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ASSESSMENT OF GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT FOR YIELD AND ITS CONTRIBUTING TRAITS IN EXOTIC AND INDIGENOUS BARLEY (*HORDEUM VULGARE* L.).

Kuldeep Yadav[1]*, K. N. Maurya[1], Abhinav Yadav[1], Raj Kumar[2], Nirdesh Kumar Chaudhary[3] and Ankitesh Kumar[4]

[1]Department of Genetics and Plant Breeding, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad-224229(U. P.), India.
[2]Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, U.P., India.
[3]Department of Genetics and Plant Breeding, R B S College, Agra, U.P., India.
[4]Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur–208002 (U.P.) India.
*Corresponding author E-mail: kynduat@gmail.com
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ABSTRACT

A total of forty-nine exotic and indigenous barley genotypes, along with four check varieties, were evaluated to assess grain yield and its contributing traits. Analysis of variance indicated significant differences among genotypes for all examined traits, reflecting a broad spectrum of genetic variability. Moderate to high levels of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed, with PCV values slightly exceeding GCV for all traits suggesting limited environmental influence. Notably, the highest GCV was recorded for productive tillers per plant (16.62), followed by peduncle length (14.83). Correlation analysis showed that grain yield per plant had a highly significant positive association with biological yield, harvest index, and productive tillers per plant, and a significant positive correlation with 1000-seed weight. In contrast, days to maturity exhibited a non-significant negative correlation. Path coefficient analysis revealed that biological yield per plant and harvest index exerted the strongest positive direct effects on grain yield, whereas days to 50% flowering had a notable negative direct effect. These findings suggest that traits such as productive tillers per plant, peduncle length, biological yield, harvest index, and 1000-seed weight are valuable selection criteria for improving barley genotypes.

***Keywords*:** Barley (*Hordeum vulgare* L.), Genetic variability, Path coefficient analysis, Phenotypic and genotypic variation, Grain yield, Productive tillers, Correlation analysis, Breeding program, Harvest index, Agronomic traits.

Introduction

Barley (*Hordeum vulgare* L.) is one of the earliest domesticated crop species (Zohary and Hopf, 1993), and it is believed to be among the first plants cultivated by humans. It ranks as the fourth most important cereal crop globally and is grown extensively across temperate regions (Von Bothmer *et al*., 1995). Barley serves multiple purposes primarily as animal feed, for brewing malt, and to a lesser extent, in human diets (Brown, 1992; Von Bothmer *et al*., 2003). It is a self-pollinating diploid species (2n=2x=14) with a genome size of approximately 5.3×10^9 base pairs, corresponding to about 5.5 picograms of DNA per haploid nucleus (Bennett and Smith, 1976).

Having been cultivated since the Stone Age, barley holds historical significance as one of the oldest domesticated plants (Salamini *et al*., 2002). In India, however, barley yields remain below the global

average due to its cultivation under minimal input conditions. Recently, the rising demand from the malting and brewing industries, along with a push to diversify wheat-based cropping systems, has brought renewed attention to barley cultivation. There is potential to improve productivity under better agronomic management, but this requires the development of high-yielding varieties.

The success of breeding programs depends heavily on the extent of available genetic variability within the germplasm. Conserving genetic resources and identifying variability are therefore essential for crop improvement. Historically, plant breeders relied on pure-line selection from limited gene pools, but strategic hybridization and appropriate mating systems can broaden the genetic base. Modern biometrical tools have facilitated a more precise understanding of the genetic architecture of yield and its components.

Given the increasing need for resilient, high-yielding varieties with improved protein content and resistance to biotic and abiotic stresses, there is an urgent demand for developing superior barley cultivars suited to diverse agro-climatic conditions and cropping systems.

Materials and Methods

This study aimed to assess the extent of genetic variability, the associations among yield-related traits, and the direct and indirect effects of these traits on grain yield per plant across forty-nine barley genotypes. The experiment was conducted during the Rabi season of 2015–16 at the Genetics and Plant Breeding Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.), India.

