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Evaluation of barley (*Hordeum vulgare* L.) genotypes for yield and yield attributing traits in Vindhyan Region of Uttar Pradesh

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Abstract

The present study at Field Experimentation Centre, Department of Genetics, SHUATS, Prayagraj during *Rabi* season of 2023-24 evaluated 20 Barley genotypes, including one check variety, for genetic variability, heritability, genetic advance and correlation. Twenty-three quantitative traits were analyzed, showing significant variation among genotypes. The highest yielding genotypes per plant in six row barley are IBT-51 (1.86 t), IBT-2 (1.80 t), IBT-31 (1.79 t), IBT-52 (1.73 t), IBT-25 (1.71 t), The highest yielded genotypes in two row barley among 6 genotypes are IBT-47 (1.48 t), IBT-20 (1.31 t), IBT-79 (1.31 t), IBT-72 (1.01 t), IBT-69 (0.99 t). The genotypic coefficient of variation was higher than the phenotypic coefficient of variation, with minimal differences between the two. GCV (%) values ranged between least of 0.70 (days to maturity) to a highest value of 32.74 (Grains per spike). PCV (%) followed a similar pattern had a range of 0.90 (days to maturity) to 32.84 (Grains per spike). The genotypic correlation coefficients for nearly all features surpassed the corresponding phenotypic correlation coefficients.

Key words: Barley genotypes, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PVC), Correlation.

Introduction

Barley (*Hordeum vulgare* L.) symbolizes our ancient agricultural heritage, having been domesticated around 10,000 years ago in the Fertile Crescent. It was one of the first grains cultivated by humans. Its genetic diversity has influenced civilizations and nourished generations, from the fertile soils of Abyssinia to the high plateaus of Tibet. Barley thrives in various climates, from subarctic regions to subtropical lands, and is known as the "poor man's crop" due to its drought resistance, making it a resilient choice for marginal lands. Its two primary varieties, six-row and two-row, serve diverse purposes: animal feed, malting, and direct human consumption. Barley is more than just sustenance; it's a functional food rich in carbohydrates, protein, and micronutrients, aiding digestion, boosting immunity, and protecting against heart disease and diabetes. For centuries, it has been a staple in our diets, from hearty stews to frothy pints of beer. Plant breeders aim to enhance grain productivity by selecting high-yield genotypes. Barley's environmental footprint is modest, making it an eco-friendly choice. Efficient selection requires adequate phenotypic variance and high heritability. Correlation helps understand the relationships between yield traits and yield, indicating the relationship's strength and direction (Dewey and Lu, 1959). Studies have been conducted to examine variability, heritability, and potential genetic gains in yield improvement. Additionally, correlation analyses have been used to examine grain yield and its contributing traits in barley. Barley serves as an experimental model crop because of its brief life cycle and notable morphological, physiological, and genetic characteristics. As a result, evaluat-

ing barley genotypes for yield and yield-attributing traits, and estimating genetic variability, has provided valuable insights into their performance and diversity, contributing to a better understanding and potential improvement of the barley crop.

Materials and Methods

The study evaluated twenty genotypes including 1 check variety comprising with six-row as well as Two- row types of barley collected from the ICARDA (BHOPAL). Conducted during the *Rabi* season of 2023-2024 in the Research Experimentation centre, Department of Genetics and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment used a Randomized Block design (RBD). Sown during the November, 25th 2023. In one replication each plot comprised of 6 rows and three-meter length with spacing distance between row-to-row 30cm and plant to plant 10cm (30 × 10) respectively. All the cultural operations were carried to grow the crop effectively. Five representative plants from each plot were randomly marked to record the data for 23 Characters viz., field emergence, plant height at 30, 60, 90DAS, lodging Percentage, flag leaf length, flag leaf breadth, spike length, peduncle length, awns length, number of tillers per plant, canopy temperature at booting stage, canopy temperature at early grain filling stage, canopy temperature at late grain filling stage, days to heading, days to maturity, spikelets per spike, grains per spike, test weight, biomass, grain yield per plant, grain yield per plot and grain yield per hectare. Genetic parameters, including variability, heritability, and genetic advance, were computed following (Johnson *et al.*, (1955). Character association was analyzed using variance and covariance components (Fisher, 1954; Al-Jibouri *et al.*, 1958).

Experimental Material

In experimental material includes 20 genotypes with one check.IBT-38/ASA-12201097, IBT-23/ASA-2200959, IBT-24/ASA-2200351, IBT-25/ASA-2200394, IBT-2/ASA-2201025, IBT-56/FFM-220276, IBT-51/FFM-220974, IBT-47/FFM-220176, IBT-72/FFM-220966, IBT-26/ASA-2200396, IBT-79/FFM-221172, IBT-20/ASA-2200977, IBT-52/FFM-220374, IBT-69/FFM-220807, IBT-40/ASA-2201062, IBT-9/ASA-2200984, IBT-31/ASA-2200346, IBT-75/FFM-221131, IBT-48/FFM-221194, IBT-80/VLB-118 (CHECK)

Results and Discussion

Growth and yield parameters mean performances

Field emergence: Ranged from 43.39% to 88.61% The maximum Field emergence was recorded in IBT-51 (88.61%). The genotype IBT-31 (43.39%) was recorded lowest Field emergence. **Plant height at 30 DAS:** After sowing ranged from 29.69cm to 32.93cm. The maximum Plant height at 30DAS of 32.93cm was observed in the genotype IBT-75 whereas, plant height of 29.69cm was observed minimum in the genotype IBT-31 followed.

Plant height at 60DAS: Ranged from 58.11cm to 84.71cm. The maximum Plant height at 60DAS of 84.71cm was observed in the genotype IBT-38. The plant height of 58.11cm was observed minimum in the genotype IBT-52. The maximum

Plant height at 90DAS: Ranged from 92.59cm to 120.31cm. The maximum Plant height at 90DAS of 120.31cm was observed in the genotype IBT-40, whereas minimum in the genotype IBT-75 92.59cm was observed.

Lodging percentage: Out of 20 genotypes, the maximum Lodging percentage of 94.67% was observed in the genotype IBT-52, whereas the minimum Lodging percentage was observed in genotype IBT-47 (32.33%).

