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STABILITY ANALYSIS TO ASCERTAIN THE PERFORMANCE OF DIFFERENT GENOTYPES OF WHEAT [*TRITICUM AESTIVUM* L.]

B. S. JAT, B. R. RANWAH, BAUDH BHARTI AND A. K. PARIHAR[1]*
Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, Udaipur - 313 001
Maharana Pratap University of Agriculture and Technology Udaipur (Rajasthan) - 313 001
e-mail: ashoka.parihar@gmail.com

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***Corresponding author**

ABSTRACT

The current study aimed at ascertaining the performance of bread wheat genotypes under different environmental conditions. The stability parameters were estimated for yield and its contributing trait which exhibited homogeneous error mean square in different environments. The mean squares due to genotypes, E + (G x E), G x E and pool deviation were significant for the studied characters. This suggesting differential response of the genotypes and need to stability analysis. Results revealed that two genotypes PBW 373 and Raj 3765 had non- significant deviation from regression (S^2di) for grain yield per plant. Furthermore, three crosses *viz.*, HD 2687 x Raj 3077, DBW 17 x PBW 373 and PBW 373 x Raj 4037 showed high per se performance with below average response (bi > 1) which indicating suitability for favourable environment. Hence, above mentioned genotypes and crosses could be used to accelerate wheat improvement programmes for different cropping system

INTRODUCTION

Bread wheat [*Triticumaestivum*(L.) em.Thell] is the second most important cereal crop of the world, described as the stuff of life or king of the cereals for centuries. India is the second largest contributor of the world wheat production with 12 % share in global production (Sarkar *et al.*, 2014; Jaiswal *et al.*, 2013). It is consumed mainly in the form of chapatti, while straw is used for feeding the cattle's. However, it is predominantly consumed in tropical and subtropical regions of the world. As it is a well known that wheat is thermo sensitive crop and in subtropical regions it is cultivated in winter season but it exposed to high temperature or heat stress at the end of the season *i.e.* at grain filling stage (Stone, 2001). Heat stress at post-anthesis stage is one of the major limiting factors for growth and productivity in wheat crop (Dhyani *et al.*, 2014; Ram *et al.*, 2014; Farooq *et al.*, 2011). Heat stress is anticipated to become more important in coming year due to climatic irregularities and rice-wheat cropping system which has compelled wheat crop to be subjected to rapidly rising temperature coupled with hot dry winds. In recent times, in India area of wheat is increasing in North-Western Plains Zone (NWPZ) and North-Eastern Plains Zone (NEPZ) under delayed planting due to rice-wheat crop rotation, where crop is exposed to high temperature stress at the post anthesis phase. Consequently to keep continuous rise in future wheat production, we have to pave the way to combat severe challenges ahead like drastic irregularities in climatic conditions. However, breeding for yield stability for a wide range of different environmental conditions has always been important. Where, the phenotypic performance of a genotype may not be the same under diverse climatic conditions. This variation in performance is due to G x E interaction which reduces the stability of a genotype under different environment (Ashraf *et al.*, 2001; Hassan *et al.*, 2013). Thus the information and understanding about G x E interaction are very important as it play a significant role in the expression of performance of different genotypes in different environments. Therefore present investigation was undertaken to identify consistent performer genotypes and crosses, in future which could be used to accelerate wheat improvement programmes for different cropping system.

MATERIALS AND METHODS

Experimental material and site

The experimental material comprised of 8 varieties, their 28 F_1s and a check variety LOK 1. The 28 F_1s were obtained by crossing 8 varieties in diallel fashion (without reciprocal).The eight parents were selected on the basis of genetic variability for major yield components. Experiment was laid out at the Research Farm of Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Udaipur (Rajasthan). Udaipur is situated at an elevation of 579.50 meters above sea level on latitude of 24°35' North and longitude of 37°42' East.