The experimental material comprised forty-nine genotypes of barley, including four check varieties: BH 902, RD 2552, RD 2035, and DWRB 92. These germplasm lines were obtained from the Coordinated Barley Research Unit of the Department of Genetics and Plant Breeding at the same university. The trial was laid out using an Augmented Block Design.

For phenotypic data collection, five competitive plants were randomly selected from each genotype to record observations on the following nine traits: plant height (cm), flag leaf area (cm^2), peduncle length (cm), ear length (cm), number of productive tillers per plant, 1000-seed weight (g), biological yield per plant (g), grain yield per plant (g), and harvest index (%). In addition, two traits days to 50% flowering and days to maturity were recorded on a plot basis.

The analysis of variance was performed using the method described by Federer (1956) for augmented designs. Estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed as per Burton and de Vane (1953). Correlation coefficients were calculated following the method of Searle (1961), and path coefficient analysis was carried out based on the approach by Dewey and Lu (1959). Genetic divergence was assessed using methods outlined by Beale (1969) and Spark (1973).

Results and Discussion

The analysis of variance revealed highly significant differences among the 49 barley genotypes for all the traits studied, indicating the presence of substantial genetic variability (Table 1). Both genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) showed moderate to high values. Although PCV values were slightly higher than GCV for all traits, the differences were minimal, suggesting limited environmental influence on trait expression.

The highest GCV was observed for productive tillers per plant (16.62), followed by peduncle length (14.83), indicating considerable scope for selection and improvement in these traits. These findings are consistent with previous reports by Hailu *et al.* (2016) and Anil *et al.* (2012).

Correlation coefficients among eleven characters are presented in Table 2. Grain yield per plant showed a highly significant and positive correlation with biological yield per plant (r = 0.7807), harvest index (r = 0.5313), and productive tillers per plant (r = 0.4472). A significant positive correlation was also observed with 1000-seed weight. These results suggest that biological yield, harvest index, and productive tillers are key contributors to grain yield, and have also been reported in earlier studies (Yadav *et al*., 2002; Butta *et al*., 2005; Singh *et al*., 2003; Singh *et al*., 2006).

Path coefficient analysis (Table 3) identified biological yield per plant as having the highest positive direct effect on grain yield, followed by harvest index. Other traits such as plant height, flag leaf area, peduncle length, ear length, productive tillers per plant, and 1000-seed weight exerted strong positive indirect effects via biological yield. These results are supported by the findings of Karami (2005), Singh *et al.* (2006, 2008), Mittal *et al.* (2009), and Pal *et al.* (2010).

Furthermore, 1000-seed weight and productive tillers per plant had substantial positive indirect effects on grain yield through biological yield, reinforcing their importance in yield enhancement. In contrast,

days to 50% heading and plant height exhibited negative direct effects on grain yield.

The presence of both positive and negative direct or indirect effects among traits reveals a complex network of interactions influencing grain yield. Thus, a balanced selection strategy considering both direct contributors and influential indirect traits is essential for effective improvement of barley yield potential.

Conclusion

This study revealed substantial genetic variability among the evaluated barley genotypes for all agronomic traits related to grain yield. The moderate to high estimates of GCV and PCV, particularly for productive tillers per plant and peduncle length, highlight the potential for genetic improvement through selection. Correlation and path coefficient analyses further emphasized that biological yield per plant, harvest index, and productive tillers per plant are key traits with strong direct or indirect effects on grain yield.

The significant positive associations of these traits with grain yield suggest their utility as effective selection criteria in barley breeding programs. Additionally, the minimal environmental influence on trait expression underscores the stability of these genetic parameters across genotypes.

Overall, the findings support the strategic selection of genotypes with superior performance in biological yield, harvest index, and tillering capacity to enhance grain yield. These insights contribute valuable information for designing efficient breeding programs aimed at developing high-yielding, well-adapted barley cultivars.

Table 1: Analysis of variance of Augmented Block Design for 11 characters in barley (*Hordeum vulgare* L.)

