Plant Archives Vol. 26, No. 2, 2026 pp. 2485-2492 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.340

ASSOCIATION AND PATH COEFFICIENT ANALYSIS OF YIELD AND QUALITY ATTRIBUTES IN F_1 AND F_2 GENERATIONS OF LENTIL (*Lens culinaris* MEDIK.)

Sachin Yadav[1*], Rajendra Kumar Yadav[1], Sarvendra Kumar[1], Shweta[1], Lokendra Singh[1], C.L. Maurya[2], Kirti Singh[1] and Madan Lal[1]

[1]Department of Genetics and Plant Breeding, C. S. Azad University of Agriculture and Technology, Kanpur-208 002, India.
[2]Department of Seed Science and Technology, C. S. Azad University of Agriculture and Technology, Kanpur-208 002, India.
*Corresponding author E-mail : sy5812707@gmail.com

(Date of Receiving-23-07-2026; Date of Revision-16-09-2026; Date of Acceptance-28-09-2026)

ABSTRACT

The present study was undertaken to assess the association among phenological, morphological, yield-contributing and quality traits and to identify their direct and indirect effects on seed yield in F_1 and F_2 generations of lentil (*Lens culinaris* Medik.). Genotypic and phenotypic correlation coefficients were estimated for 15 traits, followed by genotypic and phenotypic path coefficient analyses using seed yield per plant as the dependent variable. In the F_1 generation, seed yield exhibited strong positive genotypic correlations with biological yield per plant (r = 0.771), seeds per pod (r = 0.718) and harvest index (r = 0.485). In the F_2 generation, biological yield per plant (r = 0.766), seeds per pod (r = 0.644), days to maturity (r = 0.476) and harvest index (r = 0.420) showed positive genotypic associations with seed yield. Genotypic path analysis revealed substantial positive direct effects of primary branches, plant height, seeds per pod, protein content and biological yield in F_1, whereas plant height, number of clusters per plant and protein content showed notable positive direct effects in F_2. At the phenotypic level, biological yield per plant exhibited a strong positive direct effect in both F_1 and F_2 generations. The residual effects were 0.0819 and 0.0160 for genotypic path analysis in F_1 and F_2, respectively, indicating that the traits included in the analysis accounted for a substantial proportion of the variation in seed yield. Overall, biological yield per plant, seeds per pod, plant height, number of clusters per plant and harvest index showed important associations and/or direct contributions to seed yield and may be considered during selection for yield improvement in lentil.

Key words : Lentil, *Lens culinaris*, Correlation, Path coefficient analysis, Seed yield, Yield components, F_1, F_2.

Introduction

Lentil (*Lens culinaris* Medik.) is an important cool-season pulse crop valued for its high-quality protein, dietary nutrients and role in sustainable agricultural systems. Seed yield in lentil is a complex quantitative trait controlled by several interrelated characters and influenced by environmental conditions. Therefore, understanding the association among yield and its component traits is essential for developing effective selection strategies in lentil breeding programmes (Chahota and Sharma, 1993; Singh and Ceccerelli, 1996).

Correlation analysis provides useful information about the degree and direction of association among traits. Genotypic correlations are particularly useful for understanding the genetic relationships among characters, whereas phenotypic correlations represent the combined effects of genetic and environmental factors. Previous studies in lentil have reported significant associations of seed yield with biological yield, pods per plant, branches per plant, seeds per pod, plant height and harvest index (Mekonnen *et al*., 2014; Sharma *et al*., 2014; Kumar *et al*., 2017; Chowdhury *et al*., 2019). Similar associations have also been reported in recombinant inbred lines and

diverse lentil germplasm, emphasizing the importance of yield components in selection (Singh *et al*., 2017; Sarker *et al*., 2022).

However, correlation coefficients alone cannot distinguish whether an association with seed yield results from a direct contribution or from indirect effects through other characters. Path coefficient analysis overcomes this limitation by partitioning correlations into direct and indirect effects, thereby facilitating the identification of traits with greater potential as selection criteria (Wright, 1921; Dewey and Lu, 1959). In lentil, biological yield, pods per plant, harvest index, primary branches and seed-related traits have frequently shown important direct effects on seed yield (Sharma *et al*., 2014; Chowdhury *et al*., 2019; Ram Kishor *et al*., 2020; Pilania *et al*., 2026). The expression and association of quantitative traits may also vary between generations because of segregation and recombination. Evaluation of both F_1 and F_2 generations can consequently provide useful information about the consistency of trait relationships and their potential value for selection. Recent studies have further demonstrated the importance of character association and path analysis for identifying yield-contributing traits in lentil breeding programmes (Kumar *et al*., 2022; Satpathy *et al*., 2025). In the present study, genotypic and phenotypic correlation coefficients were estimated for phenological, morphological, yield-component and quality traits in the F_1 and F_2 generations of lentil. Path coefficient analysis was subsequently employed to partition the associations into direct and indirect effects on seed yield per plant. The study aimed to identify important traits associated with seed yield and to determine their relative direct and indirect contributions, thereby providing useful information for selection and genetic improvement of lentil.

