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SCREENING FOR LEAF RUST RESISTANCE AND ASSOCIATION OF LEAF RUST WITH EPEDIOMOLOGICAL FACTORS IN WHEAT (*Triticum aestivum* L.)

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Three hundred and twenty five genotypes of bread wheat (*Triticum aestivum* L.) were evaluated for leaf rust resistance against local pathotypes under field conditions during crop season of 2010-11 and 2011-12. On the basis of leaf rust severity scale in the year 2010-2011, 225 wheat genotypes showed no reaction against leaf rust, 12 genotypes showed resistance response, 20 moderately resistance, 40 moderately susceptible, 15 moderately resista-nt to moderately susceptible and 13 genotypes showed susceptible response against leaf rust**.** During the year 2011-12, 233 wheat genotypes showed no reaction, 8 genotypes showed resistance response, 14 moderately resistance, 40 moderately susceptible, 8 moderately resistant to moderately susceptible and 22 genotypes showed susceptible response against leaf rust of wheat. Slow rusting cultivars corresponded low AUDPC values but high rusting lines corresponded high values**.** Epidemiological factors have greatly influenced the development of leaf rust. Rust reactions of different genotypes showed statistically significant correlation with environmental conditions. Average temperature, maximum temperature, minimum temperature, rainfall and relative humidity correlated with leaf rust reactions. It was also observed that some genotypes showed varying response during the two crop seasons which may be attributable to variations in environmental factors.
Keywords: *Puccinia triticina***,** AUDPC, biotic stress, environment, wheat genotypes

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the world's leading cereal crops and the most important food grain (Sleper and Poehlman, 2006). According to FAO (FAO, 2014) global wheat production in 2013-14 was 713.2 million metric tonnes, thereby making it the third most produced cereal crop after maize (872.79 million metric tonnes) and rice (719.74 million metric tonnes). In Pakistan, wheat was cultivated on 9.03 million hectares with production level of 25.3 million tons and contributes 10.3% value addition in agriculture and 2.2% GDP of the country (Anonymous, 2014). It is a staple food of 35% the world's population (Ogbonnaya *et al.,* 2013). It is among the most important food crops and is one of the most traded commodities in the world markets (Curtis and Halford, 2014). Its demand has been increasing with the ever increasing population since the times of its domestication in 15,000-10,000 BC. It is expected that its demand will increase by 40% by the year 2030 (Dixon *et al.,* 2009).

Wheat crop is prone to many biotic and abiotic stresses. Among biotic stresses diseases like rusts, smuts, bunts, leaf spots etc. can cause serious losses whereas rusts i.e. stem rust, leaf rust and yellow rust are the most devastating fungal diseases continuously posing threat to world wheat production due to emergence of new identifiable virulent races through mutation and genetic recombination (Roelfs *et al*., 1992; Dadkhodaie *et al*., 2011) and their intercontinental movement.

Leaf rust, caused by *Puccinia triticina* Eriks., is a severe fungal disease in most of the wheat growing areas (Park *et al*., 2007). Leaf rust has potential to cause losses up to 50% and because of its more frequent and widespread occurrence, leaf rust probably results in greater total annual losses worldwide than stem and stripe rusts (Huerta-Espino *et al*., 2011). The wheat leaf rust fungus can adapt to diverse climates and due to interruption in photosynthesis and translocation of photosynthates, it affects the overall quality, productivity and market value of wheat due to decreased numbers of kernels per head and lower kernel weight depending on the stages of crop development when infection occurs (Kolmer, 2005). In 1978, a major leaf rust epidemic in Pakistan caused 10% yield loss that cost a national loss of US $86 million (Hussain *et al*., 1980).

Genetic resistance is most efficient system of reducing yield losses caused by leaf rust (Kolmer, 1996). The resistance to leaf rust disease in wheat is the most economical and environmental friendly and preferable method to tackle this disease. Developing and managing durable resistance in cultivars is very difficult. The hidden and the new evolving races of the leaf rust recurrently have sensitized the resistance of newly resistant cultivars. The resistance exploited is centered on genes which are effective during the course of the plant growth cycle (Fahmi *et al.*, 2005). Most resistance genes are expressed at seedling stage and continue to be effective till maturity. Genes, for example *Lr1, Lr10 and Lr21* are excellent examples of race specific resistance genes effective at seedling as well as adult stages (Dyck and Kerber, 1985). These genes confer hypersensitive flecks of very low infection types or reduce uredinia surrounded by necrosis and chlorosis. Some genes like Lr13 and Lr16 are temperature sensitive and their behavior changes with change in temperature (McIntosh *et al*., 1995)

Though genetic resistance is considered an efficient disease management system, the combination of newly-developed and previously-existing virulent races can easily circumvent the race-specific major genes in commonly grown cultivars, resulting in frequent epidemics (Chen, 2007). To date, at least 73 leaf rust resistance genes derived from *Triticum* and related genera or species have been formally named (McIntosh *et al*., 2012; Park *et al.,* 2014), most of which confer race-specific resistance.

Plants have manifested different resistance mechanisms in order to shield themselves against invading pathogens. Such resistance could be qualitative controlled by one major gene or could be quantitative controlled by many minor genes called as quantitative trait loci (QTLs). Resistance governed by most major genes halts fungal growth after the invasion of parasite inside host plant cell, and is escorted by suicide of the infected cell or constellation of cells surrounding the spot of encounter, called as the hypersensitive response (HR). Partial resistance results in as the minor genes checks the fungal growth prior to or during penetration in cell wall (Niks and Rubiales, 2002; Collins *et al.*, 2007), contrary *HR* the defended plant cells remain alive.

Systematic breeding for disease resistance started after discovery of genetic mechanism of resistance (Biffen, 1905) and resistance based on hypersensitive host response, dominated the wheat breeding for resistance against leaf rust. The hypersensitivity is characterized by discrete phenotypes and is conferred by a single or a few major genes (*Lr*). Race specificity is a prominent characteristic of such resistance type where every host resistance is elicited by recognition of a certain avirulence factor produced by pathogen as postulated in the gene-for-gene model (Flor, 1971) and coined as vertical resistance by Van der Plank (1963). Resistance based on single, major and race-specific genes often become ineffective within 5 years after its introduction in commercial cultivars (Kilpatrick, 1975).

