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Genetic variation and heritability studies for yield and yield components in barley genotypes under normal and limited moisture conditions

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Abstract
Thirty promising barley (*Hordeum vulgare* L.) genotypes were grown in *rabi* season of 2012 under normal and limited moisture conditions to assess the presence of variability for desired traits and amount of variation for different parameters. Genetic parameters variability, heritability and genetic advance were estimated for all the traits. Analysis of variance revealed significant differences among entries for all the characters. In normal condition the estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for number of effective tillers per plant, biological yield per plant, plant height and spike length. In limited moisture condition the highest genotypic coefficient of variation was recorded for number of effective tillers per plant. The other characters which showed high genotypic coefficient of variation were relative water content, seed yield per plant, spike length and biological yield per plant. High heritability along with high genetic advance (%of mean) was observed for plant height, number of effective tillers per plant, spike length, biological yield per plant, relative water content and seed yield per plant in both the environments.

Keywords: Barley, variability, heritability, genetic advance as per cent of mean

Introduction
Barley [*Hordeum vulgare* L.] is the world's fourth most important cereal crop after wheat, maize and rice. Barley belongs to the family poaceae with chromosome number 2n=2x=14 Barley is considered as most cosmopolitan of the crops, grown over the wide environmental range as well as it has been considered, as poor man's crop because of its low input requirement and better adaptability to harsh environments, like drought, salinity and alkalinity and marginal lands. Owing to its hardiness, in many countries around the world, it is often considered the only possible rainfed cereal crop under low input and stressful environments.
The development of new high yielding varieties requires knowledge of the existing variability. The variability in plant population is the first need for genetic improvement in any crop. The amount of variability for improving economic characters in the germplasm of any crop sets the limit of progress that can be achieved through selection. The extent of variability is measured by GCV and PCV which provides information about relative amount of variation in different characters. Heritability provides sufficient indication about the cause or complexity of improvement in a character in any breeding programme. Development of a plant breeding strategy hinges mainly on the support provided by genetic information on the inheritance and behaviour of major quantitative characters associated with the yield or any other economic trait of concern to the plant breeder.

Material and Method
The germplasm of 30 genotypes was studied at Research Farm of College of Agriculture, Beechwal, Bikaner during *rabi* season 2012-13. Genotypes were obtained from Agriculture Research Station Durgapura, Jaipur, which were differing in growth and morphological characters. The experiment was laid out in Randomized Block Design with three replications. Each genotype was sown in double row with spaced apart at 23 x 10 cm in a plot of 4x3 m size. The genotypes were evaluated in two environments i.e. (i) normal moisture condition and (ii) limited moisture condition.

(i) Normal moisture condition: All the standard agricultural practices were followed to raise the good and healthy crop in normal environment.

(ii) Limited moisture condition: One irrigation was given at the time of sowing and two life-saving irrigations were given after 30 days of sowing and after 80 days of sowing. After that no irrigation was given.

The sample size consisted of five plants, selected randomly from each plot in both environments. The observations on different characters plant height, number of effective tillers per plant, spike length, number of spikelet per spike, test weight, seed yield per plant, biological yield per plant, harvest index, Membrane stability index, Relative water content and chlorophyll content except days to 50%flowering, days to maturity were recorded on the basis of five selected plants and averaged to obtain the mean.

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated as per formula suggested by Burton (1952) [3] and Johanson *et al*. (1955) [5]. Heritability was estimated by the formula as suggested by Johanson *et al*. (1955) [5]. The expected genetic advance at 5% selection intensity was calculated by formula as given by Lush (1940) [6] and Johanson *et al*. (1955) [5].

Results and Discussion

The analysis of variance revealed that significant variability was present in the genotypes for all the characters under normal and limited moisture condition and this was also revealed on pooled analysis basis. This suggested that the material had adequate variability and response to selection may be accepted in the breeding programme for seed yield or any of its supporting characters. The estimates of GCV, PCV, h2 and GA% of mean for characters have been given in Table 1 and Table 2 for normal and limited moisture condition respectively.

Table 1: Estimates of genetic parameters of variation for the observed characters in barley under normal moisture condition

Characters	Mean	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Heritability (%)	Genetic Advance	G.A. as % of mean
					Genotypic	Phenotypic			
Days to 50% flowering	80.73	74-89.67	17.73	21.17	5.22	5.70	83.72	7.94	9.83
Days to maturity	120.93	107-127.33	16.81	21.55	3.39	3.84	78.02	7.46	6.17
Plant height (cm)	75.61	44.03-117.23	256.23	292.85	21.17	22.63	87.49	30.84	40.79
No. of effective tillers per plant	10.57	6.33-15.63	6.86	7.92	24.78	26.63	86.60	5.02	47.50
Spike length (cm)	8.11	6.2-11.73	2.94	3.21	21.12	22.10	91.32	3.37	41.58
Number of spikelets per spike	16.36	12.3-23.33	5.68	6.78	14.56	15.91	83.77	4.49	27.46
Test weight (g)	29.83	24.48-36.5	9.10	11.57	10.11	11.40	78.68	5.51	18.48
Biological yield per plant (g)	50.42	32.38-79.59	122.19	133.11	21.93	22.88	91.79	21.82	43.27
Harvest index (%)	41.23	30.29-58.89	26.98	42.60	12.60	15.83	63.35	8.52	20.66
Relative water content (%)	71.34	33.57-71.3	127.63	144.92	20.75	22.11	88.07	21.84	40.12
Membrane stability index	54.44	60.38-84.11	31.07	36.27	7.81	8.44	85.66	10.63	14.90
Chlorophyll content (mg/g)	2.55	2.21-2.81	0.02	0.04	6.09	7.77	61.43	0.25	9.84
Seed yield per plant (g)	20.53	14.06-31.04	18.71	21.62	21.07	22.65	86.53	8.29	40.37

