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# Genetic Divergence in Barley (*Hordeum vulgare* L.) under Normal and Limited Moisture Stress Conditions

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**A B S T R A C T**

Genetic divergence of thirty genotypes of barley (*Hordeum vulgare* L.) was assessed under normal and limited moisture conditions using Mahalanobis's $D^2$ statistics (Mahalanobis, 1936). It was revealed that thirty genotypes were grouped into seven clusters in both the environments. Under normal condition spike length, membrane stability index, relative water content and test weight contributed maximum towards total genetic divergence. Under limited moisture condition membrane stability index number of effective tillers per plant and biological yield per plant contributed maximum towards total genetic divergence. It is suggested that crossing between genotypes of clusters II and IV for normal environment and clusters II and III for limited moisture condition might provide good chance for transgressive segregates in the segregating generations and may end in some promising genotypes.

## Introduction

Barley (*Hordeum vulgare* L.) has been known as one of the ancient crops and used for animal feed and human food in the world (Nevo, 1992). Since ancient times, the importance of barley (Cossani *et al.*, 2009), barley has wide adaptation ability to different climatic conditions and various environments comprising drought and irrigated environments. Importance of barley production is tremendously increasing with increasing need to feed animal production and industrial purpose (Sayre *et al.*, 1997; Jayahar, 2012).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 knowledge of nature and degree of divergence at inter and intra allelic level is very useful in understanding the course of evaluation of varieties and also selecting desirable parents for breeding programme. The more genetic diverse parents, greater are the chances of obtaining higher heterotic expression in $F_1$ and broad spectrum of variability in the segregating population. To estimate the degree of divergence between biological populations at genotypic level and to assess the relative contribution of different characters to the total divergence, multivariate analysis by means of Mahalanobis's $D^2$ statistic has been used as a powerful tool. This analysis provides the basis for grouping the germplasm collection into different more or

less homogenous groups and therefore helpful in reducing the size of germplasm collection to be evaluated. Present study was conducted to determine the genetic divergence among thirty genotypes of barley under normal and limited moisture conditions.

## Materials and Methods

The germplasm of thirty 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.

### Normal moisture condition

All the standard agricultural practices were followed to raise the good and healthy crop in normal environment.

### Limited moisture condition

One irrigation was given at the time of sowing and two life saving irrigations was given after 30 days of sowing and after 80 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 spikelets 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 genetic divergence was estimated by Mahalanobis $D^2$ statistic as suggested by (Rao, 1952). A method suggested by (Rao, 1952) for grouping the different genotypes into clusters was used.

## Results and Discussion

Multivariate analysis based on Mahalanobis $D^2$ statistic revealed that 30 genotypes were grouped into seven clusters in both the environments (Tables 1 and 2). This suggested the presence of high degree of divergence in the material studied. Under normal condition maximum numbers of genotypes were 18 which were included in the cluster I. Cluster II had 7 genotypes and cluster III, IV, V, V and VII had 1,1,1,1 and 1 genotype each, respectively. Under limited moisture condition maximum numbers of genotypes were 23 which were included in the cluster I. Cluster II had 2 genotypes and cluster III, IV, V, V and VII had 1,1,1,1 and 1 genotypes, respectively.

Contribution of individual character towards total divergence was calculated for both the environments as per the method given by (Singh *et al.*, 1977) and has been presented in Tables 3 and 4. Under normal condition this relative contribution of various characters indicated that the spike length (15.17%) contributed highest towards total divergence which was followed by membrane stability index (12.64 %), relative water content (12.18 %) and test weight (9.89 %). Thus, these characters are important and should be considered while selecting genetically diverse genotypes.

Under limited moisture condition this relative contribution of various characters indicated that the membrane stability index (21.84%) contributed highest towards total divergence which was followed by number of effective tillers per plant (21.38%), biological yield per plant (12.41%). Thus, these characters are

important and should be considered while selecting genetically diverse genotypes. The intra and inter cluster values among the six clusters are presented in tables 7 and 8 for normal and limited moisture environment respectively. Average intra cluster $D^2$ value under normal condition ranged from (0.00 to 6.68). Under normal condition the maximum inter cluster distance (12.56) was observed between II and IV while the lowest (6.48) between V and VI. Average intra cluster $D^2$ value under limited moisture condition ranged from (0.00 to 8.20). Under limited moisture condition minimum average inter cluster $D^2$ values (6.48) was recorded between cluster V and cluster VI. The maximum average inter cluster $D^2$ values (12.56) was recorded between cluster II and cluster IV (Tiwari, 1975) also deduced the same conclusion in barley.

