Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 290-297
Received: 21-05-2018
Accepted: 25-06-2018

Shah Siddhi
Department of Genetics & Plant Breeding, Junagadh Agricultural University, Junagadh, Gujarat, India

Patel JB
Department of Genetics & Plant Breeding, Junagadh Agricultural University, Junagadh, Gujarat, India

Nikita Patel
Department of Genetics & Plant Breeding, Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
Shah Siddhi
Department of Genetics & Plant Breeding, Junagadh Agricultural University, Junagadh, Gujarat, India

Stability analysis in bread wheat (*Triticum aestivum* L.)

Shah Siddhi, Patel JB and Nikita Patel

Abstract
Stability for grain yield performance and genotype x environment (G x E) interaction was studied in 45 genotypes (Nine diverse parents and their 36 hybrids made by using half diallel mating design) of bread wheat by evaluating them in different environments [Early (25th October), timely (15th November) and late sowing (5th December)] following randomized block design with three replications during *rabi* 2016-17 at Sagadividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Two parents (NW 5013 and QLD 46) and twelve hybrids (PHSC 5 × GW 2010-287, DBW 90 × GW 2010-287, DBW 90 × BW 5872, NW 5013 × QLD 65, BW 5872 × QLD 65, GW 2010-287 × BW 5872, Raj 4238 × GW 496, QLD 65 × QLD 46, GW 2010-287 × QLD 46, BW 5872 × QLD 46, BW 5872 × Raj 4238 and GW 2010-287 × Raj 4238) expressed their stability across the environments for grain yield per plant due to their high *per se* for grain yield per plant, non-significant regression coefficient (b_i) and deviation from linear regression (S^2d_i). The hybrids, NW 5013 × QLD 46, GW 2010-287 × QLD 65 and PHSC 5 x BW 5872 were having more grain yield per plant and had the least deviation from linear regression, but significant regression coefficient (bi >1) and thus, found to be highly responsive to better environments. The stable parents QLD 46 (15.78 g) and NW 5013 (15.94 g) were also showed stability for important yield components like grain filling period, plant height, length of main spike, peduncle length of main spike, number of spikelets per main spike, 1000 grain weight and biological yield per plant. Stable hybrids with respect to grain yield per plant also showed stability for one or more component traits like days to heading, grain filling period, days to maturity, plant height, number of effective tillers per plant, length of main spike, peduncle length of main spike, number of spikelets per main spike, number of grains per main spike, grain weight per spike, 1000 seed weight, biological yield per plant and harvest index. This indicated that stability of various component traits might be responsible for the observed stability of various hybrids for grain yield per plant. Hence, chances of selection of stable hybrids for yield could be enhanced by selecting for stability for yield components.

Keywords: bread wheat, environment, genotype x environment interaction, stability

Introduction
Wheat is one of the most important staple food crops of the world, feeding about 40 per cent of the world population and providing 20 per cent of total food calories and protein in human nutrition (Gupta *et al*., 2008) [11]. India's share in world wheat area is about 13.8 per cent, whereas it occupies 14.06 per cent share in the production, but ranks 8th position in productivity (Anon., 2014) [3]. Wheat is an important crop of India not only in terms of acreage, but also in terms of its versatility for adoption under wide range of agro climatic conditions and crop growing situations. Wheat is a major contribute to the food security system in India as well, occupying nearly area 30.23 million hectare during 2015-16, producing 93.50 million tonnes of wheat with the productivity of 3093 kg/ha (Anon., 2016a) [1]. State wise analysis indicated that Uttar Pradesh has maximum area and production under wheat followed by Punjab and Madhya Pradesh. In Gujarat, during 2015-16, wheat is grown in about 0.85 million ha with total production of 2.48 million tonnes and a productivity of 2919 kg/ha (Anon., 2016b) [2].
Genotype and its interaction with prevailing environment is the basic factor determining the final yield. The genotype x environment interaction is particularly important in the expression of quantitative characters, which are controlled by polygenic systems and are greatly modified by the environmental influences. Thus, in order to have unbiased estimates of various genetic components, it is imperative that the experiment should be repeated over different environments. Crop yield in which the plant breeder is most interested is dependent on the genotype, the environment and the interaction between genotype and environment. The result of the genotype x environment interaction is expressed as adaptability and stability of the genotype. When interaction between genotype and environment exists, ranking of genotype

will be different under different environments. The stability of productivity is, therefore, very important. Hence, it is always desirable to study the stability of hybrids in respect of economically important characters. The estimates of genotype x environment interactions give an idea of stability or buffering ability of populations under study. The present investigation was, therefore, planned to measure the genotype x environment interaction and to estimate stability parameters for grain yield and its components in bread wheat.

Materials and Methods

The experimental material comprised of 36 crosses developed from 9 diverse parents using half diallel mating design. The materials was evaluated in a Randomized Block Design with three replications in three different environments [Early (25th October), timely (15th November) and late sowing (5th December)] during *rabi* 2016-2017 at Sagadividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Each entry was sown in a single row plot of 1.0 m length keeping row-to-row and plant-to-plant distance of 22.5 cm and 10 cm, respectively. Five competitive plants per genotype in each replication in each environment were selected randomly for recording observations on different characters *viz*., plant height (cm), number of effective tillers per plant, length of main spike (cm), peduncle length of main spike (cm), number of spikelets per main spike, number of grains per main spike, grain weight per main spike (g), 1000 grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%), while observations on days to heading, grain filling period and days to maturity were recorded on plot basis. The data were analyzed for G x E interactions and stability parameters following the model of Eberhart and Russell (1966) [7].

Results and Discussion

The pooled analysis of variance (Table 1) revealed that the mean squares due to genotypes as well as environments were found significant for all the traits except days to heading, number of effective tillers per plant, number of grains per main spike, biological yield per plant and harvest index due to genotypes when tested against pooled deviation. This revealed that significant variations exist among genotypes and environments. G x E interaction was found highly significant for grain filling period only when tested against pooled deviation. The coincidence of genotypic performance with environmental values was observed for grain filling period as evident by significant G x E (linear) mean squares when tested against pooled deviation, indicating that performance of genotypes over environments could be predicted reasonably for this trait. The mean sum of squares due to environments (linear) was also noted significant difference for all the characters studied when tested against pooled error, suggesting that differences between environments were considerable for all the traits studied and it was influenced greatly by environment indicating thereby that large differences between environments along with the greater part of genotypic response was a linear function of environment. This also indicated that environments created by sowing dates was justified and had linear effects. Mean sum of squares due to pooled deviation were significant for all the characters, expect grain filling period, peduncle length of main spike and number of spikelets per main spike, which suggested that prediction of performance of genotypes over environments based on regression analysis for these traits might not be very reliable. The results, in general, are in agreement with those of Yadav and Choudhary (2004) [18], El-Badawy (2012) [8], Ranjana and Kumar (2013) [15] and Pansuriya *et al.* (2014) [13] reported in wheat for stability analysis.

