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Stability analysis for physiological and quality parameters in wheat (*Triticum aestivum*)

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ABSTRACT

A study was conducted during 2006–08 to assess the stability of genotypes for different physiological and quality parameters using 49 diverse wheat (*Triticum aestivum* L. emend. Fiori & Paol) genotypes. The pooled analysis of variance with respect to all the 12 traits indicated that the variance due to environment was significant for all the 12 traits which showed distinctly differential effect of the different sowing conditions in the name of environment. The variance for genotypic effect was also highly significant for all the traits under study indicating thereby differential response of all the genotypes selected for the study. The varieties 'HD 2923', 'CBW 14', 'CBW 17', 'CBW 23', 'CBW 12', 'CBW 24', 'RS 951', 'DBW 16', 'DBW 17, 'PBW 559', 'Raj 3765', 'PBW 343 'and 'NIAW 845' have shown higher mean values, desirable regression coefficient and deviation from the regression coefficient for yield, quality parameters and physiological traits. Based on the mean performance, linear regression and S^2d values, the above varieties can be said to be stable.

Key words: Bread wheat, Physiological traits, Quality parameters, Stability analysis

Wheat (*Triticum aestivum* L. emend. Fiori & Paol) is one of the major staple food crops in the world. India stands second in wheat production in the world with its production of 80.98 million tonnes during 2009–10 (FAO 2010). This crop is being increasingly grown in areas where the ambient temperatures exceed the optimum temperature. Heat stress at late growth stages is a problem in 40% of wheat areas in the temperate environments (Blum 1983). The ideal genotype for high temperature stress conditions must combine a reasonably high yield potential with specific physiological characters which could buffer yield against severe temperature stress (Kumar 2002).

Improvement of end-use quality in bread wheat depends on thorough understanding of current wheat quality and the influence of genotypes, environments and genotype by environment interactions on quality traits (Zhang Yong *et al.* 2004). Wheat varieties differ significantly with respect to their grain quality. However, environmental factors play a major role in the expression of genotype characteristics (Zhang *et al*. 2002). Their impact, however, is rarely optimal, one or more of them will always limit the yield and quality of the product. Stability of quality characters is also important in increasing varietal selection efficiency for breeders in breeding programme (Korkut *et al*. 2007). Economic instability as defined by the end users is commonly caused by both environment and genotype×environment interaction effects (Letta *et al.* 2008).

The present study was carried out to investigate the stability for physiological and quality traits under normal and high temperature stress in wheat during the grain-filling stage and identification of tolerant genotypes suitable for higher production and productivity in the target environments.

MATERIALS AND METHODS

The present study comprised 49 elite genotypes of bread wheat (*Triticum aestivum* L. emend. Fiori & Paol) meant for all the agronomic conditions, like timely-sown irrigated conditions, late-sown irrigated conditions and also timely-sown rainfed conditions. These lines were genetically diverse, released and pre-released wheat genotypes developed by cooperating centers of All India Wheat and Barley Improvement Project. Experiment was laid out during 2 seasons (2006–07 and 2007–08) in a 7×7 double lattice design with 2 replications and 3 dates of sowing. Sowing was done

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on 15 November 2006 and 2007; 15 December 2006 and 2007 and 10 January 2007 and 2008. Each genotype was planted with the help of self-propelled Norwegian seed drill. The gross plot size of timely-sown experiment was 1.38 m×6.0 m, with rows at 23 cm apart, whereas in the late and very late-sown experiments, the gross plot size was 1.08 m×6.0 m with row-to-row spacing of 18 cm. The standard cultivation practices prescribed for wheat under irrigated conditions were followed precisely. The field observations were recorded in crop growing season. The data were recorded from each plot for grain yield, canopy temperature depression, membrane thermostability, relative water content, SDS-sedimentation test, hectoliter weight, flour recovery percent, kernel hardness index and micronutrient analysis (Fe and Zn content).

The canopy temperature depression was measured at anthesis and 10 days after anthesis of the un-irrigated crop using a portable infrared thermometer (Model AG–42, Teletemp Corporation, Fullerton, CA) with a view of 2.50. Relative water content was determined following the method described by Weatherley (1950). Kernel hardness was measured using Single Kernel Characterization System 4100 from Perten Instruments, Austria. The protein content of grain was measured by Kjeltech method using Autokjeltech 3100 system of Foss Tecator, USA. The SDS-sedimentation value for gluten strength was measured manually. The hectoliter weight for estimating the plumpness of the grains was measured using instrument designed by Directorate of Wheat Research, Karnal. The flour recovery percentage was worked out using Barbender senior mill and micronutrient contents (Fe and Zn) were estimated using Atomic absorption spectrophotometer (Perkin Elmer, Singapore). The stability analysis was carried out with the model proposed by Eberhart and Russell (1966) using software SPAR II.

