



Genetic analysis of NBPGR-exotic collections of wheat germplasm for yield and yield related traits under leaf rust condition

K.J. Yashavantha Kumar* and S.A. Desai

Department of Genetics and Plant Breeding, UAS, Dharwad-580005, India

*e-mail: yashavanth.17@gmail.com

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Abstract: Genetic variability, genotypic and phenotypic coefficients of variation, heritability and genetic advance and simple correlation for twelve characters in one hundred and twenty genotypes of Exotic wheat germplasm collection of NBPGR, including five check varieties of were studied under leaf rust condition at UAS, Dharwad. The analysis of variance revealed, highly significant differences for mean sum of squares for yield, yield related traits and leaf rust disease reaction. The estimates of genotypic and phenotypic coefficients of variation (GCV and PCV) were moderate for many characters except but low for days to 50% flowering, days to physiological maturity and plant height. High heritability along with high genetic advance was obtained for 100 grain weight, number of grains per spike, days to 50% flowering and plant height. The trial was maintained under leaf rust condition, out of 120, 72 genotypes displayed race-specific resistance were either immune or near immune, 30 genotypes displayed resistant to moderately resistant reaction (MR) and moderately susceptible (MS) reaction, and 10 genotypes displayed compatible susceptible interaction with larger uredinia but without chlorosis or necrosis. With respect to final leaf rust disease reaction, range observed was resistant to susceptible (FRS: 0-100, AUDPC: 0-2310). A significant positive correlation was observed between days to 50% flowering and days to maturity($r=0.67$), spikelet per spike and spike length($r=0.49$), Spikelet per spike and seeds per spike ($r=0.71$) and between final rust severity and AUDPC($r=0.99$).

Key words: Genetic variability, Heritability, Genetic advance, Augmented design, Wheat and leaf rust

Introduction

Rich in protein, carbohydrates, and minerals, wheat (*Triticum aestivum* L.) is one of the world's most important cereal grain crops, serving as the staple food source for 30% of the human population. One key factor in the success of wheat as a global food crop is its adaptability to a wide range of climatic conditions, attributable, in part, to its allohexaploid genome structure (Marcussen *et al.*, 2014). A systematic evaluation and characterization of germplasm lines helps in the identification of superior and genetically divergent germplasm lines for changing climatic conditions (Nayak *et al.*, 2002). Characterization of accessions provides the information on favorable traits/genes of the material for utilization in combination breeding may help in generating high yielding varieties/hybrids. Among the several constraints towards realizing the potential yield in wheat, the rust diseases pose major threat to wheat production worldwide including India. Leaf rust is considered as the most epidemic disease of wheat toll heavy losses in South Asia, Europe and East Africa. Having disseminating ability, wheat rusts are scattered all around and travelling the continents (Kolmer, 2005). Simmonds and Rajaram (1988) gave ample evidence that minor genes for resistance can affect rust development at various stages. Each gene has a relatively small effect but when several of them are combined. The degree of such resistance is often measured as the area under the disease progress curve (AUDPC) when the disease severity has been measured several times during the development of the epidemic. Buchenau (1975) reported relationship between yield loss and AUDPC of stem and leaf rust of wheat. Evaluation of wheat cultivars for ability to retard

development of leaf and stem rust, AUDPC was a convenient and reliable approach for data summation but rate of disease development was not (Wilcoxson *et al.*, 1975). Therefore, the present study was undertaken with the objectives of identifying slow leaf rusting genotypes and assessing of genetic diversity among the genotypes with respect to yield, yield related traits and leaf rust disease reaction for further utilization in breeding programmes.

