International Journal of Plant & Soil Science

Volume 38, Issue 7, Page 518-529, 2026; Article no.IJPSS.161848
ISSN: 2320-7035

Correlation and Path coefficient analysis of Morphological Characters and Seed Yield in Chickpea (*Cicer arietinum* L.) Germplasm

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i76178

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/161848

Original Research Article

Received: 13/05/2026
Accepted: 06/07/2026
Published: 10/07/2026

Abstract

Chickpea (*Cicer arietinum* L.) is a major pulse crop with significant nutritional value; however, its productivity remains below its genetic potential. This study evaluated genetic variability, character association, and selection criteria for seed yield improvement in twenty chickpea genotypes and one check. The experiment was conducted using a randomised block design with three replications. Twelve quantitative

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Cite as: *Ankem, H. C., Lavanya, G. R., Bukke, S. D. N., & Marapaka, P. (2026). Correlation and Path coefficient analysis of Morphological Characters and Seed Yield in Chickpea (Cicer arietinum L.) Germplasm. International Journal of Plant & Soil Science, 38(7), 518–529. https://doi.org/10.9734/ijpss/2026/v38i76178*

traits, including yield and yield-component characters, were recorded and analysed for association among the recorded traits. The present study assessed the relationships between yield and its component traits in chickpea using phenotypic and genotypic correlation, along with path coefficient analysis. The results indicated that genotypic correlations were generally stronger and more informative than phenotypic correlations, suggesting the predominant influence of inherited factors over environmental variation in the expression of yield-related traits. Seed yield per plant showed positive and significant associations with seed index, harvest index, days to 50% pod setting, days to maturity, and number of pods per plant. In addition, number of seeds per plant was strongly associated with pods per plant, while biological yield exhibited strong positive correlations with pods per plant and number of seeds per plant. Phenological traits also displayed positive interrelationships, indicating coordinated trait expression during crop development. Path coefficient analysis revealed that seed index, number of pods per plant, and harvest index exerted the strongest positive direct effects on seed yield per plant, while days to 50% pod setting and days to maturity contributed positively as secondary traits. In contrast, plant height and number of primary branches per plant showed negative direct contributions to yield. The study suggests that selection for seed index, pods per plant, and harvest index may be effective for improving grain yield in chickpea.

Keywords: Chickpea; Cicer arietinum; morphological traits; seed yield; genotypic correlation; phenotypic correlation; path coefficient analysis; harvest index; seed index; pods per plant; selection criteria.

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in South Asia and a major source of dietary protein, minerals, and bioactive compounds, especially in vegetarian diets. In India, chickpea occupies a central position among pulse crops, contributing nearly half of the country's pulse production, and its cultivation is concentrated in states such as Maharashtra, Madhya Pradesh, Rajasthan, Gujarat, and Uttar Pradesh. Recent estimates indicate that India's chickpea production was about 13.75 million tonnes from 10.91 million ha with a productivity of 12.6 q ha−1 in 2021–22, while more recent projections for 2025–26 suggest production of around 11.337 million metric tonnes, reflecting year-to-year fluctuations caused by weather, area shifts, and market conditions. These figures highlight both the economic importance of chickpea and the continued need to stabilise and enhance productivity through breeding (AgPulse Analytica, 2025). Recent biochemical evaluation of chickpea genotypes also indicates that nutritional and biochemical attributes differ across germplasm and can support the selection of useful material for crop improvement (Rajput et al., 2023).

Although chickpea has achieved substantial improvement over time, productivity remains lower than the crop's genetic potential under many growing environments. Yield in chickpea is a complex quantitative trait that is influenced by several morphological and yield-related characters, such as plant height, number of primary and secondary branches, pods per plant, seeds per pod, biological yield, 100-seed weight, and harvest index (Phiri et al., 2023). Because direct selection for seed yield can be less effective due to its polygenic nature and strong environmental influence, correlation analysis is a useful approach for identifying traits that are associated with yield and can be used as indirect selection criteria in breeding programmes (Patel et al., 2025). Recent association and path-analysis studies in chickpea further indicate that yield-related traits should be interpreted through both correlation and direct-effect estimates before they are used as selection criteria (Sharma et al., 2026; Patil et al., 2024).

Morphological characterisation has long been recognised as an important first step in evaluating genetic variability among chickpea genotypes and identifying agronomically valuable traits for improvement. Previous studies have reported substantial variation among chickpea genotypes for plant height, pod number, seed weight, dry matter accumulation, and harvest index, and several of these traits showed significant positive associations with grain yield (Behera et al., 2023; Bharath et al., 2024). Recent evaluations of chickpea germplasm have also shown that yield-related trait variation and genetic diversity information can help identify useful breeding material (Philanim et al., 2025; Choi et al., 2024).

However, the available literature does not fully address the trait-association pattern of the present set of chickpea genotypes under the specific experimental conditions described in this study. A focused evaluation of correlation and path relationships is therefore required to identify dependable indirect selection traits for seed yield improvement in this germplasm.

In this context, correlation analysis of morphological characters is valuable for understanding trait interrelationships and identifying yield-contributing attributes that can be exploited in selection. Such information is especially useful when the objective is to develop high-yielding chickpea genotypes with improved plant architecture, better sink capacity, and stable productivity across environments. Therefore, the present study was undertaken to evaluate the association among morphological traits in chickpea genotypes and identify characters that may serve as effective selection criteria for seed yield improvement.