S.N.	Characters	Sources of variation		
		Blocks	Checks	Error
	D.F.	4	3	12
1	Days to 50% flowering	38.177	16.850 **	2.100
2	Days to Maturity	52.100	19.517 *	4.268
3	Plant Height (cm)	70.095	219.478 **	3.635
4	Flag Leaf Area (cm²)	65.033	19.921 **	2.325
5	Peduncle Length (cm)	27.524	41.187 **	1.097
6	Ear Length (cm)	2.130	3.328 **	0.469
7	Productive Tillers/ Plant	1.642	5.659 **	0.062
8	1000 Seed Weight (g)	33.827	25.056	7.204
9	Biological Yield/ Plant	1.911	14.190 **	0.683
10	Grain Yield/ Plant	0.326	2.477 **	0.061
11	Harvest Index (%)	3.554	26.409 **	1.799

*and** Significant at 5% and 1% probability levels, respectively

Table 2: Range, mean, coefficient of variation and least significant differences for 11 character of barley genotypes

Characters	Range (Min-Max)	Mean Value	Coefficient of variation (%)			Range of parameters			
			PCV (%)	GCV (%)	Coefficient of variation (%)	LSD_1 5%	LSD_2 5%	LSD_3 5%	LSD_4 5%
Days to 50% flowering	60.75-85.75	73.26	6.05	5.72	7.11	1.99	4.46	4.99	3.86
Days to maturity	107.45-129.45	117.22	3.86	3.43	4.38	2.84	6.36	7.11	5.51
Plant height (cm)	51.85-89.85	73.21	10.51	10.18	11.93	2.62	5.87	6.56	5.08
Flag leaf area (cm^2)	18.31-37.99	24..49	15.87	14.62	17.50	2.10	4.69	5.25	4.06
Peduncle length (cm)	20.16-38.06	26.74	15.33	14.83	17.09	1.44	3.22	3.60	2.79
Ear length (cm)	6.45-11.45	8.04	12.89	9.69	13.32	0.94	2.11	2.35	1.82
Productive tiller $plant^{-1}$	4.03-8.45	6.016	17.14	16.62	20.91	0.34	0.76	0.85	0.66
1000-seed weight (g)	32.13-48.80	41.16	8.38	5.21	9.71	3.69	8.27	9.24	7.16
Biological yield $plant^{-1}$ (g)	26.49-36.32	32.48	6.16	5.60	7.17	1.13	2.54	2.84	2.20
Grain yield $plant^{-1}$ (g)	7.74-11.54	10.03	6.58	6.10	7.83	0.34	0.76	0.85	0.66
Harvest index (%)	27.28-37.41	31.23	5.22	2.90	6.85	1.84	4.13	4.62	3.57

LSD_1 = difference between adjusted yield of two genotype in the same block.
LSD_2 =difference between two check means.
LSD_3 = difference between adjusted mean of two genotypes in the different block.
LSD_4 = difference between adjusted yield of genotype and check mean.
PCV = phenotypic coefficient of variance. GCV = genotypic coefficient of variance.

Table 3: Simple correlation coefficients among different characters in barley germplasm

Characters	Days to maturity	Plant height (cm)	Flag leaf area ($cm^{2)}$	Peduncle length (cm)	Ear length (cm)	Productive tiller/ plant(cm)	1000 Seed Weight (g)	Biological Yield/ plant	Harvest Index (%)	Grain Yield/ plant (g)
Days to 50% heading	**0.8630****	0.2734	-0.2850*	0.0463	-0.0140	0.0484	-0.1917	-0.0707	-0.2881	**-0.1698**
Days to maturity		0.1097	**-0.2009**	-0.0783	-0.0088	0.1957	-0.2468	-0.0411	-0.2362	**-0.0872**
Plant height (cm)			-0.0729	0.3783**	**0.2358**	-0.0399	-0.0960	-0.0328	-0.1809	**-0.1603**
Flag leaf area (cm^2)				-0.0344	0.1223	-0.2256	**0.0754**	-0.2193	0.2108	**-0.0544**
Peduncle length (cm)					0.1446	-0.4211**	-0.0605	0.0410	**-0.1592**	**-0.0799**
Ear length (cm)						-0.2651	0.0905	-0.3308*	0.0170	**-0.2760**
Productive tiller/plant(cm)							-0.0307	0.4715**	-0.0088	**0.4472****
1000 Seed weight (g)								0.0876	0.4190**	**0.2991***
Biological yield/ plant(g)									0.0106	**0.7807****
Harvest index (%)										**0.5313****

