Indian J. Genet., **67**(2): 145-148 (2007)

Stability of wheat genotypes for yield and moisture stress tolerance traits

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(Received: September 2006; Revised: February 2007; Accepted: February 2007)

Abstract

Forty genotypes of wheat were evaluated over six environments under different moisture regimes for their yield performance. Genotype × environment interaction was found significant for plant height, peduncle length, grain yield, biological yield, LPH/PH index, PL/LPH index PL/PH index, ear length, tillers per meter and harvest index. On partitioning it into linear and non-linear components, both were responsible for expression of the traits. However, the linear component was found larger in magnitude than the non-linear component suggesting that the variation in the performance of different cultivars could be predicted. The genotypes RR 49 and IB2K1-37 were found to be stable across environments for grain yield, while genotypes RR 888, RR 49, IB2K1-66, RS 897, RR 24 and IB2K1-37 were found to be stable across environments for yield components like 1000 grain weight, biological yield and tillers per meter. Genotypes DL 153-2, DL 788-2 and RR 19 were found to be having stable performance for plant height and component characters under stress environments. Thus these genotypes could be included in the hybridization programme to converge the stability characteristics of seed yield for development of a stable variety adapted to wider range of environments.

Key words: Wheat, stability, regression coefficient, moisture stress

Introduction

Food supply for the continuously increasing population is a major concern in India. The solution to the food problem largely depends on the increase and stabilization of grain productivity and the improvement of its quality. Wheat constitutes one of the five major crops of the world and the second most important cereal crop in India after rice. Many of the crops characteristics were probably well known 2000 years ago when it evidently was grown for food. It has been used as a major source of food since prehistoric times. The area under cultivation of wheat crop in India is 26.6 M ha with the production of 72.1 M tonnes. A major part of area under cultivation is of semi-dwarf type genotypes under timely sown irrigated condition. However, a part of wheat belt in India falls under rainfed/restricted irrigated conditions. The ideal genotype for moisture stress condition must combine a reasonably high yield potential under varied environmental conditions with specific plant characters which could buffer yield against severe moisture stress [1].

Information about phenotypic stability is useful for the selection of crop varieties as well as for breeding programmes. An understanding of environmental and genotypic causes leading to GE interactions are important at all stages of plant breeding including ideotype design, parental selection, selection based on traits and selection based on yield [2,3]. This understanding can be used to establish breeding objectives, identify ideal test conditions and formulate recommendations for areas of optimal cultivar adaptation. Thus this study was undertaken to evaluate wheat genotypes for their yield stability under diverse moisture regimes.

Materials and methods

Field experiments were conducted at Experimental Farm, Division of Genetics, Indian Agricultural Research Institute, New Delhi, India (28°41' North latitude and 77°13' East latitude, 228 m above mean sea level). The area is semi arid, sub tropical climate with alluvial soil which is slightly alkaline with clay loam texture and low organic matter. The experimental material comprising of 40 wheat genotypes were grown under six different moisture regimes and two planting dates (late and timely) during 2003-04 and 2004-05 crop season as mentioned below:

Environment 1 : Timely sown, moisture stress condition (rainfed); Environment 2: Timely sown limited irrigation, low fertility; Environment 3: Timely sown limited irrigation, optimum fertility; Environment 4: Timely sown irrigated, optimum fertility; Environment 5: Late sown limited irrigation, optimum fertility, Environment 6: Late sown, irrigated, low fertility.

The material was planted in randomized complete block design (RCBD) with three replications. Six, 5m row were planted by keeping a distance of 23 cms between the rows. The fertilizer (N: P: K) were applied as per the recommended dose for the different growing conditions. Under the low fertility conditions, half dose of the recommended fertilizer was applied. Normal cultural practices were followed. Under the restricted irrigation condition, two irrigation were provided (CRI and booting). The data were recorded for plant height (cms), days to heading, peduncle length PL (cms), ear length EL (cms), lower plant height LPH (cms) (LPH = PH-PL-EL), PL/PH index (PL/PH × 100), LPH/PH index (LPH/PH × 100), PL/LPH index (PL/LPH × 100), tillers per meter, tillers per plant, grain number per spike, grain weight per spike, 1000 kernel weight, biological yield, grain yield and harvest index. The stability analysis was carried out with the model proposed by Eberhart and Russell [4].