2. Materials and Methods

2.1 Experimental Material and Site

The investigation was conducted during the *Rabi* season 2022 at the experimental farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The study consisted of 20 chickpea genotypes and one check, Pusa 362. The experimental site is located at 25.57°N latitude and 81.56°E longitude, at an altitude of 98 m above mean sea level. The soil at the experimental site was sandy loam and was characterised by low levels of organic carbon, nitrogen, phosphorus, and potash.

The experiment was laid out in a randomised block design (RBD) with three replications. Each genotype was sown in a plot size of 1 m2, with row spacing of 30 cm and plant spacing of 10 cm, following standard agronomic practices.

2.2 Morphological Traits Recorded

Twelve morphological and yield-related traits were recorded on a per-plant basis (unless otherwise stated) from five randomly selected competitive plants in each replication, avoiding border plants. The traits included phenological traits (days to 50% flowering, days to 50% pod setting, and days to maturity), plant height, number of primary and secondary branches per plant, number of pods per plant, seeds per plant, seed yield per plant, seed index, biological yield per plant, and harvest index.

The data collected for twenty chickpea genotypes and one check, across three replications, encompassed twelve different characteristics. This dataset was then subjected to statistical analysis for further examination and evaluation.

3. Results and Discussion

3.1 Correlation Studies

Correlation analysis of breeding materials is useful for formulating selection strategies aimed at improving the genetic potential of a crop. It provides dependable information on the magnitude and direction of associations among traits, particularly when breeders seek to combine high yield potential with desirable agronomic attributes and seed quality characteristics. In the present study, the genotypic and phenotypic correlation coefficients of various traits with seed yield per plant, along with their interrelationships, are presented in Tables 1 and 2 and discussed below.

3.2 Genotypic Correlation

3.2.1 Association of Seed Yield and its Components

Seed yield per plant showed positive and significant genotypic correlations with days to 50% flowering (r = 0.265*), days to 50% pod setting (r = 0.404*), days to maturity (r = 0.380*), number of pods per plant (r = 0.343*), seed index (r = 0.516**), and harvest index (r = 0.439**). Number of secondary branches (r = 0.0264), seeds per plant (r = 0.1827), and biological yield (r = 0.0798) were positively but non-significantly associated with seed yield. Plant height (r = -0.1710) and primary branches per plant (r = -0.1933) showed negative, non-significant correlations. These results agree with recent chickpea studies in which seed yield was positively associated with pods per plant, seed index, and harvest index (Kumar et al., 2025; Kumar et al., 2024).

3.2.2 Genotypic Interrelationship among Yield Components

Phenological traits showed positive and significant interrelationships. Plant height had a negative and significant correlation with days to maturity (r = -0.333*) and negative, non-significant correlations with days to 50% flowering and pod setting.

Secondary branches per plant were positively and significantly correlated with plant height (r = 0.322*) and negatively correlated with primary branches (r = -0.290*). Number of seeds per plant was highly and positively correlated with pods per plant (r = 0.843**). Biological yield was negatively correlated with days to 50% flowering (r = -0.256*) and days to maturity (r = -0.358*) and positively correlated with pods per plant (r = 0.682**) and seeds per plant (r = 0.687**). Harvest index showed mostly negative, non-significant relationships with other traits. Seed index was positively and highly correlated with biological yield (r = 0.622**).

Overall, seed index, harvest index, pods per plant, and phenological traits (days to pod setting and maturity) were the most important selection criteria for improving seed yield in chickpea (Kumar et al., 2025; Kumar et al., 2024). The corresponding genotypic correlation matrix is presented in Fig. 1 and Table 1.

