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Genetic variability, heritability, correlation and path coefficient analysis in coriander (*Coriandrum sativum* L.)

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Abstract

A field experiment was conducted at Experimental farm of Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand, during the Rabi season of 2025-2026 to evaluate different coriander varieties and identify superior performing genotypes. A randomized complete block design with three replications was employed to cultivate and assess fourteen distinct coriander varieties under uniform environmental conditions. The researchers recorded sixteen important morphological and yield parameters, including plant height, flowering duration, number of branches, and seed yield. All coriander varieties exhibited significant variation in their performance, demonstrating adequate genetic diversity within the germplasm. This diversity provides valuable opportunities for plant breeders to select superior genotypes for developing improved coriander varieties. Furthermore, the study revealed that while genetic factors primarily controlled most important traits, environmental conditions also influenced plant performance. Yield-related characteristics, particularly seed yield per plant and seed yield per hectare, showed high heritability estimates indicating strong potential for selection-based genetic improvement. Correlation analysis revealed that plants with higher numbers of primary branches, increased umbel count, greater seeds per umbel, and elevated thousand seed weight typically achieved superior seed yields. Among all tested varieties, LC-D1, LG-3, and ML-1 demonstrated exceptional performance for yield and programs aimed at developing high-yielding coriander cultivars.

Keywords: Coriander, genetic diversity, heritability, correlation, seed yield, breeding

Introduction

Coriander represents one of the most significant spice crops within the Apiaceae family and is cultivated extensively throughout India for both its dried seeds and fresh green leaves. The seeds and leaves are commonly utilized in culinary applications to enhance food aroma and flavor. Beyond their culinary applications, coriander seeds possess considerable medicinal and nutritional value due to their content of essential oils, antioxidants, vitamins, and other beneficial compounds. India ranks among the world's leading producers and consumers of coriander, making this crop essential to the nation's spice industry. Previous research by scholars such as Basol *et al.* [1] demonstrated substantial variation among different coriander cultivars, highlighting the importance of investigating genetic diversity for crop improvement (Abdurrahman Basol *et al.*, 2024) [1]. Consequently, enhancing coriander yield and overall plant performance has become a primary objective for plant breeders. Despite its economic importance, coriander production remains suboptimal in many regions. This limitation stems primarily from the scarcity of high-yielding varieties, climate change impacts, and insufficient systematic breeding programs. Therefore, improving seed yield and other relevant characteristics constitutes one of the principal goals of coriander breeding initiatives. Understanding the extent of genetic diversity and inheritance patterns of various traits is essential before selecting superior plants for improvement programs, as yield represents a complex trait influenced by multiple genes and environmental factors. Genetic diversity serves as the foundation of every crop improvement program, as it enables breeders to identify and select superior plant genotypes. Parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, and genetic advance measure the level of diversity within a crop population and the extent to which traits can be improved through selection

(Abdurrahman Basol *et al.*, 2024) ^[1]. Traits exhibiting high heritability and high genetic advance, which are predominantly controlled by genetic factors, can be effectively improved through direct selection. Heritability and genetic advance provide breeders with insights into the genetic influence on traits and the potential improvement achievable through selection. Traits demonstrating high heritability and high genetic advance are generally considered more suitable for crop improvement, as they respond favorably when superior plants are selected. Studies by Kulumsa *et al.* and Moharana *et al.* have reported comparable findings regarding genetic diversity and inheritance in coriander. Correlation analysis serves as a vital statistical tool for examining relationships between various plant characteristics and their influence on seed yield. However, correlation alone cannot determine whether a character's effect on yield is direct or indirect. Path coefficient analysis is therefore employed to differentiate between the direct and indirect effects of various traits on yield.

This enhances the efficiency of selection within breeding programs and assists researchers in identifying the critical characteristics that contribute to increased seed production. Recent studies conducted by Kumar *et al.* ^[6] and Marker ^[11] have further underscored the importance of correlation and path coefficient analysis for recognizing significant yield-related traits in coriander. Although coriander represents a major commercial crop, environmental conditions and the complex genetic control of yield-associated traits continue to influence coriander productivity. Consequently, it becomes crucial to evaluate different coriander genotypes and identify superior varieties possessing higher yield potential and desirable characteristics. Given these considerations, the present study was conducted under Rabi conditions in Uttarakhand to evaluate genetic variability, heritability, genetic advance, correlation, and path coefficient analysis among different coriander genotypes (Abdurrahman Basol *et al.*, 2024) ^[1]. The primary objective of this study was to identify superior coriander genotypes and important selection criteria that could contribute to enhancing seed production in future breeding programs.

2. Materials and Methods: The current experiment was conducted in the Experimental field of Dev Bhoomi Uttarakhand University in Dehradun, Uttarakhand, during

the Rabi season of 2025-2026. The study's primary objective was to evaluate various coriander cultivars and identify those best adapted to Uttarakhand's climatic conditions.

