Received: 04 Jan 2021 | Revised: 05 Mar 2021 | Accepted: 06 Mar 2021

Electronic Journal of Plant Breeding

Research Article

Assessment of stability performance and G X E interaction for yield and its attributing characters in bread wheat (*Triticum aestivum* L.)

Anuj Kumar*[1], Pooran Chand[2], Ravi Singh Thapa[1] and Tejbir Singh[1]

[1]Department of Genetics and Plant Breeding, Kisan PG College, Simbhaoli, Hapur, Uttar Pradesh, India
[2]Department of Genetics and Plant Breeding Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India
***E-Mail:** anujkumar271@gmail.com

Abstract

The present study was undertaken to identify the stable genotypes for grain yield and yields related components with desirable performance under different environmental conditions taking forty wheat genotypes and were evaluated for two years (2017-19) with different dates of sowing. Pooled analysis of variance showed highly significant variations for genotypes, environments and genotypes x environments (G X E). Stability analysis for grain yield revealed that the genotypes LOK-1, NI-5439 and HUW-468 has a high mean value and non-significant regression coefficient (bi) and non-significant deviation from regression and found more stable across the four environments. Therefore the above mentioned genotypes were found most stable for grain yield and can be incorporated as breeding stocks in any future breeding programs aiming to produce high yielding lines of bread wheat.

Key words

Wheat, Genotype X Environment interaction, Stability, Yield performance

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's largest cereal crop and second most important staple food crop after rice. In India, the production of wheat during 2019-20 is estimated at a record level of 107.18 million tonnes (Anonymous, 2020) which is higher by 5.98 million tonnes than the previous record production of 101.20 million tonnes in 2018-19 and higher by 7.40 million tonnes as compared to the wheat production of 99.70 million tonnes in 2017-18. The quantitative trait such as grain yield is influenced by the environment because the environmental factor such as soil fertility, moisture, temperature, sowing time and day length is not consistent across the year and location which ultimately affect the yield of the wheat genotypes. When the interaction between genotypes and environment occurs, the relative ranking of the cultivar for grain yield differs over a series of environment or years. Many plant breeders engaged in the crop improvement programme with the aim to improve the agronomic and grain quality traits and to develop desire genotypes which have the ability to survive in the wide range of climate, especially with the diverse condition. Genotypes often do not perform in s similar manner when tested in multiple environments. This phenomenon is due to the presence of genotype by environment interaction (GEI). GEI differential genotypic expression across environments, GEI complicates the identification of superior genotypes, pointing out the need for growing different genotypes in different areas (Gauch and Zobel, 1997). Also, GEI is of major importance because it provides information about the effect of different environments on genotypes performance and plays a vital role in the assessment of performance stability of the genotypes. So, new wheat varieties generally need to be evaluated in different environments for several years before being released.

(Mustatea *et al.,* 2009) reported that high yielding genotypes can differ in stability and suggest that yield stability and high grain are mutually exclusive. Also (Shah *et al*., 2009) found highly significant variances for genotypes X year and genotypes X locations X year interactions for all studied traits in wheat. Many studies have been conducted to estimate the stability of wheat genotypes in different environments (Parveen *et al*., 2010; Al- Otayk, 2010; El- Amin, 2012; Mohamed *et al*., 2013; Nehe *et al*., 2019; Balcha *et al*., 2020; Verma *et al*., 2016; Krupal *et al*., 2018).

The yield stability of genotypes over a wide range of environments is of great concern to plant breeders. The awareness about G X E interaction is important to accurately find out the stability of cultivar and enhance the capability of selection in breeding programs (Sabaghnia *et al.,* 2008). Various statistical procedures have been reported to find out the stability of cultivars and the most popular and most widely used procedures is Eberhart and Russell (1966) which suggested that regression coefficient (bi) and deviation from regression coefficient (S^2d) might predict stable genotype. The genotypes with unit regression coefficient (bi = 1) and deviation not significantly different from zero ($S^2d = 0$) is said to be the most stable genotype and which had regression coefficient greater than one would be more adapted to favorable conditions, while those regression coefficients less than one would be more adapted to unfavorable environmental conditions.

With the background information, the present study was undertaken with forty bread wheat genotypes, released for different agro-climatic and production conditions of India to identify consistent performer genotypes under different environments by joint regression analysis, which can be gainfully utilized in future wheat hybridization programmes for transgressive segregants.