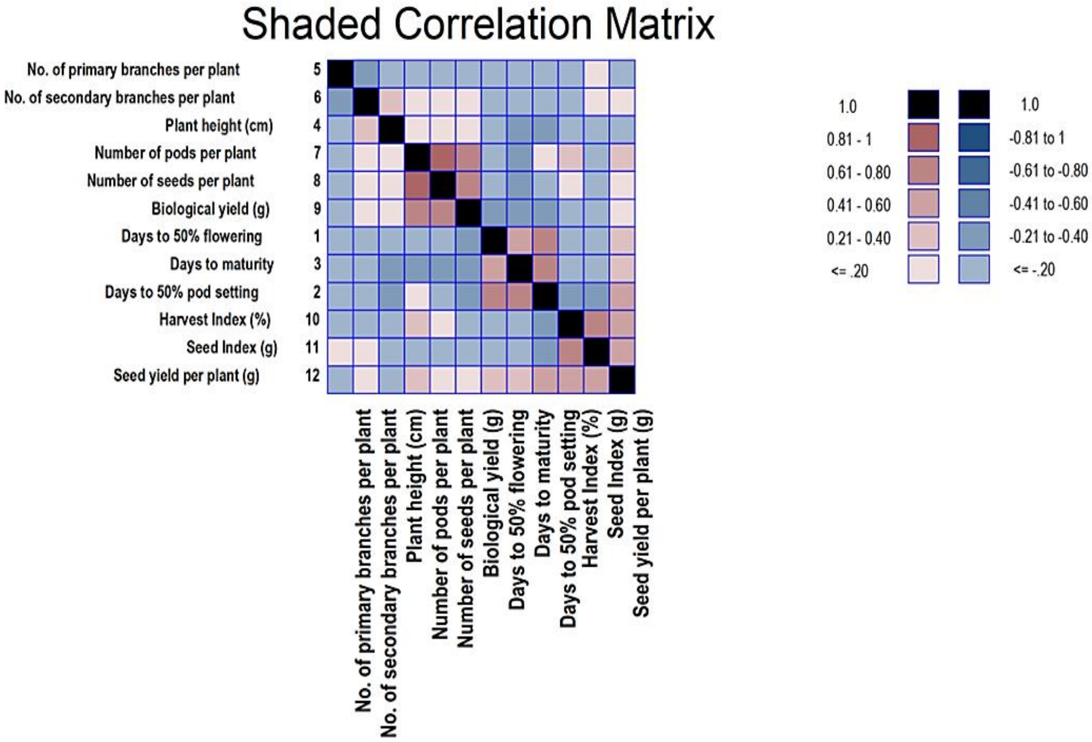

Fig. 1. Genotype shaded correlation matrix

3.3 Phenotypic Correlation

3.3.1 Association of Seed Yield with its Components

Seed yield per plant showed positive and significant phenotypic correlations with days to 50% flowering (r = 0.266*), days to 50% pod setting (r = 0.405**), days to maturity (r = 0.379*), number of pods per plant (r = 0.343*), seed index (r = 0.516**), and harvest index (r = 0.439**). Number of secondary branches (r = 0.0264), seeds per plant (r = 0.1827), and biological yield (r = 0.0798) were positively but non-significantly associated with seed yield, while plant height (r = -0.1743) and primary branches per plant (r = -0.1955) showed negative, non-significant correlations. These findings align with recent chickpea studies in which seed yield was positively correlated with pods per plant, seed index, harvest index, and phenological traits (Adem & Fikre, 2018; Sharma et al., 2023; Kumar et al., 2025).

3.3.2 Phenotypic Interrelationship of Yield Components

Days to 50% pod setting showed a positive and highly significant correlation with days to 50% flowering (r = 0.639**), and days to maturity was positively and significantly associated with both days to 50% flowering (r = 0.432**) and days to 50% pod setting (r = 0.778**). Plant height exhibited a negative and significant correlation with days to maturity (r = -0.342*) and negative, non-significant relationships with days to 50% flowering and pod setting. Secondary branches per plant were positively and significantly correlated with plant height (r = 0.329*) and negatively correlated with primary branches (r = -0.291*). Number of seeds per plant was highly and positively correlated with pods per plant (r = 0.845**), while biological yield showed positive and significant correlations with pods per plant (r = 0.682**) and seeds per plant (r = 0.689**) and negative and significant correlations with days to 50% flowering (r = -0.256*) and days to maturity (r = -0.360*). Harvest index showed mostly negative, non-significant relationships with other traits, while seed index was positively and highly correlated with biological yield (r = 0.622**). These patterns are consistent with recent reports on chickpea yield component associations (Kiran et al., 2023; Sharma et al., 2023; Gimenez et al., 2025).

Genotypic and phenotypic correlation coefficients reveal associations among traits; significant associations indicate that such characters can be improved simultaneously through selection. The present study shows that seed index, harvest index, number of pods per plant, days to 50% flowering, days to maturity, and days to 50% pod setting were strongly and positively associated with seed yield, making them effective indirect selection criteria for chickpea breeding (Kiran et al., 2023; Sharma et al., 2023; Kumar et al., 2025). The corresponding phenotypic correlation matrix is presented in Table 2 and Fig. 2.

3.3 Path Coefficient Analysis

Path coefficient analysis was performed to separate the correlation coefficients into the direct and indirect effects of component traits on seed yield per plant. At both the phenotypic and genotypic levels, the residual effect showed that the traits examined accounted for a considerable proportion of the variation in seed yield, indicating that the selected characters were important determinants of yield expression.

3.3.1 Phenotypic Path Analysis of Yield and Associated Traits

Phenotypic path coefficient analysis showed that seed index (0.6128) had the highest positive direct effect on seed yield per plant, followed by number of pods per plant (0.5037) and harvest index (0.0818). Moderate positive direct effects were also observed for biological yield (0.0790) and days to 50% pod setting (0.1270), indicating that these traits contributed positively to yield expression at the phenotypic level.

Among the yield-associated traits, days to 50% flowering (0.266*), days to 50% pod setting (0.405**), days to maturity (0.379*), number of pods per plant (0.343*), harvest index (0.439**), and seed index (0.516**) showed significant positive associations with seed yield per plant. These correlations suggest that improvement in these traits would likely enhance seed yield directly or indirectly (Babbar et al., 2012).

In contrast, plant height (-0.1743) and number of primary branches per plant (-0.1955) showed negative associations with seed yield per plant, indicating that these traits were not favourable for yield improvement in the present material. Number of secondary branches per plant (0.0265) and number of seeds per plant (0.1841) showed only weak positive associations with seed yield.

The residual effects and indirect contributions indicate that the influence of some traits on seed yield occurred mainly through other component characters. For example, days to maturity had a relatively high positive correlation with yield, but its direct effect appeared to be much smaller than that of seed index and pods per plant, suggesting an important indirect contribution through yield components. Similarly, the strong positive association of harvest index and seed index with yield supports their usefulness as selection criteria in chickpea breeding. The phenotypic path relationships are presented in Fig. 3 and Table 3.

