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Assessment of Leaf Rust Resistance in Wheat Genotypes in Natural Environmental Conditions of Tandojam

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ABSTRACT

Identification of sources of resistance and their incorporation in crop germplasm is the most effective method for disease management. Therefore, present work has been conducted to find out resistance in thirty two (32) wheat genotypes against leaf rust during wheat season 2015-2016 and 2016-2017. The results of the study revealed significant variation among these genotypes against leaf rust in both seasons. In 2015-16 wheat season genotypes C217 and C228 were free of leaf rust, T11, T12, T16 and T18 were found resistant and T1, T2 and T19 showed moderately resistant reaction. Maximum leaf rust severity of 50S has been noticed on T14. In 2016-17 normal sowing trial, less rust development has been observed on all genotypes due to late appearance of disease. While in late sowing trial, seventeen genotypes have been found susceptible with maximum rust severity of 60S on T20. Twelve are rated moderately susceptible to susceptible. While the genotypes T1and T2 showed moderately resistant - moderately susceptible reaction against the disease in late sowing trial. Among thirty two genotypes, T16 has been found free of leaf rust in both trials. Thus the potential of T1, T2 and T16 as source of resistance against leaf rust can be investigated further. These results can be used in wheat breeding program to incorporate leaf rust resistance in wheat genotypes.

1. Introduction

Wheat (*Triticum aestivum* L.) is an important crop in Pakistan. It is a major source of nutritional requirements for masses in the country. However, its average yield per unit area in Pakistan is not up to its potential. It is cultivated as rain fed and irrigated crop throughout the country. Sufficient availability of moisture in rain fed conditions results in better wheat production. Apart from water scarcity, proper sowing time and the use of good quality inputs can assist in achieving the potential yield in wheat [1]. The current fluctuations in environment have threatened its production. These climatic changes have resulted in the emergence of new pathotypes of crop diseases [2]. Consequently changes have been observed in the virulence of wheat rusts throughout the world [3]. In Pakistan virulence for a number of leaf rust resistance sources is present [4-5].The proliferation of these virulence challenges the local wheat production. Ultimately yield, quality and market price of wheat is reduced [6]. During the wheat season, presence of suitable environmental conditions favors the outbreak of leaf rust and build up its inoculum [7-8]. Under such circumstances, cultivation of resistant varieties is the best option against this disease particularly for the underdeveloped countries where use of chemical fungicides not only increases the production costs but also become a serious concern for environment. Availability of good quality resistant wheat varieties can play a vital role in sustainable farm production. For this purpose a number of resistant genes have been deployed in wheat germplasm which proved very useful against leaf rust in different environmental conditions. However, their effectiveness depends upon the prevailing races of *Puccinia recondita*. Surveillance and field screening of wheat material is a key to determine the role and performance of existing sources of leaf rust resistance in the field [9-12]. In Pakistan wheat is grown throughout the country in different ecological conditions. Therefore, the presence of wheat rusts is also related to the geographical conditions of the area. Tariq et al. [13] reported variations in leaf rust virulence. The leaf rust resistance in local wheat varieties in Pakistan is due to the presence of Lr3, Lr10, Lr13, Lr14a, Lr23, Lr26, Lr27, Lr31 and Lr34 genes [14]. Wheat is major crop in Sindh province and is subjected to the attack of wheat rusts. Therefore, current study has been planned to screen wheat genotypes against leaf rust in the field conditions of Tandojam during 2015-16 and 2016-17. This preliminary screening will help to find their resistance potential against this disease. The new sources of resistance can be helpful in strengthening the leaf rust resistance program.

Similarly their deployment in wheat cultivars, with desirable agronomic traits, can limit the risk of leaf rust outbreak [15]. Such approaches not only improve the farm yield but also contribute in sustainable crop production in the country.

2. Materials and Methods

The experiment was conducted in wheat season 2015-16 and 2016-17 at the experimental farm of Nuclear Institute of Agriculture, Tandojam. The trial was conducted in normal sowing (November) in 2015-16 and 2016-17. In order to avoid the disease escape and late sowing (December) trial was also conducted in 2016-17. Thirty two (32) genotypes of wheat were evaluated against leaf rust

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Table 1: Scale for measuring the host reaction against leaf rust.