Materials and Methods

Experimental material and study site

The study was conducted during the *rabi* season of 2025–2026 at the Student Instructional Farm (SIF), College of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India. The experimental site is located at approximately 26.49° N latitude and 80.31° E longitude, with an elevation of about 125.9 m above mean sea level. The region has a semi-arid climate, with hot summers and cold winters, and the experimental farm possesses deep loamy soil with irrigation and drainage facilities.

The experimental material consisted of 10 diverse lentil (*Lens culinaris* Medik.) parental lines, namely KLS 1457, KLS 1465, KLS 1467, KLS 1469, PL 357, IPL 220, PL 370, IPL 241, LL 1655 and LL 1694. The parental lines were selected on the basis of morphological variation from the legume section, Department of Genetics and Plant Breeding, CSAUAT, Kanpur, U.P., India. These parents were crossed in a half-diallel mating design, resulting in 45 F_1 crosses. The corresponding F_2 populations were developed through selfing of the F_1 plants. Thus, the experimental material comprised 10 parents, 45 F_1s and 45 F_2s, representing 100 genetic entries.

Development of F_1 and F_2 generations

For development of the F_1 generation, all 10 parental lines were grown at the Student Instructional Farm during the rabi season and crossed according to a half-diallel mating scheme. The resulting F_1 seeds from the 45 crosses were harvested separately along with seed from the parental lines. For development of the F_2 generation, F_1 seed from each cross was used to raise the F_2 generation through self-pollination.

Experimental design and layout

The final evaluation of the parental lines, F_1 hybrids and F_2 populations was conducted in a randomized block design at the Student Instructional Farm during *rabi* 2025–2026. A total of 100 treatments, comprising 10 parents, 45 F_1s and 45 F_2s, were evaluated. The parents and F_1 hybrids were grown in single-row plots, whereas the F_2 populations were maintained in double-row plots. Individual plant observations were recorded for the characters under study.

Recording of observations

Data were recorded for 15 phenological, morphological, yield and quality traits, *viz*., days to 50% flowering, days to maturity, plant height, primary and secondary branches per plant, clusters per plant, pods per cluster, total pods per plant, seeds per pod, 100-seed weight, protein content, methionine content, biological yield per plant, harvest index and seed yield per plant. Flowering and maturity were recorded as days from sowing, while plant height, branches, clusters and pods were recorded at maturity. Seeds per pod and 100-seed weight were determined from randomly selected mature seeds. Biological yield and seed yield were recorded in grams per plant, and harvest index was calculated as the ratio of seed yield to biological yield × 100. Protein and methionine contents were estimated using laboratory biochemical assays.

Statistical analysis

Data from the parents, F_1 and F_2 generations were analyzed using analysis of variance according to Panse

and Sukhatme (1967). Genotypic and phenotypic correlations were estimated according to Al-Jibouri *et al*. (1958). The significance of correlation coefficients was tested at 5% and 1% probability levels.

Path coefficient analysis

Path coefficient analysis was performed according to Dewey and Lu (1959), considering seed yield per plant as the dependent variable. Direct and indirect effects of the associated traits were estimated separately at genotypic and phenotypic levels in F_1 and F_2 generations. The residual effect was calculated as:

$$P_R = \sqrt{1 - R^2}$$

Where, R^2 represents the coefficient of determination of the traits included in the analysis.

Results and Discussion

Genotypic and phenotypic correlation in parents and F_1 generation

Days to 50% flowering showed negative associations with most yield-related traits and seed yield (r = –0.364), whereas days to maturity showed a positive association with seed yield (r = 0.362). Similar relationships between flowering/maturity and yield components have been reported in lentil by Vanave *et al*. (2019).

Plant height showed positive associations with total pods per plant (r = 0.627), biological yield (r = 0.382) and seed yield (r = 0.391). Similar positive associations of plant height with seed yield and its components have been reported by Sarker *et al*. (2022).

Among the yield components, seeds per pod and biological yield showed strong positive correlations with seed yield, with genotypic correlation coefficients of 0.718 and 0.771, respectively, while harvest index showed a positive association (r = 0.485). These findings are consistent with Chowdhury *et al*. (2019) and Yadav *et al*. (2005), who reported positive associations of seed yield with seeds per pod, biological yield and harvest index in lentil.

Protein and methionine contents were strongly correlated with each other (r = 0.908) and both showed positive associations with seed yield (r = 0.343 and 0.391, respectively). A positive association between protein content and seed yield has also been reported by Sarker *et al*. (2022).