The stability of performance is one of the most desired characters of a genotype for wider adaptation. The stability parameters *viz*., mean performance (Xi), regression coefficient (bi) and deviation from linear regression (S^2di) for parents as well as hybrids were estimated for fourteen characters to assess the relative phenotypic stability of performance over environments.

Recently, interest has been focused on regression analysis. The regression approach was first proposed by Yates and Cochran (1938) [19] which was later modified by Finlay and Wilkinson (1963) [9] to interpret the varietal adaption to varying environments. Regression technique was slightly improved by adding one more parameters i.e. deviation from regression by Eberhart and Russell (1966) [7]. According to them, both linear (b_i) and non-linear (S^2d_i) function should be considered while judging the phenotypic stability of genotype. Eberhart and Russell (1966) defined a stable genotype as one which produces high mean yield, depicts regression coefficient.

Table 1: Analysis of variance for phenotypic stability for different characters in wheat.

Sources of variation	D.F.	Characters						
		Days to heading	**Grain filling period**	**Days to maturity**	**Plant height (cm)**	**Number of effective tillers per plant**	**Length of main spike (cm)**	**Peduncle length of main spike (cm)**
Genotypes	45	15.07	31.48**	12.67**	42.31**	0.74	1.74**	7.98**
Genotype x Environment	90	14.96	9.79**	8.17	22.85	0.52	0.59	2.28
Environments	2	1883.59**	591.35**	957.31**	287.45**	87.34**	16.78**	559.19**
Environments (linear)	1	3767.18**	1182.69**	1914.63**	574.90**	174.67**	33.57**	1118.37**
Genotype x Environment (linear)	45	13.85	19.58**	9.98	24.72	0.24	0.57	1.73
Pooled deviation	46	15.72**	-0.00	6.22*	20.52**	0.80**	0.60**	2.77
Pooled error	270	1.74	7.01	3.85	5.93	0.21	0.31	3.46

Table 1: Contd...

Sources of variation	d.f.	Characters						
		Number of spikelets per main spike	**Number of grains per main spike**	**Grain weight per main spike (g)**	**1000 grain weight (g)**	**Grain yield per plant (g)**	**Biological yield per plant (g)**	**Harvest index (%)**
Genotypes	45	2.60**	17.24	0.07**	21.77*	6.69*	13.44	42.71
Genotype x Environment	90	0.89	8.86	0.04	8.71	3.20	19.73	46.73
Environments	2	76.65**	3986.91**	10.19**	168.46**	77.86**	1208.88**	210.90*
Environments (linear)	1	153.30**	7973.81**	20.38**	336.92**	155.73**	2417.77**	421.80*

Genotype x Environment (linear)	45	0.88	5.89	0.03	6.28	2.99	15.77	29.36
Pooled deviation	46	0.88	11.58**	0.02**	10.90**	3.34**	23.17**	62.70**
Pooled error	270	0.98	5.86	0.01	0.88	0.94	5.82	11.55

* And ** significant at 5 and 1 per cent level probability, respectively.

(b_i) around unity and deviation from regression (S^2d_i) near zero. Later on Breese (1969) [5] and Paroda and Hayes (1971) [14] suggested that linear regression (b_i) should simply be regarded as a measure of response of a particular genotype, whereas the deviation from regression (S^2d_i) as a measure of stability. Mehra and Ramanujan (1979) [12] and Singh and Singh (1980) [17] suggested the methodology to classify different genotypes in to different groups.

It is always justified to breed for genotypes with only high yield potential because of the times the yield potential cannot be expressed. Therefore, a much higher priority should be given to improve yield stability (Ceccarelli, 1989) [6]. Stability is genetically controlled characters (Bradshaw, 1965 [4] and Scott, 1967 [16]), therefore, one can breed also for stability. Stability for yield may be dependent upon stability of different yield components. Hence, information on the relative stability for different yield components is essential to understand diverse mechanism contributing to yield stability.

Stability in performance is one of the most desirable properties of a genotype for its wide adaptability. The stability parameters *viz*., mean performance (X_i) across the environments, regression coefficient (b_i) and deviation from linear regression (S^2d_i) for parents and hybrids were estimated as per Eberhart and Russell (1966) [7] for 14 characters to assess the relative stability of genotypes over environments and are presented in Table 2 to 4. The perusal of stability parameters for grain yield per plant and other 13 characters revealed that none of genotypes was stable for all the characters which indicated that any generalization pertaining to stability of genotypes for all the traits was not possible. For grain yield per plant, 2 parents (NW 5013 and QLD 46) and 12 hybrids (PHSC 5 × GW 2010-287, DBW 90 × GW 2010-287, DBW 90 × BW 5872, NW 5013 × QLD 65, BW 5872 × QLD 65, GW 2010-287 × BW 5872, Raj 4238 × GW 496, QLD 65 × QLD 46, GW 2010-287 × QLD 46, BW 5872 × QLD 46, BW 5872 × Raj 4238 and GW 2010-287 × Raj 4238) expressed their stability across the environments due to their high grain yield per plant, non-significant regression coefficient (b_i) and deviation from linear regression (S^2d_i) (Table 4). The hybrids, NW 5013 × QLD 46, GW 2010-287 × QLD 65 and PHSC 5 x BW 5872 were having more grain yield per plant and had the least deviation from linear regression, but significant regression coefficient (bi >1) and thus, found to be highly responsive to better environments. The performance of 4 hybrids, NW 5013 × DBW 90, NW 5013 × BW 5872, DBW 90 × GW 496 and PHSC 5 × QLD 46 could not be predicted due to their significant deviation from linear regression.

In general, parents found stable for grain yield per plant also depicted their stability of performance across the environments for one or more yield attributing traits. The highest yielding stable parent, QLD 46 (15.78 g) was found to be stable for days to heading, days to maturity, plant height, length of main spike, peduncle length of main spike, number of spikelets per main.