Field Experiment and statistical analysis

All the 37genotypes were grown in a randomized block design in three different environments. Each genotypewas accommodated in one row plot of 2 meter length. Row to row and plant to plant distances were 30 cm and 10 cm, respectively. The experiment was conducted under irrigated conditions. Recommended crop production and protection practices were followed to raise the successful crop. The environments were created by three dates of sowings. The details of environments were as follows

Environment	Date of sowing
E_1 (Normal sowing)	November 16, 2008
E_2 (Late sowing)	December 06, 2008
E_2 (Very late sowing)	December 26, 2008

Five competitive plants from each plot were randomly selected in all the environments for recording the observations for various characters *viz.*, plant height, spike length, number of grains per spike, flag leaf area, and 1000-grain weight and grain yield. However, observations for days to heading and days to maturity were based on plot basis. The analysis of variance was carried out by the method as proposed Panse and Sukhatme, 1985. Stability analysis was done using the model of Eberhart and Russel (Eberhart and Russell, 1966).

RESULTS AND DISCUSSION

In this investigation analysis of variance for phenotypic stability

Table 1: Analysis of variance over the environment (Eberhart and Russel, 1966)

SN	Characters	Genotype	E+(G x E)	E (L)	G x E (L)	Pool dev.	Pool Err
1	Days to heading	35.52**	75.26**	3.3	130.87**	23.11**	1.78
2	Days to maturity	10.44**	159.46**	8.3*	321.39**	5.99**	1.62
3	Plant hieght	60.84**	113.33**	4.56	210.91**	21.32**	8.31
4	Spike length	1.68**	1.06**	0.03	1.81**	0.35**	0.16
5	No of grains/spike	60.45**	26.15**	0.34	35.25**	18.00**	5.67
6	Flag leaf area	102.00**	84.34**	3.10	141.59**	30.83**	4.67
7	1000 Grain weight	17.19**	5.54**	0.10	8.62**	2.69	2.08
8	Grain yield / plant	10.71**	7.95**	0.26	12.51**	3.73**	0.38

Table 2: Stability parameters for days to heading, days to maturity, plant height and spike length