Table 2: Estimates of genetic parameters of variation for the observed characters in barley under limited moisture condition

Characters	Mean	Range	Genotypic variance	Phenotypic variance	Coefficient of variance		Heritability (%)	Genetic Advance	G.A. as % of mean
					Genotypic	Phenotypic			
Days to 50% flowering	80.02	73.67-87	16.27	17.65	5.04	5.25	92.15	7.98	9.97
Days to maturity	112.34	104-121.33	16.77	18.83	3.64	3.86	89.05	7.96	7.09
Plant height (cm)	74.62	51.6-107.03	229.08	249.85	20.28	21.18	91.69	29.86	40.01
No. of effective tillers per plant	8.41	5.73-11.87	3.85	4.06	23.34	23.97	94.82	3.94	46.83
Spike length (cm)	6.93	5.37-10.53	2.05	2.21	20.68	21.46	92.81	2.84	41.04
Number of spikelets per spike	13.68	10.6-18.5	3.10	4.71	12.88	15.86	65.95	2.95	21.54
Test weight (g)	27.30	21.3-36.2	12.37	14.54	12.88	13.97	85.05	6.68	24.47
Biological yield per plant (g)	44.92	28.99-67.58	86.00	90.45	20.65	21.17	95.08	18.63	41.47
Harvest index (%)	41.78	31.47-63.29	54.09	69.71	17.60	19.99	77.59	13.34	31.94
Relative water content (%)	66.94	32.6-69.5	128.28	139.52	21.77	22.70	91.94	22.37	43.00
Membrane stability index	52.03	55.96-79.5	32.57	43.65	8.53	9.87	74.62	10.16	15.17
Chlorophyll content (mg/g)	2.49	2.2-2.71	0.02	0.03	5.39	7.08	57.92	0.21	8.45
Seed yield per plant (g)	18.54	11.52-27.69	16.16	18.61	21.68	23.26	86.84	7.72	41.62

Coefficient of variation

The estimates of coefficient of variations were in general higher in normal environments than in stress environment. In both environments high estimates of variation were observed for plant height, number of effective tillers per plant, spike length, biological yield per plant, relative water content and seed yield per plant, it indicates the existence of enormous inherent variability that remains unaltered by environmental conditions among the genotypes, which is more useful for exploitation in selection and hybridization programs. Moderate GCV and PCV were observed for number of spikelets per spike, test weight and harvest index. Low GCV and PCV were observed for days to 50% flowering, days to maturity, membrane stability index and chlorophyll content in

both the conditions, which indicated that selection might not be effective for these characters.

Heritability and genetic advance as percentage of mean

The heritability estimates along with the genetic advance are more meaningful. Estimates of heritability serves as a useful guide to the breeder. Broad sense heritability was observed to be high for days to 50% flowering, plant height, number of effective tillers per plant, spike length, test weight, biological yield per plant, relative water content and seed yield per plant in both the environments, in normal environment number of spikelets per spike and membrane stability index had high heritability but in stress environment, they show moderate heritability. Days to maturity showed high heritability in stress environment.

High heritability estimates for grain yield, number of kernels per main spike, plant height and thousand kernel weight indicate a high response to selection in these traits (Shadakshari *et al*., 1995 [10]; Shan and Mishra, 1995) [11] and this results were also reported by (Sachan and Singh, 2003 [9]; Siddique *et al*. 2006 [13]; Ali *et al*., 2008 [2]; Adewale *et al*., 2010 [1]; Rahim *et al*., 2010 [7]; Riaz-Ud-Din *et al*., 2010) [8] which support the present findings.

In the present investigation, genetic advance (% of mean) was also estimated in order to determine the relative merits of different characters that can be further utilized in the selection programmer. Relative comparison of heritability along with genetic advance (% of mean) over the characters indicated that characters viz. plant height, number of effective tillers per plant, spike length, biological yield per plant, relative water content and seed yield per plant had high heritability estimates along with high genetic advance (% of mean) in both the environment.

High heritability accompanied with high genetic advance as percent of the mean in case of plant height, number of effective tillers per plant, spike length, biological yield per plant, relative water content and seed yield per plant in both the environments indicate that these are simply inherited traits and most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. Similar findings have been reported by some authors (Dwivedi *et al*., 2002 [4]; Sharma and Garg, 2002 [12]; Ali *et al*., 2008) [2]. However, maturity date, heading date, number of tillers per plant and harvest index had high heritability coupled with low genetic advance indicates non-additive gene effects.

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