Table 2: Stability parameters of different genotypes for days to heading, grain filling period, days to maturity, plant height (cm) and number of effective tillers per plant in bread wheat

S. No.	Genotype	Days to heading			Grain filling period			Days to maturity			Plant height (cm)			Number of effective tillers per plant		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
Parents																
1.	NW 5013	50.55	0.94	2.07	41.33	0.12	0.54	103.89	0.70	-3.49	56.17	0.93	12.28	9.67	0.86	-0.15
2.	DBW 90	49.67	1.15	2.10	43.78	0.86**	1.68	106.44	1.22	-0.90	57.37	-0.13	11.54	9.22	1.36	-0.08
3.	PHSC 5	48.89	0.95**	-1.72	39.55	0.59**	-3.83	102.00	0.58*	-3.81	51.67	0.26	-5.24	9.55	0.72	-0.13
4.	GW 2010-287	48.22	1.01**	-1.73	39.11	0.86**	-4.11	101.67	0.61	-2.90	55.14	-0.69	-5.16	9.44	0.55	-0.19
5.	BW 5872	47.67	1.54	47.48**	40.67	0.91**	1.81	101.22	1.57	5.71	54.54	-1.15	24.09*	9.67	0.86	-0.15
6.	QLD 65	48.67	0.65	12.40**	46.44	2.25**	2.96	108.22	1.50	-2.25	56.82	0.22	0.26	9.61	1.43	-0.10
7.	QLD 46	47.89	0.79*	-1.64	38.89	0.97**	-3.76	100.89	0.45	-3.34	57.89	-0.41	-4.92	10.67	0.51	1.45**
8.	Raj 4238	55.55	0.76	22.04**	38.44	1.37	13.05	105.89	1.85	-2.40	53.20	-0.72	-5.24	9.67	0.92**	-0.21
9.	GW 496	51.22	0.32	17.82**	39.78	1.48*	-6.96	103.33	0.83	-3.51	52.77	-0.09	23.75*	9.55	0.79	1.27**
Hybrids																
10.	NW 5013 × DBW 90	47.78	0.88	27.99**	41.22	0.35	-5.62	102.22	0.44	0.78	54.38	0.04	11.46	10.33	0.78*	-0.21
11.	NW 5013 × PHSC 5	45.44	0.88	-0.91	43.00	0.40	2.37	102.78	0.55	-3.70	56.22	-1.16	23.49*	9.80	1.15	-0.14
12.	NW 5013 × GW 2010- 287	46.11	2.19	38.90**	40.44	-0.21	-1.45	102.11	1.24*	-3.59	59.59	2.76	8.53	9.83	1.21	0.05
13.	NW 5013 × BW 5872	48.22	1.17	-0.92	40.89	0.51	77.48**	103.11	0.30	-3.33	56.42	0.77	1.82	10.29	1.43	2.23**
14.	NW 5013 × QLD 65	49.22	0.71	38.44**	43.00	0.59	-5.01	103.78	1.15	-2.64	54.40	0.25	-5.80	9.81	0.83	0.20
15.	NW 5013 × QLD 46	51.11	0.20	4.43	40.00	0.38	42.98**	101.89	0.26	1.67	60.24	2.82	22.54*	10.16	0.89*	-0.20
16.	NW 5013 × Raj 4238	53.33	0.42	21.59**	38.11	-0.19	-6.51	101.00	0.34	-3.00	58.03	3.79	44.16**	9.60	1.36	-0.08
17.	NW 5013 × GW 496	51.33	0.43	5.97*	40.11	0.38	36.54*	103.55	0.40	10.07	50.92	-1.56	13.91	9.60	0.53	0.74*
18.	DBW 90 × PHSC 5	50.22	0.63**	-1.73	43.44	1.15*	-6.95	103.89	1.61	5.31	56.89	2.19	28.25*	9.79	0.74	1.95**
19.	DBW 90 × GW 2010-287	48. 33	0.66	8.64*	41.11	2.01*	-6.95	101.78	1.24	36.16**	65.36	0.82	134.92**	10.49	1.03	-0.01
20.	DBW 90 × BW 5872	47.00	1.04	27.33**	40.44	2.42	10.98	102.55	1.87	57.31**	52.05	-0.60	15.75	10.64	0.97	0.02
21.	DBW 90 × QLD 65	45.89	0.88	-0.91	40.78	3.22	-1.45	103.67	1.79*	-3.05	52.42	-0.05	89.27**	9.13	1.25	-0.07
22.	DBW 90 × QLD 46	45.44	0.63	18.72**	43.89	0.97	73.21**	99.89	0.94	20.07*	59.00	1.35	24.20*	9.52	0.71	-0.17

Table 2: Contd...

