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RESEARCH ARTICLE

Analysis of crossover and non-crossover GxE interaction to identify suitable genotypes of barley (*Hordeum vulgare* L.) for rainfed conditions of Himalayas

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SUMMARY

To identify suitable genotype(s) of barley for cultivation in the rainfed conditions of Kashmir valley 30 accessions of barley were evaluated for seven quantitative traits in *Rabi* 2005-2006, 2006-2007 and 2007-2008 in nine environments created by applying three different doses of nitrogen *i.e.* 120 kg N/ha, 140 kg N/ha and 160 kg N/ha each year and data were subjected to regression analysis and also the analysis to detect the presence of crossover and non crossover interactions. Ten genotypes namely, IBCB-05-90, IBCB-05-89, IBCB-05-85, IBCB-05-91, IBCB-05-93, IBCB-05-101, IBCB-05-20, IBCB-05-82, IBCB-05-86 and IBCB-05-83, were identified to be significantly superior to the check DL 85 in terms of mean seed yield. The performance of two genotypes namely, IBCB-05-85 and IBCB-05-93 were identified to be stable using regression analysis and crossover and non crossover analysis concept. Four genotypes IBCB-05-90, IBCB-05-91, IBCB-05-20, and IBCB-05-86 were identified to be instable using both technique *i.e.* regression analysis and crossover and non crossover interaction analysis techniques and out of these three genotypes IBCB-05-90, IBCB-05-91 and IBCB-05-20 had specific adaptability and found to be responsive to higher fertility regimes by both regression analysis and crossover and non-crossover interaction concept. The genotypes IBCB-05-89 and IBCB -05-101 were identified to be stable ones using regression analysis whereas they fail to qualify the stability test of crossover and non-crossover interaction analysis concept. The genotype IBCB-05-82 exhibited instability for seed yield using regression analysis techniques whereas its performance was stable by crossover and non-crossover interaction concept. Thus, genotypes had specific adaptability to the specific environment rather than possessing general adaptation.

Key Words : Barley, Rainfed, Low yielding environment, Regression analysis, Crossover and non crossover, Genotype x Environment interaction, Specific adaptability

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Genotype x environment (GxE) interaction introduces inconsistency in the relative rating of genotypes across environments and plays a key role in the developing strategies for crop improvement (Becker and Leon, 1984). The GxE interaction can be either qualitative (crossover type) or only quantitative (non-crossover type). Since presence of cross over type interaction has a strong implication for breeding for specific adaptation, therefore, it is important to assess the presence and magnitude of cross over interactions. In general, selection of genotypes is based on their evaluation in a number of environments. The relative response of the genotypes varies over the environments indicating a change in the superiority of one genotype over the others with respect to the environment including a change in the rank of the genotypes. Selection of genotypes with an objective of yield maximization in the case of rank change over environments is complicated (Haldane, 1947; Weber and Wricke, 1990) due to non separatibility of response behaviour (Gregorius and Namkoong, 1986).

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Because of high probability of low yields and crop failures in the unfavourably environments, the use of inputs such as fertilizers is seen by the farmers as risky. Therefore, the adoption of improved agronomic practices has been very limited and the only economic solution to increase crop yields in unfavourable environment is through breeding. However, empirical breeding for these environments has been historically much less successful than for favourable environments which could be made favourable by the use of fertilizer and by irrigation. About 3.3 per cent of total geographical area of Jammu and Kashmir is under cultivation, of which 60 per cent is rainfed with frequent moisture stress. The productivity of crop in the state is low due to lack of irrigation and low input use. Therefore, present investigation was carried out to find out the promising genotypes for utilization in breeding programme and to detect the presence of crossover and non crossover genotype x environment interactions for yield and yield contributing traits by manipulating the nitrogenous fertilizer doses over the years.