Because of lack of durability of hypersensitive resistance genes, research was initiated to investigate other ways to protect the crops against such pathogens. Non hypersensitive partial resistance (Parlevliet, 1975), is considered to be more durable (Parlevliet, 1985) and the most valuable alternative to hypersensitive resistance.

Partial resistance is characterized by reduced epidemic build and its infection type indicates the absence of hypersensitive resistance (Parlevliet and Van Ommeren, 1975). Partial resistance is assumed to be due to joint effect of longer latency period, lower infection frequency and smaller spore production, latency period being the most important component (Shaner and Finney, 1980; Teng *et al*., 1977).

Partial resistance is well thought-out as an isolate-nonspecific and durable, thus consistent with concept of 'horizontal' resistance as described by Van der Plank (1968). However a detailed explanations of partial resistance to leaf rust (*Puccinia hordei*) in Barley (*Hordeum vulgare*) exposed small cultivar × isolate interactions (Parlevliet, 1978; Parlevliet and van Ommeren, 1985). Parlevliet and Zadoks (1977) elucidated these interactions by presuming an interaction of minor-gene-for-minor-gene conferring resistance like 'vertical' resistance. They even altercated that the minor-gene-for minor- gene interaction would elucidate the stability of this polygenic resistance (Parlevliet, 2002).

Adult plant resistance (APR) is generally considered to be effective against a broad range of races for a longer duration of time. Some race-nonspecific APR genes have been identified and used in breeding programs for many years. The most utilized APR genes *Lr34*/*Yr18*, *Lr46*/*Yr29,* and *Lr67*/*Yr46* are mapped on the 7DS, 1BL, and 4DL chromosomal regions of common wheat respectively (Dyck, 1987; Herrera-Foessel *et al*., 2011; Hiebert *et al*., 2011; Krattinger *et al*., 2009; Singh *et al*., 1998; William *et al*., 2003). In the United States, many sources of high-temperature APR have been identified and used in breeding programs to enhance durable resistance (Kolmer *et al*., 2009; Chen, 2013). With the advancement of genomics, many race-specific and nonspecific leaf rust and yellow rust resistance genes have been tagged with molecular markers that can be used in marker-assisted breeding (Chen, 2013; McIntosh *et al*., 2012; Rosewarne *et al*., 2013).

The objectives of the current study were to characterize the adult wheat genotypes for the effectiveness of their response to leaf rust under field conditions to identify potential sources of novel resistance for use in future breeding programs and to correlate the resistance response with epidemiological factors.

MATERIALS AND METHODS

Three hundred and twenty five genotypes of bread wheat (*Triticum aestivum* L.) collected from Pakistan, CIMMYT, ICARDA and other countries were used for current studies. Seeds of collected germplasm were sown in November in the experimental area of Plant Pathology in the University of Agriculture Faisalabad (Latitude = 31°-26' N, Longitude =

73°-06' E, Altitude = 184.4m) during the years 2010-11 and 2011-12. Each entry was planted in 1.5 m long row by keeping row to row distance of 30 cm and sowing was done by putting two seeds per hole by maintaining 8 cm plant to plant distance. The recommended package of agronomic practices was followed to raise the crop in Faisalabad.

The experiment was conducted following the augmented design. The whole material was divided in to 5 sets each comprising of 65 entries, similarly experimental field was divided into 5 blocks. A set of 65 test entries and 13 check genotypes (Lasani 2008, Auqab, 7096, Inqulab 91, Morocco, Pak-81, Sehar-2006, 3094, Lu-26, Shafaq, Fsd- 2008, Chenab 70 and Mexipak) were randomized in each block. The experimental material in each block was flanked by susceptible cultivar Morocco (Morocco is highly susceptible (Jacob, 1990) to all the prevalent rust races and provides a substrate for rapid multiplication and distribution of rust inoculums). Two rows of Morocco were planted across the experimental material i.e. along the paths on each side of experimental material. The inoculum collected from the field during 2009-10 and 2010-11 was preserved, multiplied on Morocco in November 2010 and 2011 in green house and was used for inoculation during 2010-11 and 2011-12 respectively. Artificial inoculation of experimental material was done by spraying uredospore suspension (30 gm of spore/16L of water). The inoculation was done in the evening at regular intervals (4-5 times) from mid January to mid February. Leaf rust reaction and field response were recorded using modified Cobb's scale described by Peterson *et al*. (1948) given in Table 1. Data were recorded after seven days interval from mid February to end of March. Area under disease progressive curve (AUDPC) was calculated using CIMMYT software (Singh *et al.*, 2000).

$$AUDPC = \sum_{i=1}^{n-1}\left(\frac{X_i + X_{i+1}}{2}\right)(t_{i+1} - t_i)$$

Where X_i= rust intensity on date *i,* t_i= time in days between *i* and date *i*+1, n= number of dates on which disease was recorded

Environmental data consisting of maximum and minimum temperature, relative humidity and rainfall of disease data collection period were collected from meteorological station of the university. Average values of epidemiological factors were correlated with leaf rust severity using Pearson's correlation coefficient (r). The formula to calculate (r) is as under.

$$r_{xy} = \frac{Cov.(X,Y)}{\sqrt{Var(X).Var(Y)}}$$

RESULTS

Screening of wheat genotypes against leaf rust: Genetic resistance is the most economical and environment friendly, preferable and efficient system of reducing yield losses caused by leaf rust. So a study was conducted to find the novel sources for leaf rust resistance during the years 2010-11 and 2011-12. During the year 2010-11, 225 wheat genotypes showed no reaction against leaf rust, 12 genotypes showed resistance response, twenty moderately resistance, 40 moderately susceptible, 15 moderately resistant to moderately susceptible and 13 genotypes showed susceptible response against leaf rust of wheat. The AUDPC showed varying values for different genotypes for the year 2010-2011 (Table 4). For the year 2011-12, 233 wheat genotypes showed no reaction against leaf rust, 8 genotypes showed resistance response, 14 exhibited moderately resistance response, 40 moderately susceptible, 8 moderately resistant to moderately susceptible and 22 genotypes exhibited susceptible response against leaf rust of wheat. The AUDPC also showed varying values for different wheat genotypes for the year 2011-2012 (Table 5).

