Original Research Article……….

International Journal of Agricultural Invention

(online available at www.agriinventionjournal.com)

International Journal of Agricultural Invention **11(1): 6-15: January-June, 2026**

ISSN: 2456 – 1797 (P)

Assessment of genetic divergence among Lentil (*Lens culinaris* Medik.) genotypes using quantitative and yield-related traits

Sumit Kumar[1], *Amit Nagar[1], Parvesh Kumar[2], R. K. Gupta[1], Ashvani Panwar[3], Anurag Tripathi[1], Akankhya Guru[1], Ranjeet Kumar[1]

[1]Department of Genetics and Plant Breeding, J. V. College, Baraut (Baghpat) U.P., India
[2]Department of Genetics and Plant Breeding, C. C. S. University, Meerut, U.P., India
[3]Department of Genetics and Plant Breeding, Gochar Mahavidyalaya, Rampur Maniharan, Saharanpur, U.P., India
*Corresponding email: *amitnagar39013901@gmail.com*

ARTICLE INFO

Original Research Article
Received on January 04, 2026
Revised on January 09, 2026
Accepted on February 03, 2026
Published on February 07, 2026

Article Authors
Sumit Kumar, Amit Nagar, Parvesh Kumar, R. K. Gupta, Ashvani Panwar, Anurag Tripathi, Akankhya Guru, Ranjeet Kumar

Corresponding Author Email
amitnagar39013901@gmail.com

PUBLICATION INFO
International Journal of Agricultural Invention (IJAI)
RNI: UPENG/2016/70091
ISSN: 2456-1797 (P)
Vol.: 11, **Issue:** 1, **Pages:** 6-15
Journal Homepage URL
http://agriinventionjournal.com/
DOI: 10.46492/IJAI/2026.11.1.2

ABSTRACT

The present study was conducted to assess the extent of genetic divergence among different genotypes of lentil (*Lens culinaris* Medik.) using quantitative traits related to growth, yield, and yield components. A set of diverse lentil genotypes was evaluated under field conditions using a randomized block design with appropriate replications. Significant variation among 20 lentil genotypes for 12 important quantitative traits the present investigation J.V College Baraut Baghpat Uttar Pradesh was observed among the genotypes for most of the traits studied, indicating the presence of substantial genetic diversity. Genetic divergence analysis grouped the genotypes into distinct clusters, suggesting wide genetic variability among the experimental material. Genotypes belonging to divergent clusters exhibited greater inter-cluster distances, indicating their potential usefulness as parents in hybridization programmes for the development of high-yielding and widely adapted lentil varieties. The results of the study emphasize the importance of exploiting genetic divergence in lentil breeding programmes to enhance productivity and broaden the genetic base.

KEYWORDS

Lentil, *Lens culinaris* Medik., Genetic Divergence, Variability, Cluster Analysis

HOW TO CITE THIS ARTICLE

Kumar, S., Nagar, A., Kumar, P., Gupta, R. K., Panwar, A., Tripathi, A., Guru, A., Kumar, R. (2026) Assessment of genetic divergence among Lentil (*Lens culinaris* Medik.) genotypes using quantitative and yield-related traits, *International Journal of Agricultural Invention*, 11(1): 6-15. DOI: 10.46492/IJAI/2026.11.1.2

Pulses are an integral component of the Indian farming system and play a crucial role in human nutrition due to their high protein content and ability to improve soil fertility through biological nitrogen fixation. India produces a wide range of pulse crops, including chickpea, pigeonpea, urdbean, mungbean, lentil, and field pea, thereby contributing significantly to national food and nutritional security (Ali and Kumar, 2007).

Among these, lentil (*Lens culinaris* Medikus subsp. *culinaris*) is one of the most important winter season pulse crops cultivated in the country. Botanically, lentil belongs to the family *Leguminosae* (Fabaceae), tribe *Vicieae*, and possesses a diploid chromosome number of 2n = 14. It is a bushy, annual legume grown primarily for its lens-shaped seeds.

The crop generally attains a height of 40-50 cm and has a moderately deep taproot system, which enables it to tolerate moderate drought and temperature stress. Lentil is an important component of sustainable cropping systems, as it improves soil structure and fertility and helps in the suppression of weeds, insect pests, and diseases when included in crop rotations. Lentil is a highly nutritious food legume and is mainly consumed as dhal. Compared to many other legumes, lentil seeds contain relatively higher levels of protein, carbohydrates, and calories and are preferred in several regions due to their fast cooking characteristics (Hoffman *et al*., 1985). Nutritionally, lentil seeds provide approximately 340-346 kcal energy, 20.2g protein, 65.0g carbohydrates, and appreciable amounts of essential minerals such as calcium, phosphorus, iron, and potassium, along with vitamins including thiamine, riboflavin, and niacin (Muehlbauer *et al*., 1985). Although lentil seeds contain certain anti-nutritional factors such as trypsin inhibitors and oligosaccharides, these can be substantially reduced through processing methods like heating and sprouting (Jambunathan *et al*., 1994).

