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Stability analysis for grain yield and quality parameters in barley (*Hordeum vulgare* L.) germplasm

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ABSTRACT
Thirty five genotypes of barley (*H. vulgare* L.) were evaluated for grain yield /plant, 1000 grain weight, number of seeds/ spike, tillers/ plant, malt percentage and starch percentage under eight environments. Pooled analysis of variance for all the traits indicated high difference among the genotypes and environments. The mean squares due to varieties were found significant for all the six traits indicating presence of sufficient variability for these traits. It is clear from the results that the linear and non-linear component of GXE interaction played an important role in all the traits under study. Following the stability criteria, seven genotypes for grain yield, ten for 1000 grain wt. Six for number of seeds spike, four for tillers/ plant, seven for malt and four for starch percentage were identified as desirable and stable under varying environmental conditions.

Key words : Barley, Linear, Non-linear and GXE interaction.

INTRODUCTION

Barley is an important cereal crop in the world agriculture. The barley grains are primarily used for human consumption in various preparations as a feed for livestock and to a limited extent for the manufacture of beverages. Barley based agro-industries are market bear, pearl barley, lemon barley, water and lime barley. The barley grains available to the industries possess higher husk and protein content and less carbohydrate, which results in poor malting qualities. The continuous decline in barley area and production during 80's and 90's triggered a shortage for good quality grains of malting. Due to progress in agriculture and easily availability of fine grains cereals like wheat and rice, it has been pushed to be utilizing only as feed/ industrial crop. In order to check this declining trend, high yielding varieties with stability of production are needed. Several models, including regression approach model of Yates and Cohran (1938) static model of Plasted and Peterson (1959) and Ecovalence model of Wricke (1962) have been proposed for the estimation of genotype X environment interaction. Later on Finlay and Wilkinson (1963) used the regression approach model to select stable genotypes in barley. Eberhart and Russell (1966) later improved regression approach model and added another parameter, deviation from regression (S^2di) besides regression coefficient (bi) for stability. They defined a stable genotype with unit regression and least deviation from regression. Perkins and Jinks (1968) used the same two parameters, but at the same time modified the method of estimation of regression coefficient. The potential of genotypes and stability of their performance can be judged by multi environment testing. Sometimes the uni-location trials can also serve the purpose provided different environments are created by different sowing dates, using various spacing and dose of fertilizers and irrigation levels, etc. Therefore, the present investigation was conducted to assess the genotype X environment interaction and stability of barley germplasm under varying environments.

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MATERIALS AND METHODS

The experimental material consisted of 35 genotypes of barley obtained from National Bureau of Plant Genetic Resources (NBPGR), Pusa Campus, New Delhi. These were evaluated at experimental farm of Kisan Post Graduate College Simbhaoli, Distt. Ghaziabad (UP) during rabi seasons of 1997-1998 and 1998-1999 in randomized block design with three replications in eight different environments, which were created by using two fertility levels (40:20:20 and 20:20:20 NPK) and two levels of irrigation (Three and one). Each genotype was grown in a 2 m row length with a spacing of 25 cm. All the recommended cultural and agronomic practices were followed to raise the crop. Five randomly selected plants/plot/ replication in each genotypes were labeled and observations were recorded for tillers/ plant, number of seeds/ spike, grain yield / plant, 1000 grain / wt., malt percentage and starch percentage and data were subjected to stability analysis as per the method proposed by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

In present investigation, the pooled analysis of variance for different characters is presented (Table 1). The mean squares due to varieties were found significant for all the characters under study indicating the presence of sufficient variability for these traits. Coasta *et. al.,* (2001) observed significant differences among barley cultivars for grain yield, plant height and heading date. The linear component of G X E interaction played an important role in all the characters under study. As earlier reported by May *et al.,* (1993), Fekadu Fufa (1995), Das *et al.,* (1998) and Salem *et al.,* (1998) and Upreti (1999). The non-linear component of G X E interaction and variance due to deviation were significant only for three characters i.e., number of seeds/ spike, malt and starch percentage reflecting considerable genetic diversity for these traits. All the three parameter of stability for six traits are presented in Table 2.