Host reaction	Field response	Response value
0	No visible infection	0
R	Necrotic areas with or without minute uredia	0.2
R- MR	Necrotic areas with or without minute uredia with necrotic areas	0.3
MR	Small uredia present surrounded by necrotic area	0.4
MR-MS	Small uredia surrounded by necrotic areas as well as medium uredia with no necrosis but distinct chlorosis	0.6
MS	Medium uredia with no necrosis but possible some distinct chlorosis	0.8
MS-S	Medium uredia with no necrosis but possible some distinct chlorosis as well as large uredia with little or chlorosis present	0.9
S	Large uredia and little or no chlorosis present	1.0

(0) = No disease, (R) =Resistant, (R- MR) = Resistant – Moderately resistant, (MR) = moderately resistant, (MR-MS) = Moderately resistant- Moderately susceptible, (MS) = Moderately susceptible (MS-S) = Moderately susceptible - Susceptible, (S) = Susceptible

under the natural environmental conditions. Each entry was sown in six (6) square meter plot with four rows of five meter length. The row to row distance was maintained at 30 cm. The susceptible check morocco was planted all around the experimental area and repeated after every 10th entry for the rapid multiplication and spread of disease in the experimental plot. For the vigorous growth of test entries agronomic practices like irrigation, fertilizer and weeding were applied at their recommended rates. The experimental area was irrigated regularly to provide humid conditions for rust development. On the appearance of leaf rust, observations were made on daily basis to witness the spread of disease in the entire plot. As the susceptible variety morocco showed the highest disease reaction (90S) against leaf rust, data regarding the disease severity and genotype response in the field was recorded following the modified Cobb scale [16]. Rust severity was measured as the percent leaf area infected with leaf rust pustules and genotypes response was recorded following Roelfs et al. [17]. All the tested genotypes were grouped in various categories depending up on the final rust reaction at physiological maturity of crop. Coefficient of infection (CI) for each entry was calculated according to [18-19] by multiplying the response value of each reaction with final rust severity (Table 1).

3. Results and Discussion

The field response of test entries against leaf rust in this study has been summarized in Tables 2 and 3. All the tested genotypes exhibited significant variation against the

Table 2: Field response of wheat genotypes against leaf rust during 2015-16.

Genotype Response	Genotypes	Range of CI
No disease	C217, C228	0
Resistant	T11, T12, T16, T18	1-2
Resistant -Moderately resistant	-	-
Moderately resistant	T1, T2, T19	0.4-0.4
Moderately resistant-Moderately susceptible	T4, T17, T20, T23(R), C273, C580, C591	3-6
Moderately susceptible	C271	0.8
Moderately susceptible- Susceptible	T3, T24, T25	4.5-9
Susceptible	T5, T6, T7, T8, T9, T10, T13, T14, T15, T21, T22, T23(W)	10-50

Table 3: Field response of normal and late sown wheat genotypes against leaf rust during 2016-17.

Genotype response	Genotypes (2016-17) November sowing	CI	Genotypes (2016-17) December sowing	CI
No disease	T4, T10, T11, T12, T16	0	T16	0
Resistant	-	-	-	-
Resistant-Moderately resistant	-	-	-	-
Moderately resistant	T1, T2, T3, T17, T22, T23(W), T25, C271	2-4	-	-
Moderately resistant –Moderately-susceptible	T5, T6, T7, T8, T9, T18, T23(R), T24, C591	3-6	T1, T2	6-12
Moderately susceptible	T19, C228	6-12	-	-
Moderately susceptible-susceptible	T13, T14, T15, T20, T21, C217 C273, C580	9-18	T3, T4, T5, T6, T7, T9, T15, T25, C271, C273, C217, C228	18-36
Susceptible	-	-	T8, T10, T11, T12, T13, T14, T17, T18, T19, T20, T21, T22, T23(R), T23(W), T24, C580, C591	20-60