For the experiment, fourteen coriander genotypes were selected along with one check, representing different coriander lines and varieties. The investigation employed a Randomized Block Design (RBD) with three replications. This methodology enhanced the experiment's accuracy and reliability by minimizing the influence of environmental variations including soil fertility, moisture content and sunlight distribution across the field. Sixteen important plant characteristics related to plant growth, flowering, maturity, and seed production were monitored throughout the trial. These included the number of umbels per plant, the number of seeds per umbel, the number of primary branches per plant, the number of leaves per plant, days to flowering, days to maturity, seeds per plant, seeds per hectare, and days required for 50% germination. These characteristics were comprehensively analyzed as they contribute to understanding the overall productivity and performance of each coriander genotype. After data collection, the observations were statistically analyzed to determine whether significant differences existed among the coriander varieties.

Analysis of Variance (ANOVA) was conducted using the Randomized Block Design methodology proposed by Panse and Sukhatme. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated using the methodology recommended by Burton and DeVane. These analyses quantified the extent of diversity among coriander genotypes and revealed the degree to which environmental factors influenced the expression of various traits.

Heritability and genetic advancement were calculated using methods suggested by previous research. These parameters helped determine whether genetic factors predominantly controlled the traits and assessed the potential for selection to improve them in future breeding programs. Additionally, correlation analysis and path coefficient analysis were employed to examine the relationships between various plant characteristics and their direct and indirect contributions to seed yield. These investigations helped identify the most important traits associated with enhanced seed yield for selecting superior coriander varieties in future crop improvement programs.

Table 1: Experimental materials for this study consist of 14 genotypes of coriander collected from different source

Sr. No.	Genotypes	Source of genotype
1.	LC-D1	Local Coriander Dehradun-1
2.	LC-D2	Local Coriander Dehradun-2
3.	LG-1	Sahaspur Dehradun Local Farmer Variety
4.	LG-2	Vikasnagar Dehradun Local Farmer Variety
5.	LG-3	DOIwala Dehradun Local Farmer Variety
6.	NDC-2	ND cor-2(Check variety)
7.	LC-D3	Local Coriander Dehradun-3
8.	LG-4	Badowala Dehradun Local Farmer Variety
9.	JL-1	Jhakhya local variety-1
10.	ML-1	Masoori local variety -1
11.	ML-2	Masoori local variety -2
12.	ML-3	Masoori local variety -3
13.	ML-4	Masoori local variety -4
14.	ML-5	Masoori local variety -5
15.	ML-6	Masoori local variety -6

3. Results and Discussion

This analysis presents the results of analysis of variance (ANOVA) for sixteen significant parameters associated with growth, flowering, and yield characteristics examined across multiple coriander genotypes during the Rabi season. ANOVA was employed to assess whether the coriander genotypes exhibited genuine and significant differences for the traits under study. The results demonstrated substantial variation among all genotypes for each evaluated characteristic. This finding indicates considerable genetic diversity among the coriander cultivars, which proves highly advantageous for selecting superior-performing plants in future breeding and crop improvement programs. The treatment value for days to 50% germination (D50G) was highly significant (2.651**), indicating that germination patterns among the coriander genotypes differed substantially. Plant height (PH) similarly showed significant variation among genotypes with a treatment value of 8.927*, with certain genotypes achieving greater height while others remained more compact. Days to first flowering (DFF), days to 50% flowering (D50F), days to maturity (DM), number of primary branches per plant (NPB), and number of leaves per plant (NLP) all exhibited comparable significant differences. These results demonstrate that the growth and flowering characteristics varied considerably among genotypes. The coriander genotypes also showed significant differences in critical yield-related traits including test seed weight (TSW), number of umbels per umbel (NUU),

number of umbels per plant (NUP), and number of seeds per umbel (NSU). This variation indicates that genotypes differed in their capabilities for seed development, flowering capacity, and seed production. The documented variation can support researchers in identifying genotypes with superior yield potential, as these characteristics directly influence seed production. The genotypes demonstrated significant differences in seed yield parameters, including seed yield per plant (SYP), seed yield per genotype or plot (SYPG), seed yield per kilogram (SYPK), seed yield per hectare in kilograms (SYHK), and seed yield per hectare in tonnes (SYHT). Seed yield per hectare in kilograms (SYHK) exhibited the highest treatment value (16804.224**), followed by seed yield per genotype or plot (4201.026**). This pattern suggests that the coriander genotypes demonstrated substantial variation in seed production performance. Such diversity indicates strong potential for enhancing seed yield through targeted breeding and selection strategies. The relatively low error values for most traits indicate that the experiment was conducted with appropriate precision and that environmental effects were minimized. Overall, the ANOVA results confirmed that the coriander genotypes exhibited significant variation across growth, flowering, and yield-related traits. This diversity can be effectively utilized in future coriander breeding programs to develop improved and higher-yielding coriander varieties.