S. No.	Genotype	Days to heading			Grain filling period			Days to maturity			Plant height (cm)			Number of effective tillers per plant		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
23.	DBW 90 × Raj 4238	49.89	1.33*	-1.25	36.00	1.32	105.48**	106.55	0.43	11.58*	62.82	1.49	-5.52	9.58	0.97*	-0.19
24.	DBW 90 × GW 496	51.22	0.55	1.64	42.89	2.79*	-6.78	102.67	2.18	9.82	60.99	2.95	26.74*	10.32	1.32	5.84**
25.	PHSC 5 × GW 2010-287	46.89	0.97	58.74**	41.78	2.17	-0.28	106.67	1.45	6.95	65.09	-0.30	31.39*	9.64	1.02	4.70**
26.	PHSC 5 × BW 5872	52.00	0.90	36.21**	40.33	1.32	33.48*	102.11	1.49	-0.32	56.88	-0.40	-1.61	9.61	0.70	-0.00
27.	PHSC 5 × QLD 65	47.11	1.20	3.54	39.89	1.15	2.37	102.78	0.62*	-3.78	60.74	2.47	96.35**	10.62	1.11	-0.13
28.	PHSC 5 × QLD 46	48.22	1.38	4.05	40.00	1.15	-5.62	100.44	1.57	9.88	55.39	0.45	-1.19	10.22	1.48	4.00**
29.	PHSC 5 × Raj 4238	47.00	1.32**	-1.71	39.33	-0.00	3.87	99.33	0.83	-1.42	56.19	1.54	4.60	9.44	0.95	0.00
30.	PHSC 5 × GW 496	46.11	1.99	29.46**	37.33	1.05	61.04**	105.00	0.58	20.26*	60.24	0.82	14.52	10.18	0.93	1.80**
31.	GW 2010-287 × BW 5872	49.33	1.16**	-1.72	42.22	0.11	120.98**	98.00	1.61	3.93	58.03	2.57	-2.22	10.76	0.98	-0.01
32.	GW 2010-287 × QLD 65	47.78	1.40	0.82	36.00	-0.03	22.37*	102.00	0.03	2.99	57.50	3.74	43.06**	10.89	1.02	2.82**
33.	GW 2010-287 × QLD 46	51.33	0.64	19.13**	39.89	0.75	0.98	104.11	0.91	7.78	60.51	1.61	-3.10	9.51	0.84	0.02
34.	GW 2010-287 × Raj 4238	48.33	1.25	-0.86	40.33	1.80	-4.28	103.55	1.22	2.07	58.49	-0.81	58.81**	10.42	0.77	1.11*
35.	GW 2010-287 × GW 496	52.33	0.49	12.87**	40.33	0.67*	-6.95	102.11	0.89	1.14	63.99	2.24	38.07**	9.33	0.67	0.07
36.	BW 5872 × QLD 65	47.33	1.96	25.47**	40.67	1.18	3.87	104.78	1.67	15.52*	62.07	2.33	4.69	10.00	1.09	-0.03
37.	BW 5872 × QLD 46	51.55	0.66	0.80	40.67	0.46	13.04	103.33	0.78	-2.33	59.36	0.58	-4.34	10.22	1.09	-0.03
38.	BW 5872 × Raj 4238	51.44	0.81	17.76**	38.22	0.89	-4.28	100.89	0.45	5.96	58.23	0.29	-1.97	9.98	0.94	0.15
39.	BW 5872 × GW 496	50.44	1.02*	-1.57	37.00	0.75	-5.01	104.67	0.65	-1.15	60.38	0.86*	-5.92	10.20	0.83*	-0.21
40.	QLD 65 × QLD 46	47.89	1.50*	-1.68	41.78	1.40	3.87	106.89	1.09	-0.20	60.17	1.23	3.79	10.59	1.33	4.14**
41.	QLD 65 × Raj 4238	48.55	1.13	11.05**	44.44	0.91	15.21	101.89	1.55	6.28	64.48	3.06	60.75**	9.04	1.36	-0.08
42.	QLD 65× GW 496	46.22	1.34	0.51	41.67	0.78	-2.51	103.78	0.83	-0.45	57.71	2.35	118.15**	9.18	0.73	0.05
43.	QLD 46 × Raj 4238	48.33	1.18	89.54**	41.89	0.97**	-7.01	102.78	0.99	-3.14	66.37	3.66	58.44**	9.81	1.34	1.38**
44.	QLD 46 × GW 496	52.00	1.13	116.40**	38.44	0.91	-3.45	102.67	0.94	4.49	61.19	1.95	138.44**	10.40	1.56	-0.11
45.	Raj 4238 × GW 496	47.89	0.91	16.55**	41.67	1.13**	-7.01	105.00	0.93*	-3.62	55.62	-0.38	-4.97	10.49	1.14	-0.01
Mean		49.04	-	-	40.63	-	-	103.10	-	-	58.06	-	-	9.91	-	-
S.Em. ±		2.23	0.44	-	2.43	0.02	-	1.65	0.40	-	2.76	1.28	-	0.42	0.46	-
C.D. at 5 %		NS	-	-	NS	-	-	4.63	-	-	7.75	-	-	NS	-	-

* and ** significant at 5 and 1 per cent level probability, respectively.

Table 3: Stability parameters of different genotypes for length of main spike (cm), peduncle length of main spike (cm), number of spikelets per main spike, number of grains per main spike and grain weight per main spike (g) in bread wheat

S. No.	Genotype	Length of main spike (cm)			Peduncle length of main spike (cm)			Number of spikelets per main spike			Number of grains per main spike			Grain weight per main spike (g)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
Parents																
1.	NW 5013	9.62	0.09	0.29	28.61	1.16	-0.86	14.46	1.13	-0.79	42.79	0.77*	-5.82	2.01	0.87*	-0.01
2.	DBW 90	9.19	0.29	-0.19	24.03	0.24	-3.27	12.44	0.06	0.19	38.44	0.90	10.20	1.64	1.12*	-0.01
3.	PHSC 5	10.24	0.38	-0.29	28.00	1.35	-3.06	14.04	1.07	-0.94	42.98	0.95	1.91	1.93	1.10	0.02
4.	GW 2010-287	8.52	1.15	0.27	24.81	0.62	-2.81	13.11	0.23	-0.63	39.55	0.99	46.25**	1.89	1.30	0.09**
5.	BW 5872	8.69	0.81	0.98*	24.12	1.06	0.36	13.44	1.75	0.44	41.11	1.11	4.65	1.76	1.13	0.02
6.	QLD 65	8.12	0.43	0.24	26.58	0.83*	-3.45	12.89	0.50	-0.85	43.11	0.81*	-5.57	1.83	0.45	-0.01
7.	QLD 46	10.09	-0.55	-0.22	27.79	1.02	-2.34	14.36	1.19	-0.94	44.51	0.93	-1.64	2.05	0.96	-0.01
8.	Raj 4238	9.50	-0.42	3.16**	25.09	0.91	-1.84	13.89	1.21	1.52	41.78	0.84	-1.42	1.84	0.82	0.00
9.	GW 496	7.99	2.15	0.97*	24.81	1.17	4.19	12.89	1.47	-0.46	41.33	1.15	12.61	1.75	1.03	0.02
Hybrids																
10.	NW 5013 × DBW 90	10.33	0.05	0.22	28.38	0.97	-2.87	14.83	1.44	1.83	42.94	1.38*	-5.38	1.96	1.32*	-0.01
11.	NW 5013 × PHSC 5	8.89	2.04	-0.19	26.90	0.94	19.20*	13.11	0.49	-0.58	41.78	0.69	-2.50	1.79	1.00*	-0.01
12.	NW 5013 × GW 2010- 287	8.84	2.34	0.18	23.49	1.10	3.90	12.33	0.62	2.47	41.33	0.90	17.23*	1.65	0.70	0.05*
13.	NW 5013 × BW 5872	10.31	-0.71	-0.24	28.17	1.16*	-3.39	14.78	1.32*	-0.96	43.69	1.02	13.06	1.94	1.03	0.01
14.	NW 5013 × QLD 65	10.12	-0.19	-0.28	28.06	0.83	-2.51	15.04	1.03	-0.83	45.83	0.98	-1.69	2.05	1.12	-0.01
15.	NW 5013 × QLD 46	10.44	-0.77	3.90**	27.46	0.51*	-3.45	15.14	1.10	-0.03	44.17	1.15	8.64	1.81	1.02	0.01
16.	NW 5013 × Raj 4238	8.54	0.87	2.42**	24.37	1.38	10.72*	13.00	0.53	-0.95	42.78	0.91**	-5.84	1.54	0.59	-0.01
17.	NW 5013 × GW 496	8.13	1.62	0.45	26.70	0.76	-2.62	12.22	0.36	2.44	42.67	0.65	1.30	1.89	1.01	0.04*
18.	DBW 90 × PHSC 5	9.23	1.82	0.54	26.03	1.16	-1.07	13.67	0.85	0.99	42.89	0.74*	-5.69	1.59	0.23	0.01
19.	DBW 90 × GW 2010-287	10.12	0.48	-0.30	28.55	0.99*	-3.34	14.00	0.28	0.44	45.36	0.85**	-5.85	1.84	0.82	0.02
20.	DBW 90 × BW 5872	10.14	0.12	0.85	28.61	0.50	4.23	14.17	0.44	0.03	43.79	1.15*	-5.74	1.77	0.86**	-0.01
21.	DBW 90 × QLD 65	8.73	2.07	0.47	23.81	0.79	6.06	12.22	0.83	-0.08	41.96	0.92	-3.20	1.82	1.08	0.01
22.	DBW 90 × QLD 46	9.53	1.40	1.37*	26.99	1.04	0.82	12.22	0.13	4.96*	42.33	0.86	69.99**	1.81	0.80	0.11**

