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GENERATION MEAN ANALYSIS IN BARLEY (*HORDEUM VULGARE* L.) UNDER DROUGHT STRESS CONDITION

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Abstract

Barley is one of the drought tolerant crop in rabbi season. The objective of study is was to generate genetic information, which can help to study genetic control of drought tolerance in barley. Four varieties (K 603, RD 2508, Lakhan and BH 902) evaluated to make four different cross combination and to determine the genetic parameters contributing to 13 characters. Generation mean analysis was carried out on six generations (P_1, P_2, F_1, F_2, Bc_1 and Bc_2) to complement the genetic information obtained from analysis. The gene effects indicate that additive component was predominant over dominant one for majority of the character under rainfed condition. While among the epistatic interaction the major role played by additive x additive type of epistasis which was followed by additive x dominance and dominance x dominance in all the four crosses, which shows that transgressive segregants obtained from these crosses may perform well in the next generations and variety can be develop by selection from these breeding material.

Key words : Drought, rainfed, generation mean, gene effect, yield.

Introduction

Barley (*Hordeum vulgare* L.) is belongs to the family Poaceae, tribe Triticaeae and genus Hordeum. Barley ranks fourth among cereal crops after wheat, maize and rice and is among the top ten crop plants in the world (Akar *et al*., 2004). Barley (*Hordeum vulgare* L.) has a long history as a domesticated crop, as one of the first crops adopted for cultivation. Migration of people together with their crop seeds led to a major diversification and adaptation to new areas, and the crop is now virtually found worldwide. The development of new technology and methods increased the genetic diversity even further and turned barley into the universal, highly diverse crop (Harlan, 1976).

Before introduction of semi dwarf high yielding varieties of wheat in mid-sixties (1960's) about 80% barley produced in India was being consumed as food grains. But with the availability of plenty of wheat and rice grains, consumption of barley declined as food grains and ultimately bulk of barley area was replaced by semi dwarf wheat varieties wherever irrigation facilities were developed. However, still barley is cultivated on about 0.67 million hectare and major portion of barely produce is utilized as feed grain and food grains by poor people. Barley is wonderful gift of nature to human civilization as evident from its multitude of uses both as medicinal and industrial values.

The plant breeders now have recognized the importance of utilizing genetic variability and diversity in breeding programmes to meet the continuously expanding needs of hybrid and varietal improvement. Although, the assemblage, evolution and preservation of the entire germplasm are essential to more rewarding breeding efforts, a selection of most potential lines on biometrical analysis and on genetic-diversity is very essential for the success of breeding programmes and also for increasing the agricultural productivity. The plant breeder is interested in the estimation of gene effects in order to formulate the most advantageous breeding procedures for improvement of the attribute in question.

Therefore, breeders need information about nature of gene action, heterosis, inbreeding depression, heritability and predicted genetic gain from selection for yield and yield components. Sprague (1963) listed three major factors that must be considered and which may limit progress in the analysis of quantitative genetic variation: the number of genes involved, the type of gene action, and the genotype environment interaction. Seed yield is very complex character whose manifestation results from multiplicative interactions of several quantitative traits and environmental factors (Grafius, 1959).

The main objective of present study to identify the genetic architecture of different yield related and drought tolerance traits on grain yield in barley.

Materials and Methods

The experimental material consisted of the six populations (P_1, P_2, F_1, F_2, Bc_1 and Bc_2) derived from four crosses between the two rainfed variety (Lakhan and K-603) and irrigated varieties (BH-902 and RD-2508) for generation mean analysis (table 1), at the Agriculture Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in rainfed condition during the successive growing seasons of 2012-13, 2013-14 and 2014-15. In 2012-13 season, the four crosses were made among the parents to produce F_1 hybrid seeds. In 2013-14 four F_1's along with their parents were grown under rainfed condition in a single row plot of 5 m length in the Compact Family Randomized Block Design with three replications. F_1's were selfed to produce F_2 seeds. Fresh F_1's and back crosses (B_1 and B_2) were made for generation mean analysis. While in 2014-15, P_1, P_2 and F_1's were planted in two rows while, B_1s and B_2s were planted in three rows and F_2s in five row plots in each replication. The 3 meter rows were space planted 30 cm apart at a distance of 10 cm between the seeds.

Observations recorded

Ten competitive plants from each of the parents and F_1s', 20 plants from backcrosses (B_1 and B_2) and 50 plants from each F_2 population from each replication were randomly selected and tagged for recording of data on thirteen quantitative yield and yield related and drought tolerance traits.