Table 2: Analysis of variance

Trait	Replication	Treatment	Error
D50G	0.158	2.651**	0.647
PH	1.521	8.927*	3.203
NPB	0.264	0.795**	0.223
NLP	18.431	20.482*	7.354
DFF	1.493	2.704*	0.970
D50F	0.306	2.103*	0.753
DM	3.133	7.557*	2.717
NUP	4.356	17.988*	6.458
NUU	0.199	1.624**	0.435
NSU	4.16	16.314*	5.857
TSW	0.335	0.422*	0.151
SYP	0.028	0.421**	0.077
SYPG	246.128	4201.026**	748.162
SYPK	0	0.004**	0.001
SYHK	984.628	16804.224**	2,866.414
SYHT	0.095	1.68**	0.266

*Significant at 5% level of probability, **significant at 1% level of probability

The Significant variation was observed among coriander genotypes regarding growth, flowering, and yield-related parameters. This variation demonstrates that characteristics such as plant development, flowering duration, seed production, and overall yield capacity differed substantially across genotypes. Through systematic evaluation of genotypic performance, researchers identified superior genotypes possessing desirable attributes that may contribute to future breeding programs and agricultural improvement strategies (Choudhary *et al.*, 2025) [2].

Among all evaluated genotypes, LC-D1 demonstrated exceptional performance across multiple critical yield-related parameters, including seed yield per plant, seed yield per plot, and seed yield per hectare. Furthermore, this genotype exhibited elevated values for leaf number per plant and 1000-seed weight, indicating considerable potential for enhanced productivity. The superior performance characteristics of LC-D1 position it as a promising candidate for developing high-yielding coriander cultivars. The genotype LG-3 consistently exhibited strong performance across several important yield-contributing

parameters, including plant height, umbel number per plant, seed number per umbel, and total seed production. The robust performance of this genotype indicates favorable growth and yield characteristics, establishing its value for subsequent breeding initiatives aimed at enhancing coriander productivity.

Similarly, genotype ML-1 demonstrated superior performance in yield-related characteristics, particularly regarding primary branch number and leaf count per plant. Given the positive correlation between these traits and seed production, the exceptional performance of ML-1 suggests its potential utility in coriander improvement programs (Choudhary *et al.*, 2025) [2].

Genotype LG-2 exhibited reduced values for days to 50% germination and days to first flowering, both characteristics

associated with earliness. This indicates that the genotype achieved earlier germination and flowering compared to other genotypes. Early maturity and flowering represent critical attributes in crop breeding, as they enable plants to complete their developmental cycle more rapidly and potentially avoid unfavorable environmental conditions. Therefore, LG-2 may prove valuable in developing early-maturing coriander cultivars (Choudhary *et al.*, 2025) [2]. The superior performance of these genotypes indicates strong potential for incorporation into future hybridization and crop development programs. These genotypes may serve as valuable parental lines for creating coriander varieties characterized by high yield, enhanced productivity, and adaptability to diverse cultivation environments as represented under table 3 and 4.

Table 3: Summary means table for different genotypes of coriander with different parameters

Treatment	D50G	PH	NPB	NLP	DFF	D50F	DM
LC-D1	10.333	84.397	7.517	50.117	34.733	44.697	101.030
LC-D2	9.000	81.527	6.183	42.063	36.383	45.377	101.043
LG-1	11.333	80.697	6.343	42.053	35.713	45.377	101.040
LG-2	8.000	82.393	7.020	44.037	33.707	45.700	99.033
LG-3	10.000	85.473	7.347	48.107	35.377	45.027	102.037
NDC-2	9.000	79.413	6.343	44.060	37.393	46.047	101.030
LC-D3	11.333	82.420	6.173	42.043	35.707	45.363	102.030
LG-4	10.000	83.850	6.670	43.073	35.380	44.360	102.027
JL-1	9.667	83.700	6.347	44.057	35.377	44.363	103.027
ML-1	9.333	82.280	7.843	49.130	36.373	43.040	105.023
ML-2	9.333	85.520	7.187	45.067	34.370	45.363	98.030
ML-3	8.333	81.673	6.503	44.063	35.033	44.690	101.030
ML-4	9.333	82.323	6.710	43.050	36.390	45.377	102.040
ML-5	9.333	81.577	6.600	45.090	35.357	44.357	101.023
ML-6	9.000	81.257	6.490	42.040	34.363	43.357	101.030
Mean	9.556	82.567	6.752	44.537	35.444	44.833	101.365
Min	8.000	79.413	6.173	42.040	33.707	43.040	98.030
Max	11.333	85.520	7.843	50.117	37.393	46.047	105.023
CV (%)	8.417	2.168	6.994	6.089	2.778	1.936	1.626
Sem	0.464	1.033	0.273	1.566	0.569	0.501	0.952
CD@5%	1.345	2.993	0.790	4.535	1.647	1.451	2.757
CD@1%	1.815	4.038	1.065	6.118	2.222	1.958	3.719

Treatment	NUP	NUU	NSU	TSW	SYP	SYPG	SYPK
LC-D1	39.027	5.270	44.033	11.420	3.817	401.700	0.397
LC-D2	31.027	6.570	38.023	10.310	2.817	301.700	0.300
LG-1	30.023	6.770	37.027	10.213	2.717	291.700	0.290
LG-2	33.030	7.727	39.023	10.413	2.887	308.633	0.307
LG-3	37.030	7.573	45.030	11.213	3.717	391.700	0.387
NDC-2	33.023	7.073	40.020	10.377	3.017	321.700	0.317
LC-D3	31.033	6.267	38.020	10.310	2.817	301.700	0.300
LG-4	32.030	6.603	39.027	10.513	2.913	312.533	0.310
JL-1	33.030	7.207	40.023	10.613	2.863	306.533	0.307
ML-1	35.697	7.030	43.023	11.013	3.617	381.700	0.377
ML-2	34.027	8.637	41.023	10.713	2.920	312.200	0.313
ML-3	32.027	6.903	39.023	10.310	2.717	291.700	0.290
ML-4	33.027	7.003	40.027	10.413	2.817	301.700	0.300