Correlation of environmental factors with leaf rust: Environmental factors play a significant role in the spread of rust diseases. The correlation coefficients estimated between of environmental conditions and leaf rust response given in Tables 2 and 3 for the year 2010-11 and 2011-12 respectively. Twelve genotypes (MH 97, PARI 73, PBW 343, PBW 450, HARTOG, NING 8319, WATAN/2*ERA, PB-96/87094//MH-97, V-08164, KIRITATI//SERI/RAYON, FRET2*2/KUKUNA, MEXIPAK 65) have significant negative correlation with average temperature and one genotype (YANAC/3/PRL/SARA//TSI/VEE#5/4/) has significant positive correlation with average temperature during 1[st] crop season. Sixteen genotypes (PAK 81, ZINDAD-2000, SEHER-06, ZARDANA 89, RASKOH 05, SHAFAQ-06, MH 97, PARI 73, SATLUJ 86, PBW 450, PB-96/87094//MH-97, LU 26, V-03094, V-08164, CHENAB-70, FRET2*2/KUKUNA) having significant negative correlation with maximum temperature and the genotype YANAC/3/PRL/SARA//TSI/VEE#5/4/ showed

Table 1. Leaf rust reaction, symbol and field response

Reaction	Symbol	Field response
No disease	0	No visible infection
Resistant	R	Necrotic areas with or without minute uredia
Moderately resistant	MR	Small uredia present surrounded by necrotic area
Moderately susceptible	MS	Medium uredia with no necrosis but possible some distinct chlorosis.
Moderately resistant-moderately susceptible	MRMS	Small uredia present surrounded by necrotic areas as well as medium uredia with no necrosis but possible some distinct chlorosis.
Susceptible	S	Large uredia and little or no chlorosis present.

Table 2. Correlation of environmental conditions with leaf rust for 2010-2011

Genotypes	Avg. Temp	Max. Temp	Min. Temp	Rainfall	RH
T.J-83	-0.912	-0.659	-0.963*	0.293	-0.263
PAK 81	-0.870	-0.954*	-0.541	0.817	-0.135
ZINDAD-2000	-0.817	-0.931*	-0.467	0.870	-0.051
SEHER-06	-0.817	-0.931*	-0.467	0.870	-0.051
ZARDANA 89	-0.817	-0.931*	-0.467	0.870	-0.051
RASKOH 05	-0.930	-0.970*	-0.635	0.728	-0.250
SARIAB 92	-0.706	-0.869	-0.327	0.943*	0.097
SHAFAQ-06	-0.817	-0.931*	-0.467	0.870	-0.051
MH 97 (ATTILA)	-0.982*	-0.959*	-0.747	0.577	-0.405
BLUEBIRD	-0.982*	-0.959*	-0.747	0.577	-0.405
SATLUJ 86	-0.817	-0.931*	-0.467	0.870	-0.051
PBW 343	-0.984*	-0.910	-0.808	0.570	-0.317
PBW 450	-0.982*	-0.959*	-0.747	0.577	-0.405
BT 2549/FATH	-0.822	-0.483	-0.998**	0.000	-0.389
HARTOG	-0.969*	-0.857	-0.841	0.556	-0.244
CHENAB-70	-0.969*	-0.857	-0.841	0.556	-0.244
NING 8319	-0.969*	-0.857	-0.841	0.556	-0.244
WATAN/2*ERA	-0.980*	-0.892	-0.821	0.566	-0.291
PFAU/WEAVER	-0.706	-0.869	-0.327	0.943*	0.097
PB-96/87094//MH-97	-0.982*	-0.959*	-0.747	0.577	-0.405
LU 26	-0.817	-0.931*	-0.467	0.870	-0.051
V-03094	-0.817	-0.931*	-0.467	0.870	-0.051
MOROCCO	-0.706	-0.869	-0.327	0.943*	0.097
V-08164	-0.982*	-0.959*	-0.747	0.577	-0.405
YANAC/3/PRL/SARA//TSI/VEE#5/4/	0.982*	0.959*	0.747	-0.577	0.405
CHENAB-70	-0.817	-0.931*	-0.467	0.870	-0.051
KIRITATI//SERI/RAYON	-0.969*	-0.857	-0.841	0.556	-0.244
FRET2*2/KUKUNA	-0.982*	-0.959*	-0.747	0.577	-0.405
MEXIPAK 65	-0.939*	-0.915	-0.718	0.700	-0.174
V-08081	-0.926	-0.764	-0.867	0.522	-0.138

*** = Significant ($P<0.05$); ** = Highly significant ($P<0.01$)**

significant positive correlation with maximum temperature for year 2010-2011. Two genotypes (T.J-83, BT 2549/FATH) have statistically significant negative correlation with minimum temperature for year 2010-2011. Two genotypes (SARIAB 92, PFAU/WEAVER) having statistically significant positive correlation with rainfall for year 2010-2011 (Table 2).

Thirty five genotypes (CHAKWAL 86, CHAKWAL 97, MIRAJ-08, KHIRMAN, SKD-1, SOGHAT-90, ZARGOON 79, ZARDANA 89, RASKOH 05, SARIAB 92, CHENAB 70, FAISALABAD 83, LYP 73, PARI 73, PARWAZ 94, PUNJAB 81, PUNJAB 96, SA 42, SARSABZ, SHAHKAR 95, YECORA 70, ZAMINDAR 80, BAYA'S', NACOZARI F 76, WL 711, NING 8319, PAS.90/SH.88, LU26/KEA'S' , SHAFAQ-06, V-03094, V-04188, V-03BT007, V-06068, V-07200, KIRITATI//2*SERI/RAYON) have significant positive correlation with average temperature for year 2011-2012. Seventeen genotypes (CHAKWAL 86, CHAKWAL 97, MIRAJ-08, KHIRMAN, MEHRAN-89, SKD-1, SOGHAT-90, ZARGOON 79, ZARDANA 89, RASKOH 05, SARIAB 92, CHENAB 70, FAISALABAD 83, FAISALABAD 85, LU 26, LYP 73, FSD-2008, PARI 73, PARWAZ 94, PUNJAB 76, PUNJAB 81, PUNJAB 96, SA 42, SARSABZ, SHAHKAR 95, ZAMINDAR 80, BAYA'S', NACOZARI F 76, WL 711, PBW 450, NING 8319, LU26/KEA'S', TAN/PEW//SARA/3/CBRD, NEELKANT'S', BB # 2/PT//CC/INIA/3/ALD ‘S’, SHAFAQ-06, V-03094, V-04188, V-05121, V-056132, V-03BT007, V-06068, V-07200, V-08081) have significant positive correlation with maximum temperature and two genotypes (GOSHAWK'S' and PB81//F3.71/TRM/3/BULBUL// F3) showed significant negative correlation for year 2011-2012. Twenty eight genotypes (BHAKKAR-2000, LASANI-08, CHAKWAL 97, MIRAJ-08, KHIRMAN, SOGHAT-90, ZINDAD-2000, ZARGOON 79, LYP 73, PUNJAB 96, SA 42, SA 75, SARSABZ, YECORA 70, PASTOR, CHAM-6, NING 8319, PFAU/WEAVER , F60314.76/MRL//CNO79/3/KA//NAC/4/STAR , SEHER-06, SHAFAQ-06, V-03094, V-04188, V-05121, V-056132,