**Table.1** Composition of clusters under normal moisture condition

| Clusters | Number of genotypes | Composition of cluster |
|---|---|---|
| I | 18 | RD-2786, RD-2816, RD-2624, JYOTI, RD-2834, RD-2820, RD-2808, RD-2592, RD-2787, RD-2846, RD-2855, RD-2845, RD-2052, RD-2503, PL-711, RD-2808, RD-2850, RD-2839 |
| II | 7 | RD-2660, RAJKIRAN, RD-2550, RD-2794, RD-2715, RD-2668, RD-2847 |
| III | 1 | RD-2840 |
| IV | 1 | RD-2784 |
| V | 1 | RD-2835 |
| VI | 1 | RD-2508 |
| VII | 1 | RD-2035 |

**Table.2** Composition of clusters under limited moisture condition

| Clusters | Number of genotypes | Composition of cluster |
|---|---|---|
| I | 23 | RD-2592, RD-2808, RD-2550, RD-2715, RD-2786, RD-2794, RD-2855, JYOTI, PL-711, RD-2503, RD-2850, RD-2808, RD-2839, RD-2845, RD-2846, RD-2820, RD-2847, RD-2787, RD-2668, RD-2835, RD-2784, RD-2840, RD-2834 |
| II | 2 | RD-2660, RAJKIRAN |
| III | 1 | RD-2052 |
| IV | 1 | RD-2816 |
| V | 1 | RD-2508 |
| VI | 1 | RD-2624 |
| VII | 1 | RD-2035 |

**Table.3** Contribution of different characters towards total divergence under normal moisture condition

| Characters | Number of times appearing in first ranking | Per cent contribution |
|---|---|---|
| **Days to 50% flowering** | 36 | 8.28 |
| Days to maturity | 29 | 6.67 |
| Plant height (cm) | 14 | 3.22 |
| No. of effective tillers per plant | 27 | .21 |
| Spike length | 66 | 15.17 |
| Number of spikelets per spike | 23 | 5.29 |
| Test weight | 43 | 9.89 |
| Biological yield per plant | 35 | 8.05 |
| Harvest index (%) | 1 | 0.23 |
| Relative water content (%) | 53 | 12.18 |
| Membrane stability index | 55 | 12.64 |
| Chlorophyll content (mg/g) | 22 | 5.0 |
| Seed yield per plant (g) | 31 | 7.13 |

**Table.4** Contribution of different characters towards total divergence under normal moisture condition

| Characters | Number of times appearing in first ranking | Per cent contribution |
|---|---|---|
| **Days to 50% flowering** | 41 | 9.43 |
| Days to maturity | 13 | 2.99 |
| Plant height (cm) | 25 | 5.75 |
| No. of effective tillers per plant | 93 | 21.38 |
| Spike length | 35 | 8.05 |
| Number of spikelets per spike | 0 | 0.00 |
| Test weight | 5 | 1.15 |
| Biological yield per plant | 54 | 12.41 |
| Harvest index (%) | 1 | 0.23 |
| Relative water content (%) | 4 | 0.92 |
| Membrane stability index | 95 | 21.84 |
| Chlorophyll content (mg/g) | 33 | 7.59 |
| Seed yield per plant (g) | 36 | 8.28 |

**Table.5** Mean values for yield and its components in various clusters under normal moisture condition

| **Clusters** | **Days to 50% flowering** | **Days to maturity** | **Plant height (cm)** | **No. of effective tillers per plant** | **Spike length (cm)** | **Number of spikelets per spike** | **Test weight (g)** | **Biological yield per plant (g)** | **Harvest index (%)** | **Relative water content (%)** | **Membrane stability index** | **Chlorophyll content (mg/g)** | **Seed yield per plant (g)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 79.30 | 120.44 | 67.67 | 10.26 | 7.43 | 15.25 | 28.30 | 45.68 | 39.79 | 71.27 | 52.22 | 2.52 | 17.99 |
| II | 80.76 | 121.90 | 98.80 | 12.40 | 9.27 | 19.23 | 33.40 | 65.01 | 42.66 | 68.86 | 62.80 | 2.63 | 27.43 |
| III | 89.67 | 125.33 | 76.90 | 7.17 | 6.63 | 17.03 | 32.54 | 62.13 | 35.81 | 71.59 | 33.57 | 2.36 | 21.94 |
| IV | 85.67 | 125.67 | 60.63 | 9.03 | 6.33 | 13.23 | 26.10 | 32.38 | 58.59 | 68.42 | 57.40 | 2.52 | 19.07 |
| V | 88.00 | 125.33 | 68.57 | 12.57 | 10.50 | 17.43 | 28.84 | 47.08 | 41.05 | 78.60 | 664.50 | 2.79 | 19.34 |
| VI | 83.67 | 107.00 | 79.87 | 9.57 | 9.60 | 16.53 | 33.19 | 53.92 | 38.32 | 74.34 | 60.20 | 2.35 | 20.67 |
| VII | 82.33 | 123.33 | 72.77 | 7.20 | 11.73 | 17.57 | 30.96 | 39.66 | 48.11 | 82.52 | 37.87 | 2.75 | 19.03 |