ML-5	32.030	6.903	39.023	10.310	2.867	306.533	0.307
ML-6	31.027	6.703	38.023	10.213	2.717	291.700	0.290
Mean	33.139	6.949	40.025	10.557	3.014	321.562	0.319
Min	30.023	5.270	37.027	10.213	2.717	291.700	0.290
Max	39.027	8.637	45.030	11.420	3.817	401.700	0.397
CV (%)	7.668	9.489	6.047	3.679	9.188	8.506	7.560
Sem	1.467	0.381	1.397	0.224	0.160	15.792	0.014
CD@5%	4.250	1.103	4.048	0.650	0.463	45.748	0.040
CD@1%	5.733	1.488	5.460	0.876	0.625	61.713	0.054

Table 4: Genetic variability Mean, Range (Minimum and Maximums), Coefficient of variations, Standard Error of mean and Critical differences at a 5% level of significance

Trait	Mean	Min	Max	CV (%)	SEm	CD @ 5%
Days to 50% germination	9.556	8.000	11.333	8.417	0.464	1.345
Plant height in 120 days (cm)	82.567	79.413	85.520	2.168	1.033	2.993
Number of primary branches per plant	6.752	6.173	7.843	6.994	0.273	0.790
Number of leaves per plant	44.537	42.040	50.117	6.089	1.566	4.535
Days to first flowering	35.444	33.707	37.393	2.778	0.569	1.647
Days to 50% flowering	44.833	43.040	46.047	1.936	0.501	1.451
Days to maturity	101.365	98.030	105.023	1.626	0.952	2.757
Number of umbels per plant	33.139	30.023	39.027	7.668	1.467	4.250
Number of umbellets per umbel	6.949	5.270	8.637	9.489	0.381	1.103
Number of seeds per umbel	40.025	37.027	45.030	6.047	1.397	4.048
1000 seed weight (g)	10.557	10.213	11.420	3.679	0.224	0.650
Seed yield per plant (g)	3.014	2.717	3.817	9.188	0.160	0.463
Seed yield per plot (g)	321.562	291.700	401.700	8.506	15.792	45.748
Seed yield per plot (kg)	0.319	0.290	0.397	7.560	0.014	0.040
Seed yield per hectare (kg)	643.124	583.400	803.400	8.325	30.911	89.545
Seed yield per hectare (tonnes)	6.431	5.833	8.033	8.013	0.298	0.862

For all sixteen characters examined, the Analysis of Variance (ANOVA) revealed significant differences among the fourteen coriander genotypes. This demonstrates conclusively that the coriander varieties utilized in the experiment possess substantial genetic diversity. In plant breeding, genetic diversity is essential as it enables researchers to identify and select superior genotypes with desirable traits including higher yield, improved growth, and enhanced adaptability (Abdurrahman Basol *et al.*, 2024) ^[1]. Several key characteristics, including seed yield per plant, seed yield per plot, number of umbels per plant, and number of umbellets per umbel, exhibited considerable variation. The presence of this variation indicates that the coriander genotypes in this study were genetically diverse. This diversity is beneficial because it provides additional opportunities to select superior genotypes for future breeding and crop improvement programs. For every character examined in this study, the phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV). This indicates that environmental factors also influenced the expression of these traits to some extent. However, the difference between PCV and GCV values was relatively small for several traits, suggesting that genetic factors also played a substantial role in these characteristics. Therefore, these traits can be significantly improved through appropriate selection methods. Key yield-related traits including seed yield per plant (11.23 and 14.51), seed yield

per plot (10.55 and 13.55), and seed yield per hectare (10.59 and 13.47) demonstrated higher GCV and PCV values. These elevated values indicate considerable potential for improving seed production through breeding and selection, as they reflect greater variation among genotypes for these attributes. Moharana *et al.*, Kulumsa *et al.*, Meena *et al.*, and Verma *et al.* reported similar findings regarding higher GCV and PCV values for yield attributes in coriander. In contrast, traits including plant height, days to maturity, and days to flowering showed relatively limited variation among the coriander genotypes. Reduced variability for these traits suggests that these characteristics were more stable under the current environmental conditions and that the genotypes were more uniform for these attributes. This also indicates that these traits had a narrower genetic base compared to the yield-related characteristics represent in table 5.

Plant breeders can better understand how much of a trait's variation is transmitted through genes from parents to subsequent generations by utilizing the fundamental genetic concept of heritability. Simply stated, it helps researchers determine whether a trait is primarily influenced by genetic factors or by environmental factors such as temperature, soil fertility, rainfall, and climate. Genetic progress refers to the degree of improvement in a trait that can be achieved when superior-performing plants are selected and used in breeding programs.