India ranks second in the world in terms of lentil area and production, next only to Canada. Lentil cultivation in India is largely concentrated in the northern plains and the central and eastern regions of the country. During 2020-21, lentil was grown on about 1.47 million hectares with a total production of 1.49 million tonnes and an average productivity of 1017 kg ha^{-1}. Major lentil-producing states include Uttar Pradesh, Madhya Pradesh, Bihar, and West Bengal, with Madhya Pradesh recording the highest productivity and Uttar Pradesh contributing the largest area under cultivation. Several other states also contribute to national lentil production, highlighting the crop's wide adaptability. Apart from its importance as a food crop, lentil residues such as husks, stems, and bran serve as valuable livestock feed, particularly in regions experiencing forage scarcity. Lentil plants are also used as green manure, while the seeds provide commercial starch for the textile and printing industries (Kay, 1979). These multiple uses further enhance the economic value of the crop. Improvement in lentil productivity and yield stability depends largely on the extent of genetic variability available in the germplasm and the effective selection of genetically diverse parents.

The success of hybridization programmes is influenced by the magnitude of genetic divergence among parents, as crosses involving diverse genotypes are more likely to produce superior transgressive segregants in subsequent generations. Several researchers have emphasized the importance of selecting parents with optimum genetic diversity to enhance selection efficiency and genetic gains for yield and its component traits (Gupta *et al*., 2012). In view of the economic importance of lentil and the need for genetic improvement, the present investigation was undertaken to assess the extent of genetic variability among lentil genotypes and to estimate key genetic parameters such as heritability and genetic advance for important yield-related traits. The study also aimed to examine the association between seed yield and its component characters through genotypic and phenotypic correlation analysis. Further, path coefficient analysis was employed to identify traits having direct and indirect effects on seed yield. Additionally, genetic divergence analysis was carried out to identify suitable and diverse genotypes for their effective utilization in future lentil breeding programmes.

Materials and Methods

The experiment was conducted during the rabi season of 2022-23 at the research farm of J. V. College, Baraut, District Baghpat, Uttar Pradesh. The experimental material comprised 20 lentil genotypes, which were evaluated in a randomized block design (RBD) with three replications. Each genotype was sown in plots of 1.5 m × 1.0 m with a spacing of 30 cm between rows and 8 cm between plants, accommodating three rows per plot and a total of 54 experimental units. Observations were recorded on five randomly selected plants per plot for twelve characters, namely days to germination, days to 50% flowering, days to maturity, number of primary and secondary branches, plant height, number of pods per plant, number of seeds per pod, 100-seed weight, seed yield per plant, biological yield per plant, and harvest index. Analysis of variance was performed following standard statistical procedures (Fisher, 1938). Estimates of genotypic and phenotypic coefficients of variation (Burton, 1952), heritability (Burton and DeVane, 1953), genetic advance (Johnson *et al*., 1955), and genetic divergence (Beale, 1969; Sparks, 1973) were computed to assess genetic variability and relationships among the genotypes.

Table 1. ANOVA table showing mean squares for genotypes, error mean square and replication mean squares

Characters	Replication	Treatment	Error
Degree of freedom	Df=2	Df=19	Df=38
Day of germination	1.40	3.574561	0.487719
Days to 50% flowering	1.40	29.9508**	2.2771
Days to maturity	10.850	16.6281**	1.8149
Plant height (cm)	25.5409	19.3978**	11.8974
Number of primary branches plant^{-1}	2.8922	0.2945**	0.2082
Number of secondary branches plant^{-1}	0.0167	25.8981**	0.0258
Number of pods plant^{-1}	40.6632	239.6248**	30.8609
Number of seeds pod^{-1}	0.6507	0.1921**	0.0598
100-seed weight (g)	0.0199	0.5086**	0.0826
Seed yield plant^{-1} (g)	0.0380	1.5059**	0.0748
Biological yield plant^{-1} (g)	0.2167	48.9251**	0.1395
Harvest index (%)	1.9906	113.4296**	1.6982

Note: Where, Df= Degrees of freedom, ns=non-significant, * and ** indicates significant and highly significant respectively, (**significant at 1% and *significant at 5% level)

The recorded data were analyzed using analysis of variance under the GLM procedure of SAS (2004), considering genotypes as fixed and replications as random effects, with significant means separated by SNK test at 5% level, while multivariate analyses including PCA and cluster analysis were also performed using SAS software.