3.3.2 Genotypic Path Analysis of Yield and Associated Traits

The genotypic path coefficient analysis for seed yield per plant in chickpea revealed that seed index (0.6118) exerted the highest positive direct effect on seed yield, followed by number of pods per plant (0.4981) and harvest index (0.0835). Biological yield (0.0790) and days to 50% pod setting (0.1328) also showed positive direct effects, indicating their favourable contribution to yield expression at the genotypic level.

Table 1. Genotypic correlation coefficient between yield and its traits in genotypes

	DFF	DPS	DM	PH	PBP	SBP	PPP	SPP	BY	HI	SI	SYP
DFF	1	0.639**	0.430**	-0.118	-0.1976	-0.0634	-0.1158	-0.1815	-0.256*	-0.1715	-0.1118	0.265*
DPS		1	0.774**	-0.222	-0.1111	-0.1751	0.0392	-0.0293	-0.2244	-0.2233	-0.2309	0.404*
DM			1	-0.333*	-0.0805	-0.1369	-0.212	-0.2092	-0.358*	-0.1803	-0.1501	0.380*
PH				1	-0.1867	0.322*	0.1162	0.1005	0.1951	-0.0847	-0.069	-0.171
PBP					1	-0.290*	-0.088	-0.1727	-0.1132	-0.0109	0.0599	-0.1933
SBP						1	0.1481	0.1562	0.0557	-0.0559	0.1182	0.0264
PPP							1	0.843**	0.682**	0.2436	-0.0746	0.343*
SPP								1	0.687**	0.1787	-0.1685	0.1827
BY									1	-0.0966	-0.0964	0.0798
HI										1	0.622**	0.439**
SI											1	0.516**
SYP												1

** Significance at 5% ** Significance at 1%*

DFF - Days to 50% flowering, DPS - Days to 50% pod setting, DM – Days to maturity, PH – Plant height, PBP – Number of primary branches, SBP – Number of secondary branches, PPP – Number of pods per plant, SPP – Number of seeds per plant, BY – Biological yield per plant, SI – Seed index, HI – Harvest index, SYP – Seed yield per plant

Table 2. Phenotypic correlation coefficient between yield and its traits in genotypes

	DFF	DPS	DM	PH	PBP	SBP	PPP	SPP	BY	HI	SI	SYP
DFF	1.0000	0.639**	0.432**	-0.1176	-0.1970	-0.0634	-0.1156	-0.1824	-0.256*	-0.1716	-0.1114	0.266*
DPS		1.0000	0.778**	-0.2215	-0.1094	-0.1756	0.0395	-0.0308	-0.2239	-0.2234	-0.2303	0.405**
DM			1.0000	-0.342*	-0.0852	-0.1372	-0.2132	-0.2069	-0.360*	-0.1808	-0.1523	0.379*
PH				1.0000	-0.1938	0.329*	0.1180	0.1052	0.1948	-0.0884	-0.0710	-0.1743
PBP					1.0000	-0.291*	-0.0890	-0.1700	-0.1149	-0.0110	0.0581	-0.1955
SBP						1.0000	0.1476	0.1563	0.0559	-0.0548	0.1181	0.0265
PPP							1.0000	0.845**	0.682**	0.2442	-0.0751	0.343*
SPP								1.0000	0.689**	0.1791	-0.1674	0.1841
BY									1.0000	-0.0967	-0.0971	0.0793
HI										1.0000	0.623**	0.439**
SI											1.0000	0.516**
SYP												1.0000

** Significance at 5% ** Significance at 1%*

DFF - Days to 50% flowering, DPS - Days to 50% pod setting, DM – Days to maturity, PH – Plant height, PBP – Number of primary branches, SBP – Number of secondary branches, PPP – Number of pods per plant, SPP – Number of seeds per plant, BY – Biological yield per plant, SI – Seed index, HI – Harvest index, SYP – Seed yield per plant