Table 5: Estimates of genetic parameters for different traits in coriander

Trait	GCV	PCV	h ² (%)	GA	GAM (%)
Days to 50% germination	8.553	12.000	50.803	1.200	12.558
Plant height in 120 days (cm)	1.673	2.738	37.329	1.739	2.106
Number of primary branches per plant	6.466	9.525	46.081	0.610	9.042
Number of leaves per plant	4.697	7.690	37.309	2.632	5.910
Days to first flowering	2.145	3.510	37.346	0.957	2.700
Days to 50% flowering	1.496	2.447	37.408	0.845	1.885
Days to maturity	1.253	2.053	37.254	1.597	1.575
Number of umbels per plant	5.916	9.685	37.313	2.467	7.444
Number of umbellets per umbel	9.059	13.119	47.684	0.896	12.887
Number of seeds per umbel	4.665	7.637	37.309	2.349	5.869
1000 seed weight (g)	2.845	4.651	37.424	0.379	3.586
Seed yield per plant (g)	11.232	14.511	59.907	0.540	17.908
Seed yield per plot (g)	10.550	13.552	60.605	54.406	16.919
Seed yield per plot (kg)	10.385	12.845	65.358	0.055	17.294
Seed yield per hectare (kg)	10.598	13.477	61.844	110.421	17.170
Seed yield per hectare (tonnes)	10.675	13.348	63.965	1.131	17.588

Heritability and genetic progress work together to help scientists identify which plant characteristics may be enhanced more effectively through breeding and selection. Key characteristics including days to 50% germination, seed yield per plant, seed yield per plot, and seed yield per hectare exhibited moderate to high heritability values in this study. As a percentage of mean, these characteristics also demonstrated moderate levels of genetic progress. This indicates that these traits are largely controlled by additive gene action, which means that gene effects are consistently transmitted from parents to offspring. Since these traits are more influenced by genetic factors and less affected by environmental variations, direct selection can effectively improve them. Seed yield per hectare displayed both substantial genetic progress and relatively high heritability among all parameters examined. This indicates that selecting plants based on this trait would be reliable and effective for increasing coriander productivity and overall seed production. The high heritability and genetic progress of this trait suggest that breeding and selection would be more successful and stable across multiple generations. Yadav *et al.*, Choudhary *et al.*, and Kulumsa *et al.* [2] have reported similar findings indicating moderate to high heritability and genetic progress for yield-related parameters in coriander. These studies also revealed that appropriate selection and breeding methods can successfully improve yield-related characteristics in coriander. However, characteristics including plant height, days to flowering, and days to maturity demonstrated limited genetic progress and moderate heritability. This suggests that these traits are influenced by environmental factors, non-additive gene action, and genetic factors. Consequently, improving these traits through direct selection would not be highly effective; instead, more sophisticated breeding approaches might be required. Overall, the study's combined results of heritability and genetic progress indicate that selection for seed production and other important yield-related traits can be effectively implemented in coriander breeding programs. These findings suggest that there is substantial potential for developing coriander varieties with enhanced yields and

improved performance through appropriate breeding and selection strategies.

The correlation analysis revealed significant positive associations among multiple key traits influencing seed yield at both phenotypic and genotypic levels. These findings demonstrate that specific plant characteristics exhibited strong correlations with seed production, whereby enhancement of these traits correspondingly increased seed yield. Primary branches per plant, leaves per plant, umbels per plant, seeds per umbel, and test weight all demonstrated robust positive correlations with seed yield per plant. These results suggest that plants exhibiting greater numbers of branches, leaves, umbels, and seeds, along with superior seed weight, typically generated higher seed yields.

Particularly noteworthy were the exceptionally strong positive correlations observed between seed yield and both the number of umbels per plant and the number of seeds per umbel. These findings establish these two characteristics as fundamental determinants for enhancing overall coriander productivity and maximizing seed production. Consequently, breeding programs may achieve greater success in developing high-yielding coriander varieties through selection of plants possessing increased umbel numbers and higher seed counts per umbel.

Notably, genotypic correlation coefficients consistently exceeded their phenotypic counterparts. This pattern indicates that genetic factors exerted greater influence on trait relationships than environmental factors. These characteristics therefore demonstrate enhanced reliability for implementation in breeding and selection programs due to their inherent genetic linkage through inheritance mechanisms.

The positive correlations observed among yield-contributing traits indicate that enhanced seed yield may be achieved through direct yield selection or through selection of plants demonstrating superior performance for associated traits. Consequently, indirect selection utilizing key component traits such as umbels per plant and seeds per umbel represents a valuable approach in coriander improvement programs.

These findings corroborate previous coriander research. The present results demonstrate strong concordance with investigations conducted by Kumar *et al.* and Marker, ^[6, 11]

who reported comparable significant positive correlations between coriander seed yield and both umbel number per plant and seed number per umbel.