Flag Leaf Length: The maximum Flag Leaf Length of 29.73cm was observed in the genotype IBT-56 followed by IBT-80 (27.36cm), IBT-38 (26.65cm), IBT-26 (26.21cm). The Flag Leaf Length of 16.35cm was observed minimum in the genotype IBT-72 followed by IBT-40 (17.24cm), IBT-47 (17.72cm), IBT-79 (18.09cm).

Flag Leaf Breadth: The mean value of Flag Leaf Breadth ranged from 1.22cm to 2.35cm. The maximum Flag Leaf Breadth of 2.35cm was observed in the genotype IBT-80.

Flag Leaf Length: The maximum Flag Leaf Length is 1.22cm was observed in the genotype IBT-72.

Spike Length: The maximum Spike length is 11.29cm was observed in the IBT- 31 genotype. The significantly minimum Spike length is 7.35 cm were found in the genotype of IBT-52.

Peduncle Length: The maximum Peduncle Length of 35.28cm was observed in the genotype IBT-40 and the Peduncle Length of 25.73 cm was observed minimum in the genotype IBT-52.

Awn Length: The maximum Awn Length was observed in the genotype IBT-80 (18.38 cm) and the minimum Awn Length of 10.47 cm was observed in the genotype IBT-38.

Number of Tillers per plant: The maximum Number of Tillers of 11.67 were observed in the genotype IBT-56 followed by IBT-23 (11.67), IBT-2 (11.40), IBT-25 (11.33). The minimum Number of Tillers per plant in 9.67 was observed in the genotype IBT-69 followed by IBT-72 (9.73), IBT-79 (9.80), IBT-09 (10.13).

Canopy Temperature at Booting Stage: The maximum Canopy Temperature at Booting Stage of 10.94°C was observed in the genotype IBT-80 followed by IBT-26 (10.93), IBT-69 (10.68), IBT-51 (10.51). The Canopy Temperature at Booting Stage of 8.92 was observed in the genotype IBT-09.

Canopy Temperature at Early Grain Filling Stage: The maximum Canopy Temperature at Early Grain Filling Stage of 15.21°C was observed in the genotype IBT-02 and the Canopy Temperature at Early Grain Filling Stage, it was found minimum of 13.77 in the genotype IBT-69.

Canopy Temperature at Late Grain Filling stage: The maximum Canopy Temperature at Late Grain Filling stage of 23.93°C was observed in the genotype IBT-72 and the Canopy Temperature at Late Grain Filling Stage, minimum of 19.89 was observed in the genotype IBT-69 followed by IBT-25 (19.89), IBT-20 (20.49), IBT-75 (20.57).

Days to Heading: The minimum duration of 74.33 Days to Heading was taken by the genotype IBT-56 and genotype IBT-51 took the maximum duration of 78.67 Days for Heading.

Days to Maturity: The minimum number of Days to Maturity was observed in the genotype IBT-47 (118.33 days), followed by IBT-23, IBT-20, IBT-25 which was of 120.67 Days for Maturity. The genotypes with the maximum number of Days to Maturity was 122.67 days for genotype IBT-72.

Number of Spikelets per spike: The maxi-

Table 1. ANOVA and Estimates of components of variance and genetic parameters for 23 characters of barley genotypes during *Rabi*- 2023

Source	FE (%)	Ph@ 30	Ph @60	Ph @90	Lp (%)	Fll (cm)	Flb (cm)	Sl (cm)	Pl (cm)	Al (cm)	Nt/p	Ctbs	Ctegf	Ctlgf	Dh	Dm	Sp/s	G/s	Tw (gm)	Bm (gm)	Gy/p (gm)	Gy/pl (gm)	Gy/ha (t)
Replication	46.781	0.652	845.21	61.549	19.717	38.69	0.22	0.831	8.148	3.286	3.363	0.087	0.029	0.021	2.341	0.817	0.806	5.114	0.397	7,522.41	662.421	16,560.53	1.654
Genotypes	430.031**	2.504**	134.171**	143.013**	1136.473**	42.435**	0.236**	3.288**	19.873**	9.215**	0.518*	0.825**	0.431	3.358**	3.224	2.592**	44.628**	982.865**	127.541**	336.513*	86.114**	2152.861**	0.214**
Error	93.645	0.37	14.377	17.739	4.752	3.199	0.025	0.084	1.228	0.429	0.27	0.198	0.275	0.265	2.673	0.466	0.993	1.929	7.035	174.694	22.022	550.538	0.055
GCV	15.315	2.671	8.825	5.951	25.618	16.631	15.228	10.37	8.188	12.881	2.531	4.536	1.588	4.67	1.30	0.695	19.223	32.74	14.326	6.041	16.166	16.166	16.103
PCV	20.747	3.292	10.292	7.103	25.779	18.554	17.738	10.768	8.96	13.791	5.229	6.325	3.987	5.236	1.46	0.895	19.868	32.837	15.53	12.438	23.038	23.038	22.984
Heritability	54.491	65.813	73.528	70.184	98.756	80.347	73.699	92.734	83.506	87.237	23.431	51.417	15.857	79.548	79.3	60.344	93.611	99.413	85.097	23.592	49.243	49.243	49.086
Gen-Advance	16.102	1.41	11.162	11.152	39.761	6.678	0.469	2.05	4.693	3.293	0.287	0.676	0.187	1.866	1.81	1.347	7.601	37.141	12.044	7.349	6.682	33.408	0.332
Gen-Adv % Means	23.289	4.463	15.589	10.27	52.444	30.71	26.929	20.571	15.413	24.784	2.524	6.7	1.302	8.58	2.38	1.113	38.313	67.247	27.224	6.045	23.37	23.37	23.241

Legends: **FE%- Field emergence, PH@30 - Plant height at 30DAS, PH@60 - Plant height at 60DAS, PH@90 - Plant height at 90DAS, LP(%) - Lodging percentage, FLL- flag leaf length, FLB- Flag leaf length, FLB- Flag leaf breadth, SL- Spike length, PL- Peduncle length, AL- awn length, NT/P- No. of tillers/plant, CT@BS - Canopy temperature at booting stage, CT@EGF - Canopy temperature at Early grain filling stage, CT@LGF - Canopy temperature at Late grain filling stage, DH- days to heading, DM- days to maturity, SP/S- spikelets per spike, G/S- grains per spike, TW - Test weight, BM- Biomass yield, GY/P- grain yield per plant, GY/PL- grain yield per plot, GY/Ha-grain yield per hectare.

mum Number of Spikelets was observed in the genotype IBT-2 (25.07), the minimum Number of Spikelets was 13.67 for genotype IBT-72 followed by IBT-20 (14.07), IBT-79 (14.20), IBT-47 (14.47).