MATERIALS AND METHODS

The experimental material comprised of forty wheat genotypes and was evaluated at two different dates of sowing for two successive years i.e., 2017-18 and 2018-19 at the Research Farm of Department of Genetics and Plant Breeding, Kisan P.G. College, Simbhaoli, Hapur (UP) in randomized block design with three replications (**Table 1 and 2**). Each genotype was evaluated on a single row plot of 4 m with a row to row and plant to plant distance of 25 and 10 cm, respectively. All the agronomic practices were adopted to raise a good crop.

Table 1. Details of four environments created in the present study.

Year	Location	Date of sowing	Environment
2017-18	Kisan (P.G.) College, Simbhaoli (Hapur) U.P.	Early sown 29-11-2017	I
2017-18	Kisan (P.G.) College, Simbhaoli (Hapur) U.P.	Late sown 27-12-2017	II
2018-19	Kisan (P.G.) College, Simbhaoli (Hapur) U.P.	Early sown 25-11-2018	II
2018-19	Kisan (P.G.) College, Simbhaoli (Hapur) U.P.	Late sown 25-12-2018	IV

The observations were recorded on five randomly selected competitive plants from each genotype in each replication on twelve quantitative characters viz. days to 50% heading, days to maturity, plant height (cm), the number of productive tillers per plant, the number of spikelets per spike, spike length (cm), flag leaf area (cm^2), 1000-grain weight (g), biological yield (g), harvest index (%), gluten content (%) and grain yield (g). The mean value of recorded data from each replication was subjected to statistical analysis. Combined analyses of variance over environments were conducted as outlined by Allard (1964). Stability parameters for grain yield of the forty genotypes were calculated according to the Eberhart and Russell (1966) model.

RESULTS AND DISCUSSION

The pooled analysis of variance pertaining to all the twelve traits is presented in (**Table 3**). The mean square due to genotypes and environments was found significant for almost all the traits indicating sufficient variation exists among the genotypes and environments. Genotypes x environment (G X E) was noted significant for all the traits except spike length, 1000-grain weight, harvest index and gluten content. Significant G X E indicated that the genotypes performed differently in a different environment and non significant interaction indicated that the grain yield and its attributing traits were least influenced by the environment. Mean square due to environment + (genotypes x environments) was also found significant for almost all the traits which showed that genotypes have interacted considerably with environmental conditions that existed over different environments. Mean square due to environment (linear) and G X E (linear) was also noted significant for almost all the traits. Further, it is evident from **Table 4** that the linear component of G X E was predominant for days to 50% heading, days to

https://doi.org/10.37992/2021.1201.035

Table 2. Details of the genotypes and their pedigree used in the present study.