MATERIALS AND METHODS

Thirty accessions of barley, received from the Division of Germplasm Evaluation, National Bureau of Plant Genetic Resources, New Delhi, were raised in a randomized complete block design with three replications at the Research Farm of Regional Centre of National Bureau of Plant Genetic Resources, K.D. Farm, Rangreth, Srinagar (Kashmir) during *Rabi* 2005-2006, 2006-2007 and 2007-2008. Each year three micro-environments were created by applying three different doses of nitrogen (N) *i.e.* 120 kg N/ha, 140 kg N/ha and 160 N/ha. Thus, nine environments, three micro-environments each year, *i.e.* in the year 2005{[Env.-I (120 kg N/ha), Env.-II (140 kg N/ha), Env.-III (160 kg N/ha)}, in 2006 {[Env.-IV (120 kg N/ha)}, Env.-V {(140 kg N/ha), Env.-VI (160 kg N/ha)}, and in 2007 {[Env.-VII (120 kg N/ha), Env.-VIII (140 kg N/ha), Env.-IX (160 kg N/ha)} were created. The nitrogen was applied in the field uniformly in each case in three equal amount *i.e.* at the time of sowing, initiation of tillering and booting stage of plant growth. The initial soil fertility status was worked out and was found to be similar across the field. In each environment plots consisted of three rows of 3 meter length with row to row distances of 10 cm. The doses of P_2O_5 @ 70 kg/ha and K_2O @ 50 kg/ha was applied uniformly at the time of sowing. The experiments were sown in the last week of October each year. The crop was raised under rainfed conditions. The data were recorded on ten randomly taken plants from middle row of plot in each environment on seed yield per plant (g), number of grains per spike, spike length (cm), number of spikelets per spike, 100 seed weigh (g), number of tillers per plant and plant height (cm). The data were analyzed separately for each environment. Adjusted progeny means were used for the combined analysis and for the traits exhibiting the presence of gxe interaction, regression analysis and analysis to detect the presence of crossover and non cross over interactions were carried out as per Eberhart and Russell (1966) and Perkins and Jinks (1966) and Gail and Simon (1985).

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among genotypes for all studied seven traits in nine environments. The combined analysis revealed the presence of gxe interaction for seed yield per plant, number of grains per spike, spike length (cm), number of spikelets per spike, 100 seed weight (g), number of tillers per plant and plant height. Regression analysis enables breeders to select desirable genotypes with respect to the responsiveness and stability in different environments. In the studied material ten genotypes namely, IBCB-05-90, IBCB-05-89, IBCB-05-85, IBCB-05-91, IBCB-05-93, IBCB-05-101, IBCB-05-20, IBCB-05-82, IBCB-05-86, IBCB-05-83 exhibited above average performance and responsiveness with respect to seed yields per plant (Table 1). Among these high yielding genotypes IBCB-05-85 and IBCB-05-93 can be designated as stable ones with average responsiveness (Kang and Pham, 1991). Four genotypes IBCB-05-90, IBCB-05-91, IBCB-05-20, and IBCB-05-86 were identified to be instable using both techniques *i.e.* regression analysis and crossover and non crossover interaction analysis and out of these three genotypes IBCB-05-90, IBCB-05-91 and IBCB-05-20 had specific adaptability and were found to be responsive to higher fertility regimes by both regression analysis and crossover and non-crossover interaction concepts. These genotypes exhibited highest yield in Env.V, Env IX, and Env II, respectively. The genotypes IBCB-05-89 and IBCB -05-101 were identified to be stable ones using regression analysis whereas they fail to qualify the stability test of crossover and non-crossover interaction analysis concept. The genotype IBCB-05-82 exhibited instability for seed yield using regression analysis techniques whereas its performance was stable by crossover and non-crossover interaction concept.

The regression technique describes the response pattern of individual genotype without differentiating the kind of gxe interaction involving change in magnitude of response or direction among the genotype (Baker, 1988 ; Virk and Mangat, 1971 and Ramgosa and Fox, 1993). Baker (1988) described a test that was initially proposed by Gail and Simon (1985) and illustrated its application to test the kind of interaction in crop plants. The concept of cross over and non-crossover interaction is important in decision making relating to crop improvement strategies (Baker, 1988) since the presence of crossover interaction is a substantial evidence in favour of breeding for specific adaptation to certain situation. Baker (1988) further suggested that in the absence of crossover interaction, there is little substance for argument in the favour of breeding for adaptation to specific environment.The genotype exhibiting crossover interaction against a standard variety can be said to have specific adaptation and can replace that standard variety in the specific environment(s).