Results and discussion

Forty selected genotypes were evaluated under six artificially created environments. The analysis of variance for all the traits is presented in the Table 1 for all the six environments. The analysis of variance for all the characters indicated differences among the genotypes over all the six environments except for grain weight per spike under environment 1. Mean sum of square due to genotype × environment interaction were highly significant for all the traits when tested against pooled error except for traits 1000 grain weight, biological yield and grain yield per meter. Further, Environment + Genotype × Environment interactions were significantly different in pooled analysis of variance for stability for all the characters studied except ear length.

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

Source of variation	df	Mean squares													
		Days to flowering	Plant height	Peduncle length	Lower plant height	Ear length	PL/PH index	LPH/PH index	PL/LPH index	Tillers per meter	Grain wt per spike	1000 grain weight	Biological yield/m	Grain yield	Harvest index
Varieties (V)	39	65.66**	609.506**	67.67**	486.43**	3.818**	63.72**	104.41**	1029.11**	482.61**	0.107**	41.96**	4193.93**	271.15*	59.90*
Env. (E)	5	649.88**	1880.65**	11.44**	1173.75**	3.63**	65.11**	219.37**	2376.43**	8045.22**	0.405**	392.84**	63752.1**	2793.06**	192.67**
G × E	195	3.895**	24.66**	9.924*	25.04**	0.49**	10.51**	12.48*	160.71*	261.09**	0.048*	17.66**	2068.24**	233.21*	39.46**
Env.+(G×E)	200	20.045**	71.06**	12.53**	53.73**	0.562	11.88**	17.65	216.10**	455.69**	0.057*	27.05**	3610.34**	297.21*	43.32**
Env. (linear)	1	3429.27**	9404.46**	572.44	5868.76**	15.18**	325.58**	1097.11**	11882.01**	40225.07**	20.029**	1964.47**	318756.00**	13967.57**	963.22**
G×E (linear)	39	2.67	47.23**	5.75	49.82	0.36	14.77*	19.46**	328.30**	273.31	0.041	17.28**	1731.23**	220.24*	620.22**
Pooled dev.	160	4.097**	18.53**	10.69**	18.34**	50.52**	9.21*	10.46**	115.84**	251.59	0.0448*	17.32**	2098.71**	230.53*	330.22**
Pooled error	468	1.592	6.50	7.81	12.00	0.34	8.11	8.90	127.27	135.32	0.0336	15.04	1857.71	185.51	18.64

*,**Significant at 5% and 1% level, respectively

The environment (linear) component for all the characters was significant. The G × E interaction was found to be significant. On partitioning it, into linear and non-linear components, both were significant indicating their importance in the inheritance of the traits. However, the magnitude of linear component was larger than non-linear, suggesting that differential environments and feasibility of stable production of wheat genotypes across the environments. Preponderance of linear G × E interaction is of greater importance to the plant breeder and the same is reported here.