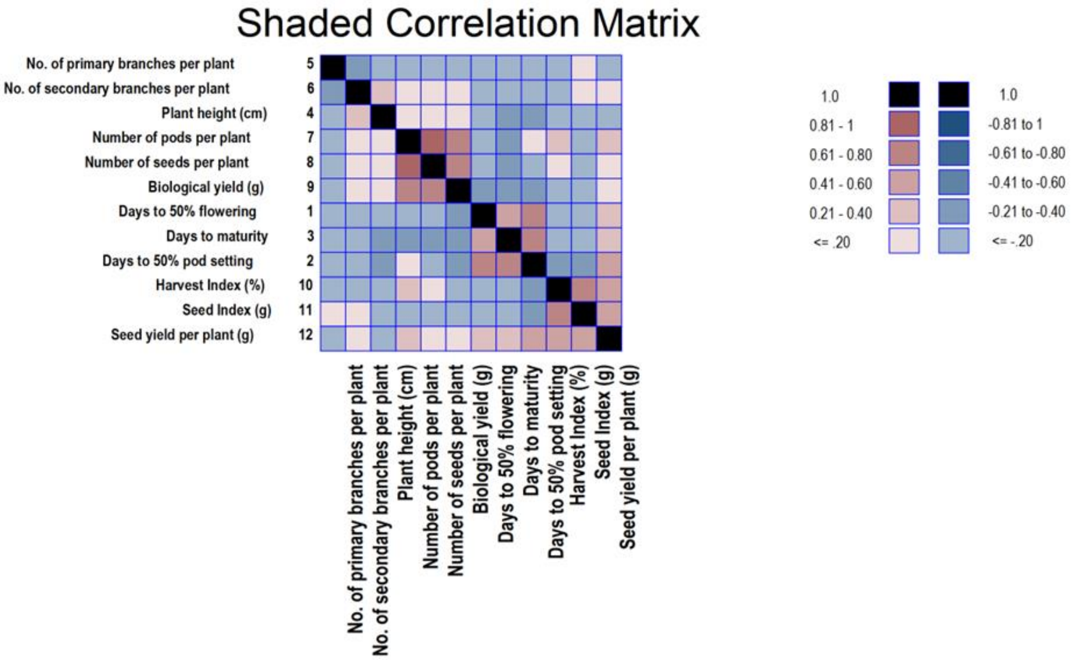

Fig. 2. Phenotype shaded correlation matrix

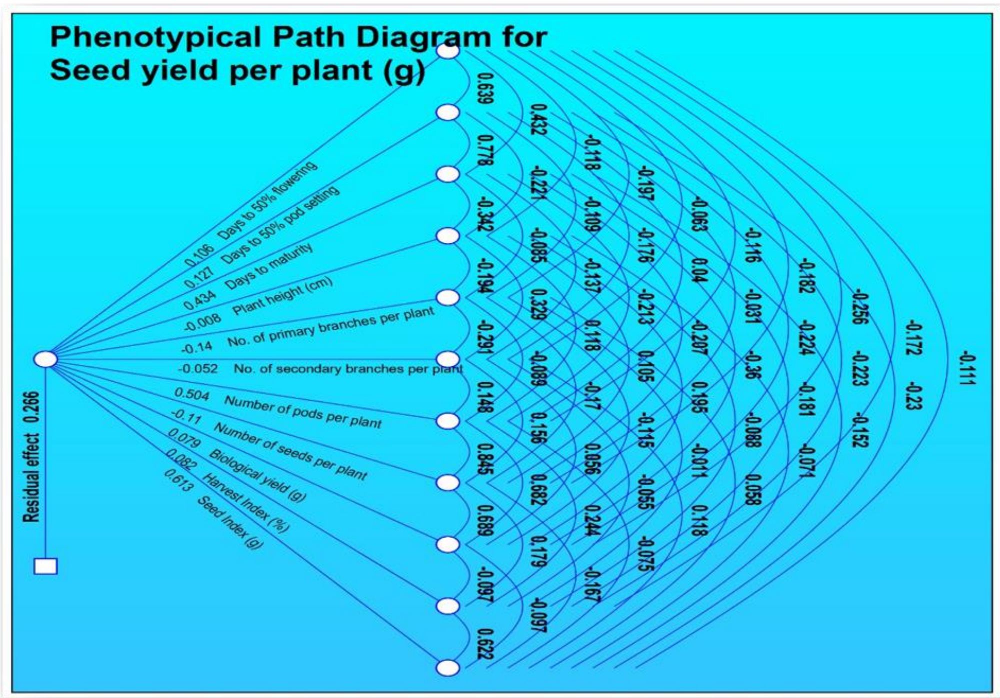

Fig. 3. Phenotypic path diagram for seed yield per plant

Among the yield components, seed yield per plant showed a significant positive association with days to 50% flowering (0.265*), days to 50% pod setting (0.404*), days to maturity (0.380*), number of pods per plant (0.343*), harvest index (0.439**), and seed index (0.516**). This indicates that these traits were closely associated with yield improvement in the studied material. In contrast, plant height (-0.1710) and number of primary branches per plant (-0.1933) showed negative relationships with seed yield per plant, suggesting that these traits were not favourable contributors to yield in the present population. Number of secondary branches per plant (0.0264) and number of seeds per plant (0.1827) exhibited only weak positive associations with seed yield.

Table 3. Phenotypic path matrix of seed yield per plant

Characters	Days to 50% flowering	Days to 50% pod setting	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	Number of pods per plant	Number of seeds per plant	Biological yield (g)	Harvest Index (%)	Seed Index (g)	Seed yield per plant (g)
Days to 50% flowering	0.1062	0.0678	0.0458	-0.0125	-0.0209	-0.0067	-0.0123	-0.0194	-0.0272	-0.0182	-0.0118	0.266*
Days to 50% pod setting	0.0812	0.1270	0.0988	-0.0281	-0.0139	-0.0223	0.0050	-0.0039	-0.0284	-0.0284	-0.0293	0.405**
Days to maturity	0.1876	0.3379	0.4343	-0.1483	-0.0370	-0.0596	-0.0926	-0.0899	-0.1565	-0.0785	-0.0661	0.379*
Plant height (cm)	0.0009	0.0017	0.0027	-0.0078	0.0015	-0.0026	-0.0009	-0.0008	-0.0015	0.0007	0.0006	-0.1743
No. of primary branches per plant	0.0276	0.0153	0.0119	0.0271	-0.1399	0.0407	0.0125	0.0238	0.0161	0.0015	-0.0081	-0.1955
No. of secondary branches per plant	0.0033	0.0092	0.0072	-0.0173	0.0153	-0.0525	-0.0077	-0.0082	-0.0029	0.0029	-0.0062	0.0265
Number of pods per plant	-0.0582	0.0199	-0.1074	0.0594	-0.0448	0.0743	0.5037	0.4255	0.3436	0.1230	-0.0378	0.343*
Number of seeds per plant	0.0200	0.0034	0.0227	-0.0115	0.0186	-0.0171	-0.0926	-0.1096	-0.0755	-0.0196	0.0183	0.1841
Biological yield (g)	-0.0202	-0.0177	-0.0285	0.0154	-0.0091	0.0044	0.0539	0.0545	0.0790	-0.0076	-0.0077	0.0793
Harvest Index (%)	-0.0140	-0.0183	-0.0148	-0.0072	-0.0009	-0.0045	0.0200	0.0146	-0.0079	0.0818	0.0509	0.439**
Seed Index (g)	-0.0683	-0.1412	-0.0933	-0.0435	0.0356	0.0724	-0.0460	-0.1026	-0.0595	0.3815	0.6128	0.516**
Seed yield per plant (g)	0.266*	0.405**	0.379*	-0.1743	-0.1955	0.0265	0.343*	0.1841	0.0793	0.439**	0.516**	1.0000
Partial R^2	0.0282	0.0515	0.1648	0.0014	0.0274	-0.0014	0.1727	-0.0202	0.0063	0.0359	0.3160	