Genotypic and phenotypic correlation in F_2 generation

In F_2, days to 50% flowering showed negative associations with several yield-related traits and seed yield (r = –0.203), whereas days to maturity showed a positive association with seed yield (r = 0.476). Plant height was positively associated with total pods per plant (r = 0.578) and seed yield (r = 0.338), indicating the contribution of plant architecture to yield formation. Similar relationships have been reported by Sarker *et al*. (2022) and Vanave *et al*. (2019).

The strongest genotypic associations with seed yield were observed for biological yield (r = 0.766), seeds per pod (r = 0.644), days to maturity (r = 0.476) and harvest index (r = 0.420). Comparable positive relationships of biological yield, seeds per pod and harvest index with seed yield have been reported by Sarker *et al*. (2022) and Meena *et al*. (2020).

Genotypic path coefficient analysis in F_1

Genotypic path analysis revealed positive direct effects of protein content (0.9587), primary branches (0.6571), biological yield (0.5827), plant height (0.5059) and seeds per pod (0.3445) on seed yield. Biological yield and seeds per pod also showed strong positive correlations with seed yield, indicating their importance in yield improvement. Similar positive direct effects of biological yield, branches and seeds per pod have been reported by Sarker *et al*. (2022) and Chowdhury *et al*. (2019).

Seeds per pod and harvest index showed positive direct effects of 0.3445 and 0.5128, respectively. These results agree with previous reports identifying harvest index and seeds per pod as important direct contributors to lentil yield (Sarker *et al*., 2022; Meena *et al*., 2020).

Phenotypic path coefficient analysis in F_1

Biological yield showed the highest positive direct effect (0.7431) and a strong positive correlation with seed yield (r = 0.731), followed by harvest index (direct effect = 0.4574) and seeds per pod (direct effect = 0.2136). Similar findings, particularly the importance of biological yield and harvest index, were reported by Sarker *et al*. (2022) and Yadav *et al*. (2005).

Days to 50% flowering showed a negative direct effect (–0.1300) and negative association with seed yield (r = –0.323). Similar negative effects of flowering or maturity-related traits have been reported in lentil (Sarker *et al*., 2022; Vanave *et al*., 2019).

Genotypic path coefficient analysis in F_2

In F_2, number of clusters per plant (0.8512), plant height (0.6525), protein content (0.4296) and biological yield (0.4699) showed positive direct effects on seed yield. Seeds per pod also showed a positive direct effect (0.2953) along with a strong positive correlation (r = 0.644). The importance of biological yield, plant height and seeds per

Table 1 : Genotypic and Phenotypic Correlation Coefficients for parents and F_1.

Components	Days to 50% flowe-ring	Days to maturity	Plant height	Primary branches /plant	Secon-dary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methio-nine content (%)	Biologi-cal yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**1.000**	0.316**	-0.128	-0.299**	-0.275**	-0.433**	0.038	-0.357**	-0.289**	-0.021	-0.940**	-0.896**	-0.246**	-0.174*	**-0.364****
DM	0.263**	**1.000**	-0.090	0.148	0.339**	-0.467**	0.330**	0.022	0.334**	0.034	-0.338**	-0.146	0.267**	0.201**	**0.362****
PH	-0.122	-0.082	**1.000**	0.360**	0.218**	0.089	0.357**	0.627**	0.073	-0.388**	0.258**	0.230**	0.382**	0.042	**0.391****
PBP	-0.260**	0.139	0.336**	**1.000**	0.821**	0.180*	-0.163*	-0.050	-0.388**	0.375**	0.335**	0.433**	0.548**	-0.507**	**0.198***
SBP	-0.253**	0.311**	0.217**	0.777**	**1.000**	0.123	-0.029	0.086	-0.338**	0.241**	0.365**	0.355**	0.350**	-0.347**	**0.105**
NCP	-0.410**	-0.435**	0.088	0.179*	0.123	**1.000**	-0.729**	-0.111	-0.062	0.415**	0.529**	0.397**	0.343**	-0.312**	**0.118**
NPC	0.040	0.286**	0.329**	-0.167*	-0.030	-0.680**	**1.000**	0.753**	0.408**	-0.678**	-0.064	-0.064	-0.196*	0.522**	**0.161***
TNPP	-0.330**	0.023	0.625**	-0.049	0.085	-0.110	0.699**	**1.000**	0.416**	-0.712**	0.446**	0.387**	-0.040	0.462**	**0.269****
SP	-0.218**	0.277**	0.058	-0.359**	-0.293**	-0.059	0.353**	0.361**	**1.000**	-0.126	0.176*	0.185*	0.332**	0.624**	**0.718****
100SW	-0.020	0.026	-0.379**	0.336**	0.237**	0.399**	-0.611**	-0.696**	-0.059	**1.000**	0.001	-0.059	0.570**	-0.518**	**0.197***
PC	-0.871**	-0.322**	0.253**	0.306**	0.355**	0.519**	-0.052	0.437**	0.153*	0.002	**1.000**	0.908**	0.297**	0.076	**0.343****
MC	-0.788**	-0.104	0.207**	0.358**	0.327**	0.354**	-0.057	0.352**	0.106	-0.057	0.816**	**1.000**	0.312**	0.144	**0.391****
BYP	-0.217**	0.242**	0.370**	0.502**	0.341**	0.334**	-0.184*	-0.040	0.287**	0.551**	0.284**	0.292**	**1.000**	-0.257**	**0.771****
HI	-0.133	0.161*	0.038	-0.410**	-0.309**	-0.263**	0.414**	0.398**	0.453**	-0.438**	0.061	0.056	-0.222**	**1.000**	**0.485****
SYP	**-0.323****	**0.318****	**0.362****	**0.159***	**0.097**	**0.108**	**0.130**	**0.249****	**0.560****	**0.177***	**0.317****	**0.348****	**0.731****	**0.382****	**1.000**

*, ** Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.

Table 2 : Genotypic and Phenotypic Correlation Coefficients in F_2 Generation.

Components	Days to 50% flowe-ring	Days to maturity	Plant height	Primary branches /plant	Secon-dary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methio-nine content (%)	Biologi-cal yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**1.000**	0.209**	-0.018	-0.349**	-0.273**	-0.354**	0.048	-0.316**	-0.151	0.082	-0.875**	-0.907**	-0.147	-0.259**	**-0.203****
DM	0.178*	**1.000**	0.004	0.202**	0.424**	-0.435**	0.402**	0.078	0.473**	0.163*	-0.287**	-0.102	0.400**	0.112	**0.476****
PH	-0.019	-0.003	**1.000**	0.287**	0.152	0.020	0.358**	0.578**	-0.164*	-0.474**	0.128	0.147	0.314**	0.122	**0.338****
PBP	-0.295**	0.182*	0.265**	**1.000**	0.808**	0.173*	-0.170*	-0.101	-0.394**	0.352**	0.315**	0.417**	0.493**	-0.493**	**0.087**
SBP	-0.247**	0.393**	0.147	0.730**	**1.000**	0.083	-0.051	0.017	-0.269**	0.210**	0.285**	0.309**	0.259**	-0.290**	**-0.045**
NCP	-0.329**	-0.407**	0.018	0.167*	0.083	**1.000**	-0.795**	-0.199*	-0.125	0.335**	0.465**	0.356**	0.293**	-0.257**	**-0.003**
NPC	0.042	0.346**	0.314**	-0.169*	-0.049	-0.733**	**1.000**	0.744**	0.351**	-0.648**	-0.120	-0.070	-0.196*	0.586**	**0.242****
TNPP	-0.286**	0.078	0.571**	-0.094	0.017	-0.198*	0.682**	**1.000**	0.187*	-0.790**	0.371**	0.339**	-0.121	0.662**	**0.258****
SP	-0.088	0.263**	-0.105	-0.200*	-0.152	-0.075	0.183*	0.105	**1.000**	0.110	0.015	0.106	0.277**	0.599**	**0.644****

Table 2 continued...

Table 2 continued...

100SW	0.061	0.127	-0.430**	0.271**	0.190*	0.297**	-0.517**	-0.717**	0.028	**1.000**	-0.062	-0.090	0.511**	-0.504**	**0.178***
PC	-0.803**	-0.267**	0.127	0.284**	0.281**	0.461**	-0.113	0.370**	0.012	-0.057	**1.000**	0.829**	0.189*	0.384**	**0.232****
MC	-0.824**	-0.095	0.148	0.377**	0.305**	0.351**	-0.067	0.336**	0.067	-0.081	0.822**	**1.000**	0.269**	0.183*	**0.304****
BYP	-0.137	0.355**	0.297**	0.431**	0.251**	0.281**	-0.153*	-0.118	0.193*	0.465**	0.180*	0.256**	**1.000**	-0.079	**0.766****
HI	-0.236**	0.135	0.105	-0.429**	-0.267**	-0.237**	0.496**	0.622**	0.316**	-0.438**	0.359**	0.176*	-0.116	**1.000**	**0.420****
SYP	**-0.189***	**0.399****	**0.291****	**0.074**	**-0.045**	**0.000**	**0.204****	**0.233****	**0.334****	**0.144**	**0.208****	**0.263****	**0.643****	**0.382****	**1.000**

*, ** Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively.

Table 3 : Genotypic path F_1 with Seed yield (g/plant).

