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Genotype by environment interaction and stability analysis of grain yield in barley (*Hordeum vulgare* L.)

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Abstract
Present study was undertaken to estimate the magnitude of genotype × environment interaction (GEI) and to identify stable barley genotypes under normal and late sown conditions. 18 barley genotypes were evaluated in Randomized Block Design in three replications on a plot size of $4m^2$ (each replication/each environment) under rainfed conditions during two successive *Rabi* crop seasons in four environments viz., 2017-18 (E_1- normal, E_2- late) and *Rabi* 2018-19 (E_3- normal, E_4- late). Yield stability was analyzed employing Eberhart and Russell's model (1966) [2] which revealed highly significant differences among genotypes and environments. Mean squares due to environment + genotype x environment interactions (E+GxE) indicated that genotypes interacted considerably with environmental conditions. Further, partitioning of E+G x E effects indicated that E (linear), G x E (linear) components were highly significant for grain yield. Genotypes DWRB 137, RD 2715, BH 902 and RD 2907 had high mean than general mean coupled with regression coefficient close to unity $bi = 1$ and $S^2di = 0$ and are identified as most stable and desirable barley varieties.

Keywords: Stability, G X E interaction, barley genotypes

Introduction
Barley (*Hordeum vulgare* L.) 2n=2x=14 belonging to family *Poaceae* is grown satisfactorily under rainfed conditions in India. It ranks 4th after wheat, rice and maize and is grown in arid and semi-arid regions due to its better ability to tolerate drought stress. In India, it is cultivated on 677 thousand hectares, with production and productivity of 1788 thousand tonnes and 26.41 q ha^{-1} respectively. As regards, J&K state barley occupies an area of 6700 hectares with production of 4400 tonnes and average productivity of 06.48 quintals ha^{-1} which is significantly very low as compared to national production and productivity (Singh, 2018) [1]. Its grain is used as feed, food and for malting purpose while, straw serves as an important source of roughage for animals. Therefore, it assumes greater importance in dry and kandi belts of Jammu region as source of feed and fodder.
The manifestation of grain yield and its attributing traits is a result of the genotype (G) of the cultivar, the environment (E) in which it is grown, and the interaction between G and E. Genotype by environment (GE) interaction is of major importance, because it provides information about the effects of test environments on genotype performance and plays an important key role for assessment of performance and yield stability. G x E interactions greatly affect the phenotypic performance of a variety, therefore, stability analysis is required to characterize the performance of genotypes in various environments so as to help plant breeders in selection of stable varieties. Eberhart and Russell (1966) [2] suggested that an ideal cultivar is one that has the highest yield over a broad range of environments. They defined a stable cultivar as that with regression coefficient (b_i) equal to one and with mean squares deviation from regression S^2d_i equal to zero. Therefore, in the present study an attempt was made to evaluate 18 barley genotypes in order to identify stable barley genotypes under normal and late sown conditions of Jammu plains.

Material and Methods
18 barley varieties obtained from Rajasthan Agricultural Research Institute (RARI) Durgapura, Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS) Almora and Indian Institute of Wheat and Barley Research (IIWBR) Karnal viz., BH 902, BH 946, BHS 352, BHS 380, BHS 400, RD 2035, RD 2052, RD 2552, RD 2592, RD 2715, RD 2794, RD 2849, RD 2899, RD 2907, VLB 118, DWRB 123, DWRB 137 along with a local check were evaluated in Randomized Block Design with three replications on a plot size of $4m^2$ (each

replication/each environment) under rainfed conditions during two successive *Rabi* crop seasons in four environments viz., 2017-18 (E_1-normal, E_2-late) and *Rabi* 2018-19 (E_3-normal, E_4-late). Observation were recorded on ten randomly selected plants in each replication in each environment for grain yield ha.$^{-1}$ and stability analysis was carried out following Eberhart and Russell (1966) [2] Model.

Results and Discussion

Plant breeders are interested in knowing buffering capacity of genotypes with respect to economic traits like yield so as to select genotypes exhibiting low genotype x environment interactions. Genotypes possessing good buffering capacity are considered as desirable and are recommended for cultivation across environments/ ecosystems. Joint regression with respect to mean performance of a genotype on an environmental index (*bi*) is the popular approach in which deviation from regression (S^2d_i) is used as a measure of stability. Joint regression analysis of variance for yield is presented in Table 1. Mean sum of squares due to genotype and environment were found to be significantly different for grain yield ha.$^{-1}$. Similar results were also reported by Costa and Bollero (2001), Lodhi *et al*. (2015) and Verma *et al*. (2016) [3, 4, 5]

Table 1: Joint regression analysis of variance for yield following Eberhart and Russell (1966) [2]

Sources of variance	d.f.	MSS Grain yield ha^{-1}(q.)
Varieties	17	78.25**
Env. + (Var.* Env.)	54	112.28**
Environments	3	1672.35**
Var.* Env.	51	20.51**
Environments (linear)	1	5017.05**
Var.* Env. (linear)	17	8.63**
Pooled deviation	36	24.98**
Pooled Error	136	4.52

Table 2: Stability parameters of yield following joint regression analysis (Eberhart and Russell, 1966) [2]

S. No.	Genotypes	Grain yield ha^{-1}.		
		μ	*bi*	S^2d_i
1	RD 2035	32.57	1.10	48.22**
2	RD 2052	34.88	1.26	31.77**
3	RD 2552	34.64	0.92	0.58
4	RD 2592	39.08	0.93	4.07
5	RD 2715	32.54	1.14	14.26*
6	RD 2794	34.78	1.20	18.52**
7	RD 2849	37.58	1.21	65.38**
8	RD 2899	37.29	1.91	7.84
9	RD 2907	33.29	0.79	0.51
10	BH 902	37.53	1.07	-2.04
11	BH 946	31.56	0.84	49.97**
12	BHS 352	37.15	0.97	27.66**
13	BHS 400	31.68	0.78	42.96**
14	VLB 118	29.09	1.16	11.88*
15	BHS 380	24.66	0.65	20.17**
16	DWRB 123	32.71	0.87	0.44
17	DWRB 137	41.03	0.91	1.20*
18	Local check	24.95	0.95	8.83
General Mean		33.72		