and* Significant at 1 % and 5%probability levels

Table 4: Path coefficients of eleven characters of barley on grain yield per plant

Character	Days to heading (50%)	Days to maturity	Plant height (cm)	Flag leaf area (cm^2)	Peduncle length (cm)	Ear length (cm)	Produ-ctive tillers /plant	1000 Seed weight (g)	Biological yield /plant (g)	Harvest index (%)	Grain yield / plant (g)
Days to heading (50%)	**-0.0211**	-0.0182	-0.0058	0.0060	-0.0010	0.0003	-0.0010	0.0040	0.0015	0.0061	-0.1698
Days to maturity	0.0717	**0.0831**	0.0091	-0.0167	-0.0065	-0.0007	0.0163	-0.0205	-0.0034	-0.0196	-0.0872
Plant height (cm)	-0.0150	-0.0060	**-0.0550**	0.0040	-0.0208	-0.0130	0.0022	0.0053	0.0018	0.0099	-0.1603
Flag leaf area (cm^2)	-0.0084	-0.0059	-0.0021	**0.0294**	-0.0010	0.0036	-0.0066	0.0022	-0.0065	0.0062	-0.0544
Peduncle length (cm)	0.0029	-0.0048	0.0234	-0.0021	**0.0619**	0.0090	-0.0261	-0.0037	0.0025	-0.0099	-0.0799
Ear length (cm)	0.0003	0.0002	-0.0044	-0.0023	-0.0027	**-0.0188**	0.0050	-0.0017	0.0062	-0.0003	-0.2760
Productive tiller/plant	0.0063	0.0253	-0.0052	-0.0291	-0.0544	-0.0342	**0.1291**	-0.0040	0.0609	-0.0011	0.4472
1000 Seeds weight (g)	-0.0075	-0.0097	-0.0038	0.0029	-0.0024	0.0035	-0.0012	**0.0391**	0.0034	0.0164	0.2991
Biological yield/plant (g)	-0.0501	-0.0291	-0.0232	-0.1554	0.0291	-0.2345	0.3342	0.0621	**0.7088**	0.0075	0.7807
Harvest index (%)	-0.1487	-0.1219	-0.0933	0.1088	-0.0822	0.0088	-0.0046	0.2162	0.0055	**0.5160**	0.5313