Components	Days to 50% flowe-ring	Days to maturity	Plant height	Primary branches /plant	Secon-dary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methio-nine content (%)	Biologi-cal yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**0.4043**	0.3484	-0.1566	-0.1754	0.2779	0.0046	0.0058	0.2732	-0.3972	-0.7197	-0.8407	0.5090	0.1918	-0.0891	**-0.364****
DM	0.1278	**0.1025**	-0.1100	0.0865	-0.1432	0.0050	0.0502	-0.0167	0.1124	0.0322	-0.1623	0.3828	-0.2080	0.1032	**0.362****
PH	-0.0518	-0.0993	**0.2213**	0.2110	-0.2207	-0.0009	0.0543	-0.1799	0.3244	-0.1666	0.5059	-0.1308	-0.2977	0.2216	**0.391****
PBP	-0.1210	0.1628	0.4399	**0.5859**	-0.8302	-0.0019	-0.0248	0.0386	-0.1304	0.3545	0.6571	-0.2461	-0.4269	-0.2600	**0.198***
SBP	-0.1111	0.3741	0.2665	0.4808	**-0.8116**	-0.0013	-0.0045	-0.0656	-0.1136	0.2281	0.5147	-0.2015	-0.2725	-0.1777	**0.105**
NCP	-0.1753	-0.5149	0.1084	0.1054	-0.1240	**-0.0106**	-0.1108	0.0846	-0.0207	0.3919	1.0371	-0.2258	-0.2674	-0.1601	**0.118**
NPC	0.0153	0.3639	0.4361	-0.0955	0.0297	0.0077	**0.1520**	-0.5763	0.1373	-0.6410	-0.1247	0.0362	0.1529	0.2677	**0.161***
TNPP	-0.1444	0.0241	0.7662	-0.0296	-0.0867	0.0012	0.1146	**-0.7649**	0.1397	-0.6734	0.8745	-0.2199	0.0310	0.2371	**0.269****
SP	-0.1168	0.3686	0.0887	-0.2272	0.3419	0.0007	0.0621	-0.3179	**0.3362**	-0.1195	0.3445	-0.1051	-0.2586	0.3199	**0.718****
100SW	-0.0084	0.0375	-0.4735	0.2197	-0.2441	-0.0044	-0.1031	0.5448	-0.0425	**0.9455**	0.0016	0.0336	-0.4445	-0.2655	**0.197***
PC	-0.1800	-0.0728	0.3154	0.1966	-0.3691	-0.0056	-0.0097	-0.3415	0.0591	0.0008	**0.9587**	-0.0160	-0.2318	0.0388	**0.343****
MC	-0.1622	-0.1606	0.2811	0.2538	-0.0588	-0.0042	-0.0097	-0.2960	0.0622	-0.0560	0.7787	**-0.0682**	-0.2428	0.0737	**0.391****
BYP	-0.0995	0.2943	0.4665	0.3209	-0.3537	-0.0036	-0.0298	0.0304	0.1116	0.5393	0.5827	-0.1770	**-0.7794**	-0.1317	**0.771****
HI	**-0.0702**	**0.2219**	**0.0514**	**-0.2971**	**0.3506**	**0.0033**	**0.0794**	**-0.3536**	**0.2098**	**-0.4895**	**0.1483**	**-0.0816**	**0.2001**	**0.5128**	**0.485****

Resi : 0.0819

*, ** significant at 5% and 1% level, respectively.

Table 4 : Phenotypic path F_1 with Seed yield (g/plant).