Table 3: Contd...

Sr. No.	Genotype	Length of main spike (cm)			Peduncle length of main spike (cm)			Number of spikelets per main spike			Number of grains per main spike			Grain weight per main spike (g)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
23.	DBW 90 × Raj 4238	9.50	2.44	0.13	26.28	1.60	8.50	13.89	1.46	-0.49	40.00	0.33*	-5.81	1.65	0.37	0.07**
24.	DBW 90 × GW 496	10.43	0.50	-0.02	28.96	0.99	-3.26	14.78	1.63	-0.03	45.07	0.97	-1.53	1.88	0.69	0.06*
25.	PHSC 5 × GW 2010-287	10.42	0.39	-0.03	27.47	0.77	0.01	14.69	1.17	2.64	44.22	1.15*	-5.72	1.96	0.99*	-0.01
26.	PHSC 5 × BW 5872	9.54	1.47	1.11*	26.24	1.13	-3.22	14.33	1.80	-0.61	42.55	0.77	3.62	1.88	0.82	0.01
27.	PHSC 5 × QLD 65	8.71	2.02	-0.27	25.76	1.15*	-3.39	12.89	0.86	1.23	40.11	0.88*	-5.66	1.70	1.02	-0.01
28.	PHSC 5 × QLD 46	8.98	2.60	0.59	25.29	1.07	-2.06	13.89	1.19	-0.76	39.44	1.20*	-4.72	1.66	1.23	-0.01
29.	PHSC 5 × Raj 4238	9.60	2.54	0.05	26.11	1.15*	-3.44	13.78	0.74	-0.52	39.33	0.76	0.67	1.55	0.63	-0.01
30.	PHSC 5 × GW 496	8.79	2.43	0.01	26.78	1.53*	-3.27	12.00	0.65	5.17*	38.78	0.99	21.48*	1.72	1.33	0.02
31.	GW 2010-287 × BW 5872	10.26	0.39	0.04	28.35	0.83	-3.17	15.38	1.58	0.79	43.71	1.09	10.85	2.04	1.35	-0.01
32.	GW 2010-287 × QLD 65	10.58	0.60	-0.10	29.05	0.40	37.87**	14.77	1.25	2.38	44.16	1.10	19.60*	1.89	1.09	0.07**
33.	GW 2010-287 × QLD 46	9.76	0.75	0.30	24.79	1.07	-3.23	12.55	0.00	-0.98	39.44	1.26*	-4.59	1.83	1.53	0.12**
34.	GW 2010-287 × Raj 4238	8.87	1.36	0.61	27.38	0.92	8.12	13.00	1.57	-0.91	39.89	1.10	1.53	1.36	0.61	0.01
35.	GW 2010-287 × GW 496	9.36	1.40	0.11	25.26	1.69	5.77	13.67	1.73	-0.23	39.00	0.90	47.85**	1.77	1.06	0.03*
36.	BW 5872 × QLD 65	10.73	-0.81	7.77**	28.69	0.84	14.99*	15.00	1.15	0.33	46.47	1.25	21.22*	2.09	1.34	0.11**
37.	BW 5872 × QLD 46	8.67	1.28	0.17	24.84	1.02	-2.81	14.00	1.13	-0.60	38.89	1.24*	-4.99	1.69	1.31*	-0.01
38.	BW 5872 × Raj 4238	9.02	2.14	1.90**	25.79	0.66	-2.40	14.11	1.85	2.37	39.22	1.15	-0.11	1.64	1.30	0.00
39.	BW 5872 × GW 496	10.08	1.69	-0.24	23.92	1.35	0.37	13.33	1.57	-0.88	37.67	1.06	45.75**	1.64	0.98	0.04*
40.	QLD 65 × QLD 46	10.57	0.20	0.64	28.79	1.21	1.68	14.53	1.17	-0.80	45.51	1.28**	-5.85	1.78	1.01	-0.01
41.	QLD 65 × Raj 4238	8.87	1.17*	-0.30	27.86	0.89	0.23	13.78	0.92	-0.92	40.55	1.24	-3.63	1.76	1.14	0.02
42.	QLD 65× GW 496	8.40	1.28	0.42	25.02	1.32*	-3.42	14.22	1.30*	-0.98	38.22	1.21	12.60	1.71	1.36	0.04*
43.	QLD 46 × Raj 4238	9.22	2.65	-0.18	26.58	0.92	-1.68	12.67	-0.23	-0.64	38.00	0.92	-4.20	1.64	1.14	-0.01
44.	QLD 46 × GW 496	9.17	0.99*	-0.30	25.81	0.99	-2.52	13.44	1.27	-0.73	39.67	1.06**	-5.82	1.61	0.84	0.03
45.	Raj 4238 × GW 496	10.33	0.12	-0.11	28.24	1.01	-2.41	15.00	1.19	-0.92	45.04	1.13*	-5.59	1.91	1.14	0.01
Mean		9.44	-	-	26.54	-	-	13.74	-	-	41.79	-	-	1.79	-	-
S.Em. ±		0.44	0.90	-	1.07	0.33	-	0.57	0.51	-	1.72	0.26	-	0.10	0.24	-
C.D. at 5 %		1.25	-	-	2.99	-	-	1.59	-	-	4.83	-	-	0.28	-	-

* and ** significant at 5 and 1 per cent level probability, respectively.