Residual factor = 0.3151 Bold figures indicate the direct effect

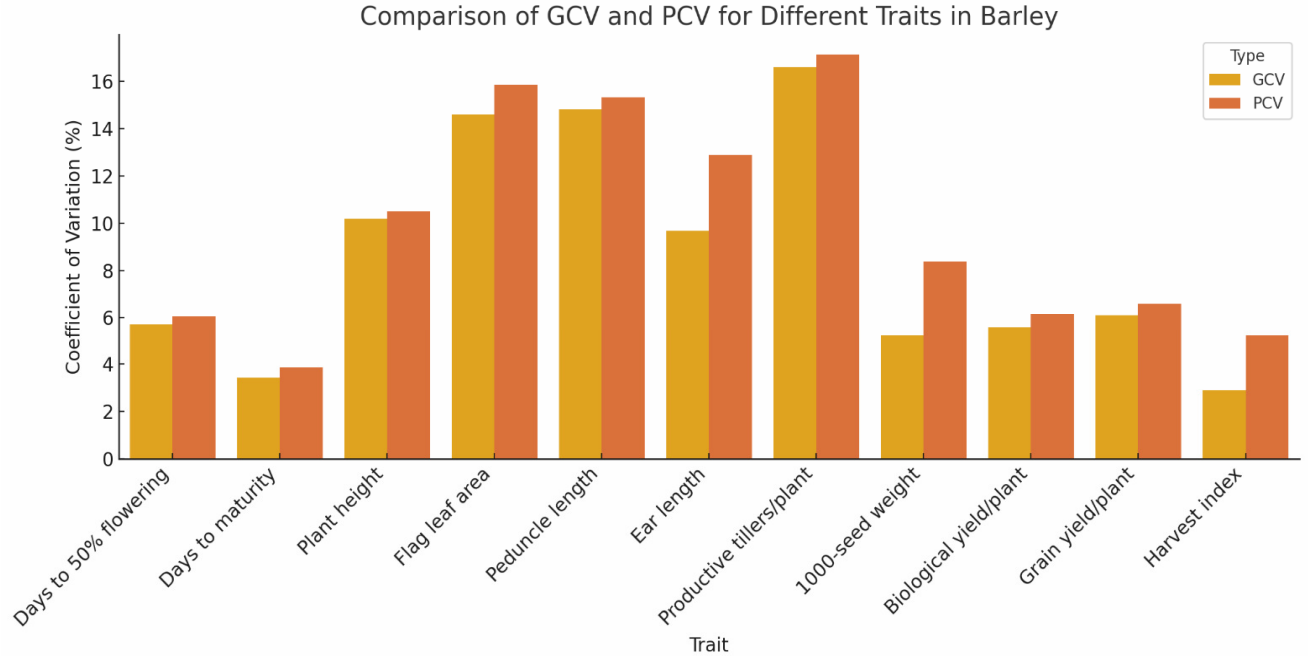

Fig. 1: Here's the bar chart comparing GCV and PCV across different barley traits. It highlights traits like **productive tillers/plant** and **peduncle length** as having the highest genetic variability, making them key targets for selection.

