singh, R.A. McIntosh and A.H. Yahyaoui. 2000. The assessment and significance of pathogenic variability in *P. striiformis* f. sp. *tritici* in breeding for resistance to stripe (yellow) rust: Australia and international studies. In: *Proc. 11th Regional Workshop East Cent. South Africa*, pp. 134-143.

Zeller, F.J. 1973. 1B/1R wheat-rye chromosome substitutions and translocations. In: *Proc. 4th Int. Genet. Symp. Columbia, MO*. pp. 209-221.

(Received for publication 27 August 2009)