RESULTS AND DISCUSSION

The pooled analysis of variance with respect to all the 12 traits has been presented in the Table 1. The variance due to environment was significant for all the traits under consideration which indicated the distinct and differential effect of the different sowing conditions. The variance for genotypic effect was also highly significant for all the traits indicating thereby differential response of all the genotypes selected for the study. The variance due to variety× environment have shown significant interaction for the characters grain yield, canopy temperature depression (at anthesis), relative water content, Fe content, protein per cent, hectoliter weight, kernel hardness index, flour recovery per cent and sedimentation value showing differential response to the varieties with different environments. These results are in line with the findings obtained by Shantha *et al.* (2007).

Highly significant mean squares due to environment + genotype×environment interactions revealed that the

Table 1 Analysis of variance of yield and yield-contributing traits under different environments

Source of variation	df	Mean squares											
		Grain yield (tonnes/ha)	CTD (at anthesis)	CTD (10 DAA)	Membrane injury per cent	Relative water content	Zn content	Fe content	Protein per cent	Hectoliter weight	Kernel hardness index	Flour recovery per cent	Sedimentation value
Rep within env.	3	2 594.3	0.076	0.012	5.95	0.079	0.076	0.50	2567.2**	2.22	7.98**	7.86	28.36
Varieties	48	308 081**	5.57**	4.74**	1223.4**	82.64**	48.7**	50.69**	2574.2	9.11*	47.54**	14.77	54.05**
Env. + (var×env)	98	292529**	0.20**	0.07*	6.77	31.01**	30.89	88.83**	2592.5**	8.50**	15.02**	19.62**	54.28**
Environments	2	12253126**	3.59**	1.52**	135.4**	728.7**	301.6**	3228**	2501.1	165.5**	61.7*	319.62**	1531.2**
Var.×env.	96	43350.8**	0.13**	0.04	4.09	16.48*	25.25	23.4*	2592.45**	5.22*	14.04**	13.37*	23.5*
Env. (lin)	1	24506252**	7.18**	3.04**	270.81**	1457.5**	603.3**	6456.1**	5002.06**	331.1**	123.5**	639.24**	3063.2**
Var.×env. (lin)	48	63333.2**	0.21**	0.04	3.42	23.53	26.00	32.89*	5183.4**	7.39**	26.69**	18.04**	33.3**
Pooled deviation	49	22891.6	0.51	0.03	4.68**	9.23**	24.00**	13.65**	1.14	3.00**	1.36*	8.53**	13.43**
Pooled error	144	18366.4	0.036	0.008	1.51	1.24	0.16	0.23	2583.5	0.54	0.81	0.49	0.43
Total	146	297642.8	1.97	1.60	406.7	47.99	36.76	76.2	2585.3	8.70	25.71	18.03	54.20

genotype interacted considerably with environmental conditions that existed under different dates of sowing. However, this interaction was non-significant for the characters membrane injury per cent and Zn content indicating thereby that these two characters of all the genotypes under all the 3 cultivation conditions had been following more or less similar pattern. The pooled deviation also contributed to the total interaction in the case of membrane injury per cent, relative water content, Zn content, Fe content, hectoliter weight, kernel hardness index, flour recovery per cent and sedimentation value which suggest that the varieties together in the name of genotypes differed considerably for all these characters.

The stability parameters like mean performance of the varieties, linear regression (bi) and deviation from the linear regression (S^2d) for the characters were studied (Table 2). For grain yield (tonnes/ha), 3 varieties, namely 'HD 2767', 'PBW 502' and 'WH 542' have shown significantly higher S^2d values. The rest of the 47 genotypes showed non-significant S^2d values. The linear regression (bi) values were significant for 'DBW 14', 'WH 542', 'Raj 3765', 'HD 2329' and 'PBW 550'. The rest of the varieties showed non-significant values for bi. None of the variety showed negative value for the linear regression (bi). The varieties 'HD 2923', 'CBW 14', 'CBW 17', 'CBW 23', 'CBW 12', 'CBW 24', 'RS 951', 'DBW 16', 'DBW 17', 'PBW 559', 'Raj 3765', 'PBW 343' and 'NIAW 845' showed higher mean values which was more than the population mean of 3.84 tonnes/ha. Based on the mean performance, linear regression and S^2d values, the above varieties can be said stable as per the criteria of the stability analysis.