Material and Methods

The study was conducted during 2014-15 cropping season at Dr. Sanjaya Rajaram wheat laboratory, MARS, UAS, Dharwad, with 15° 26' N latitude and 76° 07' E longitude an altitude of 678 m above mean sea level. The material selected from the trials of multi-location evaluation of wheat germplasm 2012-13 supplied by NBPGR, to UAS, Dharwad. Total of 120 NBPGR-Exotic germplasm collection (EC) accessions were chosen based on disease severity of moderate to high and with disease response ranging from resistance to susceptibility. Three checks, PBW343 a national check, local checks UAS 304 and GW322 varieties for yield and quantitative characters and susceptible checks Agra local and Amruth were included in the experiment. A field experiment was conducted by using augmented design, planted 20 cm apart in a plot size of 0.8 m² (1m x 4 rows). Susceptible checks were planted all around the experimental plots using the universal leaf rust susceptible check varieties like Lal Bahadur, Agra Local, Amruth and Local Red. At boot leaf stage of the crop, a suspension of mixture of predominant leaf rust pathotypes prevailing in India were sprayed on the each genotype. The trial was maintained under optimal growing conditions using recommended management

practices of region except for the fungicidal spray. Randomly selected five plants were tagged in each plot for recording infection types and disease severity of leaf rust by following Loegering scale (Joshi *et al.*, 1988) and Modified Cobb scale (Peterson *et al.*, 1948) respectively. The “Area under disease progress curve” (AUDPC) was calculated by using the formula suggested by Wilcoxson *et al.*, (1975). The same five plants were further used in recording observations of quantitative characters, yield and yield component traits, viz., days to 50% flowering, days to maturity, plant height (cm), spike length, number of spikelet per spike, number of seeds per spike, number of tillers per meter row, 1000 grain weight, grain yield (kg/ha). Statistical analysis was computed according to the standard procedures using windostat statistical software package 9.3 and PB tools from IRRISTAT, IIRI.

Results and Discussion

The analysis of variance for all the characters under study illustrated in table 1, revealed highly significant differences, thereby indicating presence of substantial genetic variation among the genotypes for all the twelve characters. The present findings corroborate the earlier reports of Kumar *et al.*, (2003) and Mahato and Kerketta (2004), Hussain *et al.*, 2008 and Shankar Rao *et al.*, (2010) in wheat. Greater variability in the initial breeding material ensures better chances of producing a desired form of a crop plant. Thus the primary objective of germplasm conservation is to collect and preserve the genetic variability in an NBPGR collection of crop

species to make it available to present and future generations (Shiva Prasad *et al.*, 2013). A wide range of mean variation was observed in the germplasms of present investigation for all the quantitative characters and leaf rust disease reaction (Table-2). However, widest range of variability was recorded for yield contributing characters, number of seeds per spike (32-104) and number of tillers per meter (51-23) followed by plant height(cm) (61 to109), yield (q/ha) (18-54), days maturity (88-118), 1000 grain weight (g) (25-54) and days to 50% flowering (47-72). The range of variation obtained for spike length (6 to 12) and spikelet per spike (13 to 25) was least when compared to all the other characters.

Coefficients of variation studies indicated that the estimates of PCV were slightly higher than the corresponding GCV estimates for all the characters under study (Table-2), were less influenced by the environment (Kumar *et al.*, 2014). Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits. GCV and PCV estimates classified as low (0-10%), moderate (10-20%) and high (>20%) classified by Johnson *et al.*, (1955). Among yield and yield related traits, 1000 grain weight recorded moderate level of PCV and GCV estimates with higher broad sense heritability estimates (0.96) and highest genetic advance (35.42) indicates selection is effective for the trait. Low PCV and GCV estimates were obtained for days to 50% flowering, days to physiological maturity and plant height (Table 2). A number of authors

Table-1: Analysis of variance for different traits in the NBPGR-Exotic collections of wheat germplasm