SN	Genotype	Days to heading			Days to maturity		
		μ_i	bi	S^2d_i	μ_i	bi	S^2d_i
1	HD 2687	68.67	0.93	1.96	121	0.8	35.58**
2	DBW 17	75.83	0.62	60.71**	117	0.89	6.73*
3	PBW 373	74.5	0.58	5.55*	117	0.82	-0.29
4	Raj 3765	68	0.76	12.90**	118	0.97	14.23**
5	Raj 3077	69.83	0.91	9.75*	118.17	1.06	2
6	Raj 4037	71.33	1.10**+	-1.78	117.5	1.1	11.29**
7	Raj 4083	72	1.5	0.73	121.5	0.86*	-0.43
8	RKA 501	69.5	1.36*	-1.56	121.67	0.89*	-0.62
9	HD 2687 x DBW-17	75.5	1.02	0.45	119.5	1.17	1.83
10	HD 2687 x PBW 373	72	0.84	7.73*	119.5	1.09	1.37
11	HD 2687 x Raj 3765	76.17	0.75	57.31**	117.83	1.04*	-0.61
12	HD 2687 x Raj 3077	73.17	0.92	-0.46	118.5	0.87*	-1.03
13	HD 2687 x Raj 4037	72	0.83	36.19**	120	0.99*	-0.7
14	HD 2687 x Raj 4083	67.67	1.02	52.23**	117.67	1.05**+	-1.62
15	HD 2687 x RKA 501	72.5	0.81	28.56**	114.33	0.85*	-1.34
16	DBW-17 x PBW 373	71	1.13	59.71**	116.5	0.74	29.58**
17	DBW-17 x Raj 3765	70.5	1.15	42.15**	116	0.74	29.58**
18	DBW-17 x Raj 3077	71.33	0.8	8.69*	119.83	1.09*	-0.78
19	DBW-17 x Raj 4037	65	1.06	25.60**	119.33	1.05*	-0.89
20	DBW-17 x Raj 4083	67.33	0.76	-0.45	118.83	0.99**	-1.6
21	DBW-17 x RKA 501	66.83	1.03	23.99**	118.67	0.87*	-1.49
22	PBW 373 x Raj 3765	68	1.38	20.94**	117.83	1.04*	-0.61
23	PBW 373 x Raj 3077	73	1.11	49.89**	120	1.19*	0.02
24	PBW 373 x Raj 4037	69	1.21	37.41**	120.67	1.34*	-1.09
25	PBW 373 x Raj 4083	71.17	0.67	75.80**	119.67	1.26*	-0.89
26	PBW 373 x RKA 501	71.5	1.02	39.71**	121.5	0.89	9.06*
27	Raj 3765 x Raj 3077	69.5	1.20**+	-1.77	119	1.2	8.26*
28	Raj 3765 x Raj 4037	69.67	1.18	0.65	117.5	1.05*	-1.42
29	Raj 3765 x Raj 4083	68	1.07	9.54*	118.33	1.07	0.62
30	Raj 3765 x RKA 501	66.5	1.15	0.19	118.17	0.98*	0.08
31	Raj 3077 x Raj 4037	68	1.35	51.33**	119.5	1.08*	0.2
32	Raj 3077 x Raj 4083	68	1.01	10.18*	120.33	1.13*	-0.66
33	Raj 3077 x RKA 501	65.5	0.99	15.13**	118.5	1	0.56
34	Raj 4037 x Raj 4083	62.17	1.01	7.54*	115.17	1.11	23.86**
35	Raj 4037 x RKA 501	63.17	0.93	23.36**	115.33	0.98	5.07*
36	Raj 4083 x RKA 501	63.5	0.91	2.06	115	0.89**	-1.59
37	Lok 1	66.67	0.96	17.24**	117.17	0.89*	-0.62

Table 2: Cont.....