S.N.	Genotypes	Pedigree	Developed By	Release year
1	WR-544	KALYANSONA/HD 1999//HD2204/DW 38	IARI, New Delhi	2005
2	WH-1105	MILAN/S87230//BABAX	CCS HAU, Hisar	2013
3	HD-3059	KAUZ//ALTAR84/ AOS/3/MILAN/KA UZ/4/HUITES	IARI, New Delhi	2013
4	DBW-71	PRINIA/UP2425	IWBR, Karnal	2013
5	DBW-88	KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUITES	IWBR, Karnal	2014
6	PBW-590	WH 594/RAJ38 14//W 485	PAU, Ludhiana	2009
7	DBW-90	HUW468/WH730	IWBR, Karnal	2014
8	DBW-621-50	KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUITES	IWBR, Karnal/ PAU, Ludhiana	2011
9	HD-3086	DBW14/HD2733//HUW468	IARI, New Delhi	2014
10	DBW-16	RAJ 3765/WR 484//HUW 468	IWBR, Karnal	2006
11	PBW-550	WH 594/RAJ 3858//W 485	PAU, Ludhiana	2011
12	PBW-725	PBW621//GLUPRO/3*PBW 568/3/PBW 621	PAU, Ludhiana	2016
13	HD -3118	ATTILA*2/PBW65 //WBLL1*2/TUKU RU	IARI, New Delhi	2015
14	HI -1544	HINDI62/BOBWHI TE/CPAN 2099	IARI RS, Indore 2008	2008
15	HD-2733	ATTILA /3/TUI /CARC //CHEN / CHTO /4/ATTILA	IARI, New Delhi	2001
16	WH-1124	MUNIA/CHTO/AM SEL	CCS HAU, Hisar	2014
17	HD-2851	CPAN 3004/WR 426//HW 2007	IARI, New Delhi	2005
18	PBW-226	C591/RN//JN/3/C HR/HD1941	PAU, Ludhiana	1989
19	HUW-234	HUW 12* 2 / CPAN 1666// HUW 12	BHU, Varanasi	1986
20	C-306	RGN/CSK3//2*C5 91/3/C217/N14 //C28	CCS HAU, Hisar	1969
21	DBW-14	RAJ 3765/PBW 343	IWBR, Karnal	2003
22	PBW-343	ND/VG9144//KAL/BB/3/Y ACO'S' /4/VEE#5 'S'	PAU, Ludhiana	1996
23	MACS-2496	SERI"S"	ARI, Pune	1991
24	RAJ-3765	HD 2402/VL639	RARI, Durgapura	1996
25	NW-1014	HAHN 'S	NDUA&T, Faizabad	1998
26	DBW-17	MH79A.95/3*CNO 79//RAJ3777	IWBR, Karnal	2007
27	LOK-1	S308/S331	Lok Bharti, Sanosara	1982
28	PBW- 34	AA 'S'/FGO'S'	PAU, Ludhiana	1985
29	NI-5439	REMP 80/3*NP710	MPKV RS, Niphad	1975
30	HD -4728	ALTAR84/STINT// SILVER 453/ SOMAT 3.1/4/ GREEN14/YAV 10 /AUK	IARI, New Delhi	2016
31	K-65	C591/NP773	CSAUA&T, Kanpur	1974
32	HUW-468	CPAN-1962 / TONI //LIRA'S'/ PRL'S	BHU, Varanasi	1999
33	K-8027	NP875/4/N10B/Y5 3//Y50/3/KT54B/5/ 2*K852	CSAUA&T, Kanpur	1989
34	HI -1605	BOW/VEE/5/ND/VG9 144//KAL/BB/3/YACO /4/CHIL/6/CASKOR/3 /CROC_1/AE.SQUAR ROSA(224)//OPATA/ 7/PASTOR/MILAN/K AUZ/3/BAV92	IARI RS, Indore	2017
35	HD-2967	ALD/COC//URES/HD216 0M/HD2278	IARI, New Delhi	2011
36	HD -2985	PBW 343/ PASTOR	IARI, New Delhi	2011
37	RAJ 1555	CITIRAJ911	RJAU	1982
38	HD-2285	49/HD2150//HD 2186	IARI, New Delhi	1984
39	HD -2189	HD 1963 / HD 1931	IARI, New Delhi	1980
40	UP -2425	HD 2320/UP 2263	GBPUA&T, Pantnagar	1999

Table 3. Joint regression analysis for yield and yield component in wheat (Eberhart and Russell, 1966).

Source of Variation	d.f	Mean squares											
		Days to 50% heading	Days to maturity	Plant height	Number of tillers per plant	Number of spikelets per spike	Spike length	Flag leaf area	1000 grain weight	Biological yield	Harvest index	Gluten content	Grain yield
Genotypes (G)	39	34.53**	11.71**	305.02**	1.98**	7.04**	4.16**	163.38**	19.34**	18.48**	11.72**	0.88	5.04**
Environ-ments (E)	3	3938.65**	7434.57**	2845.06**	48.79**	5.39**	10.28**	2370.33**	400.89**	1423.67**	99.39**	7.67**	282.94**
G X E	117	4.09**	2.53*	53.12**	1.00*	1.21*	0.52	56.11**	5.69	16.67**	11.42	0.07	4.17**
Total	159	85.79	145.01	167.59	2.15	2.72	1.60	126.09	16.49	43.66	13.15	0.41	9.64
Pooled Error	312	1.06	1.62	5.94	0.48	0.79	0.36	18.07	7.46	4.61	11.84	0.16	1.04
E+ (G X E)	120	102.45**	188.33**	122.92**	2.20**	1.32*	0.76	113.96**	15.57*	51.85**	13.62	0.26	11.14**
E (Linear)	1	11815.94**	22302.86**	8535.73**	146.36**	16.18**	30.83**	7110.85**	1202.61**	4271.06**	298.30**	23.03**	848.83**
G X E (Linear)	39	4.98**	2.97	24.09**	1.05*	1.55*	0.74	43.20**	5.30	26.16**	11.56	0.04	5.02**
Pooled Deviation	80	3.55	2.26	65.94	0.96	1.02	0.40	61.00	5.74	11.63	11.06	0.08	3.65

*, **= Significant at P = 0.05 and P = 0.01 levels, respectively.