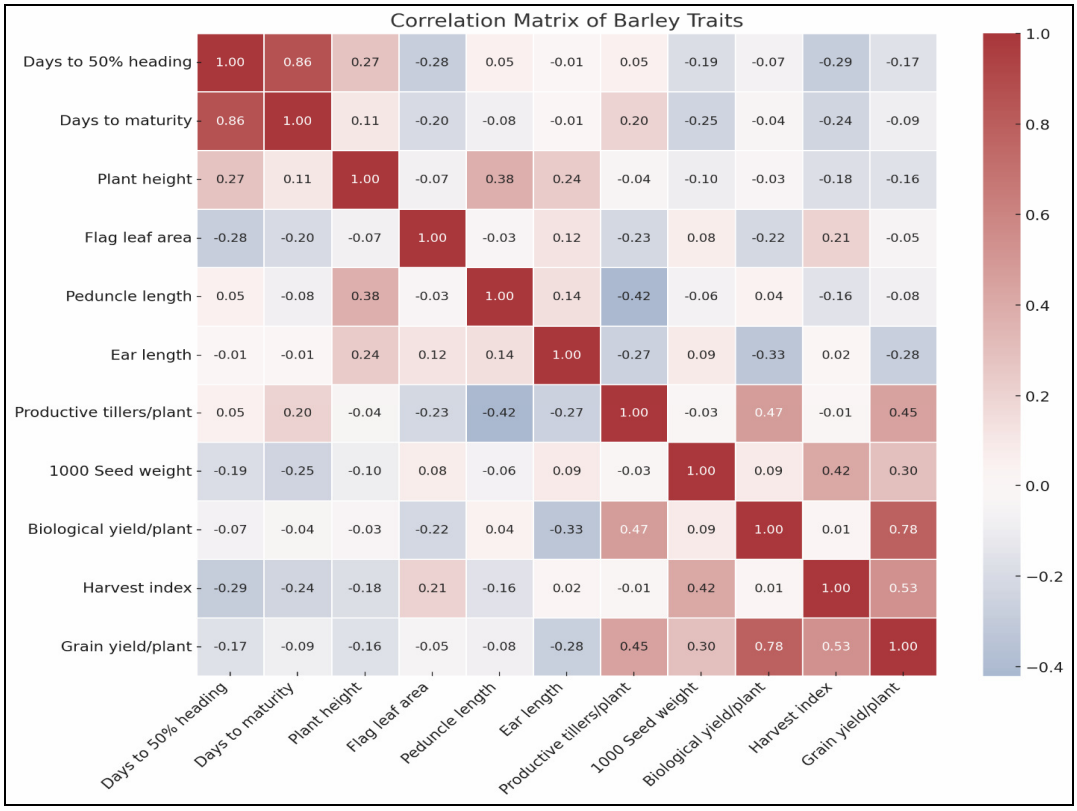

Fig. 2: Here is the correlation heatmap showing relationships among the 11 barley traits. Strong positive correlations (e.g., between grain yield and biological yield) and negative ones (e.g., between harvest index and days to 50% heading) are clearly visible.

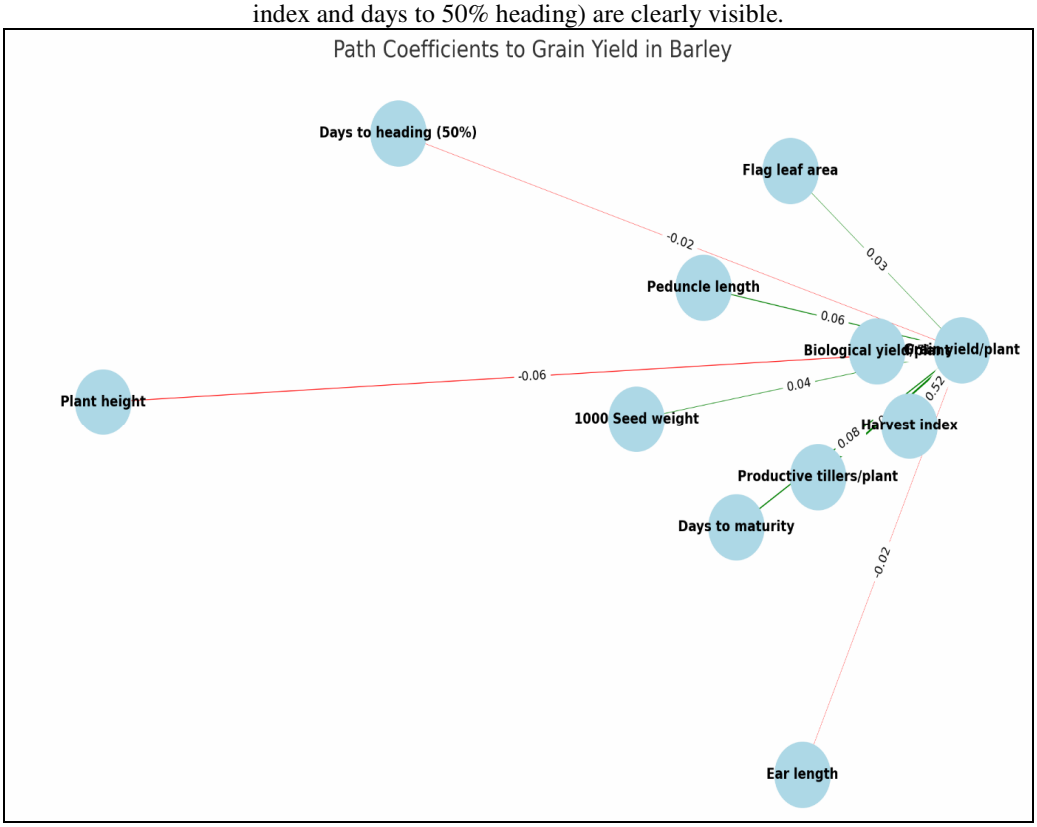

Fig. 3: Here's the path diagram showing **direct effects** of various traits on grain yield per plant. Traits like **biological yield/plant** and **harvest index** have the strongest positive direct effects, while **plant height** and **days to heading** show negative impacts.

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