SN	Genotype	Plant height			Spike length		
		μ_i	bi	S^2d_i	μ_i	bi	S^2d_i
1	HD 2687	82.67	1.45	-3.89	10.77	1.04	1.08**
2	DBW 17	75.94	0.45	54.36**	10.89	1.79	0.46*
3	PBW 373	78.68	0.67	28.86*	10.33	1.66	-0.14
4	Raj 3765	83.36	1.29	-3.63	10.47	0.36	0.07
5	Raj 3077	82.43	0.41	37.39*	10.7	2.83*	-0.12
6	Raj 4037	73.59	1.02	95.58**	10.13	0.2	-0.08
7	Raj 4083	76.92	0.79	2.82	9.99	-0.61	0.01
8	RKA 501	84.54	0.67	19.22	11.18	-0.61	-0.07
9	HD 2687 x DBW-17	82.38	0.76	13.79	11.59	1.04	0.11
10	HD 2687 x PBW 373	79.62	0.77	-5.01	11.91	1.26	0.05
11	HD 2687 x Raj 3765	81.94	0.92	-6.97	11.59	0.36	0.44
12	HD 2687 x Raj 3077	82.26	0.82	15.55	11.64	2.43	1.43**
13	HD 2687 x Raj 4037	82.63	1.13**	-8.27	11.53	2.46	0.31
14	HD 2687 x Raj 4083	82.45	0.84	-2.82	11.95	0.47	-0.15
15	HD 2687 x RKA 501	75.31	1.28	80.63**	13.21	1.15	-0.15
16	DBW-17 x PBW 373	78.2	1.88	5.7	11.94	-0.49	-0.04
17	DBW-17 x Raj 3765	71.59	0.53	13.29	10.68	1.61*+	-0.16
18	DBW-17 x Raj 3077	84.45	1.77	20.98	11.43	2.33	0.23
19	DBW-17 x Raj 4037	76.35	1.21**	-8.26	10.86	-0.21	-0.07
20	DBW-17 x Raj 4083	77.3	1.62	2.58	10.59	1.15	0.73*
21	DBW-17 x RKA 501	78.61	1.4	26.07*	12.4	1.65	1.12**
22	PBW 373 x Raj 3765	81.72	1.35	-4.49	11.83	1.94	-0.07
23	PBW 373 x Raj 3077	83.01	1.6	5.63	11.28	1.72	0.21
24	PBW 373 x Raj 4037	77.8	1.53*	-7.9	10.66	0.43	0.46*
25	PBW 373 x Raj 4083	72.48	1.37	70.62**	11.4	0.78	0.05
26	PBW 373 x RKA 501	75.38	1.57*	-6.71	10.56	2.01	-0.07
27	Raj 3765 x Raj 3077	77.53	1.93*	-5.19	10.87	0.21	-0.14
28	Raj 3765 x Raj 4037	82.66	0.69	-6.7	10.32	0.45*+	-0.16
29	Raj 3765 x Raj 4083	81.97	0.38	-1.26	12.05	1.69	0.55*
30	Raj 3765 x RKA 501	81.83	0.93	-0.28	12.57	1.64*+	-0.16
31	Raj 3077 x Raj 4037	80.9	0.29*+	-8.23	10.39	0.4	1.01**
32	Raj 3077 x Raj 4083	80.72	0.27	-5.47	10.97	1.83	0.39
33	Raj 3077 x RKA 501	80.33	0.83	-1.29	12.15	1.21	0.52*
34	Raj 4037 x Raj 4083	69.52	0.57	59.33**	11.1	-0.84+	-0.15
35	Raj 4037 x RKA 501	68.1	0.29	2.96	11.25	0.89	-0.09
36	Raj 4083 x RKA 501	68.35	0.72	16.48	12.18	-0.07	-0.14
37	Lok 1	76.1	0.99	-4.11	11.56	0.86	-0.9

was carried out only for days to heading, days to maturity, plant height, spike length, number of grains per spike, flag leaf area, 1000-grain weight and grain yield per plant, since error variance was homogeneous for these traits in different environments. The mean squares due to genotypes, E + (G × E), G × E and pool deviation were significant for all the characters except pool deviation for 1000-grain weight.The significance of all components for all the characters indicated that different genotypes influenced by the environment differentially (Table 1). These finding are in accordance to the earlier results for one or more characters in wheat (Kumar *et al.*, 2014; Shah *et al.*, 2009; Amin *et al.*, 2005; Arya *et al.*, 2004; Yadav and Choudhary, 2004;).

In present attempt the genotypes with high per se performance with non-significant S^2di were classified on the basis of regression coefficient (bi). The genotypes with bi<1 (significantly less than 1) were identified for adverse environmental conditions, bi>1(significantly higher than 1) for favourable environmental conditions and bi=1 for unknown or unpredictable environmental conditions. S^2di was non-significant for grain yield per plant of PBW 373 and Raj 3765. The parent Raj 3765 depicted high per se performance for number of grains per spike and 1000-grain weight, HD 2687 for number of grains per spike, and Raj 4037 for number of grains per spike, 1000-grain weight, Raj 3077 and Raj 4083 for 1000 grain weight and RKA 501 for spike length and flag leaf area (bi<1). Nine crosses depicted stability for grain yield per plant. Among the stable crosses, three crosses *viz.*, HD 2687 x Raj 3077, DBW 17 x PBW 373 and PBW 373 × Raj 4037 were having high grain yield with below average response (bi > 1) would be suitable for favourable environments(Table 3).These results are in consistent to the earlier finding (Kumar etal. 2014; Koemel *et al.*, 2004; Lillimo *et al.*, 2004; Lin and Binns, 1988). In present study E_2 (late sown) was best environment and E_3 (very late sown) was poorest environment for grain yield. The above said crosses also showed non-significant S^2di and high per se performance for one or more characters e.g. all these crosses for 1000-grain weight, HD 2687 x Raj 3077 for number of grains per spike and DBW 17 x PBW 373 for spike length (Table 2). Thus the genotypes and crosses in present investigation with high per se performance, regression