Table 6: Estimation of Phenotypic Correlation matrix for different characters in coriander genotypes

Trait	D50G	PH	NPB	NLP	DFE	D50F	DM	NUP	NUU	NSU	TSW	SYPG	SYPK	SYHK	SYHT	SYP
D50G	1.000	0.193	-0.083	0.013	0.069	0.049	0.167	-0.042	-0.253	-0.027	0.108	0.117	0.121	0.118	0.120	0.117
PH		1.000	0.440**	0.340*	-0.441**	0.064	-0.072	0.312*	0.165	0.336*	0.569**	0.367*	0.385**	0.368*	0.370*	0.366**
NPB			1.000	0.618**	-0.152	-0.115	0.170	0.665**	0.132	0.678**	0.570**	0.702**	0.708**	0.709**	0.708**	0.701**
NLP				1.000	0.002	0.075	0.504**	0.846**	0.066	0.840**	0.574**	0.760**	0.764**	0.761**	0.762**	0.758**
DFE					1.000	0.289	0.371*	-0.032	-0.085	0.019	-0.068	0.114	0.089	0.114	0.105	0.114
D50F						1.000	-0.104	0.087	0.178	0.089	-0.016	0.077	0.046	0.072	0.068	0.080
DM							1.000	0.436**	-0.136	0.500**	0.109	0.340*	0.308*	0.339*	0.341*	0.338*
NUP								1.000	0.017	0.974**	0.578**	0.735**	0.728**	0.736**	0.739**	0.734**
NUU									1.000	0.101	-0.131	-0.180	-0.179	-0.181	-0.185	-0.182
NSU										1.000	0.568**	0.742**	0.734**	0.743**	0.746**	0.740**
TSW											1.000	0.729**	0.744**	0.731**	0.734**	0.734**
SYPG												1.000	0.995**	1.000**	0.999**	1.000**
SYPK													1.000	0.995**	0.996**	0.994**
SYHK														1.000	1.000**	1.000**
SYHT															1.000	0.999**
SYP																1.000

Table 7: Estimation of Genotypic Correlation matrix for different characters in coriander genotypes

Trait	D50G	PH	NPB	NLP	DFE	D50F	DM	NUP	NUU	NSU	TSW	SYPG	SYPK	SYHK	SYHT	SYP
D50G	1.000	0.191	-0.067	0.004	0.075	0.041	0.173	-0.035	-0.252	-0.020	0.091	0.115	0.121	0.115	0.117	0.115
PH		1.000	0.449**	0.356*	-0.453**	0.072	-0.092	0.291	0.168	0.314*	0.575**	0.357*	0.372*	0.358*	0.360*	0.355*
NPB			1.000	0.632**	-0.180	-0.095	0.135	0.625**	0.130	0.638**	0.586**	0.685**	0.686**	0.685**	0.690**	0.683**
NLP				1.000	-0.052	0.097	0.430**	0.771**	0.070	0.763**	0.602**	0.720**	0.698**	0.721**	0.722**	0.717**
DFE					1.000	0.264	0.394**	-0.002	-0.093	0.048	-0.115	0.123	0.102	0.122	0.114	0.124
D50F						1.000	-0.118	0.073	0.172	0.046	0.008	0.076	0.042	0.072	0.063	0.079
DM							1.000	0.450**	-0.188	0.513**	0.058	0.342*	0.314*	0.341*	0.342*	0.341*
NUP								1.000	0.012	0.974**	0.520**	0.732**	0.728**	0.733**	0.735**	0.730**
NUU									1.000	0.094	-0.121	-0.137	-0.134	-0.138	-0.142	-0.137
NSU										1.000	0.508**	0.739**	0.734**	0.740**	0.743**	0.737**
TSW											1.000	0.695**	0.703**	0.696**	0.699**	0.698**
SYPG												1.000	0.994**	1.000	0.999**	1.000**
SYPK													1.000	0.995**	0.995**	0.994**
SYHK														1.000	1.000**	1.000**
SYHT															1.000	0.999**

Path coefficient analysis was employed to decompose correlation coefficients into their direct and indirect components, thereby facilitating the precise identification of traits with the greatest influence on seed production. This analytical approach enabled researchers to distinguish between plant characteristics that directly enhance seed output and those that exert their influence through intermediary pathways (Choudhary *et al.*, 2025) ^[2]. Plants exhibiting greater umbel numbers, increased seeds per umbel, enhanced seed weight, and expanded foliage consistently generated superior seed yields.

The demonstration of significant positive direct effects for these traits underscores their critical role in determining seed yield outcomes. Consequently, these characteristics may be considered reliable and effective selection criteria for coriander breeding programs. Traits demonstrating both substantial direct yield effects and strong positive correlations are generally recognized as superior candidates for indirect selection, as their improvement will ultimately contribute to enhanced overall seed production.

The present study's results suggest that these characteristics should receive priority consideration when selecting superior coriander genotypes for yield enhancement. By emphasizing traits such as umbel number per plant, seed number per umbel, test weight, and leaf number per plant, plant breeders can more effectively develop high-yielding coriander cultivars. Some of the parameters show positive response while other shows negative response to the yield. In Phenotypic as well as Genotypic path matrix parameters such as NUP, TSW and SYPG shows the direct influence to the yield of the plant leading to the selection of these parameters for the improvement of the yield traits.

Corroborating evidence from Moharana *et al.* and Kumar *et al.* ^[6] demonstrated comparable positive direct effects on seed yield from umbel number per plant, test weight, and seed number per umbel. These studies further confirmed the significant contribution of these traits to enhanced coriander seed production.