	Days to 50% flowering	Days to maturity	Plant height	Spike length	Spikelet /spike	Seeds /spike	Tillers / plant meter	Tillers per weight	1000 -grain (q/ha)	Grain yield	AUDPC	Final leaf rust severity
Block (ignoring Treatments)	52.267**	134.022**	66.467**	3.808**	5.267*	1221.030**	1.667	112.941*	51.486**	8.867	137259.000**	314.606**
Treatment (eliminating Blocks)	37.319**	35.581**	69.553**	1.439**	6.945**	1436.329**	6.449**	185.992**	31.555**	50.314**	335605.800**	799.930**
Checks	13.100*	29.400**	364.833**	4.756**	34.000**	389.333**	25.567**	2035.900**	121.804**	568.715**	2201558.000**	3916.618**
Checks+Var vs. Var.	38.127**	35.787**	59.710**	1.328**	6.043**	1471.229**	5.812**	124.329**	28.547**	33.034**	273407.300**	696.041**
ERROR	2.149	2.45	4.534	0.154	0.65	3.289	0.917	20.8	0.904	3.137	9046.337	29.915
Block (eliminating Check+Var.)	1.406	0.202	6.865	0.384	1.067	4.846	0	18.466	1.633	0.516	6905.985	16.786
Entries (ignoring Blocks)	38.140**	37.740**	70.514**	1.494**	7.013**	1455.945**	6.476**	187	32.359**	50.449**	337708.200**	804.734**
Checks	13.100*	29.400**	364.833**	4.756**	34.000**	389.333**	25.567**	2035.900**	121.804**	568.715**	2201558.000**	3916.618**
Varieties	38.545**	36.313**	56.184**	1.286**	6.164**	1489.768**	5.873**	105.105**	29.624**	29.601**	182840.900**	492.647**
Checks vs. Varieties	90.133**	240.833**	598.533**	13.245**	0.133	1697.515**	1.875	2600.904**	0.047	458.252**	11311520.000**	25495.560**
Error	2.149	2.45	4.534	0.154	0.65	3.289	0.917	20.8	0.904	3.137	9046.337	29.915
Ci - Cj	2.76	2.947	4.009	0.739	1.518	3.414	1.803	8.587	1.79	3.335	179.081	10.298
BiVi - BiVj	4.78	5.104	6.944	1.28	2.629	5.914	3.122	14.873	3.101	5.776	310.177	17.837
BiVi - BiVj	5.237	5.591	7.607	1.402	2.88	6.478	3.42	16.293	3.397	6.327	339.782	19.539
Ci - Vi	4.24	4.527	6.159	1.135	2.332	5.245	2.769	13.192	2.751	5.123	275.109	15.82

*= significant at p=0.05, **= significant at 0.01

Table-2: Genetic variability and heritability parameters for different traits in the NBPGR-Exotic collections of wheat germplasm

	Variance components		Coefficient of Variability (%)		Heritability (Broad sense)	Genetic advance	Genetic advance as % mean	Varietal mean	Range
	Genotypic	Phenotypic	Genotypic	Phenotypic					
Days to 50% flowering	32.81	34.96	9.48	9.79	0.94	11.43	18.93	60.40	47-72
Days to maturity	30.53	32.98	5.33	5.54	0.93	10.95	10.57	103.65	88-118
Plant height	46.56	51.10	8.36	8.76	0.91	13.42	16.44	81.63	61-109
Spike length	1.02	1.17	10.83	11.62	0.87	1.94	20.80	9.32	6-12
Spikelet/spike	4.97	5.62	12.01	12.77	0.88	4.32	23.26	18.57	13-25
Seeds/spike	67.06	70.34	13.81	14.15	0.95	16.47	27.78	21.11	32-104
Tillers/ plant	4.47	5.39	18.83	20.67	0.83	3.97	35.34	11.23	7-18
Tillers per meter	76.00	96.80	10.53	11.89	0.79	15.91	19.23	82.77	51-123
1000-grain weight	25.89	26.80	14.37	14.62	0.97	35.42	29.09	35.42	25-54
Grain yield (q/ha)	23.86	27.00	17.38	18.49	0.88	9.46	33.66	28.10	18-54
AUDPC	156678.50	165724.80	175.56	180.56	0.95	792.83	351.64	225.47	0-2310
Final leaf rust severity	417.16	447.07	169.57	175.54	0.93	40.64	337.42	12.05	0-100