Table 3: .Stability parameters for number of grains per spike and flag leaf area,1000-grain weight and grain yield per plant

SN	Genotype	No of grains/spike			Flag leaf area		1000-grain weight			Grain Yield Per plant			
		μ_i	Bi	S^2d_i	μ_i	bi	S^2d_i	μ_i	Bi	S^2d_i	μ_i	Bi	S^2d_i
1	HD 2687	54.35	0.94	5.51	47.60	1.40	11.11	37.05	0.03	1.86	10.45	0.88	4.62**
2	DBW 17	52.67	0.98*	-5.63	44.30	1.37**+	-4.66	36.42	0.98	-0.93	12.40	1.35	2.72**
3	PBW 373	52.04	-1.10	66.58**	46.31	1.39	-2.87	37.13	0.86	-1.21	11.14	0.72	-0.10
4	Raj 3765	56.35	-0.91	-3.15	58.54	0.34	66.69**	40.24	0.21	-0.41	9.68	0.16	0.93
5	Raj 3077	59.75	2.30	51.53**	51.99	0.66	63.05**	41.57	1.08	-1.29	12.81	0.98	1.40*
6	Raj 4037	56.02	-0.22	0.10	44.13	0.74*+	-4.63	40.98	1.36	-0.98	12.55	0.81	5.17**
7	Raj 4083	53.27	0.23	21.47*	42.69	0.85	40.30**	39.04	2.61	-1.02	11.63	1.12	4.79**
8	RKA 501	51.10	1.91	-5.22	51.37	0.90**+	-4.67	36.92	-0.04+	-2.08	9.66	0.57	1.12*
9	HD 2687 x DBW-17	45.82	1.30	9.26	50.89	2.02	51.76**	38.26	0.98	-1.13	10.62	0.72	0.82
10	HD 2687 x PBW 373	53.62	-0.09	20.96*	43.44	2.02	10.34	38.65	4.12	3.73	11.80	1.51	4.89**
11	HD 2687 x Raj 3765	51.70	0.20	-3.37	47.59	0.80	-2.06	39.42	-1.21	-1.93	11.61	0.60	5.23**
12	HD 2687 x Raj 3077	55.83	2.93	1.26	55.62	1.57	38.87**	43.35	0.91	-1.26	14.64	1.65*+	-0.36
13	HD 2687 x Raj 4037	58.75	-0.03	15.57	48.36	1.01*	-4.59	39.43	1.00	-0.47	13.64	1.52	3.15**
14	HD 2687 x Raj 4083	59.80	0.42	-0.43	53.61	1.05	6.96	38.25	-0.62	-0.87	12.88	1.07	2.32**
15	HD 2687 x RKA 501	62.87	0.19	1.28	56.25	1.83	39.86**	42.77	1.47	1.63	15.37	1.67	1.83*
16	DBW-17 x PBW 373	60.75	-1.28	31.82*	42.28	0.01	-1.12	41.46	3.60	-1.47	15.23	1.75*+	-0.36
17	DBW-17 x Raj 3765	63.32	-0.87+	-5.60	56.77	1.41	27.42**	42.83	0.51	-1.58	13.13	0.30	12.16**