prevalent leaf rust inoculum in the area. The genotypes C217 and C228 showed no disease symptoms during 2015-16 normal sowing trial, while during 2016-17 late sowing trial these showed moderately susceptible (MS) reaction. This response can be attributed to the changes in virulence spectrum of the leaf rust pathogen. The response of T1 and T2 genotypes was acceptable in both wheat seasons. Both genotypes exhibited moderately resistant (MR) and moderately resistant- moderately susceptible (MRMS) type of pustules which is comparatively less than the 90S intensity of leaf rust on susceptible check. Our results further illustrate that the genotype T16 showed better performance among all tested wheat genotypes against leaf rust in both seasons. During 2015-16 trial it produced resistant reaction (10R) while during 2016-17 seasons it was free of leaf rust. It can be assumed from the response of T1, T2 and T16 that the genotype T16 may possess a vertical resistance while the other two genotypes T1 and T2 may possess horizontal resistance. The coefficient of infection in all these lines is less than the other genotypes used in this experiment. However, their exact potential of resistance and its mechanism can be confirmed with the latest molecular approaches. On the basis of phenotypic reaction against leaf rust, Hussain et al. [20] have characterized and selected better performing wheat genotypes. While Hussain et al. [21] have identified Lr10 gene in wheat varieties of Pakistan. The genotypes T11, T12, T18 and T19 performed better in less disease pressure in both years but in late sown trial and under heavy disease pressure these genotypes were found susceptible. The results suggest variability in the prevailing inoculum of *Puccinia recondita* in the area. Kolmer et al. [22] have observed that the climatic conditions of the area, genetics of host plants and their growth stages play a significant role in the expression of disease resistance. Due to the late appearance of leaf rust, normal sown trial of 2016-17 suggests a disease escape and the response of wheat genotypes was variable. But in late sown trial incidence and severity of leaf rust was high (90S on spreader lines) which provided a complete reaction of all tested genotypes against leaf rust (Table 4). Most of the genotypes under the high disease pressure favored the leaf rust development indicating lack of resistance. Singh et al. [23] have reported a number of APR genes which limit wheat rusts in epidemic conditions. The wheat material with such combinations of resistance genes persist longer in the field [24]. Apart from T1, T2 and T16, twelve genotypes produced MSS reaction and other seventeen genotypes exhibited a susceptible reaction in 2016-17 late sowing trials. On these lines leaf rust pustules were healthy, with more mass of urediospores. Similarly no chlorosis and necrosis was found around the pustules. Subsequently the values of coefficient of infection were higher. The susceptible reactions are not only the source of rust proliferation but also affect the yield and quality in wheat [6, 17, 25]. More than 40% losses in kernel weight due to leaf rust in wheat have been reported by Bajwa et al. [26]. Thus the loss of resistance affects the overall yield [27]. The environmental conditions (Tables 5 and 6) in this area favor the development and sporulation of the pathogen, under such circumstances, the use of leaf rust resistant wheat material is the only choice to overcome this problem. McIntosh et al. [28] have catalogued 60 leaf rust resistant genes which have been deployed in various wheat cultivars all across the globe [28]. However, changes in pathogen population at times often overcome the effectiveness of these genes in wheat [29]. Majority of these genes is race specific [30]. Positive co-relation has been observed between adult plant resistance and the race specific genes; as APR results in better performance of these genes [31].

Table 4: Terminal reaction of each genotype against leaf rust at Tandojam.

Genotype	Rust reaction (25-02-2016)	Rust reaction (21-2-2017)	Rust reaction (27-03-2017)
T1	5MR	TMR	10MRMS
T2	TMR	5MR	20MRMS
T3	10MSS	10MR	10MSS
T4	5MRMS	0	10MSS
T5	30S	5MRMS	40MSS
T6	40S	10MRMS	20MSS
T7	30S	10MRMS	20MSS
T8	30S	5MRMS	40S
T9	30S	5MRMS	40MSS
T10	10S	0	40S
T11	5R	0	40S
T12	5R	0	40S
T13	20S	10MSS	40S
T14	50S	20MSS	20S
T15	40S	10MSS	40MSS
T16	10R	0	0
T17	10MRMS	5MR	40S
T18	5R	5MRMS	40S
T19	10MR	10MS	40S
T20	10MRMS	5MSS	60S
T21	20S	10MSS	40S
T22	30S	5MR	40S
T23(R)	10MRMS	10MRMS	40S
T23(W)	30S	5MR	20S
T24	5MSS	5MRMS	40S
T25	5MSS	5MR	30MSS
C217	0	5MSS	20MSS
C228	0	TMS	20MSS
C271	TMS	5MR	30MSS
C273	5MRMS	5MSS	20MSS
C580	10MRMS	5MSS	40S
C591	5MRMS	10MRMS	20S
Morroco	90S	40 S	90S