Table 4. Linear and non-linear component of different characters.

S.N.	Characters	Linear component (%)	Non-linear component (%)
1	Days to 50% heading	58.38	41.62
2	Days to maturity	56.79	43.21
3	Plant height	26.76	73.24
4	Number of tillers per plant	52.24	47.76
5	Number of spikelets per spike	60.31	39.69
6	Spike length	64.91	35.09
7	Flag leaf area	41.46	58.54
8	1000 grain weight	48.01	51.99
9	Biological yield	69.22	30.78
10	Harvest index	51.11	48.89
11	Gluten content	33.33	66.67
12	Grain yield	57.90	42.10

maturity, the number of tillers per plant, the number of spikelets per spike, spike length, biological yield, harvest index and grain yield while non-linear component was predominant for plant height, flag leaf area, 1000 grain weight and gluten content suggesting that differences between environments were considerable for all the traits studied and it was greatly affected by the environment. This also indicated that environments created by sowing dates was justified and had linear effects, significant G X E (linear) indicating differential response of the genotypes within different environments. Similar results were also reported by Siddhi *et al*. (2018), Singh *et al*. (2018), Farag *et al*. (2019) and Balcha, (2020).

Stability in performance is one of the most desirable properties of a genotype for its wide adaptability. The stability parameters *viz*., mean performance ($\bar{X}$) across the environments, regression coefficient (bi) and deviation from linear regression (S^2d) were estimated as per Eberhart and Russell (1966) model. A perusal of **Table 5** indicated that the genotypes namely LOK-1, NI-5439, HUW-468 were found desirable and stable for grain yield across the environment over the years. Genotype UP-2485 and HI-1605 having high mean grain yield with regression coefficient greater than unity (b>1), hence UP-2485 and HI-1605 were found stable for favorable environment, while genotype HD-2189 showed high mean and regression coefficient less than unity (b<1) and desirable for unfavorable environment (**Table 6**). Similar finding was also reported by Kumar *et al*. (2017), Jat *et al*. (2018) and Balcha, (2020). Genotype LOK-1 also showed stable performance for days to 50% heading, the number of tillers per plant, biological yield and harvest index, NW-1014 showed stable performance for the number of spikelets per spike, spike length, biological yield and gluten content, UP-2485 for days to maturity, days to 50% heading and 1000 grains weight, DBW-71 for days to 50 % heading and days to maturity, HD-2189 for days to 50% heading, 1000 grains weight and spike length, HD-3059 for days to maturity and the number of tillers per plant, DBW-90 for days to maturity and harvest index, HI-1544 showed stable performance for days to maturity and spike length, PBW-226 showed stable performance for days to maturity and flag leaf area.

Genotype PBW-34 showed stable performance for plant height, spike length and flag leaf area, NI-5439 for plant height and grain yield, K-65 for plant height and gluten content, DBW-621-50 for the number of tillers per plant and the number of spikelets per spike, HUW-468 for spike

Table 5. Genotypes showing high mean and stable performance for different characters (b=1 and S^2d= 0).

S.N.	Characters	Stable genotypes
1	Days to 50% heading	DBW-71, UP-2485, PBW-725, DBW-14, PBW-343, LOK-1, HD-2189
2	Days to maturity	DBW-71, UP-2485, WH-1105, HD-3059, DBW-90, HD-3086, PBW-550, HD-3118, HI-1544, PBW-226
3	Plant height	PBW-34, NI,5439, K-65
4	Number of tillers per plant	HD-4728, LOK-1, DBW-621-50, HUW-234
5	Number of spikelets per spike	HD-3059, DBW-88, DBW-621-50, NW-1014
6	Spike length	HI-1544, RAJ-3765, NW-1014, PBW-34, HUW-468, K-8027, HD-2985, RAJ-1555, HD-2189
7	Flag leaf area	PBW-226, PBW-34, HI-1605
8	1000 grain weight	PBW-725, WH-1124, HD-2985, HD-2189, UP-2425
9	Biological yield	LOK-1, NW-1014
10	Harvest index	PBW-590, DBW-90, LOK-1
11	Gluten content	PBW-590, HD-2733, WH-1124, NW-1014, K-65, K-8027, HI-1605, RAJ-1555
12	Grain yield	LOK-1, NI-5439, HUW-468

Table 6. Estimates of stability parameters of grain yield in forty genotypes of wheat.