Statistical analysis

Hayman (1958) and Jinks and Jones (1958) derived the six parameter model for the estimation of various genetic components; these components were estimated according to Hayman (1958) as follows:

m = mean = i_2

d = Additive effects = $\overline{B}_1 - \overline{B}_2$

h = Dominance effects = $\overline{F}_1 - 4.\overline{F}_2 - \frac{1}{2}.\overline{P}_1 - \frac{1}{2}.\overline{P}_2$

$2.\overline{B}_1 + 2.\overline{B}_2$

i = Additive × Additive type of gene interaction

$= 2.\overline{B}_1 + 2.\overline{B}_2 - 4.\overline{F}_2$

j = Additive × Dominance type of gene interaction

$= \overline{B}_1 - \frac{1}{2}.\overline{P}_1 - \overline{B}_2 + \frac{1}{2}.\overline{P}_2$

l = Dominance × Dominance type of gene interaction

$l = \overline{P}_1 + \overline{P}_2 + 2.\overline{F}_1 + 4.\overline{F}_2 - 4.\overline{B}_1 - 4.\overline{B}_2$

The calculated value of 't' are to be compared with tabulated value of 't' at 5% level of significance. In each test, the degree of freedom is sum of the degrees of freedom of various generations (total number of observations - total number of replications) involved.

Results and Discussion

In the present investigation a total 4 crosses for 13 characters were subjected to A, B, C, and D scaling test as suggested by Mather (1949) to examine whether epistatic gene effects were present in the material under study, and to validate the results of A, B, C and D scaling test, joint scaling test as suggested by Cavalli (1952) was also performed. The joint scaling test also revealed presence of non-allelic interactions in all four crosses for all the traits but presence of epistasis varied with crosses as well as traits. The generation mean analysis showed that both additive and dominant types of gene effects were important for most of the traits. For some crosses dominance gene effects (*h*) in general were higher than additive gene effects (*d*) under both irrigated and rainfed conditions, while in some crosses result were found vice versa (table 2).

Out of four crosses and 13 characters selected for generation mean analysis only three crosses showed complementary gene action whereas maximum number of crosses showed duplicate type of gene action. All the four scales (A, B, C and D) were observed as significant for all the characters except number of tillers per plant under irrigated condition and number of grains per spike under rainfed condition, where three parameter model

Table 1 : Pedigree and origin of the genotypes used in four barley crosses.

S. no.	Name of genotype	Pedigree/source	Origin
1.	RD 2508	RD2035 / P409	Indigenous
2.	K 603	K257 / C138	Indigenous
3.	BH 902	BH495 / EB7576	Indigenous
4.	Lakhan	K12 / IB226	Indigenous

Table 2 : Scaling test, estimate of gene effects from analysis of generation means for 13 characters under rainfed condition.