The existence of prior scientific basis to explain crossover interaction is crucial (Peto, 1982). Thus, it is advantageous to define the varietal combinations among which one has to look for qualitative interaction in advance. There will be enormous multiplicity of all possible varietal pairs for detection of crossover interaction if there is no prior basis for comparison. Such a practice will greatly increase the experiment wise error rate. In the present case the new genotypes were, therefore, compared with the standard check DL 85 for detection of cross over interaction since the aim was to find a better genotype than the check.

The H (heterogeneity of response) and Q^+ and Q^- (for the presence of crossover interaction) against a standard variety DL 85 were estimated for all the 29 accessions for the traits exhibiting the presence of gxe interaction *i.e.* seed yield, number of grains per spike, spike length, number of spikelets per spike, 100-seed weight, number of tillers per plant, plant height and their significance was tested (Baker, 1988). The genotype exhibiting either significant H or Q^+ and Q^- are given in Table 2. For seed yield per plant H was significant for 28 genotypes against DL 85. The presence of cross over interaction was observed for 17 genotypes namely, IBCB-05-90, IBCB-05-89, IBCB-05-91, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-86, IBCB-05-83, IBCB-05-81, IBCB-05-97, IBCB-05-94, IBST-GP-16, IC-420727, IBST-GP-02, IBCSGP-05-03, IC-420720 and IC-420730 for seed yield per plant against DL 85. The 13 genotypes namely, IBCB-05-90, IBCB-05-85, IBCB-05-93, IBCSGP-05-20, IBST-GP-12, IBCB-05-81, IBST-GP-15, IBCB-05-06, IC-420727, IBST-GP-02, IBST-GP-14, IC-420743 and IC-420730 had shown the presence of cross over interaction for number of grains per spike whereas 16 genotypes namely, IBCB-05-90, IBCB-05-89, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-83, IBST-GP-12, IBST-GP-15, IBCB-05-06, IBCB-05-87, IBST-GP-13, , IC-420727, ST-GP-14, IBCSGP-05-03, IC-420743, IC4207381 exhibited the presence of crossover interaction for spike length and the 14 genotypes namely, IBCB-05-90, IBCB-05-85, IBCB-05-91, IBCSGP-05-20, IBCB-05-82, IBCB-05-83, IBST-GP-12, IBCB-05-97, IBST-GP-15, IBCB-05-87, IBCB-05-94, IC-420727, , IBST-GP-14, IBCSGP-05-03 had cross over interaction for number of spikelets per spike. For 100-seed weight the 11 genotypes namely, IBCB-05-91, IBCB-05-93,IBCSGP-05-20, IBST-GP-12, IBCB-05-81, IBCB-05-06, IBCB-05-87, IBST-GP-13, IC-420727, IBCSGP-05-03, IC-420720 exhibited the cross over interaction and the 19 genotypes namely, IBCB-05-90, IBCB-05-85, IBCB-05-91, IBCB-05-101,

IBCB-05-86, IBCB-05-83, IBCB-05-97, IBST-GP-15, IBCB-

Table 1: Heterogeneity (H) test of response for the comparison of means seed yield/ plant (g) against the standard variety DL 85 alongwith Q^+ and Q^- value for cross over interaction and adaptability parameters for the genotypes

Genotypes	Adaptability parameters			Against best check DL 85		
	$\mu+d_i$	$\beta_i \pm SE$	$\sigma^2 d_i$	H	Q^+	Q^-
IBCB-05-90	21.38*	1.12*±0.25	0.38*	42.58#	93.65$	128.96
IBCB-05-89	20.24*	-0.15±0.07	-0.09	87.02#	24.52	35.62$
IBCB-05-85	20.15*	-0.14±0.19	0.14	185.23#	17.89	16.45
IBCB-05-91	19.53*	0.98*±0.23	0.29*	48.25#	58.24$	69.75
IBCB-05-93	19.27*	-0.07±0.12	-0.03	96.74#	22.63	19.56
IBCB-05-101	17.96*	0.52*±0.27	-0.01	47.35#	16.14$	22.38
IBCSGP-05-20	17.23*	-0.84*±0.38	0.98*	68.59#	69.22	88.73$
IBCB-05-82	16.48*	-1.02*±0.58	-0.41*	38.72#	177.20	45.23
IBCB-05-86	16.10*	0.96*±0.21	-0.64*	104.67#	136.35	30.54$
IBCB-05-83	16.04*	-0.29*±0.12	-0.84*	69.54#	32.49	26.35
IBST-GP-12	15.67	0.72*±0.35	0.18	182.87#	18.05	11.20
IBCB-05-81	15.55	-1.51*±0.41	0.47*	105.02#	87.96	27.65$
IBCB-05-97	15.28	0.65*±0.13	-0.39*	45.27#	38.65	93.23$
IBST-GP-15	14.06	-0.24*±0.22	0.14	64.31#	36.56	38.25
IBCB-05-06	13.96	0.91*±0.28	-0.15*	86.51#	59.12$	82.56
IBCB-05-87	13.62	0.09*±0.02	-0.07	79.28#	28.91	109.20
IBST-GP-13	12.63	-0.33*±0.17	0.17	107.58#	15.83	14.34
Grand mean	13.82 ± 2.05					
DL 85 CHECK	12.03 ± 2.13					