Table 8: Estimation of Phenotypic Path matrix for different characters in coriander genotypes

Trait	D50G	PH	NPB	NLP	DFE	D50F	DM	NUP	NUU	NSU	TSW	SYPG	SYPK	SYHK	SYHT	SYP
D50G	0.0017	0.0003	-0.0001	0.0000	0.0001	0.0001	0.0003	-0.0001	-0.0004	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.1168
PH	-0.0014	-0.0073	-0.0032	-0.0025	0.0032	-0.0005	0.0005	-0.0023	-0.0012	-0.0025	-0.0042	-0.0027	-0.0028	-0.0027	-0.0027	0.3656*
NPB	0.0001	-0.0011	-0.0026	-0.0016	0.0004	0.0003	-0.0004	-0.0017	-0.0003	-0.0017	-0.0015	-0.0018	-0.0018	-0.0018	-0.0018	0.7012**
NLP	0.0000	-0.0007	-0.0013	-0.0021	0.0000	-0.0002	-0.0011	-0.0018	-0.0001	-0.0018	-0.0012	-0.0016	-0.0016	-0.0016	-0.0016	0.7581**
DFE	0.0001	-0.0004	-0.0001	0.0000	0.0008	0.0002	0.0003	0.0000	-0.0001	0.0000	-0.0001	0.0001	0.0001	0.0001	0.0001	0.1145
D50F	0.0000	0.0000	0.0000	0.0000	-0.0001	-0.0004	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0802
DM	-0.0001	0.0000	-0.0001	-0.0003	-0.0002	0.0001	-0.0005	-0.0002	0.0001	-0.0003	-0.0001	-0.0002	-0.0002	-0.0002	-0.0002	0.3385*
NUP	-0.0006	0.0042	0.0089	0.0113	-0.0004	0.0012	0.0058	0.0134	0.0002	0.0130	0.0077	0.0098	0.0097	0.0099	0.0099	0.7336**
NUU	-0.0015	0.0010	0.0008	0.0004	-0.0005	0.0011	-0.0011	0.0001	0.0059	0.0006	-0.0008	-0.0008	-0.0008	-0.0008	-0.0008	-0.1294
NSU	0.0004	-0.0049	-0.0099	-0.0123	-0.0003	-0.0009	-0.0073	-0.0142	-0.0015	-0.0146	-0.0083	-0.0108	-0.0107	-0.0108	-0.0109	0.7400**
TSW	0.0019	0.0102	0.0102	0.0103	-0.0012	-0.0003	0.0019	0.0103	-0.0023	0.0101	0.0179	0.0130	0.0133	0.0131	0.0131	0.7337**
SYPG	0.2472	0.7759	1.4830	1.6044	0.2413	0.1625	0.7185	1.5525	-0.2748	1.5663	1.5407	2.1123	2.1013	2.1122	2.1108	0.9997**
SYPK	-0.0025	-0.0081	-0.0149	-0.0157	-0.0019	-0.0010	-0.0065	-0.0153	0.0027	-0.0155	-0.0157	-0.0210	-0.0211	-0.0210	-0.0210	0.9944**
SYHK	-0.1616	-0.5062	-0.9659	-1.0453	-0.1559	-0.0996	-0.4665	-1.0120	0.1799	-1.0208	-1.0048	-1.3742	-1.3676	-1.3743	-1.3735	0.9996**
SYHT	0.0332	0.1028	0.1964	0.2115	0.0293	0.0175	0.0945	0.2050	-0.0374	0.2070	0.2038	0.2774	0.2764	0.2774	0.2775	0.9991**

Note: Diagonal values are direct effect values and the remaining values are indirect effect values.

Table 9: Estimation of Genotypic Path matrix for different characters in coriander genotypes