Table 5: Agro-climatic conditions of Tandojam during 2015-16 Rabi season.

Month	Rainfall (mm)	Temperature (^{0}C)		Relative Humidity (%)
		min	max	
November 2015	0	14.5	30.3	48
December 2015	0	8.3	25.5	58
January 2016	0	10.3	25.4	59
February 2016	0	9.2	28.4	44
March 2016	0	17.1	34.1	47
April 2016	0	20.2	42	48

Source: Regional agro Met Centre Tandojam

Table 6: Agro-climatic conditions of Tandojam during 2016-17 Rabi season.

Month	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)
		min	max	
November 2016	0	12.9	32.6	52
December 2016	0	11.2	28.5	56
January 2017	0.6	7.3	22.1	61
February 2017	0	10	28.2	49
March 2017	0	14.5	34.4	47
April 2017	0	19.9	40.2	42

Source: Regional Agro Met Centre Tandojam

The present results suggest that only one genotype T16 performed better among all other genotypes. Similarly the response of genotypes T1 and T2 in the current study were very effective. These three genotypes can be a good source of resistance against prevailing races of leaf rust. Their potential as a source of resistance can be fruitful for breeding programs. The appearance of a new leaf rust race in Pakistan during 2011-12 has resulted in the breakdown of resistance in major local wheat cultivars [14]. It is imperative to exploit the potential of these genotypes in the breeding program. Park et al. [32] have mapped seedling resistance gene in wheat as a valuable source of resistance against leaf rust. Sohail et al. [14] have suggested the use of new combinations of resistant genes along with the existing one to have better alternates. From the above discussion it can be concluded that under low disease pressure screening data may not be fruitful. A variable response of all genotypes was evident in the field conditions of Tandojam under low and high leaf rust intensity. The present data showed that out of 32 genotypes, T16 along with T1 and T2 were found resistant. These genotypes with their agronomic compatibility can be a good source of leaf rust resistance in the area. The findings of Singh [33] revealed that the interaction of Lr34 and some minor genes resulted in durable resistance in wheat which proved very effective in adult plant stages. Their potential can be exploited through the conventional and advanced breeding techniques which can be incorporated in the upcoming wheat lines to ensure leaf rust free wheat production in the area.

4. Conclusion

From the present results, it is concluded that out of thirty two wheat genotypes only T16 performed best under high disease intensity; whereas, T1 showed MRMS and T2 showed MR reaction against leaf rust. While the remaining twenty nine genotypes exhibited MSS and susceptible reaction. The potential of T1, T2 and T16 in particular can be exploited as a source of leaf rust resistance. Such sources along with desirable agronomic traits will be very effective in disease free wheat production. This will also help to overcome leaf rust problem in the area.

References

[1] Govt. of Pakistan, "Economic Survey of Pakistan", 2015-16, Economic Wing, Ministry of finance Islamabad, pp. 28, 2016.

[2] A. Mateen, M.A. Khan, A. Rashid, M. Hussain, S.U. Rehman and M. Ahmed, "Identification of leaf rust virulence pattern on wheat germplasm in relation to environmental conditions in Faisalabad", Acad. J. Agric. Res., vol. 3, no. 8, pp.137-155, 2015.

[3] J. Huerta-Espino, R.P. Singh, S. German, B.D. McCallum, R.F. Park, W.Q. Chen, S.C. Bhardwaj and H. Goyeau, "Global status of wheat leaf rust caused by *Puccinia triticina"*. Euphytica. vol. 179, pp.143–160, 2011.