The varieties 'DBW 28', 'PBW 502', 'PBW 550' and 'NW 1014' showed significantly superior S^2d values for the physiological trait canopy temperature depression (at anthesis). The significantly superior linear regression was expressed by the varieties 'HUW 468', 'CBW 12', 'CBW 25', 'RS 926', 'PBW 563' and 'PBW 343'. On the basis of the mean performance, the varieties 'HUW 510', 'HUW 468', 'CBW 17', 'CBW 23', 'CBW 09', 'RS 950', 'URJA', 'DBW 16' and 'DBW 14' were found to be superior.

For the character membrane injury per cent, the varieties 'GW 273', 'PBW 568', 'PBW 570', 'PBW 564', 'HD 2643', 'GW 326', 'HD 2687', 'HD 2329' and 'HD 2733' showed significantly superior S^2d values. The variety INT 89 and RS 929 showed significantly superior linear regression values. On the basis of superior mean performance over the base population, the varieties 'HUW 510', 'CBW 14', 'CBW 17', 'CBW 23', 'CBW 12', 'CBW 24', 'CBW 09', 'DBW 16', 'DBW 14', 'DBW 17', 'DBW 15', 'GW 273', 'RS 925', 'RAJ 3765', 'GW 322' and 'NIAW 845' performed superior in comparison with other varieties for the character membrane injury per cent.

For the character relative water content, varieties 'HD 2851', 'HD 2824', 'CBW 12', 'CBW 9', 'RS 929', 'RS 951',

Table 2 Stability status of bread wheat varieties under present investigation on the basis of mean performance, regression coefficient and deviation from regression coefficient

	Grain yield	Canopy temperature depression	Membrane injury (%)	Relative water content	Zn content	Fe content	Hectoliter weight	Kernel hardness index	Flour recovery	Sedimentation value
Genotypes with higher stability	'HD 2923', 'CBW 14', 'CBW 23', 'CBW 12', 'CBW 24', 'RS 951', 'DBW 16', 'DBW 17'	'HUW 510', 'CBW 24', 'CBW 12', 'CBW 25', 'RS 926', 'RAJ 3765', 'GW 326', 'HD 2733'	'CBW 14', 'CBW 17', 'CBW 12', 'CBW 25', 'DBW 16', 'DBW 14', 'DBW 17', 'RS 925'	'RS 950', 'URJA', 'RS 925', 'PBW 343', 'PBW 550'	'HD 2922', 'HD 2851', 'RS 925'	'HD 2922', 'RS 926', 'RS 927'	'CBW 9', 'CBW 25', 'RS 950', 'DBW 17'	'HD 2922', 'RS 951', 'DBW 39'	'HD 2851', 'RS 950', 'RS 927'	'RS 929', 'DBW 15', 'GW 273', 'PBW 568', 'RAJ 3765'
Genotypes with moderate stability	'CBW 17', 'HD 2643', 'PBW 550', 'NW 1014'	'URJA', 'DBW 15', 'GW 273', 'HD 2329'	'HD 2733', 'HD 2329', 'GW 326'	'HD 2329', 'RAJ 3765', 'HD 2851', 'DBW 14'	'HD 2733', 'HD 2851'	'DBW 16', 'DBW 14'	'INT 89', 'HUW 468', 'CBW 17', 'DBW 39'	'HUW 468', 'HD 2733'	'CBW 24', 'DBW 16', 'DBW 14'	'CBW 23', 'HUW 468'
Genotypes with lower stability	'HUW468', 'INT 89', 'HUW 510'	'NIAW 845', 'HD 2687', 'RS 951', 'PBW 559'	'HD 2643', 'PBW 564', 'GW 273', 'PBW 568'	'HD 2851', 'HD 2824', 'CBW 12', 'CBW 9'	'DBW 16', 'PBW 568', 'DBW 14', 'DBW 39'	'PBW 563', 'HD 2323', 'PBW 502', 'NW 1014'	'PBW 550', 'NW 1014', 'PBW 550'	'PBW 564', 'RS 925'	'PBW 550', 'PBW 547', 'NW 1014', 'URJA'	'URJA', 'PBW 502'

'DBW 14', 'DBW 39', 'PBW 559', 'HD 2767', 'Raj 3765', 'HD 2687', 'HD 2329', 'HD 2733', 'PBW 343', 'PBW 547', 'NW 1012' and 'NW 1014' showed significantly superior S^2d values. For Fe and Zn content, most of the varieties showed significantly superior S^2d values indicating the amount of the interaction the environment is having with the genotypes. It is clear from the table that for protein content, none of the varieties are having significantly superior S^2d values, whereas, most of the genotypes are having significantly superior linear regression values.