**Table.6** Mean values for yield and its components in various clusters under limited moisture condition

| Clusters | Days to 50% flowering | Days to maturity | Plant height (cm) | No. of effective tillers per plant | Spike length (cm) | Number of spikelets per spike | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Relative water content (%) | Membrane stability index | Chlorophyll content (mg/g) | Seed yield per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 80.36 | 113.17 | 70.76 | 8.41 | 6.50 | 13.28 | 26.25 | 43.06 | 40.63 | 66.14 | 53.27 | 2.48 | 17.29 |
| II | 80.50 | 108.33 | 104.00 | 11.48 | 9.3 | 16.07 | 35.55 | 67.56 | 40.33 | 65.14 | 67.55 | 2.63 | 27.18 |
| III | 85.00 | 113.67 | 91.80 | 5.73 | 5.90 | 12.43 | 28.10 | 39.08 | 34.27 | 72.10 | 35.20 | 2.60 | 13.39 |
| IV | 73.67 | 109.33 | 83.43 | 6.63 | 5.37 | 10.60 | 30.85 | 50.06 | 47.39 | 55.96 | 35.30 | 2.49 | 23.73 |
| V | 73.67 | 104.00 | 95.93 | 10.23 | 9.17 | 17.60 | 30.50 | 41.53 | 55.19 | 72.60 | 55.30 | 2.30 | 22.94 |
| VI | 78.00 | 106.00 | 53.07 | 7.40 | 9.13 | 16.40 | 26.59 | 54.00 | 37.90 | 75.60 | 35.30 | 2.36 | 20.48 |
| VII | 81.00 | 117.67 | 78.77 | 5.90 | 9.73 | 15.77 | 28.10 | 37.23 | 63.30 | 79.60 | 39.60 | 2.64 | 23.59 |

**Table.7** Average intra (in bold) and inter cluster $D_2$ value under normal moisture condition

| Clusters | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|
| I | **6.01** | 9.74 | 7.44 | 7.32 | 7.59 | 8.82 | 9.30 |
| II | | **6.68** | 8.38 | 12.56 | 8.42 | 8.63 | 11.48 |
| III | | | **0.00** | 9.38 | 7.74 | 7.40 | 9.25 |
| IV | | | | **0.00** | 9.42 | 11.25 | 9.81 |
| V | | | | | **0.00** | 6.48 | 6.64 |
| VI | | | | | | **0.00** | 9.47 |
| VII | | | | | | | **0.00** |

**Table.8** Average intra (in bold) and inter cluster $D_2$ value under limited moisture condition

| Clusters | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|
| I | **8.20** | 14.30 | 9.35 | 10.25 | 11.46 | 10.15 | 11.75 |
| II | | **4.80** | 18.59 | 15.23 | 10.72 | 12.52 | 18.29 |
| III | | | **0.00** | 11.15 | 14.12 | 12.77 | 9.41 |
| IV | | | | **0.00** | 13.19 | 10.74 | 15.00 |
| V | | | | | **0.00** | 10.72 | 12.23 |
| VI | | | | | | **0.00** | 12.03 |
| VII | | | | | | | **0.00** |

The table revealed that the inter cluster distance was larger than the intra cluster distance which suggested wider diversity among the genotypes of different groups. Cluster with small statistical distances considered less diverse than those with larger distances.

The genetic differences between the clusters were reflected in the cluster means. A comparison of cluster means for the various characters is presented in tables 5 and 6 for both the environments. The comparison indicated that under normal condition cluster II with 7 genotypes had the highest mean values for seed yield per plant, biological yield per plant, test weight and plant height (98.80 cm). Under limited condition cluster II with 2 genotypes had the highest mean values for seed yield per plant, biological yield per plant, test weight, plant height, number of effective tillers per plant and membrane stability index.

The mean values of the different cluster indicating the utility of divergence analysis in identifying useful parents for hybridization. In selection of the parent for hybridization, genetic divergence of both genotypes should be taken into account.

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