Table 4. Genotypic path matrix of seed yield per plant

Characters	Days to 50% flowering	Days to 50% pod setting	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	Number of pods per plant	Number of seeds per plant	Biological yield (g)	Harvest Index (%)	Seed Index (g)	Seed yield per plant (g)
Days to 50% flowering	0.1051	0.0672	0.0452	-0.0124	-0.0208	-0.0067	-0.0122	-0.0191	-0.0270	-0.0180	-0.0118	0.265*
Days to 50% pod setting	0.0849	0.1328	0.1028	-0.0295	-0.0148	-0.0233	0.0052	-0.0039	-0.0298	-0.0297	-0.0307	0.404*
Days to maturity	0.1846	0.3324	0.4293	-0.1431	-0.0346	-0.0588	-0.0910	-0.0898	-0.1537	-0.0774	-0.0644	0.380*
Plant height (cm)	0.0010	0.0020	0.0029	-0.0088	0.0016	-0.0028	-0.0010	-0.0009	-0.0017	0.0007	0.0006	-0.1710
No. of primary branches per plant	0.0279	0.0157	0.0114	0.0264	-0.1413	0.0410	0.0124	0.0244	0.0160	0.0015	-0.0085	-0.1933

Characters	**Days to 50% flowering**	**Days to 50% pod setting**	**Days to maturity**	**Plant height (cm)**	**No. of primary branches per plant**	**No. of secondary branches per plant**	**Number of pods per plant**	**Number of seeds per plant**	**Biological yield (g)**	**Harvest Index (%)**	**Seed Index (g)**	**Seed yield per plant (g)**
No. of secondary branches per plant	0.0033	0.0092	0.0072	-0.0169	0.0152	-0.0523	-0.0077	-0.0082	-0.0029	0.0029	-0.0062	0.0264
Number of pods per plant	-0.0577	0.0195	-0.1056	0.0579	-0.0438	0.0738	0.4981	0.4200	0.3398	0.1213	-0.0371	0.343*
Number of seeds per plant	0.0192	0.0031	0.0222	-0.0107	0.0183	-0.0166	-0.0894	-0.1060	-0.0729	-0.0189	0.0179	0.1827
Biological yield (g)	-0.0203	-0.0177	-0.0283	0.0154	-0.0089	0.0044	0.0539	0.0543	0.0790	-0.0076	-0.0076	0.0798
Harvest Index (%)	-0.0143	-0.0186	-0.0151	-0.0071	-0.0009	-0.0047	0.0203	0.0149	-0.0081	0.0835	0.0519	0.439**
Seed Index (g)	-0.0684	-0.1413	-0.0918	-0.0422	0.0367	0.0723	-0.0456	-0.1031	-0.0590	0.3803	0.6118	0.516**
Seed yield per plant (g)	0.265*	0.404*	0.380*	-0.1710	-0.1933	0.0264	0.343*	0.1827	0.0798	0.439**	0.516**	1.0000
Partial R^2	0.0279	0.0537	0.1632	0.0015	0.0273	-0.0014	0.1709	-0.0194	0.0063	0.0366	0.3156	

The residual pattern also suggests that the positive influence of several traits on yield was mediated through other component characters. In particular, the strong direct effects of seed index, pods per plant, and harvest index indicate that these traits are the most reliable selection criteria for improving seed yield per plant in chickpea. Overall, the genotypic path analysis highlights the importance of seed size, pod number, and harvest efficiency in determining yield performance. Similar findings were reported by Dawane et al. (2020) and Gandam and Lal (2022), who observed significant positive associations of seed yield per plant with harvest index and positive path effects of harvest index, days to maturity, secondary branches, pods per plant, biological yield, and seed index at both phenotypic and genotypic levels. The genotypic path relationships are presented in Table 4 and Fig**.** 4.