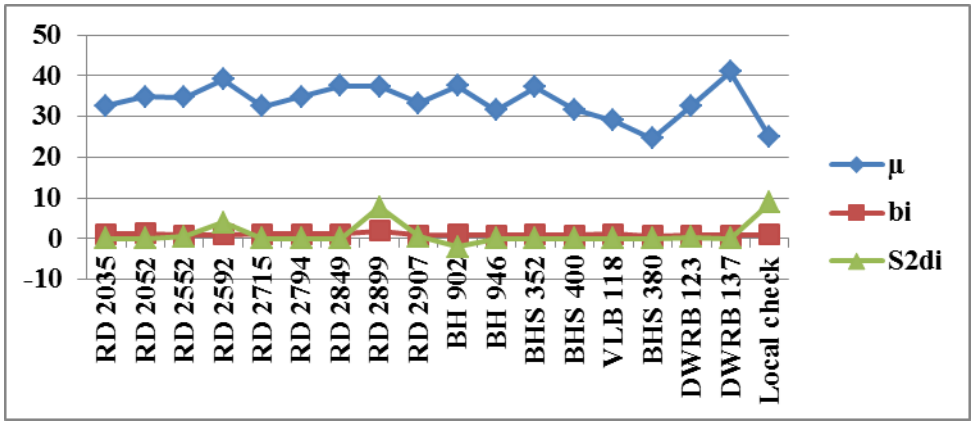

Fig 1: Stability parameters of yield following joint regression analysis (Eberhart and Russell, 1966) [2]

Stability analysis help in characterizing the performance of genotypes in different environments and enable plant breeders in selecting desirable genotypes while, instability is the result of cultivars response in different environment which usually

indicates a high interaction between genetic and environmental factors. As per Eberhat and Russell (1966) [2], three parameters mean (µ), regression coefficient (*bi*) and deviation from regression (S^2di) are indicative of stability of varieties.

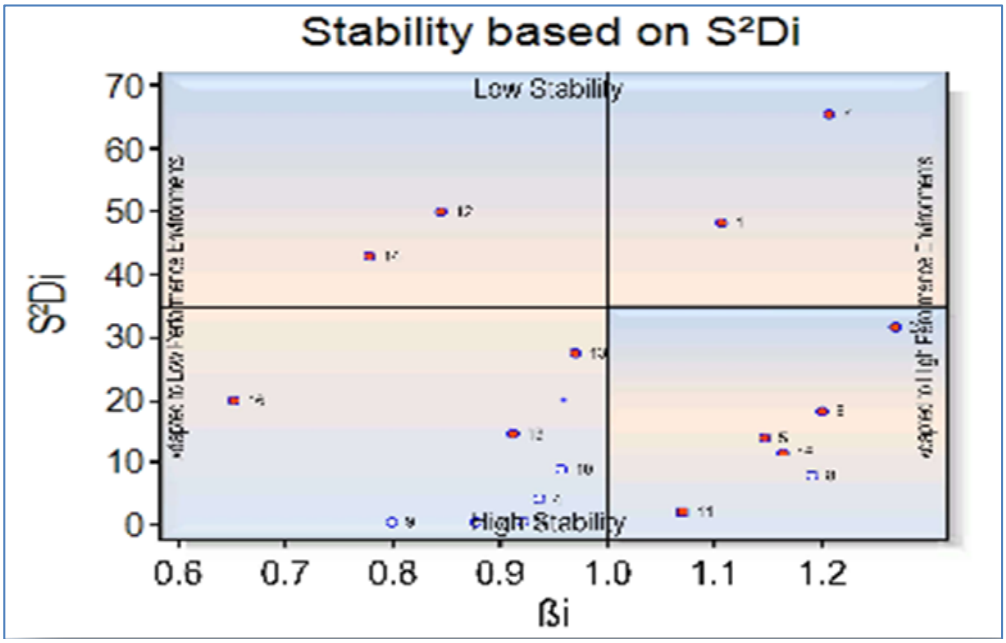

Fig 2: Yield stability of barley genotypes (Eberhart and Russell, 1966) [2]

Genotypes with high mean (µ) performance, a regression coefficient of unity (*bi*=1), minimum deviation from regression (S^2di=0) exhibit better general adaptability across environments and are considered as a stable ones. Where βi > 1, the genotype is responsive to favorable environment. If βi < 1, the genotype performs well despite an unfavorable environment. Stability analysis for yield is presented in Table 2 and Fig. 2. The varieties RD 2052, RD 2552, RD 2592, RD 2794, RD 2849, RD 2899, BH 902, BHS 352, and DWRB 137 exhibited higher mean as compared to general mean. Varieties BH 902, BHS 352, DWRB 137 and RD 2715 had high mean than general mean coupled with regression coefficient close to unity *bi* = 1 and S^2di = 0 and were identified most stable and desirable varieties. The highest performing barley varieties *viz*., DWRB 137 (41.03qha^{-1}), RD 2715 (32.54qha^{-1}), BH 902 (37.53qha^{-1}) and RD 2907 (33.29qha^{-1}) exhibited grain yield superiority of 64.45, 30.42, 50.42 and 33.42 percent over local check (24.43qha^{-1}).

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