Number of Grains Per Spike: The maximum Number of Grains Per Spike of (77.80) was observed in the genotype IBT-2, followed by IBT-26 (73.13), IBT-48 (72.07), whereas the minimum number of Grains Per Spike of 27.47 was observed for the genotype IBT-72, followed by IBT-79 (28.53), IBT-20 (28.93), IBT-47 (29.07).

Test Weight: The maximum test weight was observed in the genotype IBT- 47 which is recorded (58.37gm), while the minimum test weight was recorded in IBT-56 (35.10 gm), which was least among 20 barley genotypes.

Biomass: The maximum biomass yield was about 150.00gm for the genotype IBT-56gm, whereas the least biomass yield was observed was about 105.67 gm for the genotype IBT-69.

Grain Yield Per Plant: The mean data of 20 genotypes revealed that the six row barley genotypes yielded more than the two row barley genotypes. The highest yielding genotypes per plant in six row barley are IBT-51 (37.25gm), IBT-2 (35.94gm), IBT-31 (35.81gm), IBT-52 (34.53gm), IBT-25 (34.16gm), The highest yielded genotypes in two row barley among 6 genotypes are IBT-47 (29.53gm), IBT-20 (26.29), IBT-79 (26.12gm), IBT-72 (20.27gm), IBT-69 (19.75gm).

Grain Yield Per Plot: The maximum yield of grain yield per plot was obtained in genotype IBT-51 with (186.2 gm), whereas the minimum yield of grain per plot

Table 2(a). Mean performance of 20 barley genotypes for 23 quantitative characters evaluated during *Rabi*-2023.

Sl. No.	Genotypes	FE (%)	PH @30	PH @60	PH @90	Lp (%)	FLL (cm)	FLB (cm)	SL (cm)	PL (cm)	AL (cm)	NT/P	CT @BS	CT@ EGF	CT@ LGF	D2H	DM	Sp/S	G/S	TW (g)	BM	GY/P (gm)	GY/Pl (gm)	GY/Ha (t/ha)
1	IBT – 38/ ASA-2201097	80.82	32.19	84.71	112.89	40.67	26.65	1.69	10.17	26.32	10.47	11.53	9.77	14.65	21.95	75.67	120.67	19.87	58.93	42.03	127.73	32.82	164.1	1.64
2	IBT – 23/ASA-2200959	61.57	32.25	67.28	114.61	84.00	20.76	1.66	10.24	30.73	13.14	11.67	9.17	14.93	21.84	76.33	121.67	22.13	69.60	42.60	124.67	30.05	150.3	1.50
3	IBT – 24/ ASA-2200351	79.07	30.91	78.17	108.76	94.33	24.64	1.67	11.21	30.08	14.46	10.93	10.09	14.27	21.75	75.33	120.67	22.13	64.40	35.70	124.27	27.28	136.4	1.36
4	IBT – 25/ ASA-2200394	74.60	31.45	75.04	107.77	82.00	21.70	1.87	8.98	28.53	13.39	11.33	10.12	14.61	19.89	76.33	120.33	21.73	65.93	41.37	123.67	34.16	170.8	1.71
5	IBT – 2/ ASA-2201025	67.09	32.62	80.75	112.91	75.33	21.07	1.69	10.81	34.33	14.17	11.40	9.68	15.21	22.23	77.33	121.67	25.07	77.80	39.23	118.60	35.94	179.7	1.80
6	IBT – 56/ FFM-220276	73.32	30.64	75.25	107.21	68.00	29.73	1.79	9.27	28.55	12.68	11.67	10.17	14.03	20.88	74.33	121.33	19.87	61.00	35.10	150.00	30.77	153.8	1.54
7	IBT – 51/ FFM-220974	88.61	31.44	71.68	104.74	81.33	21.61	1.84	10.24	30.91	12.47	11.20	10.51	14.05	22.01	78.67	121.67	18.53	55.87	43.77	135.93	37.25	186.2	1.86
8	IBT – 47/ FFM-220176	78.98	32.01	64.89	106.69	32.33	17.72	1.34	8.48	29.73	12.60	11.93	9.55	14.50	22.58	76.67	118.33	14.47	29.07	58.37	120.27	29.53	147.7	1.48
9	IBT – 72/ FFM-220966	64.45	31.39	66.70	102.05	66.33	16.35	1.22	9.67	28.33	10.86	11.70	10.43	14.41	23.93	76.33	122.67	13.67	27.47	46.60	113.27	20.27	101.3	1.01
10	IBT – 26/ASA-2200396	68.68	30.74	73.17	115.53	87.67	26.21	2.07	9.47	29.21	15.21	11.80	10.93	14.41	22.09	76.67	120.67	24.13	73.13	38.27	138.67	27.06	135.3	1.35
11	IBT – 79/FFM-221172	78.79	32.85	69.79	103.55	94.33	18.09	1.25	8.93	31.35	12.71	10.63	10.24	14.58	21.57	75.33	121.67	14.20	28.53	55.90	111.33	26.12	130.6	1.31
12	IBT – 20/ASA-2200977	73.93	31.92	59.43	100.17	93.33	19.15	1.43	9.49	29.19	11.99	12.20	10.22	14.20	20.49	75.67	120.67	14.07	28.93	45.97	121.67	26.29	131.5	1.31
13	IBT – 52/FFM-220374	68.12	30.77	58.11	100.10	94.67	18.43	1.76	7.35	25.73	12.11	10.87	10.31	13.87	21.91	78.33	120.67	21.80	61.80	43.23	113.27	34.53	172.7	1.73
14	IBT – 69/FFM-220807	61.47	32.22	76.29	118.30	90.67	20.75	1.80	10.84	33.15	15.21	11.33	10.68	13.77	19.89	76.67	121.33	15.47	30.40	47.40	105.67	19.75	98.7	0.99
15	IBT – 40/ASA-2201062	61.49	32.45	73.57	120.31	81.00	17.24	1.67	11.08	35.28	13.16	11.47	9.69	13.86	21.41	76.67	122.67	21.27	63.87	35.60	112.33	27.22	136.1	1.36
16	IBT – 09/ASA-2200984	48.23	31.41	69.83	111.95	65.67	25.36	2.07	10.39	32.73	13.27	10.80	8.92	14.21	22.68	76.67	120.67	22.87	68.40	43.13	110.13	24.85	124.2	1.24
17	IBT – 31/ASA-2200346	43.39	29.69	74.86	113.71	36.67	19.93	1.82	11.29	34.15	14.20	11.00	10.39	14.51	23.56	76.33	121.67	22.93	71.13	46.83	120.33	35.81	179.1	1.79
18	IBT – 75/FFM-221131	54.95	32.93	65.51	92.59	69.33	19.51	1.84	10.90	28.49	13.70	11.53	9.88	14.00	20.57	77.67	120.67	15.93	31.73	55.43	115.53	19.48	97.4	0.97
19	IBT – 48/FFM-221194	67.59	31.75	70.51	105.29	91.00	22.64	1.99	9.46	30.53	11.53	11.27	9.97	14.73	21.37	75.67	121.33	25.00	72.07	41.73	123.53	26.05	130.3	1.30
20	IBT – 80/ VLB-118 (CHECK)	87.67	29.96	76.54	112.61	87.67	27.36	2.35	11.05	31.64	18.38	10.87	10.94	14.07	22.30	75.67	121.67	21.67	64.53	46.53	120.53	26.59	132.9	1.33
	Range Min	43.39	29.69	58.11	92.59	32.33	16.35	1.22	7.35	25.73	10.47	10.63	8.92	13.77	19.89	74.33	118.33	13.67	27.47	35.10	105.67	19.48	97.40	9.74
	Max	88.61	32.93	84.71	120.31	94.67	29.73	2.35	11.29	35.28	18.38	12.20	10.94	15.21	23.93	78.67	122.67	25.07	77.80	58.37	150.00	37.25	186.23	18.62
	Mean	69.14	31.58	71.60	108.59	75.82	21.75	1.74	9.97	30.45	13.29	11.36	10.08	14.34	21.74	76.42	121.08	19.84	55.23	44.24	121.57	28.59	142.96	1.43
	Std.D	11.97	0.91	6.69	6.90	19.46	3.76	0.28	1.05	2.57	1.75	0.42	0.52	0.38	1.06	1.13	1.15	3.86	18.10	6.52	10.59	5.36	26.79	4.01
	CV (%)	14.00	1.93	5.30	3.88	2.88	8.23	9.10	2.90	3.64	4.93	4.58	4.41	3.66	2.37	2.14	0.56	5.02	2.52	6.00	10.87	16.41	16.41	16.41
	CD at 5%	16.00	1.01	6.27	6.96	3.60	2.96	0.26	0.48	1.83	1.08	0.86	0.74	0.87	0.85	2.70	1.13	1.65	2.30	4.38	21.85	7.76	38.78	3.88
	Std.E	2.68	0.20	1.50	1.54	4.35	0.84	0.06	0.23	0.58	0.39	0.09	0.12	0.08	0.24	0.25	0.21	0.86	4.05	1.46	2.37	1.20	5.99	0.52