Table 3. Correlation of environmental conditions with leaf rust for 2011-2012

Genotypes	Avg.Temp	Max.Temp	Min.Temp	Rainfall	RH
BHAKKAR-2000	-0.861	-0.760	-0.953*	-0.336	-0.253
CHAKWAL 86	0.948*	0.955*	0.895	0.775	0.805
LASANI-08	0.861	0.760	0.953*	0.336	0.253
CHAKWAL 97	1.000**	0.981*	0.978*	0.522	0.610
FAISALABAD-08	0.533	0.587	0.437	1.000**	0.912
MIRAJ-08	0.969*	0.945*	0.955*	0.684	0.683
KHIRMAN	0.969*	0.945*	0.955*	0.684	0.683
MEHRAN-89	0.910	0.941*	0.827	0.826	0.881
MOROCCO	0.948*	0.955*	0.895	0.775	0.805
SKD-1	0.948*	0.955*	0.895	0.775	0.805
SOGHAT-90	1.000**	0.981*	0.978*	0.522	0.610
PAK 81	0.828	0.891	0.709	0.869	0.954*
ZINDAD-2000	-0.861	-0.760	-0.953*	-0.336	-0.253
ZARGOON 79	0.969*	0.945*	0.955*	0.684	0.683
ZARDANA 89	0.959*	0.982*	0.885	0.730	0.820
RASKOH 05	0.948*	0.955*	0.895	0.775	0.805
SARIAB 92	0.948*	0.955*	0.895	0.775	0.805
CHENAB 70	0.964*	0.953*	0.933	0.726	0.739
FAISALABAD 83	0.959*	0.982*	0.885	0.730	0.820
FAISALABAD 85	0.910	0.941*	0.827	0.826	0.881
LU 26	0.910	0.941*	0.827	0.826	0.881
LYP 73	0.989*	0.999**	0.931*	0.555	0.694
MEXIPAK 65	0.828	0.891	0.709	0.869	0.954*
FSD-2008	0.913	0.969*	0.797	0.575	0.792
BLUEBIRD	0.948*	0.955*	0.895	0.775	0.805
PARWAZ 94	0.948*	0.955*	0.895	0.775	0.805
PUNJAB 76	0.910	0.941*	0.827	0.826	0.881
PUNJAB 81	0.948*	0.955*	0.895	0.775	0.805
PUNJAB 96	0.969*	0.945*	0.955*	0.684	0.683
SA 42	0.969*	0.945*	0.955*	0.684	0.683
SA 75	-0.861	-0.760	-0.953*	-0.336	-0.253
SARSABZ	1.000**	0.981*	0.978*	0.522	0.610
SHAHKAR 95	0.948*	0.955*	0.895	0.775	0.805
YECORA 70	1.000**	0.981	0.978*	0.522	0.610
ZAMINDAR 80	0.948*	0.955*	0.895	0.775	0.805
BAYA'S'	0.948*	0.955*	0.895	0.775	0.805
NACOZARI F 76	0.948*	0.955*	0.895	0.775	0.805
WL 711	0.951*	0.990**	0.858	0.573	0.760
PBW 450	0.896	0.956*	0.776	0.726	0.886
PASTOR	-0.861	-0.760	-0.953*	-0.336	-0.253
GOSHAWK'S'	-0.913	-0.969*	-0.797	-0.575	-0.792
CHAM-6=NESSER	0.861	0.760	0.953*	0.336	0.253
NING 8319	1.000**	0.981*	0.978*	0.522	0.610
PB81//F3.71/TRM/3/BULBUL// F3.	-0.861	-0.760*	-0.953	-0.336	-0.253
PFAU/WEAVER	-0.861	-0.760	-0.953*	-0.336	-0.253
PAS.90/SH.88(V-96059)	0.948*	0.955	0.895	0.775	0.805
F60314.76/MRL//CNO79/3/KA//NAC/4/STAR	-0.861	-0.760	-0.953*	-0.336	-0.253
LU26/KEA'S'	0.948*	0.955*	0.895	0.775	0.805
SEHER-06	0.861	0.760	0.953*	0.336	0.253
TAN/PEW//SARA/3/CBRD	0.880	0.942*	0.759	0.776	0.914
NEELKANT'S'	0.805	0.796*	0.780	0.890	0.787
MAYA/PVN	0.828	0.891	0.709	0.869	0.954*
BB # 2/PT//CC/INIA/3/ALD ‘S’	0.910	0.941*	0.827	0.826	0.881
SHAFAQ-06	0.989*	0.999**	0.931*	0.555	0.694
BUC'S'/FLK'S'//MYNA'S'/VUL'S'	0.828	0.891	0.709	0.869	0.954*
V-03094	1.000**	0.981*	0.978*	0.522	0.610
V-04188	1.000**	0.981*	0.978*	0.522	0.610
V-04048	0.828	0.891	0.709	0.869	0.954*
V-05121	0.969	0.945*	0.955*	0.684	0.683
V-056132	-0.861	-0.760	-0.953*	-0.336	-0.253
V-03BT007	1.000**	0.981	0.978*	0.522	0.610
V-06068	0.948*	0.955*	0.895	0.775	0.805
V-07200	0.953*	0.989*	0.861	0.678	0.819
V-07151	0.828	0.891	0.709	0.869	0.954*
V-07155	-0.861	-0.760	-0.953*	-0.336	-0.253
WL-1	0.828	0.891	0.709	0.869	0.954**
KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ	0.533	0.587	0.437	1.000*	0.912
KIRITATI//2*SERI/RAYON	0.948*	0.955	0.895	0.775	0.805
MEXIPAK 65	0.828	0.891	0.709	0.869	0.954*
WHEAR/VIVITSI//WHEAR	0.710	0.728	0.653	0.963*	0.863
FRET2*2/KUKUNA	0.861	0.760	0.953*	0.336	0.253
NING MAI 50	0.533	0.587	0.437	1.000**	0.912
KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES	0.828	0.891	0.709	0.869	0.954*
V-08081	0.913	0.969*	0.797	0.575	0.792
V-08082	0.828	0.891	0.709	0.869	0.954*