*Significant at <0.05; # H was significant against $\chi 2$ 0.05 at s-1 df, where s is the number of environments. $ minimum of either Q^+ or Q^- was significant against "C" value given by Gail and Simon (1985)

Table 2: Genotype exhibiting significant *, # H (heterogeneity of response), and Q^+ and Q^- against standard variety DL 85

Characters	H	Q^+ and Q^-
Seed yield/plant(g)	All genotypes except IBST-GP-02	IBCB-05-90, IBCB-05-89, IBCB-05-91, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-86, IBCB-05-83, IBCB-05-81, IBCB-05-97, IBCB-05-94, IBST-GP-16, IC-420727, IBST-GP-02, IBCSGP-05-03, IC-420720, IC-420730 (17 genotypes)
No. of grains/ spike	All genotypes except IBCB-05-94 and IBCSGP-5-03	IBCB-05-90, IBCB-05-85, IBCB-05-93, IBCSGP-05-20, IBST-GP-12, IBCB-05-81, IBST-GP-15, IBCB-05-06, IC-420727, IBST-GP-02, IBST-GP-14, IC-420743, IC-420730 (13 genotypes)
Spike length (cm)	All genotypes except IC-420743 and IBCB-05-81	IBCB-05-90, IBCB-05-89, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-83, IBST-GP-12, IBST-GP-15, IBCB-05-06, IBCB-05-87, IBST-GP-13, , IC-420727, ST-GP-14, IBCSGP-05-03, IC-420743, IC4207381 (16 genotypes)
No. of spikelets/ spike	All genotypes	IBCB-05-90, IBCB-05-85, IBCB-05-91, IBCSGP-05-20, IBCB-05-82, IBCB-05-83, IBST-GP-12, IBCB-05-97, IBST-GP-15, IBCB-05-87, IBCB-05-94, IC-420727, , IBST-GP-14, IBCSGP-05-03, (14 genotypes).
100-seed weight (g)	All genotypes	IBCB-05-91, IBCB-05-93,IBCSGP-05-20, IBST-GP-12, IBCB-05-81, IBCB-05-06, IBCB-05-87, IBST-GP-13, IC-420727, IBCSGP-05-03, IC-420720 `(11 genotypes)
No. of tillers/plant	All genotypes except IBCB-05-89	IBCB-05-90, IBCB-05-85, IBCB-05-91, IBCB-05-101, IBCB-05-86, IBCB-05-83, IBCB-05-97, IBST-GP-15, IBCB-05-06, IBCB-05-87, IBST-GP-13, IBCB-05-94, IBST-GP-16, IBST-GP-11, IBST-GP-14, IBCSGP-05-03, IC-420743, IC-420720, IC-420730 (19 genotypes)
Plant height (cm.)	All genotypes	IBCB-05-89, IBCB-05-85, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-86, IBCB-05-81, IBCB-05-97, IBCB-05-87, IBST-GP-16, IC-420727, IBST-GP-14, IBCSGP-05-03, IC-420743, IC-420720, IC4207381(16 genotypes)

*H was significant against χ^2 0.05 at s-1 df, where s is the number of environments. # minimum of either Q+ or Q- was significant against "C" value given by Gail and Simons (1985)