Grain yield:

Out of 35 genotypes, seven genotypes were identified as desirable and stable for grain yield / plant namely IC-79476, IC-75919, IC-67227, IC-62421, IC-63954, IC-64004 and IC-73602 as they have high mean values, unit regression coefficient and non significant deviation from regression (Table 2). Therefore, these genotypes can be recommended for commercial cultivation in the environments tested under study. As earlier reported by Fekadu Fufa (1995) and Thakur *et al.* (1999). Some genotypes were stable and are suitable for commercial cultivation namely IC-63973, IC-79455, IC-73644, IC-64076, IC-62790 and IC-63972 were high yielding and stable but their corresponding "bi" values were significant lower than the unity. It shows that these genotypes would perform better in poor environment conditions hence these can be utilized as donor parent to breed a suitable line for poor environment. Mishra *et al.* (2000) were also reported that the genotypes DL-803-3 and Raj- 1555 showed stability and sustainability under poor environmental conditions. Similarly, genotypes IC-79422, IC-67248, IC-79420, IC-67207, IC-63969, IC-79422, IC-63972 and IC-67212 were observed to be high yielding and stable but its corresponding "bi" values was greater than unity. It shows that these varieties would perform better in favorable conditions and hence could be recommended for cultivation under better management practices Verma and Ram (1990) also identified the variety hulled BHO 113 and HBO 316 for high yield but suitability for better environment.

1000 grain weight:

Out of 35 genotypes ten genotypes exhibiting high mean values (>27.64), regression coefficient (bi=1) and squared deviation (S^2di=0) were recorded as desirable and stable for environments under study. Hadjichristodolu (1974) also reported that 1000 grain weight is most stable trait. Three genotypes namely, IC-64004, IC-73603 and IC-67212 had high mean performance and stable but its corresponding "bi" values were lower than the unity. Therefore, these genotypes perform better under poor environment and these could be used as donor parent to develop suitable cultivars for poor environment. However, six genotypes has b<1, which showing least response to the environments.

Number of seeds per spike:

Mean performance of 35 genotypes for number of seeds per spike ranged from 49.63 to 68.23 with population mean 57.15. Out of 35 genotypes, six genotypes showed stability for number of seeds/ spike as indicating non-significant deviation (S^2di values) and regression coefficient (b=1). Whereas, ten genotypes having b>1 showing their better adaptation to the favourable environments while, thirteen genotypes had b < 1, showing response to the environments to a certain extent.

Tiller number per plant :

Considering high mean values (>9.37), b=1 and S^2di =0 the four genotypes (IC-75919, IC-63942, IC-63982, and IC-73602) were identified as desirable and stable for tiller number per plant. While, eight genotypes, showing better response to favorable environments as they had b = >1. Similarly, twelve genotypes having b = <1 showing least response to the environments. Hence, these genotype would be used as donor parent for breed a suitable line for poor environmental conditions.

Malt percentage :

Out of 35 genotypes, seven genotypes namely, IC-79532, IC-67197, IC63973, IC-79455, IC-62421, IC63969 and IC-73602 were found desirable and stable for malt percentage as they shows high mean (>80.02), regression coefficient close to unity (b=1) and non significant deviation from regression over eight environments. Therefore, these genotypes could be recommended for commercial cultivation for malt percentage in the environments tested in the study. However, six genotypes were observed to be high yielding and stable but regression coefficient were significantly greater than unity. It shows these genotypes would perform better in favorable environmental conditions.

Starch percentage :

Of the 35 genotypes tested over eight environment, four showed stability for starch percentage. Therefore, these

Table 1 : Analysis of variance for grain yield and quality parameters in Barley

Source	D.F.	Tillers/ plant	No. of seeds/ spike	Grain yield/ plant (g)	1000 grain wt. (g)	Malt %	Starch %
Genotypes (G)	34	12.00**	145.34**	6.82**	12.97**	14.29**	13.20**
Environments (E)	7	37.05	301.09**	48.48**	24.45**	129.99**	120.89**
G X E	238	0.33	3.98**	0.39	0.27	4.10**	3.71**
E (Linear)	1	259.37**	2107.74**	339.38**	171.12**	907.96**	846.72**
G X E (Linear)	34	1.13	14.42**	1.51	0.33	8.49**	5.83**
Pooled deviation	210	0.19	2.18**	0.19	0.25	3.29**	3.25**
Pooled Error	544	0.10	4.12	0.15	0.91	1.88	1.15

** Significant at 1% level.

Table 2 : Estimation of mean and stability for grain yield and quality parameters in 35 genotypes of barley.