Table 4: Stability parameters of different genotypes for 1000 grain weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%) in bread wheat

Sr. No.	Genotype	1000 grain weight (g)			Grain yield per plant (g)			Biological yield per plant (g)			Harvest index (%)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
Parents													
1.	NW 5013	46.87	0.64	0.84	15.94	0.90	-0.33	41.81	1.05	0.33	38.44	0.90	-11.15
2.	DBW 90	41.88	2.64	14.99**	12.43	0.12	7.81**	41.72	0.14	-4.34	29.82	-1.16	13.52
3.	PHSC 5	44.36	1.37	0.80	16.74	0.23	2.93*	41.55	1.34	-4.69	41.06	1.75	56.98*
4.	GW 2010-287	47.08	2.02	-0.42	14.44	-0.10	4.06*	37.47	0.35	92.68**	40.66	3.33	245.35**
5.	BW 5872	42.62	1.52	6.24**	14.38	1.32	14.89**	38.82	1.71	56.81**	39.28	0.38	299.62**
6.	QLD 65	42.75	-1.36	-0.26	14.91	2.37	2.66*	41.34	0.37	-2.00	36.17	-2.87	-3.98
7.	QLD 46	45.84	0.17	14.67**	15.78	1.06	-0.83	41.48	1.19*	-5.51	38.47	1.12	-11.07
8.	Raj 4238	43.98	0.63	-0.22	15.66	1.06	12.80**	36.21	0.86	1.37	43.87	-1.38	80.98**
9.	GW 496	42.04	0.38	-0.85	14.24	1.74	1.79	39.72	1.29	-4.80	36.64	1.24	1.13

Hybrids													
10.	NW 5013 × DBW 90	45.28	0.31	4.76*	17.13	0.32	12.21**	42.89	-0.11	4.98	40.41	-1.91	0.81
11.	NW 5013 × PHSC 5	42.52	2.44	0.78	14.19	1.34	4.02*	42.02	0.61	2.97	33.84	-1.22*	-11.53
12.	NW 5013 × GW 2010- 287	39.89	0.18	0.05	13.44	1.57	-0.72	40.24	0.77	14.61	33.46	-1.09	-9.22
13.	NW 5013 × BW 5872	44.43	0.29	1.40	16.19	0.15	3.66*	41.89	2.24	15.58	42.24	6.06	79.54**
14.	NW 5013 × QLD 65	44.33	1.28	0.10	17.58	2.58	1.03	42.77	0.81	9.29	41.41	-2.42	-9.65
15.	NW 5013 × QLD 46	40.93	0.28	49.07**	16.04	1.55*	-0.91	43.06	1.02*	5.72	37.83	0.36	-10.47
16.	NW 5013 × Raj 4238	35.34	0.19	13.37**	15.09	1.21	-0.88	40.27	1.68	-0.71	38.08	1.99	-10.71
17.	NW 5013 × GW 496	43.55	2.37	10.32**	13.10	-1.09*	-0.93	40.74	-0.07	56.41**	32.95	1.88	7.39
18.	DBW 90 × PHSC 5	36.83	-0.94	25.90**	13.09	1.27	25.22**	38.61	1.05*	-5.78	34.74	2.70	105.33**
19.	DBW 90 × GW 2010-287	40.22	0.98	16.11**	18.12	1.66	1.42	42.66	0.93**	-5.81	42.84	0.63	10.70
20.	DBW 90 × BW 5872	40.55	0.15	0.59	17.89	2.41	1.82	42.99	0.65	-1.75	41.45	-2.01	-3.16
21.	DBW 90 × QLD 65	42.83	1.37	8.09**	15.18	1.57	-0.70	43.08	0.48	13.77	35.28	-0.65	22.78
22.	DBW 90 × QLD 46	42.16	0.68	-0.25	14.11	1.57	-0.63	41.44	0.56	-0.93	34.29	-0.92	2.55

Table 4: Contd...

Sr. No.	Genotype	1000 grain weight (g)			Grain yield per plant (g)			Biological yield per plant (g)			Harvest index (%)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
23.	DBW 90 × Raj 4238	41.37	1.03	34.20**	14.71	0.68	-0.27	39.76	1.60	-4.54	38.09	3.05*	-11.42
24.	DBW 90 × GW 496	41.75	0.14	18.17**	16.77	0.59	3.65*	43.33	1.32	59.69**	39.56	3.76	139.83**
25.	PHSC 5 × GW 2010-287	43.82	0.31	-0.33	18.88	2.03	-0.30	40.91	0.90	39.10**	47.06	-1.13	-0.52
26.	PHSC 5 × BW 5872	44.09	0.80	0.08	15.48	1.28*	-0.94	42.04	1.24	4.57	37.80	1.55	12.79
27.	PHSC 5 × QLD 65	41.77	1.91	0.20	15.43	0.10	1.78	36.56	0.64	-0.80	43.22	2.48	11.18
28.	PHSC 5 × QLD 46	41.49	1.48	-0.67	15.74	1.44	4.25*	42.14	0.10	1.41	38.55	-2.54	-4.62
29.	PHSC 5 × Raj 4238	39.17	0.42	-0.37	12.77	0.93	-0.11	47.00	0.00	32.30*	27.42	-0.97	6.52
30.	PHSC 5 × GW 496	42.91	2.56	1.57	14.93	0.51	0.19	38.02	1.91	19.52*	41.64	4.30	85.70**
31.	GW 2010-287 × BW 5872	46.24	1.05	45.99**	17.36	1.89	-0.61	43.30	0.81	2.49	40.13	0.11	44.80*
32.	GW 2010-287 × QLD 65	42.36	0.70	6.08**	17.69	1.78*	-0.92	41.71	1.58	-3.05	43.15	1.73	0.25
33.	GW 2010-287 × QLD 46	45.28	1.30	131.84**	15.91	-0.26	0.51	37.91	1.71	35.20**	44.51	4.46	113.68**
34.	GW 2010-287 × Raj 4238	33.84	-0.17	75.81**	15.50	1.62	-0.66	39.21	1.91	-3.27	41.05	2.28	13.92
35.	GW 2010-287 × GW 496	44.98	1.30	9.28**	14.54	-0.62	14.14**	38.68	0.90	38.22**	38.74	3.45	-4.09
36.	BW 5872 × QLD 65	44.49	0.91	9.50**	17.48	1.06	0.14	43.14	0.93	14.64	40.78	-0.17	21.66
37.	BW 5872 × QLD 46	42.87	1.52*	-0.86	15.72	1.51	-0.80	40.57	1.54	6.10	39.68	1.53	2.64
38.	BW 5872 × Raj 4238	40.69	2.66	42.68**	15.62	0.54	0.08	43.22	0.39	0.17	36.98	0.87	9.74
39.	BW 5872 × GW 496	42.76	1.16	-0.40	14.84	0.49	3.23*	39.89	1.15	87.36**	37.99	1.87	9.89
40.	QLD 65 × QLD 46	38.83	0.35	2.15	16.16	1.55	-0.76	42.42	0.91*	-5.75	39.43	-0.40	-11.13
41.	QLD 65 × Raj 4238	42.89	0.50	7.99**	15.00	1.17*	-0.92	41.42	0.98	-2.99	36.85	0.67	-6.32
42.	QLD 65× GW 496	42.09	2.90	0.39	14.71	0.05	1.82	38.19	1.70	1.87	40.49	4.35	17.23
43.	QLD 46 × Raj 4238	42.31	2.45*	-0.71	13.51	0.33	0.79	38.74	1.23	-1.88	35.55	2.18	-10.91
44.	QLD 46 × GW 496	39.69	0.98	48.87**	13.76	-1.19*	-0.93	41.25	1.36	83.03**	34.25	5.01	1.07
45.	Raj 4238 × GW 496	41.83	0.62	14.91**	16.52	2.59	1.55	42.69	1.19	-5.14	38.62	-0.25	29.68
Mean		42.33	-	-	15.45	-	-	40.99	-	-	38.84	-	-
S.Em. ±		1.70	1.21	-	1.03	0.99	-	2.56	0.66	-	3.95	2.61	-
C.D. at 5 %		4.79	-	-	2.90	-	-	NS	-	-	NS	-	-