05-06, IBCB-05-87, IBST-GP-13, IBCB-05-94, IBST-GP-16, IBST-GP-11, IBST-GP-14, IBCSGP-05-03, IC-420743, IC-420720, IC-420730 had cross over interaction for number of tillers per plant. The 16 genotypes IBCB-05-89, IBCB-05-85, IBCB-05-101, IBCSGP-05-20, IBCB-05-82, IBCB-05-86, IBCB-05-81, IBCB-05-97, IBCB-05-87, IBST-GP-16, IC-420727, IBST-GP-14, IBCSGP-05-03, IC-420743, IC-420720, IC4207381 exhibited the presence of crossover gxe interaction for plant height. All the genotypes failed to exhibit cross over gxe interaction for all traits against DL 85 thus, presence or absence of crossover gxe interaction was genotypic specific and trait specific.

The conclusion drawn from regression analysis and cross over and non-crossover interaction concept about identifying the genotypes having specific adaptability differs considerably. The genotypes IBCB-05-90, IBCB-05-91 and IBCSGP-05-20 identified as potential yielders having specific adaptability for Env V, IX and II, respectively on the basis of regression analysis and significant min (Q^+ and Q^-) against standard variety DL 85. The genotypes IBCB-05-82 and IBCB-05-83 were the potential yielder in Env VII and IV, respectively on the basis of regression analysis but failed to show significant min (Q^+ and Q^-) against DL 85. The genotypes IBCB-05-89 and IBCB-05-101 gave highest yield in Env VI and Env IX, respectively were stable on the basis of regression analysis but their min (Q^+ and Q^-) against DL 85 was significant. The genotype IBCB-05-83 was adapted to VII and had shown insignificant min (Q^+ and Q^-) against DL 85.

The genotypes IBCB 05-90 and IBCB-05-91 and IBCSGP-05-20 which have been identified as a high yielding genotype having specific adaptability both by using regression analysis and crossover and non cross over interaction concept gave significantly higher mean seed yield than DL 85. They gave higher seed yield in medium to higher nitrogenous regimes thus they have specific adaption to high yielding environment, *i.e.* high nitrogen regimes (140 kg N/ha and/or 160 kg N/ha), rather than possessing general adaptation.(Sharma, 1995).

REFERENCES

Baker, R.J. (1988). Test for cross over genotype-environment interaction. *Canadian J. Plant Sci.,* **64**: 405-410.

Becker, H.C. and Leon, J. (1984). Stability analysis in plant breeding. *Plant Breed.,* **101**: 1- 23.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.* **6**: 36-40.

Gail, M. and Simon, R. (1985). Testing for quantitative interaction in Schizophyllum commune.I. Analysis and character. *Heredity,* **27**: 361-372.

Gregorius, H.R. and Namkoong, G. (1986). Joint ananlysis of genotypic and environmental effects. *Theoretical & Appl. Genet.,* **72**: 413-422.

Haldane, J.B.S. (1947). The interaction of nature and nurture. *Ann. Eugen.,* **13**: 197–205.

Kang, M.S. and Pham, H.N. (1991). Simultaneous selection for high yielding and stable crop genotypes. *Agron. J.,* **83**: 161-165.

Perkins, M. and Jinks J.L. (1968). Environmental and genotype-environmental components of variability IV. Non-linear interaction for multiple inbred lines. *Heredity,* **23**: 525-535.

Peto, R. (1982). Statistical aspects of cancel trials. In: E.E. Halnan (Ed.), *Treatment of cancer*, Chapman and Hall, LONDON, UK. pp. 867-871.

Romagosa, I. and Fox, P.N.(1993). Genotype×environment interaction and adaptation. In: Hayward, M.D., Bosemark, N.O., Romagosa, I. (Ed.), *Plant breeding*: *Principles and Prospects.* Chapman and Hall, LONDON, UNITED KINGDOM, pp. 373–390.

Sharma, R.K. (1995). Breeding lentil for response to additional nitrogen application. *Crop Improv.,* **22**: 139-141.

Virk, D.S. and Mangat, B.K. (1971). Detection of crossover genotype x environment interaction in pearlmillet. *Euphytica,* **52**: 193-199.

Weber, W.E. and Wricke, G. (1990). Genotype×environment interaction and its implication in plant breeding. In: Kang, M.S. (Ed.), *Genotype-by-environment interaction and plant breeding*. Louisiana State University, Baton Rouge, LA, pp. 1–19.

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