Table-3: Response of 120 NBPGR-Exotic collections of wheat germplasm for leaf rust reaction and grain yield (q/ha)

No.	Accession	AUDPC	Adult plant reaction	Yield (q/ha)	No.	Accession	AUDPC	Adult Plant reaction	Yield (q/ha)	No.	Accession	AUDPC	Adult plant reaction	Yield (q/ha)	No.	Accession	AUDPC	Adult plant reaction	Yield (q/ha)
1	EC-597900	47	TMS	34.25	33	EC-636264	420	30MS	26.5	65	EC-664243	0	0	26.75	97	EC-693275	0	0	24.5
2	EC-597925	0	0	41.75	34	EC-660681	0	0	25.5	66	EC-664252	35	TMR	29.75	98	EC-693276	0	0	25.5
3	EC-597932	0	0	30.25	35	EC-660685	35	5MR	26.5	67	EC-664263	0	0	23.25	99	EC-693277	0	0	23.25
4	EC-597957	0	0	27.25	36	EC-660850	0	0	25.75	68	EC-664268	0	0	26.25	100	EC-693278	0	0	40.25
5	EC-597964	198	30MR	25.25	37	EC-660853	1482	80S	20.75	69	EC-664273	152	20MR	25	101	EC-693280	0	0	29.25
6	EC-597973	840	60MS	41	38	EC-660940	525	30S	24	70	EC-664282	0	0	38.5	102	EC-693281	420	30MS	25.5
7	EC-597982	1633	80S	42.75	39	EC-660941	1458	80S	30	71	EC-664285	0	0	32	103	EC-693282	0	0	27.75
8	EC-597994	1400	80S	24	40	EC-660945	280	40MR	24.5	72	EC-664292	420	30MS	22.75	104	EC-693283	23	10MR	28
9	EC-598004	0	0	21.75	41	EC-660965	0	0	21.25	73	EC-664295	513	40MS	42.25	105	EC-693284	0	0	25
10	EC-603894	0	0	26	42	EC-660966	1167	80S	25.75	74	EC-664311	583	40MS	23.25	106	EC-693285	0	0	29.75
11	EC-603895	0	0	28.5	43	EC-663899	0	0	26	75	EC-664322	327	40MR	34.5	107	EC-693286	0	0	24.25
12	EC-603897	35	TMS	32.75	44	EC-663903	0	0	22.25	76	EC-664323	1050	60S	27.25	108	EC-693287	607	60MR	30.75
13	EC-603898	0	0	27	45	EC-663905	0	0	29.25	77	EC-664325	0	0	24.25	109	EC-693290	12	TMR	28.75
14	EC-635591	0	0	34.75	46	EC-663909	0	0	31.75	78	EC-665542	280	30MS	25	110	EC-693291	0	0	33.25
15	EC-635633	117	10MS	29.25	47	EC-663914	0	0	27.75	79	EC-692228	583	30S	20.25	111	EC-693299	1517	80S	31.75
16	EC-635651	0	0	26.25	48	EC-663915	0	0	28.5	80	EC-692232	233	30MR	22.25	112	EC-693306	0	0	23.75
17	EC-635665	420	30MS	28.75	49	EC-663916	0	0	24.75	81	EC-692241	0	0	22.75	113	EC-693309	2310	100S	27.25
18	EC-635672	93	10MR	24.75	50	EC-663923	0	0	30	82	EC-692253	12	0	29.25	114	EC-693314	117	10MR	27.25
19	EC-635676	0	0	29.25	51	EC-663924	0	0	22.25	83	EC-692256	0	0	20.25	115	EC-693315	0	0	26.75
20	EC-635701	0	0	31.25	52	EC-663925	0	0	33.75	84	EC-693-57	700	40MS	23.25	116	EC-693316	0	0	26
21	EC-635713	747	40S	22.75	53	EC-663926	0	0	37.25	85	EC-693252	490	20S	27.25	117	EC-693321	0	0	24.75
22	EC-635747	0	0	34.25	54	EC-663939	0	0	42.75	86	EC-693256	292	20S	20.75	118	EC-693321	1085	60S	24
23	EC-635755	408	30S	31.75	55	EC-663941	840	60MS	28.5	87	EC-693258	327	30MS	25.5	119	EC-693322	1003	60S	32.75
24	EC-635765	0	0	27.75	56	EC-664194	0	0	24.75	88	EC-693260	0	0	30.25	120	EC-693323	0	0	25.25
25	EC-635826	140	20MR	27.25	57	EC-664198	0	0	24.75	89	EC-693261	0	0	27	121	Agra local	2217	100S	18.33
26	EC-635852	93	10MR	29.5	58	EC-664205	0	0	33.25	90	EC-693262	140	20MR	30.25	122	Amruth	2170	100S	19.75
27	EC-635858	0	0	27.75	59	EC-664213	0	0	21.75	91	EC-693264	408	20S	33.75	123	GW322	146	10S	44.17
28	EC-636234	0	0	29.75	60	EC-664219	0	0	23.25	92	EC-693266	0	0	25.25	124	PBW343	700	40S	46.5
29	EC-636239	280	40MR	30.25	61	EC-664225	0	0	29.25	93	EC-693269	0	0	24.25	125	UAS 304	700	40S	41.1
30	EC-636260	12	0	25.75	62	EC-664233	0	0	29.5	94	EC-693271	747	60MS	24.5					
31	EC-636261	0	0	20.25	63	EC-664234	0	0	28.5	95	EC-693272	0	0	54.25					
32	EC-636262	0	0	27.75	64	EC-664240	0	0	28.5	96	EC-693273	0	0	25.25					