* and ** significant at 5 and 1 per cent level probability, respectively.

Spike, number of grains per main spike, grain weight per main spike and harvest index. QLD 46 was one of the parents of the three stable hybrids (QLD 65 × QLD 46, GW 2010 - 287 × QLD 46, BW 5872 × QLD 46) for grain yield per plant. Its utilization in hybrid breeding would be useful in boosting the yield of bread wheat. The other high yielding parent, NW 5013 (15.94 g) was found to be stable for grain yield per plant, also showed stability for grain filling period, plant height, length of main spike, peduncle length of main spike, number of spikelets per main spike, 1000 grain weight and biological yield per plant. It was also one of the parents of stable hybrid DBW 90 × BW 5872 with respect to grain yield per plant. Out of 12 most promising stable hybrids for grain yield per plant, either QLD 46 or NW 5013 was one of the parents in 4 hybrids.

The twelve stable hybrids for grain yield per plant are listed in Table 5 along with their grain yield per plant and various component traits for which they showed stability. The perusal of the data revealed that the best three stable hybrids for grain yield per plant were PHSC 5 × GW 2010-287 (18.88 g), DBW 90 × GW 2010-287 (18.12 g) and DBW 90 × BW 5872 (17.89 g). Among these, first ranked stable hybrid hybrid, PHSC 5 × GW 2010-287 was found to be stable for grain filling period, length of main spike, peduncle length of main spike, number of spikelets per main spike and harvest index. It also showed stability under favourable environment for number of grains per main spike and under unfavourable environment for grain weight per main spike. Across the environments, this hybrid ranked first with respect to grain yield per plant and had significant heterosis over standard check, GW 366. The second ranked stable hybrid, DBW 90 × GW 2010-287 was found to be stable for number of effective tillers per plant, length of main spike, number of spikelets per main spike, grain weight per main spike and harvest index. It was also highly responsive to favourable environments for grain filling period, and to unfavourable environments for peduncle length of main spike, number of grains per main spike and biological yield per plant. This hybrid ranked second in *per se* performance and manifested high and significant positive sca effect as well as significant heterosis over better parent. The third ranked stable hybrid DBW 90 × BW 5872 was found to be stable for plant height, number of effective tillers per plant, length of main spike, peduncle length of main spike, number of spikelets per main spike, biological yield and harvest index. It was also highly responsive to favourable environments for number of grains per main spike. This hybrid ranked third in *per se* performance and had high and significant positive sca effect as well as significant heterosis over better parent.

In general, most of the hybrids identified as stable for grain yield per plant also showed stability for one or more component traits like days to heading, grain filling period, days to maturity, plant height, number of effective tillers per plant, length of main spike, peduncle length of main spike, number of spikelets per main spike, number of grains per main spike, grain weight per spike, 1000 seed weight, biological yield per plant and harvest index. This indicated that stability of various.

Table 5: Stable hybrids identified on the basis of high mean for grain yield per plant along with other component traits showing stability in bread wheat.

S. No.	Hybrid	Stable for grain yield per plant (g)	Stable for component traits
1.	PHSC 5 × GW 2010-287	18.88	GFP, LS, PLS, NSS, NGS^{+}, GWS^{++}, HI
2.	DBW 90 × GW 2010-287	18.12	GFP^{+}, NET, LS, PLS^{++}, NSS, NGS^{++}, GWS, BY^{++}, HI
3.	DBW 90 × BW 5872	17.89	PH, NET, LS, PLS, NSS, NGS^{+}, BY, HI
4.	NW 5013 × QLD 65	17.58	GFP, PH, LS, PLS, NSS, NGS, GWS, TW, BY, HI
5.	BW 5872 × QLD 65	17.48	NET, NSS, BY
6.	GW 2010-287 × BW 5872	17.36	DM, PH, NET, LS, PLS, NSS, NGS, GWS, BY
7.	Raj 4238 × GW 496	16.52	GFP^{+}, PH, NET, LS, PLS, NSS, NGS^{+}, GWS, BY
8.	QLD 65 × QLD 46	16.16	GFP, LS, PLS, DH^{+}, NSS, NGS^{+}, BY^{++}, HI
9.	GW 2010-287 × QLD 46	15.91	LS
10.	BW 5872 × QLD 46	15.72	GFP, NET, LS, NSS, TW^{+}
11.	BW 5872 × Raj 4238	15.62	DM, NET, NSS, BY
12.	GW 2010-287 × Raj 4238	15.50	DH, PLS, HI

+, ++, indicates better for favourable and unfavourable environments, respectively

DH	=	Days to heading	NSS	=	Number of spikelets per main spike
GFP	=	Grain filling period	NGS	=	Number of grains per main spike
DM	=	Days to maturity	GWS	=	Grain weight per spike
PH	=	Plant height	TW	=	1000 seed weight
NET	=	Number of effective tillers per plant	BY	=	Biological yield per plant
LS	=	Length of main spike	HI	=	Harvest index
PLS	=	Peduncle length of main spike			

Component traits might be responsible for the observed stability of various hybrids for grain yield per plant. Hence, chances of selection of stable hybrids for yield could be enhanced by selecting for stability for yield components. Grafius (1959) [10] also observed that stability of grain yield might be due to the stability of various yield components.