	Crosses	Scales				Gene effects						Epistasis
		A	B	C	D	$[\hat{m}]$	$[\hat{d}]$	$[\hat{h}]$	$[\hat{i}]$	$[\hat{j}]$	$[\hat{l}]$	
Days to 50% flowering												
Rainfed	**Lakhan x RD 2508**	-8.788**	-4.657**	-11.458**	-10.129**	2075.466**	13.070**	3.106	10.129**	-6.234**	3.297	-
	Lakhan x BH 902	6.979**	-11.734**	-34.779**	-58.421**	2083.107**	50.262**	47.681**	58.421**	14.026**	-20.871**	D
	K 603 X BH 902	-4.112**	-4.601**	0.061	9.187**	1264.541**	-2.805	-12.855**	-9.187**	1.543	8.295**	D
	K 603 X RD 2508	0.125	-13.405**	-1.677	8.347**	2075.466**	19.331**	-10.001**	-8.347**	10.222**	8.869**	D
Days to Maturity												
Rainfed	**Lakhan x RD 2508**	-4.449**	0.432	6.782**	20.439**	2110.997**	21.579**	-7.691**	-20.439**	-3.803**	9.690**	D
	Lakhan x BH 902	0.932	14.511**	-10.150**	-34.901**	2852.764**	-6.201**	34.013**	34.901**	-13.053**	-22.096**	D
	K 603 x BH 902	-5.868**	4.890**	8.458**	24.997**	2820.710**	-29.950**	-17.375**	-24.997**	-10.367**	8.736**	D
	K 603 x RD 2508	6.520**	5.845**	-3.436	-26.396**	2129.872**	19.335**	27.060**	26.396**	-0.697	-16.194**	D
Plant height												
Rainfed	**Lakhan x RD 2508**	-5.442**	8.140**	-0.631	-6.873**	1637.594**	-10.961**	9.900**	6.873**	-11.298**	-4.868**	D
	Lakhan x BH 902	2.852	-6.050**	-3.527	-6.571**	2201.580**	26.526**	6.966**	6.571**	10.211**	-0.556	-
	K 603 x BH 902	14.193**	-24.839**	-5.871**	-9.320**	1926.404**	59.319**	10.240**	9.320**	30.865**	-2.352	-
	K 603 x RD 2508	-8.513**	7.601**	1.883**	4.770**	1441.423**	-22.183**	2.571	-4.770**	-13.684**	2.112	-
Number of tillers per plant												
Rainfed	**Lakhan x RD 2508**	-1.101	-4.892**	3.848**	14.511**	254.039**	14.089**	-7.533**	-14.511**	3.471**	9.664**	D
	Lakhan x BH 902	-1.109	2.131	1.053	1.258	318.593**	-11.852**	-1.808	-	-	-	-
	K 603 x BH 902	-5.464**	-10.350**	4.239**	31.790**	293.948**	-4.577**	-14.434**	-31.790**	3.437	20.038**	D
	K 603 x RD 2508	-7.139	-7.029	-5.066	9.940	347.597	-0.206	-1.213	-9.940	0.375	11.371**	-
Spike Length												
Rainfed	**Lakhan x RD 2508**	5.601**	-8.927**	1.241	21.993**	868.979**	-1.547	-10.091**	-21.993**	2.068	16.753**	D
	Lakhan x BH 902	-0.645	2.271	-7.343**	-15.149**	566.139**	43.534**	19.255**	15.149**	-2.367	-7.061**	D
	K 603 X BH 902	-6.018**	15.461**	-0.755	-8.804**	942.997**	8.706**	21.777**	8.804**	-17.213**	-6.932**	D
	K 603 X RD 2508	1.177	-10.686**	3.148	28.203**	2382.997**	-11.645**	-21.636**	-28.203**	10.264**	14.811**	D

Table 2 continued...

Table 2 continued...

Awn Length												
Rainfed	**Lakhan x RD 2508**	5.452**	2.917	3.421	-2.722	527.483**	3.640**	-3.594**	2.722	1.388	-4.685**	C
	Lakhan x BH 902	-9.438**	-0.268	5.731**	12.092**	314.907**	11.818**	-15.214**	-12.092**	-5.010**	9.763**	D
	K 603 x BH 902	8.335**	7.534**	18.651**	24.061**	569.004**	2.189	-20.078**	-24.061**	0.244	-0.101	-
	K 603 x RD 2508	-2.778	-20.786**	0.884	27.027**	470.320**	9.985**	-23.500**	-27.027**	14.202**	23.454**	D
Number of grains per spike												
Rainfed	**Lakhan x RD 2508**	-8.460**	6.395**	14.140**	38.374**	886.323**	-60.586**	-20.029**	-38.374**	-14.213**	15.123**	D
	Lakhan x BH 902	-8.600**	-7.612**	7.446**	42.317**	981.039**	8.489**	-18.636**	-42.317**	-1.666	23.724**	D
	K 603 x BH 902	0.343	-5.501**	1.958	7.401**	673.480**	41.607**	4.038**	-7.401**	5.166**	6.479**	C
	K 603 x RD 2508	3.459	0.640	1.882	-0.071	402.366**	3.629**	-3.085	-	-	-	-
1000 grain weight												
Rainfed	**Lakhan x RD 2508**	-8.928**	0.703	2.197	9.009**	813.209**	-1.792	-9.814**	-9.009**	-7.888 **	7.560**	D
	Lakhan x BH 902	-12.387**	-18.685**	-3.265	35.664**	1122.520**	11.720**	-23.927**	-35.664**	6.391**	25.540**	D
	K 603 x BH 902	11.675**	-16.203**	-5.481**	-8.397**	738.197**	67.354**	2.410	8.398**	26.904**	-4.822**	-
	K 603 x RD 2508	-15.713	-5.204**	-18.648**	-4.824**	1266.815**	5.075**	1.266	4.824**	-6.222**	6.144**	-
Harvest Index												
Rainfed	**Lakhan x RD 2508**	5.917**	5.123**	16.735**	38.857**	558.346**	7.007**	-30.578**	-38.857**	10.942**	14.479**	D
	Lakhan x BH 902	-13.681**	-12.510**	2.963	86.373**	935.834**	0.719	-40.461**	-86.373**	7.419**	33.126**	D
	K 603 x BH 902	1.674	-17.555**	-27.146**	-30.338**	477.276**	30.099**	29.616**	30.338**	17.044**	-7.661**	D
	K 603 x RD 2508	-23.799**	3.275	-27.680**	-28.515**	807.436**	-27.462**	13.179**	28.515 **	-20.328**	-2.860	-
Grain Yield per plant												
Rainfed	**Lakhan x RD 2508**	-4.743**	1.744	17.682**	42.637**	457.913**	-46.830**	-21.596**	-42.637**	-6.122**	19.078**	D
	Lakhan x BH 902	-7.262**	2.782	2.368	11.685**	448.596**	-36.308**	1.851	-11.685**	-11.450**	6.858**	-
	K 603 x BH 902	-8.094**	4.301**	0.672	7.591**	455.165**	-25.098**	1.711	-7.591**	-11.481**	5.860**	-
	K 603 x RD 2508	-5.743**	-11.126**	-11.271**	-2.155	363.433**	-0.679	8.389**	2.155	3.558**	7.243**	C
Chlorophyll Content												
Rainfed	**Lakhan x RD 2508**	-5.206**	16.263**	7.246**	2.601	303.491**	-55.677**	-4.123**	-2.601	-23.455**	-3.277	-
	Lakhan x BH 902	18.463**	-3.705**	12.485**	11.734**	610.949**	24.229**	-5.520**	-11.734**	23.090**	-2.427	-