Results and Discussion

Analysis of Variance

The analysis of variance for the 12 characters studied is given in table 2. There was a highly significant difference (P <0.001) among the tested genotypes for days to germination, days to flowering, days to maturity, plant height, number pods per plant, number of seed per pod and harvest index. Significant differences (P<0.05) were observed for biological yield and seed yield. Non-significant differences were observed for traits like number of primary branches per plant, number of secondary branch/plant and 100-seed weight (table 2). On average all the genotypes were germinated nine days after sowing. Accession number T-36 (9.67) was late in germination as compared to the rest accessions. High variability was observed among genotypes tested for days to flowering, days to maturity.

On average genotypes were taken 102-112.33 and 10 days to flower, mature respectively. All genotypes were matured on average of 143 and half days after sowing, for the genotypes were 35 days after flowering. Genotypes like IPL-81 (6.00), WBL- (6.33), DPL-62, PANT L-406 and IPL-534 (6.67) earlier germination the other genotypes. Genotype K-75 and T-36 (9.67) is the late germination one among the sown genotypes. B-77, Ranjan (102.00) is the earliest genotype to give 50% flowering among the other genotypes and IC-560128, L-4147 (112.33) is the one that gave 50% flowering late. Genotype B-77 (137.67) earlier maturity than the other genotypes and IPL-534 (146.67) maturity late as compared to the rest genotypes tested. High significant differences were observed among lentil genotypes tested for plant height, but non-significant differences were observed among genotypes for number of primary branches per plant. The highest mean performance for all of the tested entries were recorded as for; plant height (38.40), number of primary branches per plant (4.27), number of secondary branch per plant B-77 (18.87). Relatively taller plants of plant height were recorded from genotypes IPL-81 (38.40) and followed by T-36 (34.57) and Narendra M-1 (34.47) (table 3).

Table 2. Mean performance for 12 characters of lentil genotypes

Genetypes	Day to Germination	Day to 50% Flowering	Day to Maturity	Plant Height	No. of Primary Branch/ Plant	No. of Secondery Branch/ Plant	No. of Pod/ Plant	No. of Seed/ Pod	100-Seed Weight	Biological Yield/ Plant	Seed Yield/ Plant	Harvest Index (%)
IPL-526	7.00	112.00	146.00	31.87	3.47	18.03	125.33	1.53	3.75	17.47	5.57	31.89
Narendra M-1	7.67	109.67	144.00	34.47	3.20	11.83	134.27	1.33	2.46	17.87	5.57	31.17
IPL-534	6.67	108.67	146.67	34.20	3.40	10.47	133.13	1.27	3.56	19.53	5.60	28.67
Bari-6	7.00	106.00	144.33	32.27	3.07	8.73	125.30	1.07	2.30	21.77	5.60	25.71
PANT L-369	8.67	111.67	145.00	29.87	4.27	11.27	138.60	1.47	2.66	14.53	4.53	31.20
L-4147	8.00	112.33	143.33	33.00	2.93	16.33	137.33	1.20	2.43	15.80	5.80	36.75
PL-3	7.67	105.00	143.33	29.93	3.23	15.40	115.33	1.40	2.92	20.13	5.10	25.33
HUL-57	8.00	109.00	142.33	29.53	3.47	14.10	128.00	1.40	2.59	23.00	5.07	22.03
K-75	9.67	111.67	144.33	33.51	3.58	11.53	128.17	1.67	3.25	21.17	5.20	24.57
IPL-321	6.67	106.00	145.33	33.07	3.73	11.53	133.73	1.07	3.52	27.57	5.50	19.94
PANT L-406	7.67	112.00	143.67	32.27	3.40	14.80	139.27	1.47	2.76	23.63	5.00	21.18
DPL-15	7.33	109.00	143.67	32.47	3.40	8.97	119.47	1.80	3.08	22.70	4.07	17.92
IPL-315	7.67	108.00	142.33	32.07	3.33	15.87	138.13	1.20	3.29	15.70	5.83	37.18
WBL-62	6.33	108.00	143.00	34.10	3.22	10.67	115.47	1.40	2.69	18.20	6.03	33.15
IPL-81	6.00	106.00	145.00	38.40	2.87	14.67	137.53	1.67	3.13	24.17	7.60	31.45
DPL-62	6.67	109.00	144.33	33.20	3.73	13.47	135.37	1.07	2.73	20.33	6.23	30.66
T-36	9.67	108.00	143.67	34.57	3.53	13.87	152.20	1.87	2.69	26.40	5.07	19.20
IC-560128	9.00	112.00	140.00	31.33	3.57	16.33	129.33	1.27	2.78	27.27	5.53	20.30
B-77	8.33	102.00	137.67	26.37	3.67	18.87	138.67	1.87	2.49	26.27	5.57	21.19
Ranjan	9.33	102.00	138.00	29.13	3.60	16.73	136.00	1.33	2.64	25.43	5.03	19.78
Mean	7.75	108.40	143.30	32.28	3.43	13.67	132.03	1.42	2.89	21.45	5.48	26.46
Range Lowest	6.00	102.00	137.67	26.37	2.87	8.73	115.33	1.07	2.30	14.53	4.07	17.92
Range Highest	9.67	112.33	146.67	38.40	4.27	18.87	152.20	1.87	3.75	27.57	7.60	37.18
C.D. at 5%	1.15	2.49	2.23	-	-	0.27	9.18	0.40	0.48	0.62	0.45	2.15
C.D. 1%	1.55	3.34	2.98	-	-	0.36	12.30	0.54	0.64	0.83	0.61	2.89