Table-4: Phenotypic correlation coefficients among twelve characters

	Days to 50% flowering	Days to maturity	Plant height	Spike length	Spikelet/spike	Seeds/spike	Tillers / plant	Tillers Per meter	1000-grain weight	AUDPC	Final leaf rust severity	Grain yield (q/ha)
Days to 50% flowering	1											
Days to maturity	0.67**	1.00										
Plant height	0.12	0.03	1.00									
Spike length	0.16	0.11	0.44	1.00								
Spikelet/spike	0.13	0.11	0.29	0.49**	1.00							
Seeds/spike	0.22	0.22	0.18	0.30	0.71**	1.00						
Tillers / plant	-0.06	-0.03	-0.11	-0.10	-0.03	-0.01	1.00					
Tillers per meter	-0.04	-0.04	0.12	0.23	0.21	0.08	0.01	1.00				
1000-grain weight	-0.04	-0.08	-0.16	-0.03	-0.10	-0.03	0.02	0.06	1.00			
AUDPC	-0.03	-0.06	0.19	0.13	0.05	0.00	0.07	0.07	-0.16	1.00		
Final leaf rust severity	-0.03	-0.06	0.18	0.14	0.07	0.02	0.09	0.09	-0.15	0.99**	1.00	
Grain yield (q/ha)	-0.11	-0.16	0.05	0.24	0.25	0.14	0.19	0.19	0.22	-0.04	-0.02	1

*= significant at p=0.05, **= significant at 0.01

in congruity with close proximity between GCV and PCV values for almost all the characters, revealed less influence of the environment on expression of the characters (Sharma *et al.*, 1995, Kumar *et al.*, 2003, Shankar Rao *et al.*, 2010).