Genotypes	Grain yield (g)		
	$\bar{X}$	b	S^2d
WR-544	11.10	0.51	-0.10
WH-1105	12.45	1.95	0.78
HD-3059	11.57	0.84	0.61
DBW-71	11.58	1.16	-0.21
DBW-88	13.14	0.72	5.46
PBW-590	11.80	1.27	-0.13
DBW-90	12.58	1.54	0.30
DPW-621-50	11.66	0.81	0.03
HD-3086	11.75	1.11	0.54
DBW-16	11.34	0.63	0.29
PBW-550	11.04	0.40	0.70
PBW-725	11.27	1.14	4.17
HD -3118	11.64	-0.07	6.05
HI -1544	10.39	0.36	2.25
HD-2733	11.65	1.15	2.17
WH-1124	11.91	1.48	4.13
HD-2851	11.89	0.59	0.44
PBW-226	12.06	1.00	2.07
HUW-234	12.93	0.67	11.38

C-306	10.35	0.66	-0.34
DBW-14	10.96	1.51	4.33
PBW-343	13.10	1.39	2.85
MACS-2496	10.29	0.53	0.14
RAJ-3765	12.28	1.39	1.68
NW-1014	12.71	1.11	1.74
DBW-17	11.70	1.13	0.81
LOK-1	14.08	1.85	0.98
PBW- 34	11.67	1.40	0.92
NI-5439	13.35	1.88	2.29
HD -4728	11.90	1.13	0.40
K-65	11.99	1.19	0.94
HUW-468	13.61	1.40	6.31
K-8027	12.95	0.46	7.66
HI -1605	15.24	1.41	9.20
HD-2967	11.26	1.25	2.10
HD -2985	12.77	0.33	0.93
RAJ-1555	11.76	0.77	0.72
HD-2285	10.88	0.69	5.20
HD -2189	13.75	0.01	23.81
UP -2425	14.56	1.22	18.67
Population mean	12.12		
SE mean	1.10		
SE bi	0.41		

length, and grain yield, K-8027 for spike length and gluten content, HD- 2985 for spike length and 1000 grains weight, RAJ-1555 for spike length and gluten content, WH-1124 for 1000grains weight and gluten content, PBW-590 for harvest index and gluten content and HI-1605 for flag leaf area and gluten content.

Genotypes DBW-14 and PBW-343 showed stable performance for days to 50% heading, WH-1105, HD-3086, PBW-550 and HD-3118 showed stable performance for days to maturity, HD-4728 and HUW-234 showed stable performance for a number of tillers per plant. Genotypes DBW-88, Raj-3765 and HD-2733 showed stable performance for a number of spikelets per spike, spike length and gluten content, respectively (**Table 5**). A similar finding was also reported by Kumar *et al*. (2014), Meena *et al*. (2014), Kumar *et al*. (2017), Siddhi *et al*. (2018), Singh *et al*. (2018), Nehe *et al*. (2019) and observed stable performance for different traits and also find some wheat genotypes stable for different-different traits under diverse environmental conditions.

In the present study, the result concluded that the combined analysis of variance exhibited significant variation due to genotypes, environment and genotype x environment (G X E). Genotypes LOK-1, NI-5439, HUW-468 were found stable across the environment over the years due to their superior mean performance, regression coefficient (b) near to one with non significant deviations from regression coefficient. These genotypes could be useful in wheat improvement programs for enhancing stability.

ACKNOWLEDGEMENT

I would like to thank Kisan P.G. College, Simbhaoli, Hapur (UP) and Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP) for providing me with research and farm facility to carry out the research work. I also thank UGC, New Delhi for providing me with the financial support as RGNF.