Note: Where **DG=** day to germination, **DF**= day to flowering, **DM=** day to maturity, **PH**= plant height, **NPBPP**= number of primary branch/plant, **NSBPP**= number of secondary branch/plant, **NPPP**= number of pods/plant, **NSPP**= number of seed/pods**, BYPP**=biological yield/plant**, SYPP**= seed yield/plant, **100 seed weight, HI**= harvest index

On the other hand, shorter plants were recorded from B-77 (26.37), Ranjan (29.13) and HUL-57 (29.53). High significant differences were observed among lentil genotypes for most yield related traits, seed and biological yield and harvest index. On average the genotypes gave 100-seed weight, biological yield, seed yield and harvest index, respectively (table 3). The mean of all of the tested entries were recorded as number of pods per plant 132.03, number of seed per pod 1.42%, 100-seed weight 2.89%, biological yield 21.45%, seed yield 5.48% and harvest index 26.46%. As reported by (Mondal *et al*., 2007), significant differences are found among lentil accessions for days to 50% flowering, days to maturity, plant height, number of primary branches/ plant, number of secondary branch/plant, number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant except plant height and number of branches per plant. Mean performance of high was recorded for number of pods per plant (152.20), number of seed per pod (1.87), seed yield per plant (7.60), biological yield (27.57) and harvest index (37.18). Top 5 high yielding lentil accessions (genotypes) are identified as; IPL-81 (7.60), DPL-62 (6.23), WBL-62 (6.03), IPL-321 (5.83) and L-4147(5.80). Very wide ranges (115.33-152.20) were recorded for number pod per plant. Narrow ranges were recorded for days to germination (6.00-9.67), number of primary branches per plant (2.87-4.27), number of secondary branch/plant (8.73-18.87), number of seed/pods (1.07-1.87), 100-seed weight (2.30-3.75), biological yield/plant (14.53-27.57) and seed yield/plant (4.07-7.60) in/plant and harvest index (17.92-37.18).

Table 3. Genotypic and phenotypic coefficient of variability, heritability, genetic advance, and genetic advance percent of the mean of the 12 traits of Lentil varieties

Characters	Heritability (Broad Sense)	Genetic Advance 5%	Genetic Advance Mean 5%	GCV	PCV
Days to Germination	67.8	1.721	22.208	13.089	15.891
Days to 50% flowering	80.2	5.603	5.169	2.802	3.129
Days to maturity	73.1	3.914	2.732	1.551	1.813
Plant height (cm.)	17.4	1.357	4.205	4.898	11.754
No. of primarybranches/ Plant	12.1	0.122	3.541	4.937	14.178
No. of secondary branches/Plant	99.7	6.041	44.178	21.48	21.510
No. of Pods/Plant	69.3	14.303	10.833	6.318	7.591
No. of Seeds/Pod	42.5	0.282	19.897	14.83	22.753
100-Seed weight(g)	63.2	0.617	21.388	13.06	16.421
Biological Yield/Plant(g)	99.1	8.272	38.569	18.80	18.883
Seed Yield/Plant(g)	86.4	1.323	24.161	12.62	13.569
Harvest Index (%)	95.6	12.995	46.661	23.06	23.582