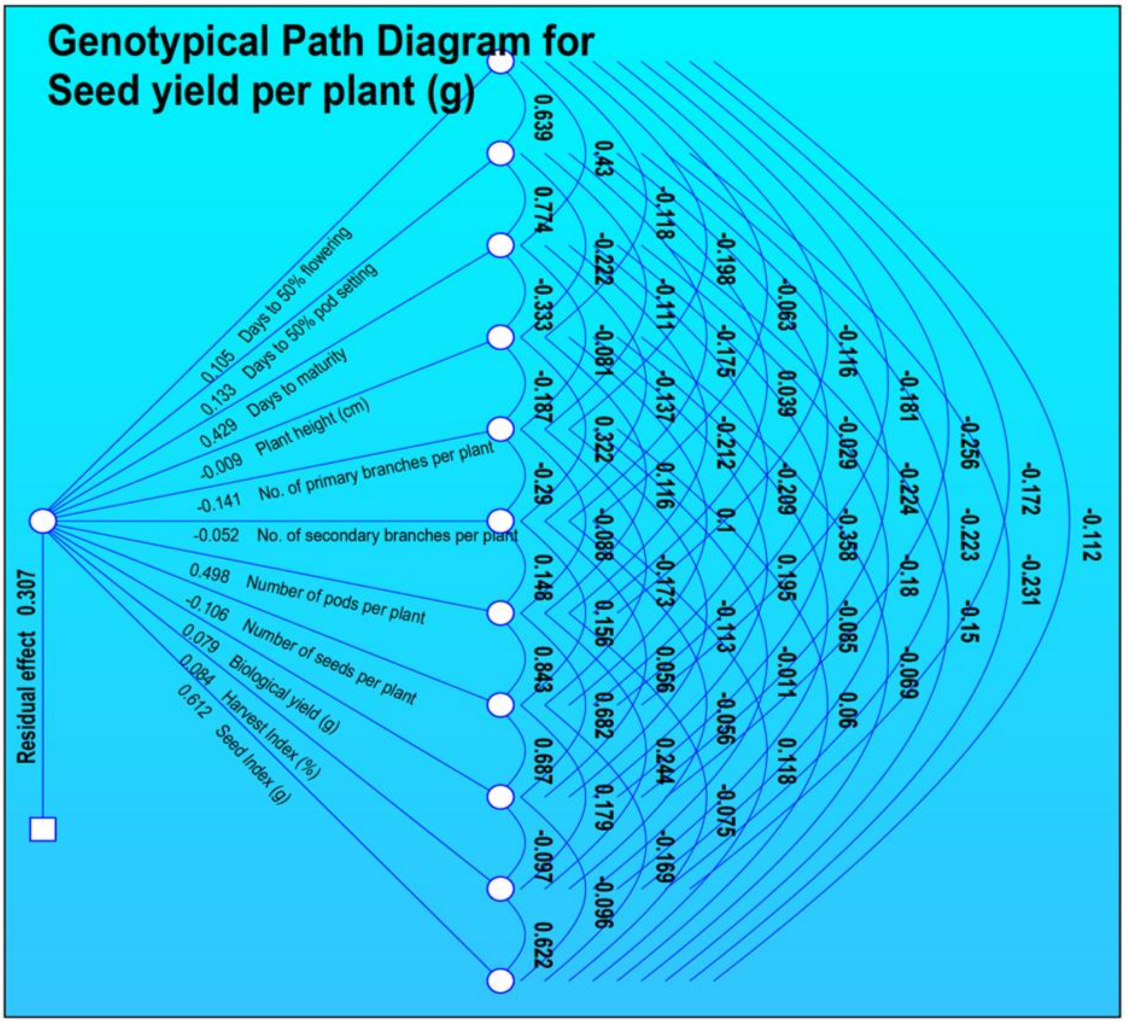

Fig. 4. Genotypic path diagram for seed yield per plant

4. Conclusion

The study indicated that seed yield per plant in chickpea was influenced by several morphological and yield-component traits. Both phenotypic and genotypic correlation analyses showed that seed index, harvest index, days to 50% pod setting, days to maturity, and number of pods per plant had positive and significant associations with seed yield. The stronger genotypic correlations suggested that these relationships were largely governed by genetic factors rather than environmental influence alone. Path coefficient analysis further showed that seed index, number of pods per plant, and harvest index had the strongest positive direct effects on seed yield per plant. Therefore, these traits may be considered reliable selection criteria for yield improvement in the studied chickpea germplasm. Days to 50% pod setting and days to maturity may also be considered secondary selection traits because of their positive association with yield. In contrast, plant height and number of primary branches showed negative relationships with seed yield in the present material.

5. Limitations

This study was conducted in one season and at one location, which may limit the wider generalisability of the findings. The experiment included 21 entries, including one check, and did not assess genotype performance across multiple environments. The analysis was limited to morphological and yield-related traits; molecular, physiological, and stress-resilience traits were not included. Multi-location and multi-season evaluation is needed to confirm the stability of the identified selection criteria.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Adem, A. M., & Fikre, A. (2018). Correlation and path coefficient analysis among seed yield and yield-related traits of Ethiopian chickpea (*Cicer arietinum* L.) landraces. *Acta Agriculturae Slovenica, 111*(3), 661–670. https://doi.org/10.14720/aas.2018.111.3.14

AgPulse Analytica. (2025). *India chickpea production for 2025–26: Third advance estimates and AgPulse Analytica forecast*.