The performance of genotypes over all the six environments with respect to the grain yield varied apparently and indicated that environments 6 (late sown, irrigated, high fertility) showed highest favorable impact, on grain yield (107.25 g) followed by the 100.27 g in timely sown, limited irrigated, high fertility conditions and 953.76 g in the environment 4 (timely sown irrigated, high fertility conditions). The favourable response of the environment 6 indicates that genotypes were most suited for the late sown conditions with adequate inputs. The 1000 grain weight under environment 6 and environment 3 were also found to be on the higher side with number of tillers per plant. The mean performance of yield related traits like plant height and peduncle length as well as PL/PH index under the environments 3 and 6 is also relatively similar. So, it appears that under favourable environments, the grain yield in invariably associated with semi dwarf plant height, better tiller number and 1000 grain weight. The extent of peduncle length and PL/PH index also supports the performance in respect of the grain yield. Mean performance for grain yield under the environment 1 and 2 is although lower, but its range indicates that under moisture stress conditions also, some of the genotypes could perform better, equivalent to genotypes under rich environments. The PL/PH index performance *per se* under the stress environments indicate that the ranges of the genotypes (31.91-52.59 and 29.11-46.67) are on the higher side as compared to those of the favourable conditions. Similar trends are also found for peduncle length which indicated that some of the genotypes having desirable peduncle length and PL/PH index can be utilized for wheat improvement for stress environments.

The stability parameters are presented in the

Table 2. It is evident from the Table 2 that genotype RR 49 and IB2K 1-37 having regression coefficient (bi) value 1.00 and non-significant deviation from regression for grain yield are stable varieties. This indicates that these genotypes perform stably over all the environments, while RR 40, DL 788-2 and HD 2329 having high mean of grain yield along with bi less than 1 and non significant deviation (S^2di) signifies their stability for moisture stress rainfed conditions and showing above average stability. Genotype HD 2865, IB2K-79-5 and RS 889 had bi more than unity and non significant deviation (S^2di) which means they are suitable under most favorable environments (irrigated high fertility conditions). Here, it is important to indicate

Table 2. Stability parameters of bread wheat genotypes for yield and moisture stress tolerance traits