Table 4. Phenotypic correlation coefficients (rp) of yield and yield related traits for the 12 Lentil genotypes

Characters	Day to Germination	Day to 50% Flowering	Day to Maturity	Plant Height	No. of Primary Branch/ Plant	No. of Secondery Branch/ Plant	No. of Pod/ Plant	No. of Seed/ Pod	100-Seed Weight	Biological Yield/ Plant	Seed Yield/ Plant	HarvestIndex (%)
Days to Germination	**1.000**	0.083	-0.569**	-0.586**	0.945**	0.296*	0.405**	0.472**	-0.351**	0.228	-0.434**	-0.574**
Days to 50% flowering		**1.000**	0.511**	0.458**	0.136	-0.147	-0.027	-0.076	0.147	-0.458**	0.316*	-0.158
Days to maturity			**1.000**	0.941**	-0.313*	-0.577**	-0.123	-0.201	0.566**	-0.439**	0.382**	0.127
Plant height (cm)				**1.000**	-2.051**	-0.647**	0.041	-0.286*	0.460**	-0.165	0.571**	0.934**
No. of primary branches/ Plant					**1.000**	-0.010	0.405**	0.044	0.162	0.170	-0.594**	-0.978**
No. of secondary branches/Plant						**1.000**	0.319*	0.200	-0.005	0.141	0.054	0.220
No. of Pod/Plant							**1.000**	0.190	-0.184	0.203	-0.017	0.163
No. of Seeds/Pods								**1.000**	0.090	0.291*	-0.424**	-0.288*
100- Seed weight (g)									**1.000**	-0.046	0.084	0.100
Biological Yield/ Plant (g)										**1.000**	-0.852**	-0.019
Harvest Index (%)											**1.000**	0.518**

Note: Where DG=days to germination, **DF**= Days to 50% Flowering, **DM**=days to maturity, **PH**=plant height (cm), **NPBPP**= Number of primary branches per plant, **NSBPP**= Number of secondary branch per plant, **NPPP**= Number of pods per plant, **NSPP**= Number of seed per pod, **HSW**= 100-Seed weight, **BYPP**= Biological yield prer plant, **SYPP**= Seed yield per plant and **HI**= Harvest Index in percentage.

Table 5. Genotypic correlation coefficients (rg) of yield and yield related traits for the 12 Lentil genotypes

Characters	**Day to Germination**	**Day to 50% Flowering**	**Day to Maturity**	**Plnt Height**	**No. of Primary Branch/ Plant**	**No. of Secondery Branch/ Plant**	**No. of Pod/ Plant**	**No. of Seed/ Pod**	**100-Seed Weight**	**Biological Yield/ Plant**	**Seed Yield/ Plant**	**Harvest Index (%)**
Days to Germination	1.000	0.083	-0.396**	-0.360**	0.160	0.242	0.301*	0.216	-0.222	0.178	-0.366**	-0.468**
Days to 50% flowering		1.000	0.455**	0.200	0.040	-0.129	0.045	-0.091	0.158	-0.419**	0.276*	-0.144
Days to maturity			1.000	0.502**	-0.009	-0.494**	-0.054	-0.147	0.395**	-0.379**	0.336**	0.133
Plant height (cm.)				1.000	-0.048	-0.269*	0.156	0.077	0.194	-0.049	0.200	0.331**
No. of primary branches/Plant					1.000	-0.006	0.168	0.101	0.067	0.054	-0.195	-0.300*
No. of secondary branches/Plant						1.000	0.259*	0.118	-0.004	0.140	0.049	0.199
No. of Pods/Plant							1.000	0.089	-0.080	0.163	-0.037	0.073
No. of Seeds/Pod								1.000	-0.023	0.206	-0.266*	-0.140
100-Seed weight(g)									1.000	-0.041	0.071	0.080
Biological Yield/Plant										1.000	-0.833**	-0.011
Harvest Index (%)											1.000	0.541**

Phenotypic and genotypic coefficients of variations are the amount of genotypic and phenotypic variability that exists in a species is essential in developing better varieties and in initiating a breeding program. Genotypic and phenotypic coefficients of variation are used to measure the variability that exists in a given population (Gemechu *et al*., 2013). Estimated variance components, phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) of the characters studied are presented in table 3. The phenotypic coefficient of variation (PCV) was generally much higher than genotypic coefficient of variation (GCV) for all characters considered indicating that environment is important in determining these traits. Relatively very high GCV was observed for harvest index (23.06), number of secondary branch per plant (21.48), and biological yield per plant (18.80).

