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ANALYSIS OF GENETIC DIVERGENCE FOR GRAIN YIELD AND ITS CONTRIBUTING TRAITS IN BARLEY (*Hordeum vulgare* L.)

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ABSTRACT

Thirty-six barley [*Hordeum vulgare* L.] genotype was evaluated at the Agricultural Research Station, Ummedganj, Kota, during *Rabi* season 2025-2026 in alpha lattice design with two replications to analysis of genetic divergence for grain yield and its contributing traits in barley (*Hordeum vulgare* L.) analysis grouped the 36 genotypes into six distict clusters by Tocher's method using Mahalanobis' D^2 analysis. with Cluster I was the largest cluster (16 genotypes) and Cluster II (11 genotypes) , and III clusters consisted three genotypes, followed by IV, V and VI each contained by two genotypes, The inter-cluster distances also showed considerable variation among the clusters. The maximum inter-cluster distance was observed between Cluster III and Cluster V (544.46), followed by Cluster I and Cluster III (616.11), Cluster I and Cluster VI (524.50), Cluster III and Cluster VI (354.65), Cluster II and Cluster IV (307.98) and Cluster II and Cluster VI (294.74). The minimum inter-cluster distance was recorded between Cluster II and Cluster V (235.00).

***Key words*:** Genetic divergence, inter-cluster distance and Mahalanobis' D^2 analysis.

Introduction

Barley (*Hordeum vulgare* L.) is one of the earliest domesticated cereal crops. It was domesticated approximately 10,000 years ago from its two-rowed wild ancestor (*Hordeum vulgare ssp. spontaneum*) in the Middle East region known as the fertile crescent (Badr *et al.*, 2000) and There are approximately 38 Egyptian barley cultivars—two- and six-rowed—but the six-rowed barleys are the most famous and widely used in Egypt (Najafi *et al.*, 2012) Barley is an important cereal crop widely used as animal feed. Naked barley is particularly valuable because it contains higher protein and digestible energy than covered barley. The absence of hull reduces insoluble fibre and improves its feed value. It has been successfully used in diets for pigs, poultry and cattle. Naked barley can provide an efficient source of energy for livestock. It has also shown potential as a suitable feed for high-producing lactating cattle. Its favorable nutritional composition makes it an important alternative feed grain. Thus, naked barley has considerable potential for livestock feeding (Meints *et al.*, 2021). The grain contains approximately 80% carbohydrates, while protein constitutes about 11.5–14.2%, lipids 4.7–6.8%, β-glucans 3.7–7.7%, and ash 1.8–2.4%. Barley also contains biologically active phenolic compounds, with total phenolic concentrations reported in the range of approximately 1.2–2.9 mg GAE/g. (Kaur *et al.*, 2024). Mahalanobis' (1928) D^2 statistic is a tool for measuring genetic divergence among populations and assessment of genetic diversity was suggest by Rao (1952). It calculates the distance between groups using multiple traits, giving a numerical estimate of genetic differences. In plant breeding, this method is useful for identifying genetically diverse parents to enhance variability in the offspring.

Materials and Methods

The material for the present investigation consisted of thirty-six diverse genotype of Barley (*Hordeum vulgare* L.), which were selected based on genetic diversity and Those genotype obtained from AICRP on wheat and barley. The experiment was conducted under the All India Coordinated Project on wheat and barley at Agricultural Research Station, Ummedganj, Kota.

Experiment were evaluated during *rabi* 2025-26 alpha lattice design (ALD) with two replications during *rabi* 2025- 2026 and Each genotype comprised of 6 rows of 5-meter length and spaced at 22.5 cm between rows, while plant to plant distance was 10 cm. The observations were recorded on five randomly selected plants per plot for 11 observation Plant height (cm), Effective tiller per plant, Spike length (cm), Number of grains per spike, Grain weight per spike (g), Test weight (g), Grain yield per plant (g), Biological yield per plant (g), Harvest index (%) except Days to 75% heading and Days to maturity

The detailed procedures adopted for taking observation were mentioned below: -

- **Days to 75% heading:** The number of days taken from the date of sowing to the day on which 75% of the plants in a genotype showed emergence of spike (heading) was recorded as days to 75% heading.
- **Days to maturity:** The number of days taken from the date of sowing to the date when plants reached physiological maturity was recorded as days to maturity.
- **Plant height (cm):** Plant height was measured in centimeters from the ground level to the tip of the main spike (excluding awns) at the time of maturity.