S. No.	Genotype	Grain yield / plant (g)			1000 g. wt (g)			No. of Seeds/ spike			Tillers / plant			Malt %			Starch %		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1.	IC-79532	10.02	2.12**	1.13**	25.06	1.31*	-0.03	57.22	1.00	-1.05	8.09	1.12	0.34**	82.41	1.12	-0.48	58.69	0.55*	0.28
2.	IC-79476	11.63	1.17	0.00	26.59	0.78*	0.12	60.88	0.73*	-0.66	10.01	0.77*	0.15	80.67	1.06	4.96**	57.95	0.60*	1.07
3.	IC-67197	10.79	1.66**	0.29*	25.84	0.68*	-0.26	53.94	0.92	-0.22	8.59	0.68*	-0.03	81.06	1.16	1.07	58.35	1.22*	2.26*
4.	IC-63973	12.04	0.56*	0.15	26.19	0.92	-0.13	59.52	1.24*	0.47	7.99	0.26**	0.015	81.70	1.18	-0.18	58.46	1.55**	2.21*
5.	IC-67218	10.09	1.62**	0.23	25.67	0.78*	-0.25	49.63	0.76*	-0.07	7.31	0.77*	0.11	80.03	0.53*	7.94**	57.83	0.68*	1.17
6.	IC-61824	9.63	1.19	0.22	25.24	1.04	-0.21	49.89	0.71*	2.11	9.17	1.63**	0.60**	83.87	1.22*	0.35	57.66	1.22*	-0.14
7.	IC-79420	9.93	1.28*	0.07	25.81	0.71*	0.20	55.94	1.14	2.18	8.66	0.41**	0.04	79.84	0.74*	2.21	58.55	1.56**	3.01**
8.	IC-79469	11.14	0.81*	0.71*	31.26	0.84	-0.19	54.79	0.17**	3.50	7.96	0.38**	0.05	81.62	1.47*	0.81	59.21	0.94	1.27
9.	IC-75919	12.10	0.93	0.04	30.06	1.11	0.21	54.45	0.96	1.30	10.40	1.18	0.02	79.42	0.84	2.78	58.51	0.91	0.37
10.	IC-67227	11.84	0.85	0.10	25.53	1.28*	-0.14	60.83	0.74*	0.37	10.69	1.40*	0.08	82.26	1.95**	8.53**	57.67	1.25*	2.78**
11.	IC-79455	12.80	0.66*	0.09	26.39	1.46*	0.19	60.14	1.65**	1.01	9.27	0.90	0.40	81.05	0.95	2.56	58.60	0.77*	-0.22
12.	IC-79580	10.98	0.68*	0.08	30.95	1.09	-0.12	54.66	1.34*	0.36	8.94	1.18	0.08	83.13	2.02**	2.06	64.87	3.28**	7.00**
13.	IC-67191	10.57	0.52*	0.10	31.08	0.96	0.10	59.75	0.93	-0.73	7.44	0.62*	0.32**	82.92	1.77*	3.03	59.59	0.52*	-0.21
14.	IC-61845	11.26	0.59*	0.16	28.22	0.98	0.02	59.67	1.39*	1.46	8.18	0.77*	0.01	81.82	1.52**	1.75	59.46	0.75*	1.58
15.	IC-73644	12.01	0.42**	0.26	30.09	1.08	-0.05	58.25	0.79*	-1.06	7.49	1.06	0.00	80.21	0.96	1.90	57.16	0.77*	0.92
16.	IC-79428	9.13	1.00	0.04	30.58	1.04	-0.16	60.93	0.52*	0.19	10.49	1.59**	0.13	78.98	1.57**	0.83	58.22	1.13	0.40
17.	IC-79587	11.02	0.82	0.04	25.57	0.90	-0.05	63.05	0.54*	-1.01	10.93	1.56**	0.09	79.81	0.69*	2.32	58.45	0.59*	0.17
18.	IC-62421	11.85	0.91	0.01	30.05	1.19	-0.16	53.46	1.44*	1.01	9.99	1.61**	0.05	81.69	1.17	0.56	58.74	0.65*	1.03
19.	IC-63954	11.68	1.13	0.03	31.03	1.04	-0.18	56.04	2.40**	10.08*	11.83	0.72*	0.30	80.30	1.40*	1.59	58.83	0.74*	0.52
20.	IC-73627	9.80	0.45**	0.13	25.31	0.84	-0.22	52.66	0.99	-0.52	9.31	1.84**	0.13	79.51	1.91**	1.79	58.61	1.05	2.01
21.	IC-62419	10.79	0.76*	-0.03	26.50	1.24*	-0.20	54.96	1.41*	0.71	8.11	0.53*	0.38**	79.67	-0.81	5.03**	59.38	0.62*	0.22
22.	IC-67207	9.53	1.26*	-0.03	25.37	0.97	0.34	53.72	1.14	-0.43	10.07	0.88	0.22	80.56	1.13	1.29	58.07	0.33**	0.83
23.	IC-63969	11.09	1.28*	0.15	31.11	1.28*	-0.16	53.05	1.51**	1.19	10.61	0.83	0.27**	81.13	1.18	1.40	58.22	1.15	2.73**