High GCV was recorded for number of seed per pod (14.83), day to germination (13.08), 100-seed weight (13.06) and seed yield (12.62). The lowest GCV was recorded for day to maturity (1.55), day to 50% flowering (2.80), plant height (4.89), number of primary branch per plant (4.93) and number of pod per plant (6.31). In line with this result (Malik *et al*., 1994) found that sufficient genetic variability in lentil genotype in traits like plant height, number of pods per plant and seed yield per plant. Tigist (2022) had also reported that high GCV for number of branches, plant height and days to germination. Seifu (2009) had reported that high GCV for number of primary branches per plant and plant height. Very higher PCV was observed for harvest index (23.58), number of seed per pod (22.75) and number of secondary branch per plant (21.51).

High PCV was recorded for biological yield per plant (18.38), 100-seed weight (16.42), day to germination (15.89) number of primary branch per plant (14.17) and seed yield per plant (13.56). The estimated PCV was relatively low for day to maturity (1.81), days to 50% flowering (3.12), number of seed per pod (7.59) and plant height (11.75). This finding agrees with the result reported by (Edossa *et al.*, 1998) in Ethiopian lentil landraces for number of pods, plant height, and days to 50% flowering. However, the differences between PCV and GCV values for days to maturity, number of primary branches per plant, 100-seed weight and harvest index were wide. High GCV recorded in biological and seed yield per plant, day to maturity, number of seed per pod and 100-seed weight indicates that the variation exist will allow selection to improve these characters. These results are in agreement with those recorded by (Afiah and Moselhy, 2001). Day to maturity, day to 50% flowering and number of pod per plant showed lower estimates of PCV indicating little opportunity for selection to improve these traits. In line with this result (Singh and Singh, 1997 and Sinha and Choudhury, 1991) were reported lower estimates of variability for these traits.

Heritability Estimates in Broad Sense

The estimated heritability for the 12 studied characters is presented in table 3. The heritability values for the 12 characters ranged from 0.2% to 99.1%. As reported by (Wright, 1991), heritability values are helpful in Predicting the expected progress to be achieved through the process of selection on genetic coefficient of variation along with heritability estimate provides a reliable estimate of the amount of genetic advance to be expected through phenotypic selection. Low heritability value for day to 50% flowering (0.2) coupled with low PCV (3.12) and GCV (2.80), and number of primary branch per plant (2.1%) with high PCV (14.17%) and low GCV (4.93%) was observed indicating selection for this trait may respond effectively for phenotypic selection of lentil grown in high land area. The contribution of the environment effect to the phenotypes but, for characters with low heritability, say 40% or less, selection may be considerably difficult or virtually impractical due to the masking effect of the environment.

The result obtained in this study indicated that, heritability estimate was recorded as moderate (40-80%) for traits like number of seed per pod (42.5), 100-seed weight (63.2), days to germination (67.8) and number of pod per plant (69.3). Moderate estimate of heritability for number of seed per pod have been reported by (Yadav *et al*., 2003). However, (Fratini *et al*., 2007 and Abebe, 2008), stated that biological yield per plant was a highly heritable trait in the lentil accessions and therefore could be targeted as a trait for selection in a breeding program with parents from that accession. Low estimates of heritability values were recorded for traits like day to 50% flowering (0.2), number of primary branch per plant (2.1), day to maturity (3.1) and plant height (7.4) and number of secondary branch per plant (9.7). A likewise low estimate of heritability value with lowest values of GCV was observed for traits day to maturity (1.55) indicating that phenotypic selection for these traits is difficult. In this study, lowest estimate of heritability (Singh and Ceccerelli, 1996) stated that if heritability of a character is very high, say 80% or more, selection for such character should be fairly easy. This is because there would be a close correspondence between the genotypes and phenotypes due to the relatively small was observed for day to 50% flowering (0.2); thereby indicating limited possibility of improvement for this trait through selection.