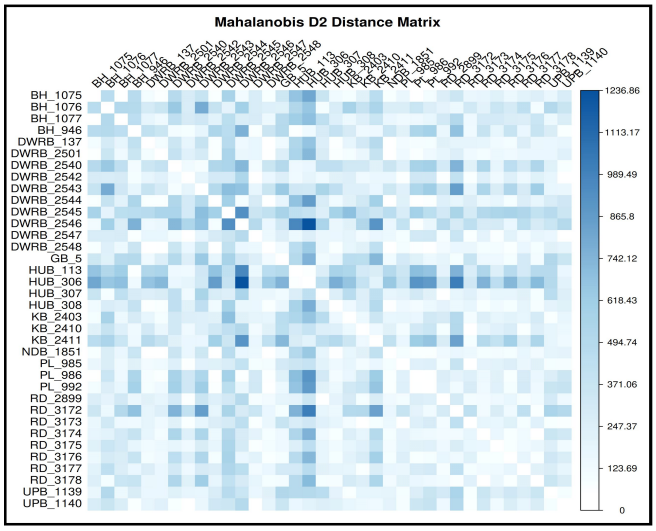


Fig. 1: Diagrammatic representation of mahalanobis D^2 distance matrix.

Table 1: Distribution of barley genotypes into different clusters.

Cluster	No. of Genotypes	Genotypes
Cluster 1	16	NDB 1851, DWRB 2548, DWRB 137, DWRB 2544, DWRB 2501, PL 986, BH 1075, PL 992, HUB 308, RD 3176, RD 3174, RD 3178, RD 3175, GB 5, RD 3172, DWRB 2546
Cluster 2	11	UPB 1140, DWRB 2547, DWRB 2542, RD 3173, PL 985, RD 2899, KB 2410, RD 3177, BH 946, KB 2411, UPB 1139
Cluster 3	3	HUB 306, HUB 113, DWRB 2540
Cluster 4	2	HUB 307, BH 1076
Cluster 5	2	KB 2403, BH 1077
Cluster 6	2	DWRB 2545, DWRB 2543

- **Effective tillers per plant:** The number of productive tillers bearing spikes in each selected plant was counted at the time of maturity and recorded as effective tillers per plant.
- **Spike length (cm):** Spike length was measured in centimeters from the base of the spike to its tip (excluding awns) from each selected plant.
- **Number of grains per spike:** The total number of grains present in each spike was counted from randomly selected spikes of each plant and the average was recorded as number of grains per spike.
- **Grain weight per spike (g):** The grains obtained from each selected spike were weighed in grams and recorded as grain weight per spike.
- **Test weight (g):** The weight of 1000 grains taken from the produce of selected plants was recorded in grams and expressed as test weight.

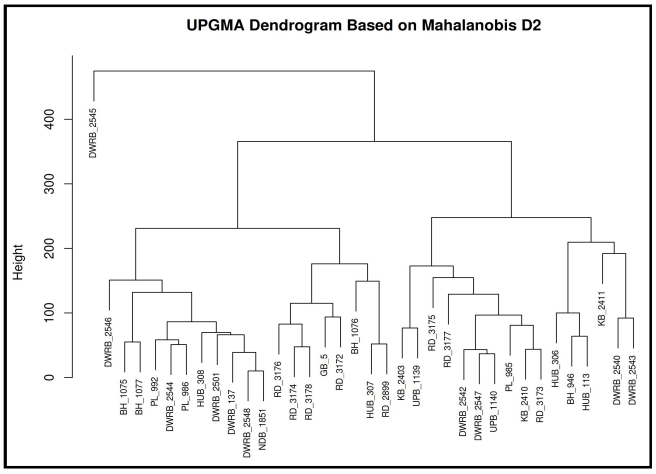


Fig. 2: Dendrogram clustering pattern for 36 genotypes of barley.