24.	IC-79422	12.18	1.30*	0.17	26.28	1.09	-0.19	53.75	0.70*	-0.86	9.61	1.14	0.66**	80.79	0.64*	3.62*	58.50	1.14	0.55
25.	IC-63972	11.34	1.31*	0.24	26.21	0.83	-0.17	53.76	1.95**	8.04*	9.75	1.01	0.11	82.80	1.07	6.25**	60.01	0.78*	0.12
26.	IC-64004	11.56	1.06	0.05	29.89	0.66*	0.04	58.54	1.04	-1.00	10.87	0.73*	0.07	82.66	-0.77	4.53**	57.77	1.41*	0.72
27.	IC-73609	10.69	1.59**	0.34*	26.49	1.19	-0.15	60.76	0.64*	-0.55	8.91	0.80	0.04	80.01	0.69*	2.67	57.58	1.02	-0.03
28.	IC-79460	11.20	1.09	-0.05	25.38	1.09	-0.20	61.69	1.06	-0.67	8.06	0.62*	-0.01	79.15	0.19**	3.73*	60.31	0.95	0.04
29.	IC-61849	10.47	0.62*	0.16	31.19	0.84	-0.01	53.93	0.78*	-0.80	9.32	1.12	0.12	80.54	1.10	2.49	58.43	0.78	1.14
30.	IC-63982	11.22	1.00	-0.02	25.85	1.49*	0.28	54.00	1.25*	0.08	10.38	1.02	-0.02	81.02	0.57*	1.24	58.90	0.94	-0.09
31.	IC-64026	12.07	0.79*	0.01	26.38	0.84	-0.11	57.22	-0.37**	6.38	11.62	0.87	0.26**	81.17	1.29*	5.82**	58.07	0.88	-0.19
32.	IC-73602	11.95	1.19	0.02	29.25	0.17**	0.31	56.31	0.80	-1.13	9.65	1.01	0.08	81.71	0.84	1.42	59.37	1.14	1.29
33.	IC-73639	10.02	0.56*	0.07	25.78	0.82	-0.10	67.21	1.05	-0.78	8.14	1.09	0.16	77.72	0.87	1.06	57.62	1.05	-0.18
34.	IC-62790	12.03	0.49*	0.16	25.39	1.02	-0.10	57.47	0.66*	0.11	9.75	1.21*	0.00	81.03	0.68*	2.52	58.23	0.93	2.01*
35.	IC-67212	9.74	1.33*	0.06	30.00	1.44*	-0.08	68.23	1.02	-0.57	10.64	1.66**	0.03	79.95	0.51*	3.77**	58.31	1.13	-0.09
	Population mean	11.34			27.64			57.15			9.37			80.92			58.69		

genotypes could be recommended for general cultivation Among the 35 genotypes, fourteen genotypes had b=1, showing average performance to the environments, Seven genotypes having b > 1, revealed their better adaptation to the favourable environments. While fourteen had b < 1, showing least response to the environments. Twenty-seven genotypes showing their consistent performance over eight environments as they had S^2di =0.

In case of barley in addition to agronomic parameters, the quality parameters like malt, starch percentage etc. plays an important role to stabilize the crop for industrial purposes. It is clear from the results that both linear and non linear component of G X E interaction played an important role for expression of agronomic as well as quality traits. These were evaluated over eight environments and categorized for different traits. Seven genotypes for grain yield/ plant, ten genotypes for 1000 grain wt., Six for number of seeds/ spike, four genotype for tiller/ plant, seven for malt and four genotypes for starch percentage were identified as stable under the different environmental conditions. These genotypes could be recommended for commercial cultivation. Stable malting barley genotypes are important for malt industries (malting quality) and growers.

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