Estimates of Expected Genetic Advance

The genetic advance as the percentage of the mean (GAM) at 5% selection intensity is presented in table 4 below. Estimates of genetic advance as percent of mean at 5% selection intensity ranged from 2.73 for day to maturity to 46.66 for harvest index. The highest genetic advance was observed for number of pod per plant. There was relatively high genetic advance expressed as percentage of mean for harvest index (46.66) with high value of heritability, PCV and GCV values. The highest and lowest genetic advances as percent mean were recorded for harvest index (46.66) and day to maturity (2.80) respectively. The low expected genetic advances were recorded for traits like number of primary branches per plant (0.12), number of seed per plant (0.28), 100-seed weight (0.61), plant height (1.35), seed yield per plant (1.32), plant height (1.35) and day to germination (1.72) which are due to low variability for these traits indicated by respective low GCV's and PCV's (table 4).

Therefore, even if heritability estimates provide basis for selection on the phenotypic performance, the estimates of heritability and genetic advance should always be considered simultaneously, high heritability is not always associated with high genetic advance as reported by (Yadav *et al*., 2003). Likewise, estimates of genetic advance (as percent of the mean) for number of pod per plant, harvest index, biological yield per plant, number of secondary branch per plant, day to 50% flowering and day to maturity were also considerably high. A low GCV and low GAM were observed for characters like day to maturity, indicated that the characters were under high environmental influence, and that selection based on these characters would be ineffective.

Estimates of Correlation Coefficients

Seed yield is the result of many characters which are interdependent. Breeders always look for genetic variation among traits to select desirable types. Some of these characters are highly associated among themselves and with seed yield. As reported by (Singh and Ceccerelli, 1996), the analysis of the relationship among these characters and their association with seed yield is essential to establish selection criteria. Estimates of correlation coefficients between each pair of characters were presented in table 5 and 6. Similar results were also obtained on lentil crop by (Sharma, 1999). Improvement for a target character can be achieved by indirect selection via other characters that are more heritable and easier to select. This selection strategy requires understanding the interrelationship of the characters among themselves and with the target character. Positive and significant phenotypic correlation of number of secondary branch per plant with biological yield and seed yield was observed. In line with this result, (Tigist, 2015) reported that seed yield was positively correlated with day to 50% flowering, day to maturity, plant height, number of secondary branch per plant and 100-seed weight. Plant height had showed significant and positive correlation with seed yield per plant, and highly significant and positive correlation with harvest index (table 4). Positive correlation of plant height with seed yield has also been reported by (Kumar *et al*., 2004), which was also reported by (Tigist, 2015 and Vir *et al*., 2001).

Plant height had highly significant and positive genotypic and phenotypic correlation with harvest index, and very highly significant and negative correlation with seed yield per plant. Positive and very high significant correlation of number of primary branch per plant and plant height has been observed. Positive and significant genotypic correlation harvest index showed very highly significant and negative correlation with biological yield per plant. Harvest index showed very highly significant and negative correlation with biological yield (table 5). Fewer studies have associated biomass with other traits (Kumar *et al.*, 2004). Biological yield per plant was positively correlated with day to germination, number of primary branch per plant, number of secondary branch per plant, number of pod per plant and number of seed per pod.

Seed yield was significantly correlated with day to 50% flowering, day to maturity, plant height, number of secondary branch per plant and 100-seed yield and has positive relationship. In line with this result (Kumar *et al.*, 2004) had reported that seed yield had positive correlation with day to 50% flowering, day to maturity, plant height, number of secondary branch per plant and 100-seed yield. There was non significant relationship between seed yield had negative correlation day to germination, number of primary branch per plant, number of pod per plant, number of seed per pod and biological yield per plant (table 5). Moreover, seed yield was strongly correlated with both plant height and biological yield per plant at harvest, which was also reported by (Kumar *et al*., 2004). Seed yield per plant, biological yield per plant and plant height were significantly correlated with yield. Harvest index was very highly significant and negatively related to biological yield.

Conclusion

The present study revealed the existence of considerable genetic variability among the lentil genotypes, emphasizing its importance for long-term genetic improvement. High heritability coupled with high genetic advance for traits such as days to germination and plant height indicated the predominance of additive gene action and the effectiveness of selection for yield improvement.

Overall, the results confirmed substantial genetic potential among the evaluated genotypes; however, evaluation of a larger set of genotypes across locations and years would further validate the contribution of these traits to seed yield.

References

Abebe, T. (2008) Earning a living on the margins: begging, street work and the socio-spatial experiences of children in Addis Ababa, Geografiska Annaler: Series B, *Human Geography*, 90(**3**): 271-284.

Afiah, S. A. N. and Moselhy, N. M. M. (2001) Evaluation of selected barley genotypes under rainfed conditions of Ras El-Hekma, North Western Coast, Egypt.

Ali, M., Singh, K. K., Pramanik, S. C. and Ali, M. O. (2009) 14 Cropping Systems and Production Agronomy, The Lentil, 213.