Genotype	Stability parameters over six environments													
	Peduncle length		Lower plant height		Ear length		PL/PH index		LPH/PH index		PL/LPH index		Grain yield(g)	
	bi	S^2di	bi	S^2di	bi	S^2di	bi	S^2di	bi	S^2di	bi	S^2di	bi	S^2di
C 306	1.58	16.60**	0.76	0.97	2.05	0.16	–0.08	5.68**	0.38	5.95**	0.16	43.4	1.08	221.00**
HD 2329	1.42	0.15	6.51	–2.49	0.65	0.67**	–0.70	–0.35	0.28	–0.48	–0.06	–12.50	0.75	21.50
PBW 343	1.82	10.60**	0.14*	25.70**	2.50	0.22	–2.16**	14.10**	–0.56*	23.86**	–1.09**	266.0**	0.95	222.00**
HD 2009	0.84	1.00	0.78	6.59	0.58	0.08	1.23	–2.46	1.01	–2.42	1.19	–36.40	0.62	567.00**
HD 2781	2.03	13.10**	0.89	3.86	0.54	0.60**	–0.21	6.44**	0.20	6.84**	0.00	55.50	2.28	107.00**
DL 788-2	0.46	8.43**	0.59	18.80**	1.24	1.57**	1.55	0.25	1.04	–1.00	1.50	8.50	0.54	59.60
DL 153-2	0.59	–0.53	0.80	–0.58	0.57	0.15	0.95	0.21	1.02	0.17	1.25	9.61	0.56	113.00**
NI 5439	0.71	5.19**	1.35	61.20**	2.28	0.66**	1.76	7.94**	1.79	11.70**	12.44	106.0**	1.05	105.50**
K 8027	0.48	6.91**	1.32	0.78	2.07	0.65**	2.34	1.54**	1.89	1.31	2.00	–4.63	0.34	73.70
HDR 77	6.72	17.00**	1.14	44.40**	1.14	0.84	0.17	16.60**	0.76	24.00**	0.20	40.90	1.87	29.80
HD 2865	0.00	0.27	1.07	5.28	1.55	0.59**	1.58	0.44	1.21	2.89	0.99	–7.05	1.80	65.40
RS 870	2.05	2.58	1.18	8.85**	–0.75	1.74**	–0.47	2.76	0.39	–0.06	–0.02	–4.40	1.18	115.60**
RS 888	0.73	2.43	1.98**	–0.33	–1.34*	0.02	2.57	1.46	1.92	1.12	2.01	–4.52	2.23	357.00**
RS 889	0.99	0.97	0.78	9.34**	–0.49	0.15	1.47	1.29	0.97	3.30	1.22	32.70	1.46	60.60
RS 891	0.49	1.52	1.01	13.60	1.67	0.45**	1.96	3.12	1.51	5.76**	1.76	61.60*	0.97	351.00**
RS 897	0.18	–0.36	1.56	21.10**	0.10	0.26**	1.69	3.45	1.38	5.56**	1.26	30.10	1.57	550.00**
RR 4	1.66	0.26	–0.34**	4.55	2.37	0.30**	–1.73*	5.79**	–0.88**	1.07	–1.06**	45.10	1.78	26.50
RR 7(O)	0.87	39.90**	0.64	29.00**	6.67	0.03	–0.52	21.20**	–0.03	21.60**	–0.26*	226.6**	1.09	605.00**
RR 7	0.68	10.50**	1.50	5.90*	1.03	0.20**	1.40	3.22	1.30	6.78	1.20	15.30	1.70	416.00**
RR 12(O)	–0.41	0.61	0.60	7.26**	1.81	6.98**	1.45	0.18	1.17	2.09	1.40	14.00	–0.81*	–9.67
RR 12	0.53	10.50**	2.04*	3.89	0.84	0.15	2.82	6.10**	2.31	4.45*	2.62**	55.00	0.25	86.60
RR 13	1.31	6.02**	0.46	0.40	0.13	0.05	0.30	2.88	0.20	3.02	0.12	–6.74	1.38	127.60**
RR 14	0.64	5.47**	2.00*	–3.51	0.72	–0.05	3.07	0.37	2.39*	–1.10	2.36	–23.90	1.88	123.00**
RR 17	1.14	4.79**	1.49	15.30**	1.00	0.24**	2.98	6.13**	2.26*	9.08**	2.84**	92.90**	1.44	–26.20
RR 18	1.02	11.50**	0.90	20.50**	1.50	0.79**	1.40	17.50**	0.96	15.00**	1.06	211.0**	–0.32**	388.00**
RR 19	0.95	1.45	1.63	2.99	2.12	0.38**	1.97	0.50	1.81	0.65	1.88	1.39	0.49	109.00**
RR 24	0.43	–0.14	1.84*	18.20**	0.49	0.08	2.46	2.37	1.94	3.05	1.79	7.25	0.16	26.10
RR 29	2.10	3.07	0.80	14.10**	1.03	0.46**	–0.43	4.00*	0.37	5.44**	0.03	44.40	1.48	72.90
RR 40	1.13	13.5**	0.65	44.80**	0.45	0.16	–0.06	24.20**	0.42	23.80**	0.11	324.6**	0.68	–31.50
RR 43(O)	1.74	9.81**	1.22	20.00**	–0.23	–0.06	2.67	12.80**	1.83	15.30	2.90**	249.0**	1.51	5.74
RR 46(O)	0.83	–1.35	1.36	30.56**	0.99	0.20**	1.88	5.56**	1.89	9.79**	–2.55*	159.0**	1.44	–4.00
RR 47(O)	1.53	5.70**	0.86	19.00**	1.36	0.39**	–0.27	8.92**	0.40	13.90**	0.13*	189.0**	1.48	280.00**
RR 49	0.02**	2.57	1.20	2.80**	2.07	0.13	2.28	5.68	1.65	4.63*	2.25	66.80**	1.03	39.30
RR 57	1.18	0.39	0.78	–2.28	0.43	0.29**	0.15	–1.82	6.48	–1.38	0.27	–23.00	1.87	119.60**
RR 59	0.95	7.13**	–0.37**	41.80**	–0.43	1.25**	–0.66	9.83**	–0.45*	14.70**	–0.35*	102.0**	0.95	960.00**
RR 90(O)	2.35	15.80**	1.39	0.98	2.43	0.05	1.09	8.72	1.31	6.58**	1.50	122.0**	0.49	92.60*
IB2K1-37	0.70	0.12	0.54	24.80**	3.06	0.32**	0.26	5.48**	0.76	14.70**	0.64	170.0**	0.96	–50.70
IB2K1-66	0.33	44.80**	1.86*	8.37**	0.59	0.33**	3.09*	18.20**	1.91	19.30**	1.67	120.0**	0.21	326.00
IB2K1-79-1	1.70	39.30**	0.08**	16.70**	0.05	0.15	–0.20	28.70**	–0.34*	23.30**	–0.29*	186.0**	1.60	–2.76
IB2K1-287	1.03	6.10**	1.02	36.40**	1.15	0.59**	0.93	1.48	1.02	1.77	0.81	0.76	0.11	107.00*
Pop. mean	38.13		49.89		10.44		39.05		50.11		80.40		94.71	
SEbi±	0.86		0.35		1.17		1.06		0.61		0.62		0.81	
S.Em±	1.46		0.19		0.32		1.35		1.44		4.81		6.79	