18	DBW-17 x Raj 3077	55.87	0.56	-1.22	57.61	1.21	15.18*	41.17	-0.16	7.84*	12.57	0.63	14.80**
19	DBW-17 x Raj 4037	59.73	-0.81	21.36*	51.41	1.18	12.31	43.71	1.13	6.02*	15.68	2.03	0.36
20	DBW-17 x Raj 4083	50.57	0.47	-5.60	40.50	0.78	62.39**	37.49	2.56*	-1.97	11.78	1.50	1.68*
21	DBW-17 x RKA 501	51.05	3.10	45.66**	44.16	0.68	-3.04	36.13	2.54*	-2.00	10.85	1.19	8.83**
22	PBW 373 x Raj 3765	51.58	3.54	71.05**	47.04	0.84	14.77*	38.30	2.00	1.58	9.87	0.54	0.53
23	PBW 373 x Raj 3077	61.17	0.58	3.12	41.61	0.12	-2.32	39.27	0.79	-2.04	12.61	1.01	11.21**
24	PBW 373 x Raj 4037	62.60	0.69	-5.49	43.73	0.78	136.91**	42.72	-0.54	0.42	14.95	1.24**+	-0.38
25	PBW 373 x Raj 4083	55.90	2.14	27.52*	47.61	0.59	3.75	37.37	1.99	8.06*	13.45	1.26	2.80**
26	PBW 373 x RKA 501	58.50	2.27*+	-5.64	44.49	0.88	2.56	34.51	1.88	4.09	9.63	0.93	2.55**
27	Raj 3765 x Raj 3077	57.53	1.19	1.93	51.69	1.07	42.24**	39.06	1.63	1.56	10.55	0.98	1.15*
28	Raj 3765 x Raj 4037	52.52	3.26	18.71*	47.17	0.93	220.96**	41.48	1.11	-1.31	13.34	1.04	10.76**
29	Raj 3765 x Raj 4083	50.32	3.48	34.82**	47.13	1.37	3.90	39.14	0.67	16.29**	10.57	0.28	-0.12
30	Raj 3765 x RKA 501	55.71	1.40	33.59**	51.64	1.00	87.40**	39.93	0.61	-1.57	9.97	-0.14	-0.12
31	Raj 3077 x Raj 4037	49.63	1.30	27.35*	51.00	0.90	-3.80	40.43	1.38	-0.82	13.22	1.37	10.55**
32	Raj 3077 x Raj 4083	48.50	2.38	1.00	41.90	0.18+	-4.30	38.72	-0.77	0.32	9.48	0.86	1.52*
33	Raj 3077 x RKA 501	53.80	0.47	-4.66	53.29	0.96	25.44*	40.09	0.85	-1.32	13.17	1.58	-0.38
34	Raj 4037 x Raj 4083	57.07	2.43	4.10	61.68	1.03	-2.05	43.70	-1.28	-1.36	15.56	0.81	2.37**
35	Raj 4037 x RKA 501	61.65	1.07	-2.57	60.11	1.02*	-4.62	44.82	0.83	-0.41	15.40	1.08	1.36*
36	Raj 4083 x RKA 501	61.92	0.17	-5.61	59.63	1.00	32.89**	40.04	1.43	-0.34	11.10	0.07	3.85**
37	Lok 1	54.75	0.38	-4.98	50.18	1.10*	-4.38	39.62	0.48	-1.17	12.56	1.34	0.002