* = Significant (P<0.05); ** = Highly significant (P<0.01)

Table 4. Reaction of 325 genotypes against leaf rust during the year 2010-2011

Reaction	No of genotypes	Name of Genotypes
No Disease	225	AUQAB 2000, CHAKWAL-50, FAREED-06, INQILAB 91, MANTHAR, MIRAJ-08, SHAFAQ-06, V-04178 = AARI-10, ABADGAR-93, BHITTAI, KIRAN-95, SULEMAN 96, SALEEM 2000, PIRSABAK 2004, PIRSABAK 2005, ZARLASHTA 99, CHENAB-2000, KARAWAN-2, KOHINOOR 83, KOHISTAN 97, NAEEM 82, PASBAN 90, OASIS F 86, FRET-1, FRET-2, SAAR, BOBWHITE'S'=BOW, GOSHAWK'S', CHAM-6=NESSER, FRONTANA, TRAP#1, OASIS/SKAUZ//4*BCN/3/2*PASTOR, BABAX/LR42//BABAX*2/3/VIVITSI, PBW 343*2/CHAPIO, PBW 343*2/KUKUNA, PBW 343*2/KURUKU, PBW 343*2/KONK, PBW 343*2/KHVAKI, INQ-91*2/KUKUNA, INQ-91*2/TUKURU, INQ-91*2/KONK, INQ-91*2/KHVAKI, SNI/TRAP#1/3/KAUZ*2/TRAP//, PVN//CAR422/ANA/3/KAUZ*2/, PVN/YACO/3/KAUZ*2/TRAP//, TRAP#1/PBW65/3/KAUZ*2/TRAP, CAR 422/ANA//TRAP#1/3/KAUZ*2, KAKATSI, PVN/PBW65/3/KAUZ*2/TRAP//, PARULA=PRL, SONOITA=SNI, HARRIER 17.B, PRL'S'/PVN, SNI/PBW 65 /3/KAUZ*2/TRAP// KAUZ , CON.'S'/ANA 75//CON.'S' , PB81//F3.71/TRM/3/BULBUL// F3., WEEBILL-1 = V-3158, PVN//CAR422/ANA/5/ , OPATA//SORA/AE.SQ. 323) , LU26/6/LIB64-8-15//INIA/ , WL711/CROW'S'/3/KVZ/ , PF 70402/ALD'S'//PAT 72/160// , SANDAL/CMH912//CMH76A.769/ , BLS//F3.71/TRM/3/SKA/PRL'S'// , TUC'S'/MON'S'//VEE'S'/3/LIRA'S , KASYON//PVN'S'/SPRW'S' , ALTAR84/AE.SQ(224)//2*ESDA = V94195, PAS.90/SH.88 = V-96059 , F60314.76/MRL//CNO79/3/KA//NAC/4/STAR , TURACO/PRINIA , TAN/PEW//SARA/3/CBRD , V-4022' , BOW'S'/SPT'S' , MAYA 74'S'/MON'S' , GAMDOW-6, LAKTA-1, PF 70402/ALD'S'//PAT 72/160//, NL 750, TRAP#1/BOW'S', SANDAL/CMH912//CMH76A.769/3/, , VEE'S'/ALD'S'//HUAC'S', BUC'S'/FLK'S'//MYNA'S'/VUL'S', VS73.600/MRL'S'/3/BOW'S'//YR/TRF'S', AMD/HN4/3/GTO/7C//BB/CNO67/5/, UP 262, BOW'S'//URES/VEE'S', V-02192, V-02156, V-04181, V-04188, V-04009, V-04048, V-05066 (Punjab-11), V-05082 (Millat-11), V-05100, V-05115, V-06129, V-06140, V-056037, V-056132, V-066205, TW69019, V-03BT007, V-05BT006, V-06016, V-06018, V-06034, V-06056, V-06067, V-06096, V-06103, V-06111, V-06117, V-07189, WAXWING*2/KRITATI = V-7194, V-07200, V-07151, V-07155, V-06007, V-07032, V-07067, V-07076, V-07096, V-07100, V-07102, V-07142, V-08171, V-08173, D-07663, 9272, TWS7091, 05BT014, 07BT007, 76309, 76317, NR381, KRICHAUFF/2*PASTOR (08158), V-07007, WBLL1*2/KIRITATI, KIRITATI//PBW65/2*SERI.1B, WHEAR/VIVITSI//WHEAR, WHEAR/KUKUNA//WHEAR, WHEAR/CHAPIO//WHEAR, WHEAR/TUKURU//WHEAR, WHEAR/KIRITATI/3/C80.1/3*BATAVIA//2*WBLL1, WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1, INQALAB 91*2/KUKUNA//KIRITATI, SUNCO//TNMU/TUI, SUNCO//TNMU/TUI, SHARP/3/PRL/SARA//TSI/VEE#5/5/, BRBT1*2/KIRITATI, EMB16/CBRD//CBRD, PYN/BAU/3/MON/IMU//ALD, HARTOG, KIRITATI, PFAU/WEAVER*2//KIRITATI, PGO/SERI//BAV92, NING MAI 50, TAM200/TUI, YANG87-158*2//MILAN/SHA7, CROC_1/AE.SQUARROSA (205)//FCT/3/PASTOR, V-87094/2*FSD85, Pb-96/2*V-87094, HD 2169/C591//PBW343, PRL/V-87094//TRAP/V-87094, PRL/LU26//TRAP/LU26, V-86711TC/SH-88//CROW, PAK-81/2*V-87094, V-03144, V-87094/2*ERA/3/PAK-81/2*V-87094/4/SHAFAQ, AS2002/WL711//SHAFAQ, V-87094/CHK86//SHAFAQ, TUKURU//BAV92/RAYON*3/3/T.SPELTAP1348449, FRET2/WBLL1//TACUPETOF2001*3/3/, WEBLLI*2/TUKURU/3/T.DOCOCCUMP194624/, WBLLI*2/VIVITSI//T.SPELTAP1348764/3/WBLL1, WBLLI*2/VIVITSI/3/T.DICOCCOMP194624/AE.SQ, WBLLI*2/VIVITSI/3/T.DICOCCOMP194624/AE.SQ, NAC/TH.AC//3*PVN/3/MIPLO/BUC/4/2*PASTOR/5/, REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, INQ.91*2/TUKURU//T.SPELTAP1348599/3/2*, INQ.91*2/TUKURU/3/T.DICOCCOM P194624/, FRET2/WBLLI//TACUPETO F2001*2/3/T., NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/, KAUZ//ALTAR84/AE.SQ/3/MILAN/KAUZ/4/, KAUZ//ALTAR84/AE.SQ/3/MILAN/KAUZ/4/, TOBA97/PASTOR*2//T.SPELTA P1348774, TOBA97/PASTOR/3/T.DICOCCON P194624/AE., CROC_1/AE.SQ444/3/T.DOCOCCON T194625, T.SPELTA P1348764//INQ.91*2/TUKORU/3/, V-08057, V-08064, V-08068, V-09221, V-08008, V-09194, V-09196, V-08082, V-08203, NR 388, NR 378, V-06BT005, V-08BT016, V-9407, TW 76004, V-076422, V-088132
Resistant	12	JAUHAR-78, PASINA 90, PUNJAB 81, WATAN (V-87094), BAYA'S', BAU'S' = BAGULA, BT 2549/FATH, BYRSA-87 = SUNBIRD, CHAM-4, CROW"S", HD2236//SA.42/HARRIER'S= V-97088 , V-04179, WHEATEAR
Moderately resistant	20	CHAKWAL 86, CHAKWAL 97, SEHER-06, SASSI, ZINDAD-2000, FAISALABAD 83, PARI 73 BLUEBIRD, SH-2002, PBW 343=ATTILA, PBW 450, KARIEGA, HARTOG=HTG.(PAVON), PAVON 76, SHAFAQ-06, V-03094, V-07178, YANAC/3/PRL/SARA//TSI/VEE#5/4/, PFAU/MILAN/3/SKAUZ/KS94U215//SKAUZ, DOLLARBIRD, TAM200/TUI/6/PVN//CAR422/ANA/5/BOW/CROW//BUC/PVN/3/YR/4/TRAP#1= Kingbird#1, TAM200/TUI
Moderately resistant-moderately susceptible	40	BHAKKAR-2000 (V-92T001), KOHSAR 95, ANMOLE-91, RASKOH 05, SARIAB 92, MH 97 = ATTILA, ZAMINDAR 80, HOOSAM-3, BAVIACORA M 92 = V-97097, PFAU/WEAVER , LU26/KEA'S' , PB-96/87094//MH-97, BLS/KLT'S', KIRITATI//SERI/RAYON, KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ
Moderately susceptible	15	AS-2002=WD-97603, UFAQ, MEHRAN-89, SOGHAT-90=PVN, T.J-83, T.D-1, ZARGOON 79, ZARDANA 89, BLUE SILVER = SONALIKA, FAISALABAD 85, LYP 73, PAK 81, PARWAZ 94, PUNJAB 85, PUNJAB 96, SATLUJ 86, SINDH 81, ZA 77, WL 711, WH542, PASTOR, PEWEE'S', BACANORA T88=BCN, BULBUL, CHILERO=CHIL'S', NING 8319, V-03007, MAYA/PVN, WL 711/3/KAL/BB//ALD = V-85054, WL 711/CROW "S"//ALD #1 / CMH, V-06068, WL-1, V-08164, PFAU/MILAN/5/CHEN/A. SQ (TAUS), KIRITATI//2*SERI/RAYON, FRET2*2/KUKUNA, PVN//CAR422/ANA/5/BOW/CROW//BUC/PVN/3/YR/4/TRAP#1= Kingbird#2, REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//, V-08081
Susceptible	13	CHENAB 70, LU 26 (Salt Tolerant), MEXIPAK 65, PUNJAB 76, SA 75, SARSABZ, SHAHKAR 95, SHALIMAR 88, KAUZ'S', EAGLE, NEELKANT'S', BB # 2/PT//CC/INIA/3/ALD 'S', V-05121, REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//