[4] A.R. Rattu, M. Fayyaz, A. Munir, J.I. Mirza, K.A. Khanzada, M. Imtiaz, Y. Rauf, M.Y. Mujahid, I. Ahmad, S. Masood, R. Ward, I.A. Shah, F. Muhammad, S.A. Khan and K. Nazari, "Virulence spectra of wheat rusts in Pakistan during 2012-13 BGRI 2013 Technical Workshop", August 19–22, 2013. New Delhi, India, pp. 100, 2013.

[5] J.I. Mirza, I. Ahmad, A. Munir, H. Saffdar, R. Sultan, A. Majeed, A.R. Rattu, I. Hussain, M. Imtiaz and R. Ward, "Race analysis of wheat rust pathogens in Pakistan BGRI 2014 Technical Workshop", March 22-25, 2014. Obregon, Mexico. pp. 9, 2014.

[6] C.N. Marasas, M. Smale and R.P. Singh, "The economic impact in developing countries of leaf rust resistance breeding in CIMMYT-related spring bread wheat". International Maize and Wheat Improvement Center, Mexico, DF. 2004.

[7] E.E. Saari and J.M. Prescott, "World distribution in relation to economic losses", A.P. Roelfs, W.R. Bushnell (Eds.), The Cereal Rusts, Acad. Press, Orlando, FL, vol. 2, pp. 259–298, 1985.

[8] T.M. Abdel-Hak, N.A. EL-Sherif, A.A. Bassiouny, I.I. Shafik and Y.H. EL-Dauadi, "Control of wheat leaf rust by systemic fungicides", Proceedings of the Fifth European and Mediterranean Cereal Rusts Conference, Bari, Italy, pp. 255–266, 1980.

[9] R.A. McIntosh, "Close genetic linkage of genes conferring adult-plant resistance to leaf rust and stripe rust in wheat", Plant Pathol. vol. 41, pp. 523-527, 1992.

[10] R.P. Singh, D.N. Sharma, Mehta and Harsh, "Resistance to Puccinia recondita tritici in synthetic hexaploid wheats", Ind. J. Genet. vol. 58, pp. 263–269, 1998.

[11] M. Fayyaz, A.R. Rattu, I. Ahmad, M.A. Akhtar, A.A. Hakro, K.A. Mujeeb, "Current status of the occurrence and distribution of (*Puccinia triticina*) wheat leaf rust virulence in Pakistan", Pak. J. Bot. vol. 40, pp. 887-895, 2008.

[12] A.R. Rattu, I. Ahmad and M. Fayyaz, "Virulence analysis of Puccinia triticina cause of leaf rusts of wheat", Pak. J. Bot. vol. 41, no. 4, pp. 1957-1964, 2009.

[13] A.H. Tariq, S. Ahmad, M.A. Hussain, L.H. Akhtar, M. Arshad and S.Z. Siddiqi, "The virulence spectrum of wheat leaf rust in Southern Punjab, Pakistan", Pl. Pathol., vol. 2, pp. 80–84, 2003.

[14] Y. Sohail, Z.K. Shinwari. M. Fayyaz, A.R. Rattu and A.S. Mumtaz, "A perspective of leaf rust race FHPRN and its impact on leaf rust resistance in Pakistani wheat varieties", Pak. J. Bot. vol. 47, no. 4, pp. 1559-1567, 2015.

[15] G. Mustafa, M.M. Alam, S.U. Khan, M. Naveed and A.S. Mumtaz, "Leaf rust resistance in semi dwarf wheat cultivars: a conspectus of post green revolution period in Pakistan", Pak. J. Bot. vol. 45, pp. 415-422, 2013.

[16] R.F. Peterson, A.B. Campbell and A.E. Hannah, "A diagrammatic scale for estimating rust intensity on leaves and stems of cereals", Can. J. Res. vol. 60, pp. 496–500, 1948.

[17] A.P. Roelfs, R.P. Singh, E.E. Saari, "Rust diseases of wheat concepts and methods of disease management", CIMMYT, Mexico, D.F., 1992.