Trait	D50G	PH	NPB	NLP	DFE	D50F	DM	NUP	NUU	NSU	TSW	SYPG	SYPK	SYHK	SYHT	SYP
D50G	0.0011	0.0002	-0.0001	0.0000	0.0001	0.0000	0.0002	0.0000	-0.0003	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.1146
PH	-0.0011	-0.0056	-0.0025	-0.0020	0.0025	-0.0004	0.0005	-0.0016	-0.0009	-0.0018	-0.0032	-0.0020	-0.0021	-0.0020	-0.0020	0.3546*
NPB	0.0003	-0.0022	-0.0049	-0.0031	0.0009	0.0005	-0.0007	-0.0031	-0.0006	-0.0031	-0.0029	-0.0034	-0.0034	-0.0034	-0.0034	0.6832**
NLP	0.0000	-0.0037	-0.0066	-0.0105	0.0005	-0.0010	-0.0045	-0.0081	-0.0007	-0.0080	-0.0063	-0.0075	-0.0073	-0.0076	-0.0076	0.7168**
DFE	0.0001	-0.0006	-0.0002	-0.0001	0.0013	0.0004	0.0005	0.0000	-0.0001	0.0001	-0.0002	0.0002	0.0001	0.0002	0.0002	0.1242
D50F	0.0000	-0.0001	0.0001	-0.0001	-0.0002	-0.0009	0.0001	-0.0001	-0.0002	0.0000	0.0000	-0.0001	0.0000	-0.0001	-0.0001	0.0793
DM	0.0002	-0.0001	0.0001	0.0004	0.0004	0.0001	0.0010	0.0004	-0.0002	0.0005	0.0001	0.0003	0.0003	0.0003	0.0003	0.3406*
NUP	-0.0007	0.0062	0.0133	0.0165	0.0000	0.0016	0.0096	0.0213	0.0003	0.0208	0.0111	0.0156	0.0155	0.0156	0.0157	0.7304**
NUU	-0.0018	0.0012	0.0009	0.0005	-0.0006	0.0012	-0.0013	0.0001	0.0070	0.0007	-0.0008	-0.0010	-0.0009	-0.0010	-0.0010	-0.1367
NSU	0.0004	-0.0056	-0.0114	-0.0137	-0.0009	-0.0008	-0.0092	-0.0175	-0.0017	-0.0179	-0.0091	-0.0132	-0.0131	-0.0133	-0.0133	0.7373**
TSW	0.0014	0.0087	0.0088	0.0091	-0.0017	0.0001	0.0009	0.0078	-0.0018	0.0077	0.0151	0.0105	0.0106	0.0105	0.0105	0.6976**
SYPG	0.2289	0.7115	1.3647	1.4338	0.2450	0.1520	0.6807	1.4579	-0.2727	1.4718	1.3842	1.9927	1.9813	1.9926	1.9913	0.9997**
SYPK	-0.0038	-0.0116	-0.0215	-0.0218	-0.0032	-0.0013	-0.0098	-0.0228	0.0042	-0.0229	-0.0220	-0.0311	-0.0313	-0.0311	-0.0311	0.9939**
SYHK	-0.1452	-0.4504	-0.8623	-0.9063	-0.1538	-0.0904	-0.4288	-0.9221	0.1732	-0.9306	-0.8758	-1.2578	-1.2511	-1.2579	-1.2572	0.9996**
SYHT	0.0348	0.1068	0.2047	0.2141	0.0339	0.0186	0.1014	0.2180	-0.0420	0.2203	0.2074	0.2964	0.2952	0.2964	0.2966	0.9990**

Note: Diagonal values are direct effect values and the remaining values are indirect effect values.

The present investigation's results conclusively established substantial genetic diversity among the examined coriander genotypes. This genetic variability represents a fundamental asset for plant breeding programs, as it facilitates the identification and selection of superior cultivars possessing desirable characteristics (Crossa *et al.*, 2017) [3]. Seed yield-related traits demonstrated moderate to high heritability values coupled with moderate genetic advance, indicating that these attributes are predominantly governed by genetic factors and can be effectively improved through direct selection methodologies.

Among the evaluated coriander genotypes, LC-D1, LG-3, and ML-1 displayed superior performance across critical growth and productivity parameters. These exceptional genotypes present valuable opportunities as potential parental material for future hybridization programs and breeding initiatives focused on enhancing seed production and other commercially important traits in coriander. The selection of plants based on these significant yield-determining characteristics may facilitate the development of high-yielding coriander cultivars well-suited to Uttarakhand's environmental conditions.

The outcomes of this research provide substantial value to both researchers and coriander breeding specialists. Additionally, these findings may contribute significantly to future crop improvement programs dedicated to increasing productivity, improving environmental adaptation, and

developing enhanced coriander varieties for agricultural producers and commercial cultivation enterprises.

4. Conclusion

This investigation demonstrated substantial genetic diversity among fourteen coriander genotypes evaluated under Rabi growing conditions in Uttarakhand. Significant genotypic variations were observed across all sixteen morphological, phenological, and yield-related traits analyzed. This genetic variability represents a valuable resource for plant breeding programs, providing opportunities for selective improvement and enhanced agricultural productivity through systematic breeding approaches.

The analysis revealed that phenotypic coefficients of variation (PCV) consistently exceeded genotypic coefficients of variation (GCV) across all measured traits. This pattern indicates moderate environmental influence on character expression. Nevertheless, several key yield-related traits exhibited moderate to high heritability coupled with substantial genetic advance. These findings suggest that additive gene effects primarily govern the inheritance of these characteristics, indicating reliable transmission of genetic traits across generations. Consequently, these attributes can be effectively improved through strategic selection methodologies.

Among the evaluated coriander genotypes, LC-D1, LG-3, and ML-1 emerged as superior performers based on seed

yield and associated yield-contributing parameters. These genotypes demonstrated consistently enhanced performance relative to other entries in the evaluation. Their exceptional characteristics position them as valuable parental material for future coriander improvement programs and hybridization efforts aimed at developing high-yielding and efficient cultivars.

The research findings provide significant contributions to coriander genetic improvement strategies. These results will assist researchers and breeding specialists in developing cultivars with enhanced adaptability, superior yield potential, and improved performance under Uttarakhand's specific agroclimatic conditions. However, comprehensive evaluation across diverse environments and climatic scenarios remains essential to assess the stability and consistent performance of these promising genotypes before their widespread integration into breeding and cultivar development initiatives.

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