Legends: **FE%- Field emergence, PH@30 - Plant height at 30DAS, PH@60 - Plant height at 60DAS, PH@90 - Plant height at 90DAS, LP(%) - Lodging percentage, FLL- flag leaf length, FLB- Flag leaf length, FLB- Flag leaf breadth, SL- Spike length, PL- Peduncle length, AL- awn length, NT/P- No. of tillers/plant, CT@BS - Canopy temperature at booting stage, CT@EGF - Canopy temperature at Early grain filling stage, CT@LGF - Canopy temperature at Late grain filling stage, DH- days to heading, DM- days to maturity, SP/S- spikelets per spike, G/S- grains per spike, TW - Test weight, BM- Biomass yield, GY/P- grain yield per plant, GY/PL- grain yield per plot, GY/Ha-grain yield per hectare.

was about (97.4 gm) obtained from the genotype IBT-75. The results concluded six row barley yielded more than two row barley. **Grain Yield Per Hectare:** The maximum yield of grain yield per hectare was obtained in genotype IBT-51 with (1.86 t), whereas the minimum yield of grain per hectare was about (0.97 t) obtained from the genotype IBT-75. The results concluded six row barley yielded more than two row barley.

Estimation of Genetic parameters

Wide range of phenotypic variance were observed in the experimental material for all the characters under study. GCV (%) values ranged between least of 0.70 (days to maturity) to a highest value of 32.74 (Grains per spike). PCV (%) followed a similar pattern had a range of 0.90 (days to maturity) to 32.84 (Grains per spike). Estimates of heritability in broad sense revealed that the highest heritability was for Grains per spike (99.40%) whereas least values heritability was recorded for Canopy temperature at early grain filling stage (15.90%), Number of tillers per plant (23.40%). Genetic advance as percent mean estimates revealed maximum range for Lodging percentage (39.78%) followed by Grains per spike (37.14%) whereas least values which were of low range, were recorded for Canopy temperature at early grain filling stage (0.19%) and Number of tillers per plant (0.29%). In the present study, high estimates high genetic advance as percent of mean was observed for Grains per spike (67.24%), Lodging percentage (52.47%), Spikelets per spike (38.31%), Flag leaf length (30.69%), Test weight (27.22%) and Flag leaf breadth (26.95%). However, the moderate genetic advance mean (10-20%) was found in plant height at 60DAS (15.58), peduncle length (15.41), plant height at 90DAS (10.27), and lower genetic

Table 4. Estimation of correlation coefficient at genotypic level among 23 quantitative traits in barley