REFERENCES

Allard, R.W. and Bradshaw, A.D. 1964. Implication of genotype-environment interactions in applied plant breeding. *Crop Sci.* **4**:503-508. [Cross Ref]

Al-Otayk. S.M. 2010. Performance of yield and stability of wheat genotypes under high stress environments of the Central Region of Saudi Arabia. Met. Env. *Arid Land Agric. Sci*. **21**: 81-92. [Cross Ref]

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

Anonymous, 2020. Directorate of Economics and Statistics, Ministry of Agriculture and Farmer Welfare

Government of India.

Balcha 2020. Genotype by environment interaction for grain yield and association among stability parameters in bread wheat (*Triticum aestivum* L.).*American J. Plant Sci*., **11**:1-10. [Cross Ref]

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

Farag, F.M., Awad, H.A., Abdel-Ahmeed, I.M., Addul-Hamid, M.I.E. and Morsy, A.M. 2019. Stability of grain yield in bread wheat genotypes under different environments. *Zeigaziga J. Agric. Res*., **46**(6A):1-11. [Cross Ref]

Jat, R.K., Singh, P., Jat, M.L., Dia, M., Sidhu, H.S., Jat, S.L., Bijarniya, D., Jat, H.S., Parihar, C.M., Kumar, U. and Ridaura, S.L. 2018. Heat stress and yields stability of wheat genotypes under different sowing dates across agro-ecosystems in India. *Field Crops* Sci., **218**: 33-50. [Cross Ref]

Krupal, S.M., Rathod, S.T. and Kamble, B. 2018. Stability analysis for yield and quality traits in wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding*, **9**(1):160-168. [Cross Ref]

Kumar, A., Kumar, P., Singh, G. and. Tiwari, K.N. 2017. Stability analysis for different agromorphological traits under different temperature regimes in bread wheat (*Triticum aestivum* L.). *Res. Environ. Life Sci*., **10**(3):270-274.

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 (*Triticum aestivum* L). *Indian J. Agric Sci*., **84**(8):931-936.

Meena, H.S., Kumar, D., Srivastava, T.K. and Rajendra, P.S. 2014. Stability for grain yield and its contributing traits in bread wheat (*Triticum aestivum* L). *Indian J. Agric. Sci*., **84**: 1486-1495.

Mohamed, S.H., Mohamed, G.I.A. and El-Said, R.A.R. 2013. Stability analysis for grain yield and its components of some durum wheat genotypes (*Triticum durum*) under different environments. *Asian J. of Crop Sci*. **5**(2): 179-189. [Cross Ref]

Mustatea, P., Saulescu, N.N., Ittu, G., Paunescu, G. and Voinea, L. 2009. Grain yield and yield stability of winter wheat cultivars in contrasting weather conditions. Rom. *Agric. Res.* **26**: 1-8.

Nehe, A., Akin, B., Sanal, T., Evlice, A.K., Unsal, R. and Dincer, N. 2019. Genotype x environment interaction and genetic gain for grain yield and grain quality traits in Turkish spring wheat released between 1964 and 2010. *PLoS ONE*, **14**(7):1-18. [Cross Ref]

Parveen, L, Khalil, I.H. and Khalil, S.K. 2010. Stability parameters for tillers grain weight and yield of wheat cultivars in North-West of Pakistan. *Pak. J. Bot*. **42**: 1613-1617.

Sabaghnia, N., Dehghani, H. and Sabaghpour S.H. 2008. Graphic analysis of genotype by environment interaction for lentil yield in Iran. *Agron. J.,***100**:760–764. [Cross Ref]

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.

Siddhi, S., Patel, J.B. and Patel, N. 2018. Stability analysis in bread wheat (*Triticum aestivum* L.). *J. Pharmaco. Phytochem.*,**7**(4):290-297.

Singh, C., Shrivastva, P., Sharma, A., Kumar, P., Chhuneji, P., Sohu, V.S. and Bains, N.S. 2018. Stability analysis for grain yield and some quality traits in bread wheat (*Triticum aestivum* L.). *J. App. Natural Sci*., **10**(1):466-474. [Cross Ref]

Verma, A., Chatrath, R. and Sharma, I. 2016. Yield stability of wheat genotypes for northern western plains zone of India. *Electronic Journal of Plant Breeding*, **7**(1):10-20. [Cross Ref]

Gauch, H.G. and Zobel, R.W. 1997. Identifying genotypes and targeting genotypes. *Crop Sci.* **37**: 311– 326. [Cross Ref]