Table 5. Reaction of 325 genotypes against leaf rust during the year 2011-2012

Reaction	No. of genotypes	Name of Genotypes
No Disease	233	AS-2002=WD-97603, AUQAB 2000, BHAKKAR-2000 (V-92T001), CHAKWAL-50, FAREED-06, INQILAB 91, KOHSAR 95, MANTHAR, V-04178 = AARI-10, ABADGAR-93, BHITTAI, KIRAN-95, MARVI-2000, T.D-1, SULEMAN 96, SALEEM 2000, PIRSABAK 2004, PIRSABAK 2005, CHENAB-2000, KARAWAN-2, KOHINOOR 83, KOHISTAN 97, MH 97 = ATTILA, NAEEM 82, PASBAN 90, PUNJAB 85, SATLUJ 86, SH-2002, SINDH 81, ZA 77, BAU'S' = BAGULA, OASIS F 86, PBW 343=ATTILA, HUW 234 + LR34, FRET-1, FRET-2, WH542, HOOSAM-3, SAAR, KARIEGA, BOBWHITE'S'=BOW, PEWEE'S', BACANORA T88=BCN, BT 2549/FATH, BYRSA-87 = SUNBIRD, BAVIACORA M 92 = V-97097, CHAM-4, CROW"S", FRONTANA, TRAP#1, SHAFAQ-06, OASIS/SKAUZ//4*BCN/3/2*PASTOR, BABAX/LR42//BABAX*2/3/VIVITSI, PBW 343*2/CHAPIO, PBW 343*2/KUKUNA, PBW 343*2/KURUKU, PBW 343*2/KONK, PBW 343*2/KHVAKI, INQ-91*2/KUKUNA, INQ-91*2/TUKURU, INQ-91*2/KONK, INQ-91*2/KHVAKI, SNI/TRAP#1/3/KAUZ*2/TRAP//, PVN//CAR422/ANA/3/KAUZ*2/, PVN/YACO/3/KAUZ*2/TRAP//, TRAP#1/PBW65/3/KAUZ*2/TRAP, CAR 422/ANA//TRAP#1/3/KAUZ*2, KAKATSI, PVN/PBW65/3/KAUZ*2/TRAP//, PARULA=PRL, HARRIER 17.B, PRL'S'/PVN, SNI/PBW 65 /3/KAUZ*2/TRAP// KAUZ , CON.'S'/ANA 75//CON.'S' , HD2236//SA.42/HARRIER'S= V-97088 , WEEBILL-1 = V-3158, PVN//CAR422/ANA/5/ , WATAN/2*ERA , OPATA//SORA/AE.SQ. 323) , LU26/6/LIB64-8-15//INIA/ , WL711/CROW'S'/3/KVZ/ , PF 70402/ALD'S'//PAT 72/160// , SANDAL/CMH912//CMH76A.769/ , BLS//F3.71/TRM/3/SKA/PRL'S'// , TUC'S'/MON'S'//VEE'S'/3/LIRA'S , KASYON//PVN'S'/SPRW'S' , ALTAR84/AE.SQ(224)//2*ESDA = V94195, TURACO/PRINIA , V-4022' , BOW'S'/SPT'S' , MAYA 74'S'/MON'S' , GAMDOW-6, LAKTA-1, PF 70402/ALD'S'//PAT 72/160//, NL 750, PB-96/87094//MH-97, WL 711/3/KAL/BB//ALD = V-85054, WL 711/CROW "S"//ALD #1 / CMH, TRAP#1/BOW'S', SANDAL/CMH912//CMH76A.769/3/, VEE'S'/ALD'S'//HUAC'S', VS73.600/MRL'S'/3/BOW'S'//YR/TRF'S', AMD/HN4/3/GTO/7C//BB/CNO67/5/, FSD-2008, UP 262, BOW'S'//URES/VEE'S', V-02192, V-02156, V-04179, V-04009, V-05082 (Millat-11), V-05100, V-05115, V-06129, V-06140, V-056037, V-066205, TW69019, V-05BT006, V-06016, V-06018, V-06034, V-06056, V-06096, V-06103, V-06111, V-06117, V-07189, WAXWING*2/KRITATI = V-7194, V-06007, V-07032, V-07067, V-07076, 3094, V-07096, V-07100, V-07102, V-07142, V-08171, V-08173, D-07663, 9272, TWS7091, 05BT014, SHAFAQ-06, 07BT007, 76309, 76317, NR381, KRICHAUFF/2*PASTOR (08158), FSD-2008, V-08164, V-07007, YANAC/3/PRL/SARA//TSI/VEE#5/4/, WBLL1*2/KIRITATI, KIRITATI//PBW65/2*SERI.1B, KIRITATI//SERI/RAYON, PFAU/MILAN/5/CHEN/A. SQ (TAUS), PFAU/MILAN/3/SKAUZ/KS94U215//SKAUZ, WHEAR/KUKUNA//WHEAR, WHEAR/CHAPIO//WHEAR, WHEAR/TUKURU//WHEAR, WHEAR/KIRITATI/3/C80.1/3*BATAVIA//2*WBLL1, WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1, INQALAB 