For hectolitre weight, varieties 'INT 89', 'HD 2824', 'HUW 468', 'CBW 17', 'CBW 12', 'CBW 24', 'RS 926', 'DBW 39', 'RS 925', 'HD 2643', 'GW 326', 'HD 2687', 'HD 2733', 'NW 1012', 'NIAW 845', 'PBW 550' and 'NW 1014' showed significantly superior S–2d values. Very few varieties like 'CBW 23', 'URJA', 'HD 2767' and 'PBW 547' showed significantly superior linear regression values (bi). Based on the mean performance, the superior genotypes were 'HD 2851', 'RS 926', 'DBW 16', 'DBW 14', 'DBW 15', 'PBW 559', 'HD 2767' and 'GW 326'.

For kernel hardness index, varieties 'HUW 468', 'PBW 564', 'RS 925', 'PBW 343' and 'HD 2733' showed significantly superior S–2d values. For flour recovery percent, varieties 'HD 2922', 'Raj 3765', 'PBW 547' and 'CBW 12' showed significant bi values. For sedimentation values, 'HD 2923', 'HD 2851', 'CBW 09', 'RS 950', 'HD 2733' and 'NW 1012' showed significant values for linear regression.

Based on the mean performance, regression coefficient (bi) values and deviation from regression values, some of the genotypes have been identified to suit with stability of performance under unfavorable environments in respect of grain yield and other Physiological and quality traits (Table 3). In the present study, it seems that the above stable genotypes could be used to develop a new strain with combination of stable characters. Singh and Chaudhary (2007) also reported similar findings.

Table 3 Effect of environment in the expression of grain yield, quality parameters and physiological traits

Character	Environmental index		
	Normal sowing	Late sowing	Very late sowing
Grain yield	501.660	–3.207	–498.452
Canopy temperature depression at anthesis	0.228	0.071	–0.299
Canopy temperature depression (10 days after anthesis)	0.159	0.031	–0.190
Membrane injury per cent	–0.811	–1.101	1.912
Relative water content	4.062	–0.450	–3.612
Zn content	2.176	0.526	–2.702
Fe content	8.908	–1.930	–6.977
Protein per cent	–4.059	8.250	–4.191
Hectoliter weight	1.630	0.360	–1.992
Kernel hardness index	–1.287	0.510	0.777
Flour recovery per cent	1.719	2.932	–1.215
Sedimentation value	–6.401	2.476	3.925

The effect of environment (normal, late and very late sowing), which is taken as indicator for the terminal heat exposure to the 49 genotypes and worked out as comparison of mean of the genotypes over the 3 environments for physiological and quality parameters by way of environmental index is presented in Table 3. A perusal of the Table shows that for grain yield (tonnes/ha), the environmental index for normal sowing was 501.66 which gradually decreased in the late and very late sowing. For the physiological traits, like canopy temperature depression at anthesis and canopy temperature depression at 10 days after anthesis, the values of environmental index indicated that the character can be better utilized for very late sowing. Membrane injury index showed negative values for normal sowing (–0.811) and late sowing (–1.011) and positive values for the very late sowing (1.912). Relative water content showed a value of 4.062 for normal sowing, –0.450 for the late sowing and –3.612 for very late sowing. These results are agreement with the findings of Hailu *et al.* (2007).

For the quality parameter like micronutrient content (Fe and Zn), the values of the environmental index decrease significantly with the exposure of terminal heat stress by delaying the sowing. For protein content, late sowing was found to be ideal, whereas, for hectoliter weight and flour recovery percent, normal and late sowing were ideal. For kernel hardness index and sedimentation value, the late and very late sowing were ideal. Genotypes selected according to stability of quality in this study verified the possibility of combining both stable and high quality. However, breeders must be aware of the difficulties in selection. As reported by Rharrabti *et al.* (2003), an integrated selection system designated to maximize the probability of production stable quality wheat with a high level of performance should be developed. The cultivation of more unsuitable cultivars should be recommended only for specific regions and agronomic conditions where they can attain a high performance with regard to quality traits independent of seasonal effects. Reynolds *et al.* (2009), emphasized on the assumption of the physiological trait strategy and physiological trait-based crossing programme will realize cumulative gene action in selected progeny. This will lead to caveat that a trait may show interaction with genetic background and environment (Reynolds and Tuberosa 2008).