TRAITS	Fe (%)	Ph 30	Ph 60	Ph 90	Lp (%)	Fll (cm)	Flb (cm)	Sl (cm)	Pl (cm)	Al (cm)	N t/p	CTBS	Ctegf	Ctlgf	Dh	Dm	Sp/s	G/s	Tw (gm)	Bm (gm)	Gy/p (gm)	Gy/pl (gm)	Gy/ha (t)
Fe (%)	1																						
Ph30	0.050^{NS}	1																					
Ph60	0.209^{NS}	-0.093^{NS}	1																				
Ph90	-0.195^{NS}	-0.170^{NS}	0.733**	1																			
Lp (%)	0.262*	0.092^{NS}	-0.204^{NS}	-0.094^{NS}	1																		
Fll(cm)	0.282*	-0.501**	0.595**	0.341**	0.001^{NS}	1																	
Flb(cm)	-0.121^{NS}	-0.564**	0.345**	0.358**	0.181^{NS}	0.680**	1																
Sl(cm)	-0.315*	0.011^{NS}	0.590**	0.476**	-0.091^{NS}	0.204^{NS}	0.335**	1															
Pl(cm)	-0.418**	0.069^{NS}	0.348**	0.678**	0.012^{NS}	-0.151^{NS}	0.137^{NS}	0.668**	1														
Al(cm)	0.029^{NS}	-0.437**	0.325*	0.431**	0.258*	0.346**	0.646**	0.500**	0.456**	1													
Nt/p	-0.008^{NS}	0.441**	-0.320*	-0.063^{NS}	-0.318*	-0.115^{NS}	-0.439**	-0.236^{NS}	-0.348**	-0.380**	1												
Ctbs	0.385**	-0.624**	0.125^{NS}	-0.151^{NS}	0.367**	0.188^{NS}	0.252^{NS}	-0.045^{NS}	-0.148^{NS}	0.451**	-0.041^{NS}	1											
Ctegf	-0.081^{NS}	0.437**	0.414**	0.167^{NS}	-0.349**	-0.016^{NS}	-0.469**	-0.067^{NS}	0.182^{NS}	-0.260*	0.251^{NS}	-0.756**	1										
Ctlgf	-0.198^{NS}	-0.428**	-0.006^{NS}	0.091^{NS}	-0.490**	-0.109^{NS}	-0.137^{NS}	0.088^{NS}	0.145^{NS}	-0.085^{NS}	-0.244^{NS}	-0.084^{NS}	0.448**	1									
Dh	-0.571**	0.610**	-0.944**	-0.300*	0.089^{NS}	-1.207**	0.085^{NS}	-0.221^{NS}	-0.001^{NS}	0.053^{NS}	-0.168^{NS}	-0.044^{NS}	-1.186**	0.259*	1								
Dm	-0.134^{NS}	-0.148^{NS}	0.298*	0.215^{NS}	0.331**	-0.113^{NS}	0.047^{NS}	0.473**	0.452**	0.053^{NS}	-0.396**	0.328*	-0.263*	0.223^{NS}	0.146^{NS}	1							
Sp/s	-0.218^{NS}	-0.417**	0.436**	0.495**	0.108^{NS}	0.494**	0.714**	0.213^{NS}	0.244^{NS}	0.292*	-0.419**	-0.156^{NS}	0.523**	0.144^{NS}	0.200^{NS}	0.080^{NS}	1						
G/s	-0.141^{NS}	-0.455**	0.478**	0.527**	0.058^{NS}	0.532**	0.681**	0.216^{NS}	0.231^{NS}	0.254^{NS}	-0.399**	-0.166^{NS}	0.533**	0.176^{NS}	0.065^{NS}	0.131^{NS}	0.990**	1					
Tw(gm)	0.013^{NS}	0.330*	-0.459**	-0.522**	-0.294*	-0.531**	-0.417**	-0.202^{NS}	-0.084^{NS}	-0.046^{NS}	0.007^{NS}	0.010^{NS}	-0.117^{NS}	0.075^{NS}	0.548**	-0.388**	-0.701**	-0.747**	1				
Bm(gm)	0.653**	-0.582**	0.334**	-0.052^{NS}	-0.133^{NS}	0.966**	0.370**	-0.184^{NS}	-0.429**	-0.015^{NS}	0.162^{NS}	0.358**	0.402**	-0.129^{NS}	-0.745**	-0.255*	0.406**	0.518**	-0.627**	1			
Gy/p(gm)	0.283*	-0.442**	0.254^{NS}	0.150^{NS}	-0.260*	0.178^{NS}	0.133^{NS}	-0.195^{NS}	-0.006^{NS}	-0.136^{NS}	-0.313*	-0.189^{NS}	0.871**	0.209^{NS}	0.681**	-0.186^{NS}	0.552**	0.650**	-0.367**	0.456**	1		
Gy/pl(gm)	0.283*	-0.442**	0.254^{NS}	0.150^{NS}	-0.260*	0.178^{NS}	0.133^{NS}	-0.195^{NS}	-0.006^{NS}	-0.136^{NS}	-0.313*	-0.189^{NS}	0.871**	0.209^{NS}	0.681**	-0.186^{NS}	0.552**	0.650**	-0.367**	0.456**	1.000**	1	
Gy/ha(t)	0.283*	-0.442**	0.256*	0.153^{NS}	-0.258*	0.177^{NS}	0.131^{NS}	-0.194^{NS}	-0.003^{NS}	-0.134^{NS}	-0.318*	-0.189^{NS}	0.872**	0.209^{NS}	0.678**	-0.184^{NS}	0.554**	0.652**	-0.368**	0.453**	1.000**	1.000**	1

** and * indicates significance at 1% and 5% level of significance respectively.

Legends: ** FE%- Field emergence, PH@30 - Plant height at 30DAS, PH@60 - Plant height at 60DAS, PH@90 - Plant height at 90DAS, LP(%) - Lodging percentage, FLL- flag leaf length, FLB- Flag leaf length, FLB- Flag leaf breadth, SL- Spike length, PL- Peduncle length, AL- awn length, NT/P- No. of tillers/plant, CT@BS - Canopy temperature at booting stage, CT@EGF - Canopy temperature at Early grain filling stage, CT@LGF - Canopy temperature at Late grain filling stage, DH- days to heading, DM- days to maturity, SP/S- spikelets per spike, G/S- grains per spike, TW - Test weight, BM- Biomass yield, GY/P- grain yield per plant, GY/PL- grain yield per plot, GY/Ha-grain yield per hectare.

advance mean recorded in canopy temperature @ late grain filling stage (8.57), canopy temperature at booting stage (6.70), biomass yield (6.05), plant height at 30DAS (4.46), number of tillers per plant (2.52), days to heading (2.38), canopy temperature at early grain filling stage (1.30), days to maturity (1.11).