Table 2: Average intra and inter-cluster distances based on corresponding D^2 values.

	C I	C II	C III	C IV	C V	C VI
C (I)	133.39	302.93	616.11	271.09	240.11	524.50
C (II)		130.11	254.87	307.98	235.00	294.74
C (III)			124.43	489.68	544.46	354.65
C (IV)				95.42	498.22	451.70
C (V)					151.47	428.23
C (VI)						704.34

C = Cluster

- **Grain yield per plant (g):** The spikes from each selected plant were harvested, threshed and the grains obtained were weighed in grams to record grain yield per plant.
- **Biological yield per plant (g):** Each selected plant was harvested separately and the total dry weight of the plant (excluding roots) was recorded in grams as biological yield per plant.
- **Harvest index (%):** index was calculated by using the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield (g)}}{\text{Biological yield per plant (g)}} \times 100$$

Result and Discussion

Cluster constellation

The thirty-six barley genotypes were grouped into six distinct clusters based on their genetic divergence represented in Cluster I was the largest cluster, comprising 16 genotypes, followed by Cluster II with 11 genotypes. Cluster III consisted of three genotypes, whereas Clusters IV, V and VI each contained two genotypes

Inter and intra-cluster distance

The intra-cluster distances ranged from 95.42 in Cluster IV to 151.47 in Cluster V, indicating varying degrees of genetic divergence among genotypes within individual clusters. The highest intra-cluster distance was recorded in Cluster V (151.47), followed by Cluster I (133.39), Cluster II (130.11), Cluster III (124.43) and Cluster IV (95.42). Cluster VI recorded an intra-cluster distance of 704.34 as presented in the table.

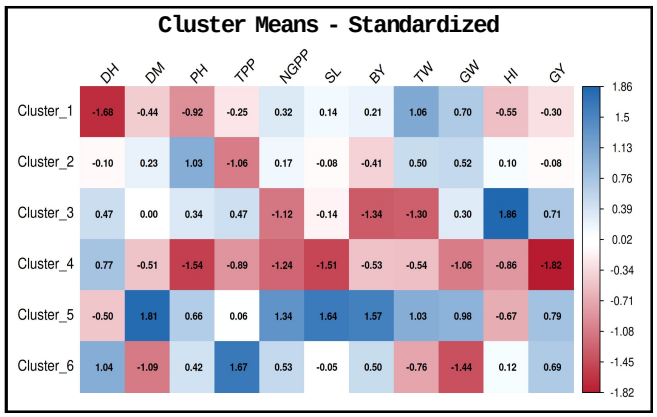


Fig. 3: Diagrammatic representation of Clusters means of grain yield per plant and its related traits for 36 genotypes of barley.

The inter-cluster distances also showed considerable variation among the clusters. The maximum inter-cluster distance was observed between Cluster III and Cluster V (544.46), followed by Cluster I and Cluster III (616.11), Cluster I and Cluster VI (524.50), Cluster III and Cluster VI (354.65), Cluster II and Cluster IV (307.98) and Cluster II and Cluster VI (294.74). The minimum inter-cluster distance was recorded between Cluster II and Cluster V (235.00).

The cluster means value of elven character of six cluster are below in table-3. Considerable variation was observed among the six clusters for all the traits studied. The mean values for days to 75% heading ranged from 67.41 days (Cluster I) to 79.75 days (Cluster VI), while days to maturity varied from 110.75 days (Cluster VI) to 114.50 days (Cluster V). Plant height ranged from 89.36 cm (Cluster IV) to 116.74 cm (Cluster II), and effective tillers per plant varied from 5.66 (Cluster II) to 8.63 (Cluster VI). Number of grains per spike ranged from 50.43 (Cluster IV) to 70.67 (Cluster V), whereas spike length varied from 16.23 cm (Cluster IV) to 18.22 cm (Cluster V). Biological yield per plant ranged from 20.18 g (Cluster III) to 40.60 g (Cluster V), while test weight

Table 3: Clusters mean of seed yield and its related traits for thirty six genotypes of barley.