[18] E.E. Saari and R.D. Wilcoxson, "Plant disease situation of high yielding durum wheat in Asia and Africa", Ann. Rev. Phytopathol. vol. 2. pp. 49–68, 1974.

[19] A.K. Pathan, and R.F. Park, "Evaluation of seedling and adult plant resistance to leaf rust in European wheat cultivars", Euphytica., vol. 149, pp. 327–342, 2006.

[20] M. Hussain, M.A. Khan, M. Hussain, N. Javed and I. Khaliq, "Phenotypic characterization of wheat selected lines for resistance against leaf stripe and stem rust through phenotypic markers application", J. Ani. & Pl. Sci. vol. 26. no. 1, pp. 185-193, 2016.

[21] W. Hussain, H. Inamullah, Ahmad, M.S Iqbal, F.M. Abbassi, Rabnawaz, W. Ahmad, Liaqat and S. Hussain, "Identification of leaf rust resistant gene Lr10 in Pakistani wheat germplasm", Afr. J. Biotech. vol. 10, no. 43, pp. 8578-8584, 2011.

[22] J.A. Kolmer, D.L. Long and M.E. Hughes, "Physiological specialization of *Puccinia triticina* on wheat in the United States in 2003", Pl. Dis. vol. 89, pp. 1201–1206, 2005.

[23] R.P. Singh J. Huerta-Espino, S. Bhavani, S.A. Herrera-Foessel, D. Singh, P.K. Singh, G. Velu, R.E. Mason, Y. Jin, P. Njau and J. Crossa, "Race non-specific resistance to rust diseases in CIMMYT spring wheats", Euphytica. vol. 179, pp.175–186, 2011.

[24] R.P. Singh, H.M. William, J.H. Espino and G. Rosewarne, "Wheat rust in Asia: Meeting the challenges with old and new technologies", Proceedings of the 4th Int. Crop Science, Cong. 26 Sep. – 1 Oct. 2004, Brisbane, Australia, 2005.

[25] J.A. Kolmer, "Genetics of resistance to wheat leaf rust". Ann. Rev. Phytopath. vol. 34, pp. 435-455, 1996.

[26] M.A. Bajwa, K.A. Aqil and N.I. Khan, "Effect of leaf rust on yield and kernel weight of spring wheat". RACHIS. vol. 5, pp. 25–28, 1986.

[27] R.P. Singh, T.S. Payne, P. Figueroa and S. Valenzuela, "Comparison of the effect of leaf rust on the grain yield of resistant, partially resistant, and susceptible spring wheat cultivars", Am. J. Altern. Agric. vol. 6, pp.115–121, 1991.

[28] R.A. McIntosh, Y. Yamazaki, K.M. Devos, J. Dubcovsky, J. Rogers and R. Appels, "Catalogue of gene symbols for wheat. Supplement", KOMUGI Integrated Wheat Science Database, 2007.

[29] J.A. Kolmer, D.L. Long and M.E Hughes, "Physiological specialization of Puccinia triticina on wheat in the United States in 2005", Pl. Dis. vol. 91, no. 8, pp. 979–984, 2007.

[30] I.S. Draz, M.S. Abou-Elseoud, A.E.M. Kamara, O.A. Alaa-Eldein and A.F. El-Bebany, "Screening of wheat genotypes for leaf rust resistance along with grain yield", Ann. Agric. Science, vol. 60, no. 1, pp. 29–39, 2015.

[31] R.P. Singh and J. Huerta-Espino, "Inheritance of seedling and adult plant resistance to leaf rust in wheat cultivars Ciano79 and Papago 86". Plant Dis. vol. 79, pp. 35–38, and 1995.

[32] R.F. Park, V. Mohler, K. Nazari and D. Singh. "Characterization and mapping of gene *Lr73* conferring seedling resistance to Puccinia triticina in common wheat". Theor. Appl. Genet. vol. 127., pp. 2041-2049, 2014.

[33] R.P. Singh, "Association between gene Lr34 for leaf rust resistance and leaf tip necrosis in wheat", Crop Science, vol. 32, pp. 874-878, 1992.