Estimation of correlation coefficient

With respect to genotypic correlation, Field emergence was positively significant with biomass yield (0.6528**), found non-significant with other traits including grain yield per plant. In phenotypic correlation, the field emergence found positively significant with canopy temperature at booting stage (0.3093*) and negatively correlated with peduncle length (-0.2887*). According to these results, an increase in Field emergence will possibly increase biomass yield and canopy temperature at booting stage, and there will be a decrease in peduncle length with the increase in Field emergence. There were significantly negative results in case of genotypic correlation, with flag leaf length (-0.5015*) and flag leaf breadth (-0.5641**), canopy temperature at booting stage (-0.6245**), grains per spike (-0.4548*), biomass yield (-0.5819**). The phenotypic correlation for plant height at 30DAS was positively significant with test weight (0.2722*), but found negatively correlated with grains per spike (-0.3226**), canopy temperature at late grain stage (-0.3202*), flag leaf length (-0.3526**), canopy temperature at booting stage (-0.3046*), awn length (-0.3459*). Both genotypic and phenotypic correlation of plant height at 60DAS was found positively correlated for plant height at 90DAS (0.7331**, 0.4603**), flag leaf length (0.595**, 0.509**), spike length (0.5901**, 0.5423**), grains per spike (0.4776*, 0.4005**), and negatively correlated with days for heading (-0.31, -0.2657*), test weight (-0.459*, -0.388**). Plant height at 90DAS was found positively correlated and found significant in both genotypic and phenotypic correlation with spike length (0.476*, 0.389**), peduncle length (0.6781**, 0.4703**), spikelets per spike (0.4953*, 0.4131**), grains per spike (0.5266*, 0.4539**), and negatively correlated with test weight (-0.5223*, -0.3749**) which is found significant. Both genotypic and phenotypic correlation of flag leaf length was found positively correlated with flag leaf breadth (0.6802**, 0.6232**), spikelts per spike (0.4941* 0.4456**), grains per spike (0.5316*, 0.4828**), biomass yield (0.966**, 0.403**) and negatively correlated and significant with test weight (-0.5314*, -0.4351**). Flag leaf breadth was positively correlated in both genotypic and phenotypic and found significant with Awn length (0.6461**, 0.5411**), spikelets per spike (0.7137**, 0.6058**), grains per spike (0.6812**, 0.5804**), and negatively correlated with test weight (-0.4174, -0.2589*) and found non-significant in genetic correlation, but found significant in phenotypic correlation. Spike length was genetically and phenotypically correlated and significant with peduncle length (0.6682**, 0.5919**), Awns length (0.4997*, 0.4114**), days to heading (0.4705*, -0.07) where it is found phenotypically non-significant, and days to maturity (0.4705*, 0.4531**) where it is found genetically non-significant. Peduncle length was positively correlated and found significant with Awns length (0.456*, 0.4247**), whereas plant height at 90DAS (0.6781, 0.4703**), spike length (0.6682, 0.5919), and with days to maturity (0.4275, 0.3905) which was found non-significant in genotypic correlation. Peduncle length was negatively correlated and non-significant in genotypic correlation but significant with biomass yield (-0.4288, -0.2648*) in phenotypic correlation. Awns length was positively correlated and found significant with canopy temperature at booting stage (0.4514*, 0.326*). Canopy temperature at booting stage was found significant and negatively correlated genotypically and phenotypically with canopy temperature at early grain filling stage (-0.7562**, -0.159). Here, only genotypic correlation was found significant in case of canopy temperature at early grain filling stage with canopy temperature at booting stage. Both genotypic and phenotypic correlation of Spikelets per spike was found positively correlated and significant with grains per spike (0.99**, 0.964**), grain yield per plant (0.5525*, 0.3647**), grain yield per plot (0.5525*, 0.3647**) and negatively correlated with test weight (-0.7011**, -0.6282**). Grains per spike positively correlated and significant with biomass yield (0.518*, 0.2569*), grain yield per plant (0.6501**, 0.4631**), grain yield per plot (0.6501**, 0.4631**s), negatively correlated test weight (-0.7469**, -06822**)

Table 5. Estimation of correlation coefficient at phenotypic level among 23 quantitative traits in barley.