Babbar, A., Prakash, V., Tiwari, P., & Iquebal, M. A. (2012). Genetic variability for chickpea (*Cicer arietinum* L.) under late sown season. *Legume Research, 35*(1), 1–7. https://arccjournals.com/journal/legume-research-an-international-journal/ARCC494

Behera, K., Babbar, A., Vyshnavi, R. G., Patel, T., & Prajapati, S. S. (2023). Exploring the chickpea genotypes through morphological characterization for improved breeding. *International Journal of Plant & Soil Science, 35*(18), 551–563. https://doi.org/10.9734/ijpss/2023/v35i183320

Bharath, K., & Lavanya, G. R. (2024). Selection strategy for yield improvement of chickpea genotypes (*Cicer arietinum* L.). *Archives of Current Research International, 24*(10), 196–204. https://doi.org/10.9734/acri/2024/v24i10922

Choi, Y.-M., Yoon, H., Shin, M.-J., Lee, S., Yi, J., Wang, X., & Desta, K. T. (2024). Diversity of major yield traits and nutritional components among greenhouse grown chickpea (*Cicer arietinum* L.) breeding lines, landraces, and cultivars of different origins. *Plants, 13*(21), 3078. https://doi.org/10.3390/plants13213078

Dawane, J. K., Jahagirdar, J. E., & Shedge, P. J. (2020). Correlation studies and path coefficient analysis in chickpea (*Cicer arietinum* L.). *International Journal of Current Microbiology and Applied Sciences, 9*(10), 1266–1272. https://doi.org/10.20546/ijcmas.2020.910.152

Gandam, N., & Lal, G. M. (2022). Genetic variability, correlation and path coefficient analysis for yield and its component traits in chickpea (*Cicer arietinum* L.). *Research Journal of Science and Technology, 14*(1), 59–65. https://doi.org/10.52711/2349-2988.2022.00009

Gimenez, R., Lake, L., Cossani, C. M., Ortega Martinez, R., Hayes, J. E., Dreccer, M. F., French, R., Weller, J. L., & Sadras, V. O. (2025). Linking phenology, harvest index, and genetics to improve chickpea grain yield. *Journal of Experimental Botany, 76*(6), 1658–1677. https://doi.org/10.1093/jxb/erae487

Kiran, K. C., Ramesh, B., Venkatraman, S., & Lavanya, G. R. (2023). Genetic variability and correlation studies for seed yield characters in chickpea (*Cicer arietinum* L.). *International Journal of Plant & Soil Science, 35*(21), 212–220. https://doi.org/10.9734/ijpss/2023/v35i213966

Kumar, A., Singh, A., Arya, M., Bhanu, A. N., Kumar, V., & Chaturvedi, S. K. (2024). Study of genetic variability and character association for yield and component traits in chickpea (*Cicer arietinum* L.) germplasm in Bundelkhand region. *Journal of Experimental Agriculture International, 46*(8), 628–639. https://doi.org/10.9734/jeai/2024/v46i82745

Kumar, S., Gupta, K., Kumar, A., & Singh, P. K. (2025). Genetic variability and correlation studies for grain yield and its component traits in desi chickpea (*Cicer arietinum* L.). *Environment and Ecology, 43*(3A), 795–801. https://doi.org/10.60151/envec/GBKD6404

Patel, T., Babbar, A., Behera, K., Anand, J. K., Patel, M., Kujur, J. M., & Katara, V. K. (2025). Integrating diversity analysis and morphological characterization for strategic trait selection in advanced breeding lines of chickpea (*Cicer arietinum* L.). *Legume Research, 48*(12), 1969–1978. https://doi.org/10.18805/LR-5468

Patil, N. S., Hegde, V., Vinod, K. K., Parida, S. K., & Jain, P. K. (2024). Genome wide association studies for flowering time, shelling percentage, harvest index and related traits in chickpea (*Cicer arietinum* L.). *Euphytica, 220*, 144. https://doi.org/10.1007/s10681-024-03398-z

Philanim, W. S., Bharadwaj, C., Kumar, N., Ngangkham, U., Iangrai, B., & Singh, B. K. (2025). Genetic diversity, population structure and marker-trait association analysis for yield-related traits in chickpea (*Cicer arietinum* L.). *Genetic Resources and Crop Evolution, 72*, 3699–3717. https://doi.org/10.1007/s10722-024-02191-0

Phiri, C. K., Njira, K., & Chitedze, G. (2023). An insight of chickpea production potential, utilization and their challenges among smallholder farmers in Malawi: A review. *Journal of Agriculture and Food Research, 14*, 100713. https://doi.org/10.1016/j.jafr.2023.100713

Rajput, S., Jain, S., Tiwari, S., Barela, A., Chauhan, S., Tiwari, P. N., Gupta, N., Sikarwar, R. S., Tripathi, N., & Tripathi, M. K. (2023). Biochemical characterization of chickpea (*Cicer arietinum* L.) genotypes. *Plant Cell Biotechnology and Molecular Biology, 24*(3–4), 1–9. https://doi.org/10.56557/pcbmb/2023/v24i3-48239

Sharma, A., Sharma, L. K., Kulkarni, G. U., Javia, R. M., & Jangid, K. K. (2026). Decoding yield-related trait interactions through genetic variability and association analysis in chickpea (*Cicer arietinum* L.). *Journal of Experimental Agriculture International, 48*(6), 194–206. https://doi.org/10.9734/jeai/2026/v48i64275

Sharma, V., Thakur, S., Kumar, A., & Mushtaq, M. (2023). Correlation coefficient analysis for seed yield and its component traits in chickpea (*Cicer arietinum*, Fabaceae). *International Journal of Plant & Soil Science, 35*(21), 810–815. https://doi.org/10.9734/ijpss/2023/v35i214048

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/161848