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

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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 a 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- Otaik, 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 cultivars 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,     | Early sown     | I           |
|        | Simbhaoli (Hapur) U.P.    | 29-11-2017     |             |
| 2017-18| Kisan (P.G.) College,     | Late sown      | II          |
|        | Simbhaoli (Hapur) U.P.    | 27-12-2017     |             |
| 2018-19| Kisan (P.G.) College,     | Early sown     | II          |
|        | Simbhaoli (Hapur) U.P.    | 25-11-2018     |             |
| 2018-19| Kisan (P.G.) College,     | Late sown      | IV          |
|        | Simbhaoli (Hapur) U.P.    | 25-12-2018     |             |

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...
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/87230/BABAX | CCS HAU, Hisar | 2013         |
| 3    | HD-3059    | KAUI/ALTAR84/AOS/3/MILAN/KA UZ/4/HUITES | IARI, New Delhi | 2013         |
| 4    | DBW-71     | PRINIA/UP2425 | IWB, Karmal | 2013         |
| 5    | DBW-88     | KAUI/ALTAR84/AOS/3/MILAN/KA UZ/4/HUITES | IWB, Karmal | 2014         |
| 6    | PBW-590    | WH 594/RAJ38 14/I/W 485 | PAU, Ludhiana | 2009         |
| 7    | DBW-90     | HUW468/WH730 | IWB, Karmal | 2014         |
| 8    | DBW-621-50 | KAUI/ALTAR84/AOS/3/MILAN/KA UZ/4/HUITES | IWB/PAU, Ludhiana | 2011 |
| 9    | HD-3086    | DBW14/HD2733/HUW468 | IARI, New Delhi | 2014         |
| 10   | DBW-16     | RAJ 3765/WR 484/HUW468 | IWB, Karmal | 2006         |
| 11   | PBW-550    | WH 594/RAJ 3858/I/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 //WBL1/2/TUKU RU | IARI, New Delhi | 2015         |
| 14   | HI-1544    | HINDI62/BOBWHI/TE/CPAN 2099 | IARI RS, Indore | 2008         |
| 15   | HD-2733    | ATTILA/3/TOJ/CHRE//CHEN /CTHT/4/ATTILA | IARI, New Delhi | 2001         |
| 16   | WH-1124    | MUNIA/CTHT/AM SEL | CCS HAU, Hisar | 2014         |
| 17   | HD-2851    | CPAN 3004/WR | IARI, New Delhi | 2005         |
| 18   | PBW-226    | C591/RJ/IN/3/CH HR/HU 1941 | PAU, Ludhiana | 1989         |
| 19   | HUW-234    | HUW 12/2 /CPAN 1666//HUW 12 | BHU, Varanasi | 1986         |
| 20   | C-306      | RGN/CS8/3/2/CS 91/3/C217/N14//C28 | CCS HAU, Hisar | 1969         |
| 21   | DBW-14     | RAJ 3765/PBW 343 | IWB, Karmal | 2003         |
| 22   | PBW-343    | ND/VG1944/IKAL/BB/3/Y ACO’S’/4/VEE#5’S’ | PAU, Ludhiana | 1996         |
| 23   | MACS-2496  | SER’s’ | IARI, Pune | 1991         |
| 24   | RAJ-3765   | HD 2402/IVL639 | RARI, Durgapura | 1996         |
| 25   | NW-1014    | HAHN’S | NDU, FA &T, Faizabad | 1998 |
| 26   | DBW-17     | MH79A,95/3/CNO 79//RAJ3777 | IWB, Karmal | 2007         |
| 27   | LOK-1      | S108/333 | Lok Bharti, Sanaora | 1982 |
| 28   | PBW-34     | AA ‘S’/FGO’S’ | PAU, Ludhiana | 1985         |
| 29   | NI-5439    | REMP 60/2/3/PB 710 | MPKV, Niphad | 1975         |
| 30   | HD-4728    | ALTAR84/STINT//SILVER 453/ SOMAT 3.1/4/ GREEN14/YAY 10 /AUK | IARI, New Delhi | 2016         |
| 31   | K-65       | C591/NP777 | CSAU, Canpur | 1974         |
| 32   | HUW-468    | CPAN-1962//TONI //LIRA’S’/PRL’S | BHU, Varanasi | 1999         |
| 33   | K-8027     | NP875/4/10B/YS 3/YS50/3/KT548/5/2*K852 | CSAU, Canpur | 1989         |
| 34   | HI-1605    | BOW/VEE/5/ND/VG9 144//KAL/BB/3/YACO//CHIL/3/CASKOR/3 /CRO/1/AE.SQUAR/ ROSA(224)/OPATA/7/PASTOR-MILAN/K AUZ/3/BAV92 | IARI, Indore | 2017         |
| 35   | HD-2967    | ALD/OCOC//URES/HB216 0M/HD2278 | IARI, New Delhi | 2011         |
| 36   | HD-2985    | PBW 343/ PASTOR | IARI, New Delhi | 2011 |
| 37   | RAJ-1555   | CITIRA/J911 | RJAU | 1982 |
| 38   | HD-2285    | 49/HD2150/HD 2186 | IARI, New Delhi | 1984 |
| 39   | HD-2189    | 1963 / HD 1931 | IARI, New Delhi | 1980 |
| 40   | UP-2425    | HD 2320/UP 2263 | GBPUA&T, Pantnagar | 1999 |

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

| Source of Variation | d.f | 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**    |
| Environments (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 (X̄) 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 | $\bar{X}$ | Grain yield (g) | $b$ | $S^2d$ |
|-----------|-----------|-----------------|-----|--------|
| 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|

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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 harvest index 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. (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.

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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., Irfaz, M., Ali, A. and Tahir, G.R. 2005. Yield stability of spring wheat (Triticum aestivum L.) in North West Frontier province, Pakistan. Songkianakar 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 yield 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., Sanai, 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. Pharmacogn. 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 Shama, 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]