TRAITS	Fe (%)	Ph 30	Ph 60	Ph 90	Lp (%)	Fll (cm)	Flb (cm)	Sl (cm)	Pl (cm)	Al (cm)	Nt/p	Ctbs	Ctegf	Ctlgf	Dh	Dm	Sp/s	G/s	Tw (gm)	Bm (gm)	Gy/p (gm)	Gy/pl (gm)	Gy/ha (t)
Fe (%)	1																						
Ph30	-0.087^{NS}	1																					
Ph60	0.100^{NS}	-0.074^{NS}	1																				
Ph90	-0.070^{NS}	-0.109^{NS}	0.460**	1																			
Lp (%)	0.196^{NS}	0.074^{NS}	-0.176^{NS}	-0.072^{NS}	1																		
Fll(cm)	0.206^{NS}	-0.353**	0.509**	0.200^{NS}	0.008^{NS}	1																	
Flb(cm)	-0.030^{NS}	-0.347**	0.285*	0.223^{NS}	0.145^{NS}	0.623**	1																
Sl(cm)	-0.220^{NS}	-0.023^{NS}	0.524**	0.389**	-0.086^{NS}	0.159^{NS}	0.278*	1															
Pl(cm)	-0.289*	0.097^{NS}	0.262*	0.470**	0.012^{NS}	-0.136^{NS}	0.156^{NS}	0.592**	1														
Al(cm)	0.006^{NS}	-0.273*	0.250^{NS}	0.337**	0.242^{NS}	0.300*	0.541**	0.411**	0.425**	1													
Nt/p	0.073^{NS}	0.120^{NS}	-0.133^{NS}	-0.078^{NS}	-0.162^{NS}	-0.123^{NS}	-0.255*	-0.050^{NS}	-0.187^{NS}	-0.263*	1												
Ctbs	0.309*	-0.304*	0.033^{NS}	0.064^{NS}	0.259*	0.019^{NS}	0.112^{NS}	-0.025^{NS}	-0.118^{NS}	0.326*	-0.089^{NS}	1											
Ctegf	0.054^{NS}	0.100^{NS}	0.189^{NS}	0.102^{NS}	-0.150^{NS}	-0.022^{NS}	-0.043^{NS}	0.010^{NS}	0.008^{NS}	-0.173^{NS}	0.063^{NS}	-0.159^{NS}	1										
Ctlgf	-0.128^{NS}	-0.321*	0.011^{NS}	0.127^{NS}	-0.454**	-0.090^{NS}	-0.093^{NS}	0.080^{NS}	0.097^{NS}	-0.054^{NS}	-0.120^{NS}	-0.047^{NS}	0.193^{NS}	1									
Dh	-0.027^{NS}	0.002^{NS}	-0.111^{NS}	-0.152^{NS}	-0.013^{NS}	-0.196^{NS}	0.137^{NS}	-0.011^{NS}	0.053^{NS}	-0.060^{NS}	-0.062^{NS}	-0.009^{NS}	0.036^{NS}	0.073^{NS}	1								
Dm	-0.181^{NS}	0.045^{NS}	0.177^{NS}	0.154^{NS}	0.248^{NS}	-0.053^{NS}	0.025^{NS}	0.337**	0.346**	0.055^{NS}	-0.189^{NS}	0.287*	-0.067^{NS}	0.107^{NS}	-0.117^{NS}	1							
Sp/s	-0.161^{NS}	-0.323*	0.370**	0.413**	0.104^{NS}	0.447**	0.606**	0.189^{NS}	0.214^{NS}	0.265*	-0.248^{NS}	-0.131^{NS}	0.218^{NS}	0.128^{NS}	-0.025^{NS}	0.107^{NS}	1						
G/s	-0.115^{NS}	-0.365**	0.400**	0.454**	0.059^{NS}	0.483**	0.580**	0.203^{NS}	0.209^{NS}	0.241^{NS}	-0.214^{NS}	-0.129^{NS}	0.208^{NS}	0.158^{NS}	-0.002^{NS}	0.115^{NS}	0.964**	1					
Tw(gm)	-0.039^{NS}	0.272*	-0.388**	-0.375**	-0.275*	-0.435**	-0.259*	-0.185^{NS}	-0.070^{NS}	-0.006^{NS}	-0.030^{NS}	0.002^{NS}	0.064^{NS}	0.084^{NS}	0.055^{NS}	-0.275*	-0.628**	-0.682**	1				
Bm(gm)	0.221^{NS}	-0.221^{NS}	0.187^{NS}	0.059^{NS}	-0.053^{NS}	0.403**	0.124^{NS}	-0.074^{NS}	-0.265*	-0.089^{NS}	0.421**	0.096^{NS}	-0.008^{NS}	-0.000^{NS}	-0.157^{NS}	-0.041^{NS}	0.165^{NS}	0.257*	-0.329*	1			
Gy/p(gm)	0.197^{NS}	-0.113^{NS}	0.197^{NS}	0.164^{NS}	-0.177^{NS}	0.081^{NS}	0.047^{NS}	-0.173^{NS}	-0.031^{NS}	-0.092^{NS}	-0.015^{NS}	0.064^{NS}	0.074^{NS}	0.116^{NS}	0.093^{NS}	-0.037^{NS}	0.365**	0.463**	-0.246^{NS}	0.418**	1		
Gy/pl(gm)	0.197^{NS}	-0.113^{NS}	0.197^{NS}	0.164^{NS}	-0.177^{NS}	0.081^{NS}	0.047^{NS}	-0.173^{NS}	-0.031^{NS}	-0.092^{NS}	-0.015^{NS}	0.064^{NS}	0.074^{NS}	0.116^{NS}	0.093^{NS}	-0.037^{NS}	0.365**	0.463**	-0.246^{NS}	0.418**	1.000**	1	
Gy/ha(t)	0.197^{NS}	-0.112 NS	0.197 NS	0.166 NS	-0.176 NS	0.080 NS	0.047 NS	-0.173 NS	-0.029 NS	-0.091 NS	-0.017 NS	0.063 NS	0.074 NS	0.117 NS	0.093 NS	-0.038 NS	0.365**	0.463**	-0.246NS	0.416**	1.000**	1.000**	1

** and * indicates significance at 1% and 5% level of significance respectively.

Legends: ** FE%- Field emergence, PH@30 - Plant height at 30DAS, PH@60 - Plant height at 60DAS, PH@90 - Plant height at 90DAS, Lp(%) - Lodging percentage, FLL- flag leaf length, FLB- Flag leaf length, FLB- Flag leaf breadth, SL- Spike length, PL- Peduncle length, AL- awn length, NT/P- No. of tillers/plant, CT@BS - Canopy temperature at booting stage, CT@EGF - Canopy temperature at Early grain filling stage, CT@LGF - Canopy temperature at Late grain filling stage, DH- days to heading, DM- days to maturity, SP/S- spikelets per spike, G/S- grains per spike, TW - Test weight, BM- Biomass yield, GY/P- grain yield per plant, GY/PL- grain yield per plot, GY/Ha-grain yield per hectare.

and found significant. Test weight was found negatively correlated and significant with biomass yield (-0.6272**, -0.3291*) both genotypic and phenotypic correlation. Also, it is negatively correlated and non-significant with grain yield per plant (-0.3673, -0.2457).

Both genotypic and phenotypic correlation of grain yield per hectare was found positively correlated and significant with spikelets per spike (0.554**, 0.365**), grains per spike (0.652**, 0.463**), biomass yield (0.453**, 0.416**), grain yield per plant (1.000**, 1.000**), grain yield per plot (1.000**, 1.000**). Biomass yield was positively correlated and significant with grain yield per plant (0.4562*, 0.418**), grain yield per plot (0.4562*, 0.418**) which concludes that increase in biomass yield might positively impact resulting in higher grain yield.