Components	Days to 50% flowering	Days to maturity	Plant height	Primary branches /plant	Secondary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methionine content (%)	Biological yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**-0.1300**	0.0335	-0.0215	0.0423	0.0127	0.0352	-0.0001	0.0084	0.0016	-0.0023	-0.0066	-0.0742	-0.1610	-0.0607	**-0.323****
DM	-0.0342	**0.1274**	-0.0145	-0.0227	-0.0156	0.0373	-0.0007	-0.0006	-0.0021	0.0030	-0.0024	-0.0098	0.1796	0.0735	**0.318****
PH	0.0158	-0.0104	**0.1769**	-0.0546	-0.0109	-0.0076	-0.0008	-0.0159	-0.0004	-0.0437	0.0019	0.0195	0.2748	0.0175	**0.362****
PBP	0.0338	0.0178	0.0595	**-0.1624**	-0.0390	-0.0153	0.0004	0.0013	0.0027	0.0388	0.0023	0.0337	0.3733	-0.1876	**0.159***
SBP	0.0329	0.0396	0.0384	-0.1262	**-0.0501**	-0.0105	0.0001	-0.0022	0.0022	0.0274	0.0027	0.0308	0.2535	-0.1414	**0.097**
NCP	0.0532	-0.0554	0.0156	-0.0290	-0.0061	**-0.0858**	0.0016	0.0028	0.0004	0.0461	0.0039	0.0333	0.2482	-0.1203	**0.108**
NPC	-0.0052	0.0365	0.0583	0.0271	0.0015	0.0584	**-0.0024**	-0.0178	-0.0026	-0.0705	-0.0004	-0.0053	-0.1369	0.1894	**0.130**
TNPP	0.0429	0.0030	0.1105	0.0080	-0.0043	0.0095	-0.0016	**-0.0255**	-0.0027	-0.0802	0.0033	0.0331	-0.0294	0.1820	**0.249****
SP	0.0284	0.0353	0.0103	0.0583	0.0147	0.0051	-0.0008	-0.0092	**-0.0074**	-0.0068	0.0012	0.0100	0.2136	0.2072	**0.560****
100SW	0.0026	0.0033	-0.0671	-0.0546	-0.0119	-0.0343	0.0014	0.0177	0.0004	**0.1154**	0.0000	-0.0054	0.4095	-0.2004	**0.177***
PC	0.1132	-0.0410	0.0447	-0.0497	-0.0178	-0.0445	0.0001	-0.0112	-0.0011	0.0003	**0.0075**	0.0768	0.2113	0.0280	**0.317****
MC	0.1024	-0.0132	0.0366	-0.0582	-0.0164	-0.0304	0.0001	-0.0090	-0.0008	-0.0066	0.0062	**0.0941**	0.2172	0.0258	**0.348****
BYP	0.0282	0.0308	0.0654	-0.0816	-0.0171	-0.0287	0.0004	0.0010	-0.0021	0.0636	0.0021	0.0275	**0.7431**	-0.1017	**0.731****
HI	**0.0172**	**0.0205**	**0.0068**	**0.0666**	**0.0155**	**0.0226**	**-0.0010**	**-0.0102**	**-0.0034**	**-0.0506**	**0.0005**	**0.0053**	**-0.1653**	**0.4574**	**0.382****

Resi : 0.131

*, ** significant at 5% and 1% level, respectively.

Table 5 : Genotypic path F_2 with Seed yield (g/plant).

Components	Days to 50% flowering	Days to maturity	Plant height	Primary branches /plant	Secondary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methionine content (%)	Biological yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**0.1522**	0.2309	-0.0120	0.3796	0.1856	0.0583	0.0413	0.2143	-0.6445	-0.0065	-0.6265	0.3766	-0.6690	0.1165	**-0.203****
DM	0.0318	**0.1071**	0.0026	-0.2199	-0.2881	0.0717	0.3423	-0.0527	0.1397	-0.0130	-0.1962	0.5423	0.1880	-0.1801	**0.476****
PH	-0.0028	0.0045	**0.6525**	-0.3125	-0.1030	-0.0034	0.3044	-0.3920	-0.0485	0.0377	0.3101	-0.0612	0.1473	-0.1954	**0.338****
PBP	-0.0531	0.2236	0.1872	**-0.9089**	-0.5484	-0.0286	-0.1449	0.0687	-0.1164	-0.0280	0.7655	-0.1732	0.2516	0.5921	**0.087**
SBP	-0.0416	0.4696	0.0989	-0.8793	**-0.6791**	-0.0137	-0.0431	-0.0118	-0.0795	-0.0167	0.6921	-0.1282	0.1216	0.4653	**-0.045**
NCP	-0.0538	-0.1811	0.0133	-0.1888	-0.0563	**-0.1649**	-0.1767	0.1354	-0.0370	-0.0267	0.1307	-0.1478	0.1377	0.6130	**-0.003**
NPC	0.0074	0.4453	0.2334	0.1854	0.0344	0.1311	**0.8512**	-0.5049	0.1036	0.0515	-0.2910	0.0289	-0.0919	-0.9421	**0.242****
TNPP	-0.0481	0.0860	0.3769	0.1103	-0.0118	0.0329	0.6332	**-0.6787**	0.0551	0.0628	0.7009	-0.1409	-0.0570	-0.8638	**0.258****
SP	-0.0230	0.5235	-0.1071	0.4290	0.1829	0.0206	0.2986	-0.1267	**0.2953**	-0.0088	0.0363	-0.0440	0.1302	-0.9628	**0.644****

Table 5 continued...

Table 5 continued...

100SW	0.0125	0.1805	-0.3092	-0.3830	-0.1426	-0.0553	-0.5514	0.5363	0.0325	**-0.0795**	-0.1515	0.0374	0.2402	0.8106	**0.178***
PC	-0.1332	-0.3172	0.6833	-0.3431	-0.1935	-0.0767	-0.1020	-0.2516	0.0044	0.0050	**0.4296**	-0.1444	0.7889	-0.1169	**0.232****
MC	-0.1380	-0.1128	0.0961	-0.1541	-0.2097	-0.0587	-0.0592	-0.2303	0.0313	0.0072	0.9152	**-0.1152**	0.6265	-0.2938	**0.304****
BYP	-0.0224	0.4429	0.2046	-0.5368	-0.1757	-0.0483	-0.1665	0.0823	0.0819	-0.0406	0.4595	-0.1118	**0.4699**	0.1273	**0.766****
HI	**-0.0395**	**0.1241**	**0.0794**	**0.3368**	**0.1967**	**0.0424**	**0.4990**	**-0.4493**	**0.1770**	**0.0401**	**0.1328**	**-0.0759**	**-0.0372**	**-0.6068**	**0.420****

Resi : 0.0160

*, ** significant at 5% and 1% level, respectively.