Burton, G. W. (1952) Quantitative inheritance in grasses.

Ceccarelli, S. (1996) Adaptation to low/ high input cultivation, *Euphytica*, **92**: 203-214.

Devane Jr, J. C. (1978) Food of King Mackerel, Scomberomorus cavalla, in Onslow Bay, North Carolina, *Transactions of the American Fisheries Society*, 107(**4**): 583-586.

Fisher, R. A. (1938) The statistical utilization of multiple measurements, *Annals of Eugenics*, 8(**4**): 376-386.

Franz, K. B. and Kearny, C. H. (1979) Maintaining nutritional adequacy during a prolonged food crisis, Basic foods for post-nuclear attack use, (No. ORNL-5352), Oak Ridge National Lab, (ORNL), Oak Ridge, TN (United States).

Fratini, R., Durán, Y., García, P. and De La Vega, M. P. (2007) Identification of quantitative trait loci (QTL) for plant structure, growth habit and yield in lentil, *Spanish Journal of Agricultural Research*, 5(**3**): 348-356.

Gemechu, G., Alemu, S., Bezabeh, A. and Berhan, M. (2013) Prevalence and associated risk factors of bee lice in Holeta and its surroundings, *Ethiopia, J. Veterinar. Sci. Technol*., 4(**130**): 2.

Gupta, M., Verma, B., Kumar, N., Chahota, R. K., Rathour, R., Sharma, S. K. and Sharma, T. R. (2012) Construction of intersubspecific molecular genetic map of lentil based on ISSR, RAPD and SSR markers, *Journal of Genetics*, **91**: 279-287.

Jambunathan, R., Blain, H. L., Dhindsa, K. S., Hussein, L. A., Kogure, K., Li-Juan, L. and Youssef, M. M. (1994) Diversifying use of cool season food legumes through processing, Expanding the Production and Use of Cool Season Food Legumes: A global perspective of peristent constraints and of opportunities and strategies for further increasing the productivity and use of pea, lentil, faba bean, chickpea and grasspea in different farming systems, pp: 98-112.

Kumar, S., Dhingra, A. and Daniell, H. (2004) Stable transformation of the cotton plastid genome and maternal inheritance of transgenes, *Plant Molecular Biology*, **56**: 203-216.

Ladizinsky, G., Cohen, D. and Muehlbauer, F. J. (1985) Hybridization in the genus Lens by means of embryo culture, *Theoretical and Applied Genetics*, **70**: 97-101.

Malik, M. R., Li, F. and Chang, C. L. (1994) Crossflow disturbances in three-dimensional boundary layers: nonlinear development, wave interaction and secondary instability, *Journal of Fluid Mechanics*, **268**: 1-36.

Mondal, M., Trivedy, K. and Nirmal, K. S. (2007) The silk proteins, sericin and fibroin in silkworm, *Bombyx mori* Linn., A Review.

Seifu, M. (2009) Determinants of regime survival in Africa, *African Journal of Political Science and International Relations*, 3(**8**): 341-345.

Sharma, A. (1999) Central dilemmas of managing innovation in large firms, California management review, 41(**3**): 146-164.

Singh, A. (1997) Financial liberalisation, stockmarkets and economic development, *The Economic Journal*, 107(**442**): 771-782.

Sinha, Bishwajit and Kallol Bhattacharyya (2011) Retention and release isotherm of arsenic in arsenic–humic/ fulvic equilibrium study, Biology and Fertility of Soils, **47**: 815-822.

Sparks, R. S. J., Self, S. and Walker, G. P. (1973) Products of ignimbrite eruptions. Geology, 1(**3**): 115-118.

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 Agriculture and Bioscience*, 3(**1**): 9.

Tigist, G. W. (2022) A Study on the causes and impacts of price escalation and its improvement mechanisms in road construction projects in South Nation Nationalities and People Region, Ethiopia (Doctoral dissertation).

Vir, O., Gupta, V. P. and Vir, O. P. (2001) Association among yield and yield contributing characters in macrosperma and microsperma derivatives of lentil, *Crop Improvement*, 28(**1**): 75-80.

Wright, K. N. (1991) A study of individual, environmental, and interactive effects in explaining adjustment to prison, *Justice Quarterly*, 8(**2**): 217-242.

Yadav, R. L. (2003) Assessing on-farm efficiency and economics of fertilizer N, P and K in rice wheat systems of India, *Field Crops Research*, 81(**1**): 39-51.