Discussion

Grain Yield per Plant Among 20 barley genotypes, grain yield per plant ranged from 19.48 gm to 37.75 gm. Noteworthy high-yield genotypes in six-row barley included IBT-51, IBT-2, IBT-31, IBT-52, and IBT-25. In two-row barley, top-performing genotypes were IBT-47, IBT-20, IBT-79, and IBT-72. The lowest yield was observed in genotype IBT-75. Overall, six-row barley exhibited higher grain yield per plant compared to two-row barley. Variability in Other Traits Kaur *et al***.** (2022) reported wide variability in several traits, including days to spike emergence, physiological maturity, plant height, spike length, grain number per spike, and 100-grain weight. Ahmad *et al***.** (2008) evaluated 133 barley accessions from Pakistan, observing significant genetic variation across various plant characteristics.

PCV, GCV, and Heritability These estimates play a crucial role in select-

ing methods to enhance specific traits within a population. Phenotypic coefficient of variance (PCV) exceeded genotypic coefficient of variance (GCV) for all studied traits, highlighting environmental influence on trait expression. Similar findings were reported by Jalata *et al*. (2011). Notably, the number of grains per spike showed the highest variation, alongside other traits like grain yield per plot, harvest index, biological yield per plot, and number of tillers per meter. Genetic Variation and Heritability Matin *et al*. (2019) evaluated locally developed barley hybrids. High genotypic coefficient of variation (GCV) was observed for grain/spike, yield/plant, effective tiller/plant, and spike length. Traits with high GCV indicate strong potential for selection. Heritability was highest for 1000 seed weight, followed by yield/plant, grain/spike, and spike length. Effective tiller/plant and plant height had lower heritability values.

Positive Correlations Traits like spikelets per spike, grains per spike, and biomass yield per plant showed positive and highly significant correlations with grain yield per plant. Matin *et al.* (2019) reported that yield had the highest positive genotypic and phenotypic correlation with grain/spike (rg=0.84**, rp=0.68**). Negative Correlations Plant height exhibited negative significant correlations with yield, yield/plant, and 1000 seed weight at both genotypic and phenotypic levels (rg= -1.00**, rp= -0.64** and rg= -1.00**, rp= -0.72**). Hailu *et al. (*2016) found that grain yield had negative and highly significant correlations at the genotypic level with days to heading and days to maturity, specifically at Ofla.

Conclusion

The present study reveals that among the 20 genotypes, IBT-51 and IBT-2 followed by IBT-31, IBT-52 six-row barley genotypes were found superior as compared to check (IBT-80) and exhibited the best results with regards to the growth, seed yield, whereas two-row barley genotypes IBT-47, IBT-20 were found superior, but less compared to six-row barley during the evaluation. Therefore, they can be recommended for commercial cultivation in Vindhyan region of Uttar Pradesh. The character with high range of GCV and PCV (Grains per spike), heritability (days to heading), genetic advance and genetic percentage of mean (grains per spike) should be considered for further hybridization and crop improvement programme.

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Conflict of interest

The authors have no competing interests.

References

Ahmad Zaheer, Saif Ullah Ajmal, Muhammad Munir, Muhammad Zubair1 and Muhammad Shahid Masood. (2008). Genetic Diversity for Morpho-Genetic Traits in Barley Germplasm. *Pak. J. Bot*., **40**(3): 1217-1224.

Al-Jibouri, H.A., Miller, P.A. and Robinson, H.P., (1958). Genotypic and phenotypic co-variances in an upland cotton cross of inter-specific origin. *Agronomy Journal*. **50**:633- 636.

Anubhav, S., Rana, V. and Chaudhary, H. K. (2020). Study on variability, relationships and path analysis for agro-morphological traits in elite wheat (*Triticum aestivum* L.) germplasm lines under Northern Hill Zone conditions. *Journal of Cereal Research*, 12(1): 74-78.

Dewey, D. R. and Lu, K. (1959). A correlation and pathcoefficient analysis of components of crested wheatgrass seed production 1. *Agronomy Journal*, **51**(9): 515-518.

Fisher, R.A. (1954). Statistical methods for research workers, Oliver and Boyd. Ltd. London.

Hailu, A., Alamerew, S., Nigussie, M. and Assefa, E. (2016). Genetic Variability, Heritability and Genetic Advance for Yield and Yield Related

Traits in Barley (*Hordeum vulgare* L.) Germplasm. *World Journal of Agricultural Sci*. 12(1): 36-44.

Hammer, K. (1984). *The role of wild progenitors in the development of cultivated barley. In Barley: A Bibliography of the Literature on the Barley Plant, with a Discussion of the History of the Plant and the Characteristics of the Cultivated and Wild Species (pp. 3-8). American Society of Agronomy.*

Johnson, H. W., Robinson, H. F., and Comstock, R. E. (1955). Estimates of genetic and environmental variability in soyabean, *Agron*, J., **47**: 314-318.

Kaur, V., Aravind, J., Manju, Jacob, S. R., Kumari, J., Panwar, B. S. and Kumar, A. (2022). Phenotypic characterization, genetic diversity assessment in 6,778 accessions of barley (*Hordeum vulgare* L. *ssp. vulgare*) germplasm conserved in National Gene bank of India and development of a core set. *Frontiers in Plant Science*, **13**: 771920.

Kumar, A., Kishore, N., Devlash, R., and Singh, G. (2018). Genetic variability and association study in some hulled and hulless genotypes of barley (*Hordeum vulgare* L.) in north western Himalayan region. *Wheat and Barley Research,* **10**(3):185-189.

Matin, M. Q. I., Amiruzzaman, M., Billah, M. M., Banu, M. B., Naher, N. and Choudhury, D. A. (2019). Genetic variability and path analysis studies in barley (*Hordeum vulgare* L.). *International Journal of Applied Sciences and Biotechnology*, **7**(2): 243-247.

Verma, P., K, Rana, V., and Choudhary, R., (2022). Genetic variability for yield and yield related traits in barley (*Hordeum vulgare* L.). *Himachal Journal of Agricultural Research.* **48**(2): 272-275.

Wright, S. (1921). Correlation and causation. *Journal of Agricultural Research*, 20(7): 557

Zohary, D. and Hopf, M. (2000). *Domestication of Plants in the Old World* (3rd ed.). Oxford Uiversity Press.