The important goal for breeders is to find genotypes with good and stable quality and heat tolerance not only to provide quality raw material for the end users, but also to provide the parents in the future breeding programme (Mut *et al.* 2010). Breeding for separate regions will definitely increase the cost. Therefore, a balance between selection gain and breeding cost must be made (Atlin *et al.* 2000). Larger genotype×environment interaction also complicates the design of an efficient field testing system. An efficient testing system is more important for quality traits than for the agronomic traits (Young *et al.* 2004). However, breeders must keep in mind that the assessment of stability depend on the sets of genotypes and environments studied. Instability analysis, various statistics should be applied to characterize the genotypes for responsiveness to environment as much as possible to be sure of the genotype by environment interactions.

REFERENCES

Atlin G N, Baker R J, Mcrae K B and Lu X. 2000. Selection response in subdivided target regions. *Crop Science* **40**: 7–13.

Blum A. 1983. Breeding programme for improving crop resistance to water stress. (*in*) *Crop Reactions to Water and Temperature Stress in Humid Temperature Climates*, pp 263–74. Paper IrCD and Kramer P J (Ed.).

Eberhart S A and Russell S A. 1966. Stability parameters for comparing varieties, *Crop Science* **28**: 36–40.

FAO. 2010. Statistical Database. www.fao.org.

Hailu J K, Sarial A K and Assefa S. 2007. AMMI analysis for stability and location effects of grain protein content of durum wheat genotypes. *Cereal Research Communication* **35**: 1661–73.

Korkut K Z, Bilgin O, Baser I and Saolam N. 2007. Stability of grain virtuousness in durum wheat genotypes in north western region of Turkey. *Turkish Journal of Agricultural Forestry* **31**: 313–8.

Kumar A N. 2002. ‘Studies on variability and inheritance of some morpho-physiological traits in bread wheat (*Triticum aestivum* L.) under moisture stress conditions’. M Sc thesis (Unpublished). Indian Agricultural Research Institute, New Delhi.

Letta T, Egidio M G D and Abinasa M. 2008. Stability analysis for quality traits in durum wheat (*Triticum durum* Desf) varieties under south Eastern Ethiopian conditions. *World Journal of Agricultural Sciences* **4** (1): 53–7.

Mut Z, Aydin Nevzat, Bayramoglu H O and Ozcan H. 2010. Stability of some quality traits in bread wheat (*Triticum aestivum*) genotypes. *Journal of Environmental Biology* **31**: 489–95.

Reynolds M P and Tuberosa R. 2008. Translational research impacting on crop productivity in drought prone environments. *Current Opinion in Plant Biology* **11**: 171–9.

Reynolds M P, Manes Y, Izanloo A and Langridge P. 2009. Phenotyping approaches for physiological breeding and gene discovery in wheat. *Annals of Applied Biology* **155**: 309–20.

Rharrabti Y, Gracia del Moral, Villegas D and Royo C. 2003. Durum wheat quality in Mediterranean environments. III. Stability and comparative method in analyzing G×E interactions. *Field Crop Research* **80**: 141–6.

Shantha Nagarajan, Tripathi S, Singh G P and Chaudhary H B. 2007. Effect of cultivar and environment on quality characteristics of wheat (*Triticum aestivum* L.). *Indian Journal of Genetics and Plant breeding* **67** (2): 149–52.

Singh G P and Chaudhary H B. 2007. Stability of wheat genotypes for yield and moisture stress tolerance traits under diverse moisture regimes. *Indian Journal of Genetics and Plant Breeding* **67** (2): 145–8.

Weatherley P E. 1950. Studies in the water relations of cotton plants. I. the field measurement of water deficit in leaves. *New Phytology* **49**: 81–7.

Zhang Yong, He Zhonghu, Guoyou Ye, Zhang Aimin and Marten Van Ginkel. 2004. Effect of environment and genotype on bread-making quality of spring wheat cultivars in China. *Euphytica* **139**: 75–83.

Zhang Y, He Z H, Wang M F, Zhou G Y, Wang D S and Zhang Y. 2002. Investigation on milling and baking quality of Chinese spring-sown wheat. *Journal Triticeae Crops* **22** (1): 27–32.