Table 3. Stability of bread wheat genotypes over different locations for different traits

Character	Suitable for		
	Over all environments	Over moisture stress environment	Over favourable environments
Grain yield	RR 49, IB2K-1	RR 40, DL 788-2	HD 2865, IB2K1-79-5, RS 889
Tillers per meter	RR 897	IB2K1-37	NI 5439
1000-grain weight	RR 888, IB2K1-37, RR 49, IB2K1-66	RR 12, IB2K1-287	NI 5439, RR 7(O), RR 19, RR 49
Biological yield	RR 888, RR 49	RR 7(O), RR 49, RR 90(O)	-
Peduncle length	RR 889, RR 19	RR 12(O), IB2K1-37	RR 4
PL/PH index	DL 153-2	HD 2329, RR 57	DL 788-2, RR 889 RR 891, RR 7
LPH/PH index	HD 2009, DL 788-2, DL 153-2, RR 889	HD 2329, RR 4, RR 57	RR 7, RR 19

that although variety HD 2865 is identified for moisture stress rainfed condition, but because of its dwarf stature, is showing input responsiveness. For days to flowering HD 2865, RR 4, RR 14 and RR 19 were showing bi near to unity and non-significant mean square deviation indicating stability in their performance. HD 2329, DL 153-2 were found to be stable in performance in respect of plant height based on the mean performance, regression coefficient and non-significant deviation. The genotypes DL 153-2, DL 788-2, RS 889 and RR 19 were found to be having stable performance with regard to plant height and its components like peduncle length, PL/PH index and LPH/PH index. Since peduncle length has got significant contribution for storage and translocation of carbohydrates from source to sink, these genotypes can ideally be used for moisture stress conditions [5]. The other trait of importance is length of ear head, which indirectly contributes towards higher number of grains per unit area. This trait has been considered by various workers as one of the important traits [6]. Genotypes HD 2009, DL 153-2, RS 889, RR 4, RR 13 and RR 40 have been found to be stable for ear length under moisture stress conditions and hence can be used for further improvement programme. Genotypes PBW 343 and RR 99 showed stable performance in the high input conditions. Since PBW 343 is an established genotype for wider adaptability, its contribution through ear length combined with high grain number may be one of the reason.

Based on the mean performance, regression coefficient and deviation from regression values, some of the genotypes have been identified to suit with stability of performance under favourable and non-favourable environments in respect of yield and its components and related traits (Table 3). In the present investigation, stable genotypes identified could be used to develop new strains with combinations of stable characters. Madariya *et al.*, [7] also reported the similar findings where stability of tillers per meter, 1000 grain weight, biological yield and harvest index varied in compensating manner in different genotypes imparting them stability for yield.

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