Table 6 : Phenotypic path F_2 with Seed yield (g/plant).

Components	Days to 50% flowe-ring	Days to maturity	Plant height	Primary branches /plant	Secon-dary branches per plant	Number of clusters /plant	Number of pods /cluster	Total number of pods / plant	Seeds per pods	100 seed weight (gm)	Protein content (%)	Methio-nine content (%)	Biologi-cal yield per plant	Harvest Index (%)	Seed yield per plant (g)
D50F	**-0.0979**	0.0611	-0.0056	-0.0059	0.0924	0.0095	0.0011	-0.0023	-0.0017	0.0177	-0.0152	-0.1200	-0.0514	-0.0708	**-0.189***
DM	-0.0174	**0.3427**	-0.0010	0.0037	-0.1473	0.0118	0.0089	0.0006	0.0050	0.0371	-0.0051	-0.0139	0.1332	0.0405	**0.399****
PH	0.0019	-0.0012	**0.2882**	0.0053	-0.0552	-0.0005	0.0081	0.0046	-0.0020	-0.1257	0.0024	0.0216	0.1116	0.0314	**0.291****
PBP	0.0289	0.0623	0.0765	**0.0201**	-0.2732	-0.0048	-0.0044	-0.0008	-0.0038	0.0794	0.0054	0.0549	0.1617	-0.1284	**0.074**
SBP	0.0241	0.1349	0.0425	0.0146	**-0.3744**	-0.0024	-0.0013	0.0001	-0.0029	0.0556	0.0053	0.0444	0.0942	-0.0799	**-0.045**
NCP	0.0322	-0.1396	0.0051	0.0034	-0.0310	**-0.0290**	-0.0189	-0.0016	-0.0014	0.0868	0.0088	0.0511	0.1053	-0.0709	**0.000**
NPC	-0.0041	0.1186	0.0904	-0.0034	0.0182	0.0212	**0.0258**	0.0055	0.0035	-0.1511	-0.0021	-0.0098	-0.0575	0.1485	**0.204****
TNPP	0.0280	0.0266	0.1645	-0.0019	-0.0063	0.0057	0.0176	**0.0081**	0.0020	-0.2096	0.0070	0.0490	-0.0442	0.1862	**0.233****
SP	0.0086	0.0900	-0.0301	-0.0040	0.0571	0.0022	0.0047	0.0009	**0.0191**	0.0081	0.0002	0.0098	0.0725	0.0946	**0.334****
100SW	-0.0059	0.0435	-0.1239	0.0055	-0.0712	-0.0086	-0.0133	-0.0058	0.0005	**0.2923**	-0.0011	-0.0118	0.1746	-0.1311	**0.144**
PC	0.0786	-0.0917	0.0365	0.0057	-0.1052	-0.0134	-0.0029	0.0030	0.0002	-0.0166	**0.0190**	0.1196	0.0677	0.1074	**0.208****
MC	0.0807	-0.0326	0.0427	0.0076	-0.1141	-0.0102	-0.0017	0.0027	0.0013	-0.0237	0.0156	**0.1456**	0.0962	0.0527	**0.263****
BYP	0.0134	0.1217	0.0857	0.0087	-0.0940	-0.0081	-0.0039	-0.0010	0.0037	0.1360	0.0034	0.0373	**0.3753**	-0.0347	**0.643****
HI	**0.0231**	**0.0464**	**0.0302**	**-0.0086**	**0.0999**	**0.0069**	**0.0128**	**0.0050**	**0.0060**	**-0.1280**	**0.0068**	**0.0256**	**-0.0435**	**0.2994**	**0.382****

Resi : 0.289

*, ** significant at 5% and 1% level, respectively.

pod as direct contributors to lentil yield has been reported by Sarker *et al*. (2022) and Meena *et al.* (2020).

Methionine content showed a strong negative direct effect (–0.9628) despite its positive association with seed yield, indicating that its relationship with yield was largely mediated through indirect effects. Such differences between correlation and direct effects demonstrate the importance of path analysis for identifying reliable selection criteria.