91*2/KUKUNA//KIRITATI, SUNCO//TNMU/TUI, SUNCO//TNMU/TUI, SHARP/3/PRL/SARA//TSI/VEE#5/5/, BRBT1*2/KIRITATI, EMB16/CBRD//CBRD, PYN/BAU/3/MON/IMU//ALD, DOLLARBIRD, HARTOG, KIRITATI, PFAU/WEAVER*2//KIRITATI, PGO/SERI//BAV92, PVN//CAR422/ANA/5/BOW/CROW//BUC/PVN/3/YR/4/TRAP#1= Kingbird#2, TAM200/TUI/6/PVN//CAR422/ANA/5/BOW/CROW//BUC/PVN/3/YR/4/TRAP#1= Kingbird#1, TAM200/TUI, TAM200/TUI, YANG87-158*2//MILAN/SHA7, CROC_1/AE.SQUARROSA (205)//FCT/3/PASTOR, V-87094/2*FSD85, Pb-96/2* V-87094, HD 2169/C591//PBW343, PRL/V-87094//TRAP/V-87094, PRL/LU26//TRAP/LU26, V-86711TC/SH-88//CROW, PAK-81/2*V-87094, V-03144, 3094, V-87094/2*ERA/3/PAK-81/2*V-87094/4/SHAFAQ, AS2002/WL711//SHAFAQ, V-87094/CHK86//SHAFAQ, TUKURU//BAV92/RAYON*3/3/T.SPELTAP1348449, FRET2/WBLL1//TACUPETOF2001*3/3/, WEBLLI*2/TUKURU/3/T.DOCOCCUMP194624/, WBLLI*2/VIVITSI//T.SPELTAP1348764/3/WBLL1, WBLLI*2/VIVITSI/3/T.DICOCCOMP194624/AE.SQ, WBLLI*2/VIVITSI/3/T.DICOCCOMP194624/AE.SQ, NAC/TH.AC//3*PVN/3/MIPLO/BUC/4/2*PASTOR/5/, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, INQ.91*2/TUKURU//T.SPELTAP1348599/3/2*, INQ.91*2/TUKURU/3/T.DICOCCOM P194624/, FRET2/WBLLI//TACUPETO F2001*2/3/T., NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/, KAUZ//ALTAR84/AE.SQ/3/MILAN/KAUZ/4/, KAUZ//ALTAR84/AE.SQ/3/MILAN/KAUZ/4/, TOBA97/PASTOR*2//T.SPELTA P1348774, TOBA97/PASTOR/3/T.DICOCCON P194624/AE., CROC_1/AE.SQ444/3/T.DOCOCCON T194625, T.SPELTA P1348764//INQ.91*2/TUKORU/3/, V-08057, V-08064, V-08068, V-09221, V-08008, V-09194, V-09196, V-08203, NR 388, NR 378, V-06BT005, V-08BT016, V-9407, TW 76004, V-076422, V-088132
Resistant	8	FAISALABAD-08 (V-04189), KAUZ'S', CHILERO=CHIL'S', HARTOG=HTG.(PAVON), SONOITA=SNI, V-07151, V-07155, WHEATEAR
Moderately resistant	14	LASANI-08 (V-03138), SEHER-06, SASSI, ZARLASHTA 99, BLUE SILVER = SONALIKA, SHAHKAR 95, WATAN (V-87094), GOSHAWK'S', CHAM-6=NESSER, EAGLE, V-04188, V-07178, PAK 81, KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ
Moderately resistant-moderately susceptible	40	CHAKWAL 97, IQBAL2000, JAUHAR-78, PUNJAB 81, PAS.90/SH.88 = V-96059 , BLS/KLT'S', REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//, V-08082
Moderately susceptible	8	GA-2002, MIRAJ-08, SHAFAQ-06, UFAQ, ANMOLE-91, MEHRAN-89, SKD-1, SOGHAT-90=PVN, ZARGOON 79, RASKOH 05, SARIAB 92, CHENAB 79, FAISALABAD 83, FAISALABAD 85, LYP 73, PARI 73 BLUEBIRD, PARWAZ 94, PASINA 90, PUNJAB 96, SHALIMAR 88, ZAMINDAR 80, BAYA'S', NACOZARI F 76, SEHER-06, BULBUL, PAVON 76, NING 8319, V-03007, NEELKANT'S', MAYA/PVN, V-03094, V-04181, V-04048, V-05066 (Punjab-11), V-05121, V-03BT007, V-06068, FRET2*2/KUKUNA, REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//
Susceptible	22	AS-2002=WD-97603, CHAKWAL 86, KHIRMAN, T.J-83, CHENAB 70, LU 26 (Salt Tolerant), PUNJAB 76, SA 42, SARSABZ, WL 711, PBW 450, LU26/KEA'S' , TAN/PEW//SARA/3/CBRD , BB # 2/PT//CC/INIA/3/ALD 'S', V-07200, WL-1, KIRITATI//2*SERI/RAYON, WHEAR/VIVITSI//WHEAR, NING MAI 50, REH/HARE//2*BCN/3/CROC-1/AE.SQ(213)//, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, V-08081