Clusters	DH	DM	PH	ETP	GS	SL	BYP	TW	GWS	HI	GYP
Cluster I	67.41	111.59	95.995	6.54	62.66	17.28	31.05	42.85	3.34	36.74	11.36
Cluster II	74.59	112.46	116.74	5.66	61.44	17.13	26.73	41.25	3.28	44.59	11.79
Cluster III	77.17	112.17	109.38	7.32	51.38	17.1	20.18	36.1	3.21	66.13	13.36
Cluster IV	78.5	111.5	89.363	5.85	50.43	16.23	25.84	38.26	2.75	32.9	8.345
Cluster V	72.75	114.5	112.82	6.88	70.67	18.22	40.6	42.76	3.44	35.21	13.53
Cluster VI	79.75	110.75	110.28	8.63	64.28	17.15	33.09	37.64	2.62	44.91	13.33

DH: Days to 75% heading; DM: Days to maturity; PH: Plant height (cm); ETP: Effective tillers/plant; GS: Grains/spike; SL: Spike length (cm); BYP: Biological yield/plant; TW: Test weight (g); GWS: Grain weight/spike (g); HI: Harvest index (%); GYP: Grain yield/plant (g)

Table 4: Contribution of different characters towards genetic divergence.

S.No.	Character	Contribution (%)
1	Days to 75% heading	7.14
2	Days to maturity	9.84
3	Plant height	10.48
4	Effective tillers/plant	8.25
5	Number of Grains/spike	12.54
6	Spike length	11.27
7	Biological yield/plant	7.14
8	Test weight	8.25
9	Grain weight/spike	8.57
10	Harvest index	9.21
11	Grain yield/plant	7.30

varied from 36.10 g (Cluster III) to 42.85 g (Cluster I). Grain weight per spike ranged from 2.62 g (Cluster VI) to 3.44 g (Cluster V), and harvest index varied from 32.90% (Cluster IV) to 66.13% (Cluster III). Grain yield per plant ranged from 8.35 g (Cluster IV) to 13.53 g (Cluster V), with Cluster V showing the highest mean, followed by Cluster III (13.36 g) and Cluster VI (13.33 g). Overall, Cluster V exhibited superior performance for grain yield per plant, associated with higher means for number of grains per spike, spike length, biological yield per plant and grain weight per spike. Jalata *et al.*, (2020), Andersen *et al.*, (2016), Yadav *et al.*, (2018), Naresh *et al.*, (2023), Kaur *et al.*, (2019), Xhulaj *et al.*, (2018), Kumar *et al.*, (2018), Yadav *et al.*, (2024), Kumar *et al.*, (2021) and Devi (2019).

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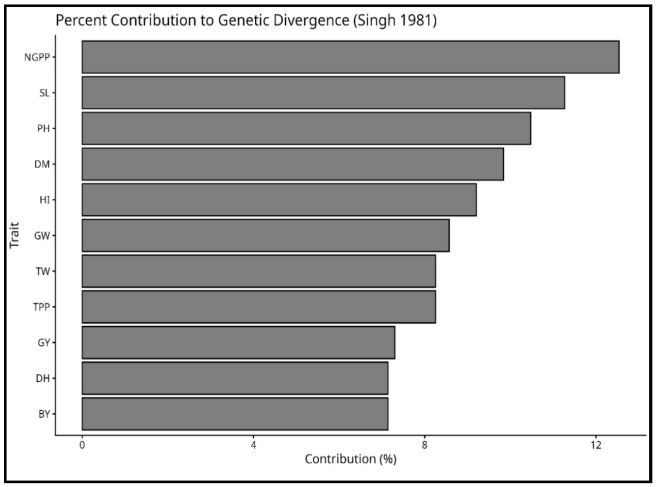


Fig. 4: Diagrammatic representation of the contribution of different characters towards genetic divergence.

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