The stability parameters for component traits revealed that none of the parents and hybrids (genotypes) was stable for all the traits. The stability parameters for component traits revealed that 10, 18 and 17 genotypes turned out to be stable for days to heading, days to maturity and plant height, respectively with low mean values (negative values were considered desirable for these traits), non-significant regression coefficient and deviations from linear regression. As many as 11, 9, 18 and 16 genotypes were found to be stable for grain filling period, number of effective tillers per plant, length of main spike and peduncle length of main spike, respectively with high mean, non-significant regression coefficient and deviations from linear regression. Total of 23, 10, 12, 12, 19 and 13 genotypes turned out to be stable across the environments for number of spikelets per main spike, number of grains per main spike, grain weight per main spike, 1000 grain weight, biological yield per plant and harvest index, respectively by recording high mean values for these traits with non-significant regression coefficient and deviations from linear regression.

Traits wise result of genotypes showing specific adaptation to favourable (better management condition) and unfavourable (poor management condition) environments revealed that 3 and 2 genotypes for days to heading, 5 and 3 genotypes for grain filling period, 1 and 2 genotypes for days to maturity, 0 and 3 genotypes for number of effective tillers per plant, 2 and 3 genotypes for peduncle length of main spike, 2 and 0 genotypes for number of spikelets per main spike, 5 and 5 genotypes for number of grains per main spike, 1 and 2 genotypes for grain weight per main spike, 1 and 0 genotypes for 1000 grain weight, and 2 and 2 genotypes for biological yield per plant were found to be highly responsive to favourable and unfavourable environments, respectively.

The potential yield of each genotype can be realized under a particular set of agronomical practices. Hence, it is suggested that in order to identify stable genotypes, actual testing under variable environments including favourable and unfavourable would be advantageous. During selection, the attention should be paid to the phenotypic stability of characters directly related to grain yield per plant *viz*., length of main spike, number of effective tillers per plant, number of grains per main spike, grain weight per main spike and 1000 grain weight for grain yield per plant in bread wheat.

Conclusion

From the foregoing discussion, it is clear that, parent QLD 46 and NW 5013 was found to be stable for grain yield per plant and some of the important yield components should be given due importance while formulating breeding programme aiming to develop high yielding and stable hybrids in bread wheat. The best stable cross combinations for seed yied per plant and important yield components PHSC 5 × GW 2010-287, DBW 90 × GW 2010-287 and DBW 90 × BW 5872 could be exploited for rational improvement in yield of bread wheat.

References

1. Anonymous. Annual Report Department of Agriculture and Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare Government of India Krishi Bhawan, New Delhi, 2016-17, 3. (http://agricoop.nic.in/sites/default/files/Annual_rpt_2016 17_E. pdf) 2016a; Accessed on February 5, 2018.
2. Anonymous. Crop-wise fourth advance estimate of area, production and yield of food grains, oilseeds and other crops for of Gujarat State, 2015-16. (https://dag.gujarat.gov.in/Portal/News/474_12_4th-Adv-ESt-2015-16.pdf) 2016b; Accessed on February 5, 2018.
3. Anonymous. Status Paper on Wheat. Directorate of Wheat Development, Ministry of Agriculture, Department of Agriculture and Cooperation, Ghaziabad, 2014. (http://dwd.dacnet.nic.in/Publication/StatusPaper.pdf) Accessed on January 31, 2018.
4. Bradshaw AD. Evolutionary significance of plasticity in plants. Adv. Genet, 1965; 13:115-155.
5. Breese EL. The measurement and significance of genotype x environment interactions in grasses. Heredity, 1969; 24(1):27-44.
6. Ceccarelli S. Wide adaptation, How wide? Euphytica, 1989; 40:197-205.
7. Eberhart SA, Russell WA. Stability parameters for comparing varieties. Crop Sci, 1966; 6(1):36-40.
8. El-Badawy MElM. Stability analysis for some wheat genotypes and genotype x environment interaction. J Pl. Prod. Mansoura Univ, 2012; 3(6):2017-2028.
9. Finlay KW, Wilkinson GN. The analysis of adaptation in a plant breeding programme. *Aust.* J Agric. Res. 1963; 14(6):742-754.
10. Grafius JE. Heterosis in barley. Agron. J. 1959; 40(1):58-83.
11. Gupta PK, Mir RR, Mohan A, Kumar J. Wheat genomics - present status and future prospects, Int. J Pl. Genomics, 2008, 1-36. (Article ID: 896451).
12. Mehra RB, Ramanujan S. Adaptation in segregating populations of Bengal gram. Indian J Genet. 1971; 39(3):492-500.
13. Pansuriya AG, Dhaduk LK, Patel MB, Vanpariya LG, Savaliya JJ, Madariya RB. Stability analysis for grain yield and its components in bread wheat (*Triticum aestivum* L.). AGRES An Int. e- J, 2014; 3(1): 62-67.
14. Paroda RS, Hayes JD. An investigation of genotype-environment interaction on rate of ear emergence in spring barley. Heredity, 26(1):157-175.
15. Ranjana Kumar S. G x E interaction over extended dates of sowing for grain yield and its attributing traits in wheat (*Triticum aestivum* L.). Annls. Biol., Res. 2013; 4(1):238-241.
16. Scott GE. Selecting for stability of yield in maize. Amer. Breeders Assoc. Rept. In Heterosis, (Ed. J.W. Gowen). Iowa State College Press. Amer, Iowa, USA, 1967; 4:296-301.
17. Singh RB, Singh SV. Phenotypic stability and adaptability of durum and bread wheat for grain yield. Indian J Genet. 1980; 40(1):86-90.
18. Yadav RB, Choudhary HB. Stability analysis for performance of rainfed bread wheat (*Triticum aestivum* L.) genotypes. Annl. Agril. Res. 2004; 25(2):248-252.
19. Yates F, Cochran WG. The analysis of groups of experiments. J Agril. Sci. 1938; 28(4):556-580.