Estimates of heritability and genetic advance are critical for predicting genetic improvement for any quantitative character (Khali and Afridi, 2004). Rabinson *et al.*, (1949) classified the heritability estimates as low (0- 30%), moderate (30-60%) and High (>60%). High estimates of heritability were observed for all the characters (Table-2). Heritability estimates indicate effectiveness of selection for phenotypic performance, but it does not necessarily mean a high

genetic gain for particular characters. Since high heritability does not always indicate high genetic gain, heritability with genetic advance should be used in predicting selection of superior genotypes (Ali *et al.*, 2002). However, the high heritability estimates along with high genetic advance is more useful for the selection (Johnson *et al.* 1955). In the present experiment high heritability along with high genetic advance was obtained for 100 grain weight, number of grains per spike, days to 50% flowering and plant height. A close proximity between GCV and PCV also noticed for these characters by Kumar *et al.*, 2003, Yadav *et al.*, 2006 and Shankar Rao *et al.*, 2010, indicating them to be less influenced by environment. It may

therefore be concluded that selection pressure can be applied in the desired direction on the basis of phenotype to improve such characters.

The trial was maintained under leaf rust condition with a suspension mixture of predominant leaf rust pathotypes prevailing in India. Leaf rust severity was initially low and later taken high and uniform throughout the experiment during *rabi* 2014-15. The susceptible genotypes showed compatible interaction with leaf rust pathogen. The leaf rust reaction response and their grain yield (q/ha) of 120 EC of NBPGR, susceptible and resistant checks were given in table 3. Among 120 genotypes, 72 were displayed with race-specific resistance were either immune or near immune (i.e., showed hypersensitive flecking), 30 were displayed moderately resistant reaction (MR) and moderately susceptible (MS) reaction noticed as small uredinia surrounded by chlorosis or necrosis. The remaining 18 genotypes were displayed compatible susceptible interaction with larger uredinia but without chlorosis or necrosis. With respect to final leaf rust disease reaction, range observed was resistant to susceptible (FRS 0-100, AUDPC 0-2310). The accessions, EC-635633, EC-693314, EC-635826, EC-693262, EC-664273 and EC-597964 had shown AUDPC value within the range of 100 to 200, which are considered to be true slow leaf rusters. These can be utilised in development of durable leaf rust resistance breeding.

Pair-wise correlation coefficients among traits are given in table 4. A significant positive correlation was observed between days to 50% flowering and days to maturity ($r=0.67$), Spikelet per spike and spike length ($r=0.49$), Spikelet per spike and seeds per spike ($r=0.71$) and between final rust severity and AUDPC ($r=0.99$). There was a negative but no significant correlation between disease level (AUDPC and FRS) and 1000 grain weight as well as for yield (q/ha) was observed. These results only partly agree with the earlier report of Sharma *et al.*, (1997), who found a significant negative correlation between disease level and kernel weight for spot blotch disease reaction in wheat. This contrast could be attributed to the different genotypes included in the studies and indicates that the kernel weights of the susceptible exotic wheat genotypes used in this study were not necessarily low, as noticed in the previous study. The magnitudes of correlation coefficient between disease variables and kernel weight were usually low. These results show that resistance to leaf rust resistance and kernel weight can be improved independently, confirming findings by Kolmer, (2005) and Draz *et al.* (2015).

The accession EC693272, showed resistance reaction to leaf rust with high yielding (54.25 q/ha) potential over the checks GW322 (44.17 q/ha) and PBW343 (46.5 q/ha). The germplasm collection displayed Immune, resistant and slow rusting phenotypes (100 to 200 AUDPC value) like MS and MR for disease reaction as well as high yielding potential, would definitely be the new source of several qualitative and quantitative traits. In the present experiment a close proximity between GCV and PCV along with high heritability and high genetic advance was noticed for 100 grain weight, number of grains per spike, days to 50% flowering and plant height. It may therefore be concluded that selection pressure can be applied in the desired direction for those character having high heritability with high genetic advance on the basis of phenotype to

improve such characters for utilization in combination breeding may help in generating high yielding varieties/hybrids.

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