Phenotypic path coefficient analysis in F_2

At the phenotypic level, days to maturity, plant height, biological yield and harvest index showed positive direct effects on seed yield, with biological yield recording a direct effect of 0.3753 and a correlation of 0.643 with seed yield. Similar positive direct contributions of biological yield and harvest index have been reported in lentil by Sarker *et al.* (2022) and Kumar *et al.* (2020).

Conclusion

The present study demonstrated substantial genotypic and phenotypic associations among phenological, morphological, yield-contributing and quality traits in the F_1 and F_2 generations of lentil. Biological yield per plant consistently exhibited a strong positive association with seed yield in both F_1 and F_2 generations, while seeds per pod and harvest index also showed positive relationships with seed yield. Path coefficient analysis further revealed that several traits contributed to seed yield through both direct and indirect pathways, with the magnitude and direction of effects varying between generations and between genotypic and phenotypic levels. The low residual effects, particularly in the genotypic analysis of F_2 (0.016), indicated that the traits included in the analysis explained a substantial proportion of the variation in seed yield. Overall, biological yield per plant, seeds per pod, plant height, number of clusters per plant and harvest index emerged as important traits for consideration in selection. The combined use of correlation and path analysis therefore provides a useful basis for identifying appropriate selection criteria and improving seed yield in lentil breeding populations.

References

Chahota, R.K. and Sharma S.K. (1993). Studies on genetic variability and component analysis in *macrospenna* and *microspenna* lentils. *Indian J. Gen. Plant Breed.*, **53**, 411–417.

Chowdhury, M.M., Haque M.A., Malek M.A., Rasel M. and Ahamed K.U. (2019). Genetic variability, correlation and path coefficient analysis for yield and yield components of selected lentil (*Lens culinaris* M.) genotypes. *Fundamen. Appl. Agricult.*, **4(2)**, 769–776. https://doi.org/10.5455/faa.21740.

Kumar, A., Gill R.K. and Singh M. (2020). Genetic variability and association analysis for various agro morphological traits in lentil (*Lens culinaris* M.). *Leg. Res.*, **43(6)**, 776–779. https://doi.org/10.18805/LR-4326.

Kumar, P., Vimal S.C. and Kumar A. (2017). Study of simple correlation coefficients for yield and its component traits in lentil. *Int. J. Curr. Microbiol. Appl. Sci.*, **6**, 3260–3265.

Maurya, K.S., Prakash S., Kumar R. and Shekhar C. (2020). Studies on correlation and path coefficient analysis and its contributing parameters in lentil (*Lens culinaris* Medik.) genotypes. *J. Pharmacog. Phytochem.*, **9(4)**, 65–68.

Meena, J.K., Singh K., Meena P.K., Kumar R. and Meena D. (2020). Studies on genetic variability, correlation and path analysis in lentil (*Lens culinaris* Medik.) genotypes. *Int. J. Curr. Microbiol. Appl. Sci.*, **9(9)**, 2078–2084. https://doi.org/10.20546/ijcmas.2020.909.259.

Mekonnen, K., Firew M., Agrawal S.K., Kemal S.A. and Sharma T.R. (2014). Correlation and path coefficient analysis of seed yield and yield components in lentil genotypes in Ethiopia.

Pilania, P., Chaudhary L. and Kumar M. (2026). Genetic variability and association analysis for various quantitative traits in lentil. *Indian J. Agricult. Res.*, **59**, 1184–1188.

Ram Kishor, Kamaluddin and Sharma V. (2020). Correlation and path analysis for yield and its component traits in lentil in Bundelkhand. *J. Pharmacog. Phytochem.*, **9**.

Sarker, A., Takele E., Mekbib F. and Mekonnen F. (2022). Genetic variability and characters association for yield, yield attributing traits and protein content of lentil (*Lens culinaris* Medikus) genotype in Ethiopia. *CABI Agricult. Biosci.*, **3**, 9. https://doi.org/10.1186/s43170-022-00079-6.

Satpathy, S., Debnath S. and Mishra A. (2025). Study on character association in *Lens culinaris* Medik. *Elect. J. Plant Breed*.

Sharma, V., Paswan S.K. and Singh V.K. (2014). Correlation and path coefficient analysis of economically important traits in lentil germplasm. *The Bioscan*, **9**, 819–822.

Vanave, P.B., Jadhav A.H., Mane A.V., Mahadik S.G., Pethe U.B. and Thaware B.L. (2019). Correlation and path analysis studies in lentil (*Lens culinaris* Medic.). *Elect. J. Plant Breed.*, **10(3)**, 1322–1328. https://doi.org/10.5958/0975-928X.2019.00169.8.

Yadav, S.S., Phogat D.S., Solanki I.S. and Tomer Y.S. (2005). Character association and path coefficient analysis under two environments in lentil. *J. Food Legumes*, **18(2)**, 147–149. https://doi.org/10.53550/jfl.v18i2.2340.