Table 2 continued...

Table 2 continued...

	K 603 X BH 902	-13.555**	5.098**	-29.532**	-38.742**	682.83**4	-0.478	27.418**	38.742**	-6.763**	-6.113**	D
	K 603 X RD 2508	14.754**	16.871**	-11.282**	-43.316**	725.382**	2.063	28.999**	43.316**	0.297	-33.372**	D
						Stomatal Condutance						
Rainfed	**Lakhan x RD 2508**	-4.925**	-6.026**	-4.942**	3.703**	660.194**	12.340**	-2.085	-3.703**	1.566	6.529**	-
	Lakhan x BH 902	4.701**	-3.540**	-3.239	-20.437**	455.829**	44.846**	1.632	20.437**	15.455**	-4.307**	-
	K 603 x BH 902	26.381**	-20.367**	-17.491**	-37.466**	617.309**	79.844**	16.716**	37.466**	36.666**	-13.615**	D
	K 603 x RD 2508	-3.829**	-12.235**	6.706**	61.545**	1343.511**	6.923**	-33.754**	-61.545**	9.106**	24.620**	D
						Proline content						
Rainfed	**Lakhan x RD 2508**	-0.195	3.431	4.567**	6.140**	327.974**	-10.606**	-2.753	-6.140**	-2.448	0.590	-
	Lakhan x BH 902	-5.223**	-2.771	-3.276	5.120**	356.575**	-26.251**	2.887	-5.120**	-3.643**	6.519**	-
	K 603 x BH 902	-1.043	-1.303	0.830	6.084**	590.225**	11.049**	-5.751**	-6.084**	0.069	3.260	-
	K 603 x RD 2508	0.754	0.763	-2.266	-10.194**	483.280**	27.087**	6.185**	10.194**	-0.157	-3.932**	D

was used to determine the gene action. The gene effects indicated that additive component was predominant over dominance component for majority of the character under rainfed condition. While among the epistatic interactions the major role was played by additive x additive type which was followed by dominance x dominance and additive x dominance, the similar result were also reported by Darrah (2005), Rohman *et al*. (2006), Eshigi *et al*. (2010), Ciulca *et al.* (2012) and Yadav *et al*. (2015).

The nature and magnitude of gene effects indicated wide variation between the crosses character-wise. Hence, specific breeding strategy has to be adopted for a particular cross to get improvement in grain yield along with desirable yield attributes and drought tolerant parameters. The presence of non-allelic interaction for most of the characters in different cross combinations signifies to adopt biometrical approach like generation mean that provides the estimates of epistasis which could otherwise inflate the measure of additive and dominance components. Epistasis must be included in a model for the unbiased estimation of genetic components. The results showed that as a consequence of higher magnitude of interactions, the fixable gene effects were higher than the non-fixable. Further, duplicate type of epistasis was also found in majority of traits. This study revealed that epistasis as a basic mechanism for gene action and cannot be ignored. Thus formulating the breeding procedure on the basis of only main gene effects *i.e.* additive and dominance could be misleading. The epistatic interactions play key role in controlling the characters.

Conclusion

On the basis of generation mean analysis result, it can be conclude that, both additive and dominant types of gene action were important for most of the traits studied. Moreover, in general the magnitude of additive gene action (d) were higher than those of dominance gene action (h) under both irrigated and rainfed conditions.

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