V-03BT007**,** V-07155**,** FRET2*2/KUKUNA) have statistically significant correlation with minimum temperature for year 2011-2012. Four genotypes (FAISALABAD-08**,** KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ**,** WHEAR/VIVITSI//WHEAR**,** NING MAI 50) have statistically significant positive correlation with rainfall for year 2011-2012. Ten genotypes (PAK 81**,** MEXIPAK 65**,**

MAYA/PVN, BUC'S'/FLK'S'//MYNA'S'/VUL'S', V-04048, V-07151, WL-1, MEXIPAK 65, KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUTES, V-08082) having statistically significant positive correlation with relative humidity for year 2011-2012 (Table 3).

DISCUSSION

In wheat growing areas of the world, leaf rust poses a potential threat and plays a devastating role in reducing crop yield resulting in socio-economic instability (Rehman *et al*., 2013). The susceptible cultivars and favourable environmental conditions play important role for the establishment of fungal disease. Resistant cultivars are the only effective and durable source to save the crop from the infection of rusts.

The present study was conducted to study the response of different wheat genotypes against leaf rust and to work out the relationship of disease development with the environmental factors. Epidemiological factors like average temperature, maximum temperature, minimum temperature and rainfall play an important role for the development of the disease. Most of the genotypes showed same pattern of disease development as evident from the data given in Table 4 and Table 5. However, there was some variation in the number of genotypes in each category i.e. no reaction, resistant, moderately resistant, moderately resistant to moderately susceptible, moderately susceptible and susceptible which happened due the varying reaction of genotypes mentioned in the Table 4 and Table 5 e.g. Ufaq, Khirman, Zargoon 79 etc. showed consistent reaction while some genotypes e.g Bakhar-2000, Chakwal 86, Lasani-08 etc. showed different types of reaction during two years. Goswani and Ahmad (1991), Singh and Tewari (2001) and Sohail *et al.* (2013) also reported variety, disease and environment interaction. It was also reported that yield losses increased with higher susceptibility level. Some genotypes were consistent in their disease reaction while some genotypes showed varying reactions during two years (Table 4 & 5). This might be due to presence of temperature sensitive rust resistance genetic mechanism in these genotypes. McIntosh *et al.* (1995) also reported temperature sensitivity of various leaf rust resistant genes.

In this study, focus was given to determine the association of epidemiological factors with the leaf rust. All the genotypic response values of leaf rust were correlated with environmental factors as evident from the Table 2 and Table 3. It is concluded from our study that epidemiological factors remained highly significant for leaf rust development and have great influence on the development of leaf rust of wheat. Khan (1985), Pasquini *et al*. (1996), Khan (1997) and Sohail *et al*. (2013) also studied different varieties of wheat in relation to epidemiology of leaf rust and they concluded the same results.

Area under disease progress curve (AUDPC) values were used to find out the intensity of disease in this study. Genotypes showed varying AUDPC values in our study. The genotypes with higher AUDPC values were regarded as susceptible while the genotypes with low AUDPC values were regarded as resistance. Similar procedure was used by Pretorious (1983) and Prabhu *et al*. (1993) to check the response of different genotypes against the infection of leaf rust on the basis of AUDPC.

In the light of the present study, it is evident that yield losses may be high in susceptible genotypes than the resistant. Similarly, yield losses may decrease as the genotypes changed their reaction from the susceptible to resistant. Similar type of prediction model may be helpful to manage the disease by forecasting the leaf rust virulence. The present study in this context may be helpful for future screening to identify the resistant source in wheat germplasm against leaf rust and their utilization in breeding program.

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