*, ** Significant at 5 and 1 percent level respectively; + Significant deviation of bi from unity at 5 percent level

coefficient near unity and non-significant deviation were desirable and stable in performance across the environments. In general it can be concluded that PBW 373 and Raj 3765 genotypes exhibited non- significant deviation from regression (S^2di) for grain yield per plant. In addition, three crosses *viz.*, HD 2687 x Raj 3077, DBW 17 x PBW 373 and PBW 373 x Raj 4037 registered high per se performance with below average response (bi > 1) which demonstrating suitability for favourable environment. Consequently, in near future the genotypes those will have good buffering ability and predictable behaviour for fluctuating environmental are most desirable and may be recommended for that particular environmental condition to accelerate the wheat production in the climate changing scenario.

REFERENCES

Amin, M., Mohammad, T., Khan, A. J., Irfaq, M., Ali, A. and Tahir, G. R. 2005. Yield stability of spring wheat (*Triticumaestivum*L.) in the North West Frontier Province, Pakistan. *Songklanakarin J. Sci. Technol.* **27:** 1147-1150.

Arya, V. D., Pawar, J. S. and Lamba, R. 2004. Phenotypic stability for yield, its components and quality traits in bread wheat. *National J. Plant Imp.* **6:** 9-13.

Ashraf, M., Qureshi, A. S., Ghafoor, A. and Khan, N. A. 2001. Genotype-environment interaction in wheat. *J. Biological Sci.* **1:** 356-357

Dhyani K, Ansari, M. W., Rao, Y. R., Verma, R. S., Shukla, A. and Tuteja, N. 2013. Comparative physiological response of wheat genotypes under terminal heat stress. *Plant Signal. Behav.* **8(6):** e24564. doi: 10.4161/psb.24564

Eberhart, S. A. and Russell, W. A. 1966. Stability parameters for comparing varieties. *Crop Sci.* **6:** 36-40.

Farooq, M., Bramley, H., Palta, J. A. and Siddique, K. H. M. 2011. Heat Stress in Wheat during Reproductive and Grain-Filling Phases. *Critical Reviews in Plant Sciences* **30:** 1-17.

Hassan, M. S., Mohamed, J. I. A. and El-said, R. A. R. 2013. Stability analysis for grain yield and its component of some durum wheat genotypes (*Triticumaestivum* L.) under different environmemts. *Asian J. Crop Sci.* **5(2):** 179-189.

Jaiswal, K. K., Marker, S. and Kumar, B. 2013. Combining ability analysis in diallel crosses of wheat (*Triticumaestivum*L.) *The Bioscan.* **8(4):** 1557-1560.

Koemel, J. E., Guenzi, A. C., Carver, B. F., Payton, M. E., Morgan, G. H. and Smith, E. L. 2004. Hybrids and pureline hard winter wheat yield and stability. *Crop Sci.* **44:** 107-113.

Kumar, V., Tyagi, B. S., Verma, A. and Sharma, I. 2014. Stability analysis for grain yield and its components under different moisture regimes in bread wheat (*Triticumaestivum*) *Indian J. Agric. Sci.* **84(8):** 931-6.

Lillimo, M., Ginkel, M., Trethowan, R. M., Hernandez, E. and Rajaram, S. 2004. Associations among international CIMMYT bread wheat yield testing locations in high rainfall areas and their implications for wheat breeding. *Crop Sci.* **44:** 1 163-9.

Lin, C. S. and Binns, M. R. 1988. A method of analyzing cultivar × location × year experiments: a new stability parameter. *Theor. Appl. Genet.* **76:** 425-30.

Ram, M., Singh, R. M. and Agrawal, R. K. 2014. Genetic analysis for terminal heat stress in bread wheat (*Triticumaestivum* L.). *The Bioscan.* **9(2):** 771-776.

Sarkar, S., Singh, A. M., Ahalawat, A. K., Chakraborti, M., Singh, G. P. and Jaiswal, J. P. 2014. Genetic variability for grain and bread making quality traits in wheat (*Triticumaestivum* L.) and their correlation validated through multi-environment trials. *Indian J. Genet.* **74:** 309-316.

Shah, S. I. H., Sahito, M. A. Tunio, S. and Pirzado, A. J. 2009. Genotype-environment interactions and stability analysis of yield and yield attributes of ten contemporary wheat varieties of Pakistan. *Sindh Univ. Res. J.* **41:** 13-24.

Stone, P. 2001. The effects of heat stress on cereal yield and quality. In: A.S. Basra (Ed.) Crop Responses and Adaptations to Temperature Stress. *Food Products Press, Binghamton,* NY. pp. 243-291.

Yadav, R. B. and Choudhary, H. B. 2004. Stability analysis for performance of rainfed bread wheat (*Triticumaestivum* L.) genotypes. *Ann. Agric. Res.* **25:** 248-252.