Website : www.asthafoundation.in
Progressive Research : An International Journal
Vol 19 (2) : 99-104 (July-2024), Print ISSN : 0973-6417, Online ISSN : 2454-6003
Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) India

Assessment of Yield and Morphological Traits in Lentil (*Lens culinaris* Medik.) Grown under Late Sowing Conditions

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Abstract

This study estimates genetic variability, correlation coefficient, path coefficient, and genetic diversity for various morpho-physiological traits among thirty-six diverse lentil genotypes under late sown conditions. A significant genetic variation was observed for eleven traits. Higher PCV values than GCV for all traits under late sown conditions indicate that the traits are more influenced by the environment. High PCV was recorded for the number of secondary branches per plant, number of pods per plant, filled pods per plant, grain yield per plant, and biological yield per plant. The variability present for these traits can be exploited by direct selection. Grain yield per plant showed a positive correlation with days to maturity, total number of pods per plant, filled pods per plant, 100-seed weight, biological yield per plant, and harvest index. The development of short-duration genotypes could be beneficial in attaining higher grain yield even under late sown conditions, which can escape from end-season heat stress. Therefore, high variability, heritability, and significant positive association with grain yield as exhibited by these traits viz, total number of pods per plant, filled pods per plant, 100-seed weight, biological yield per plants can be used as selection indices to improve yield in late sown conditions for lentil genotypes.

Key words : *Lentil, correlation coefficient, path coefficient, genetic variability ,PCV, GCV, selection.*

Introduction

The lentil or Masoor dal (*Lens culinaris* Medik) is a self-pollinated, bushy annual plant of the legume family, grown for its lens-shaped seeds. With 24-26% protein, it becomes an important part of the diet in many parts of the world. In India, lentil is being grown in 13.90 lakh hectares area, 10.93 lakh tonnes production, and 786 kg/ha productivity during 2014-15. Uttar Pradesh and Madhya Pradesh together contribute 70% lentil production with the highest production of 3.76 lakh tonnes from U.P and the highest productivity of 1209 kg/ha from Bihar. The major constraint in lentil low yield potential is due to the narrow genetic base of the cultivars. Therefore, the key to increase lentil yield in South Asia is through widening the available genetic base. This narrow genetic variability has restricted breeding progress. Considerable variations among the characters for use in breeding and selection programmes have been reported for various morphological characters (1, 2). Genetic variation between and within populations of crop species is a major interest of plant breeders and geneticists (3). During varietal development, extensive exploitation of the limited number of parents has unintentionally led to the narrowing of the genetic base of the existing breeding pool. To improve the genetic base of any crop through hybridization programme, genetic variability is a prerequisite element.

Materials and Methods

The present study was undertaken to access and evaluate the genetic variability in lentil germplasm collected from different districts on the basis of quantitative traits and to identify superior genotypes for future use. The experimental material consisted of thirty-six lentil genotypes including two check varieties viz., KLS-218 and Noori (IPL-81) under the second date of sowing i.e late sown condition. These genotypes were obtained from different regional research stations like IIPR, Kanpur, BHU, IARI, New Delhi, GBPUAT, Pantnagar, and from aboard ICARDA, Lebanon. The experiment was laid in RBD during the winter season of 2018-2019 under late sown condition (D/S: 10th December, 2018) at Pulse Research Farm, Bhitti, Bihar Agricultural University, Sabour (Bhagalpur), India. The data were recorded from five randomly selected plants from each plot on thirteen morphological characters, except days to 50% flowering and days to maturity, which was observed on a complete plot basis. The mean value of the thirteen traits as recorded was subjected to analysis of variance (ANOVA). The phenotypic and genotypic variances were calculated according to the formula suggested by (4). Heritability (h^2)

Received : July-2024; Revised : July-2024; Accepted : July-2024

Table-1 : Genetic parameters of eleven traits of lentil genotypes under late sown condition.

S. No.	Characters	MEAN	ó²g	ó²p	ó²e	GCV (%)	PCV (%)	h²bs	GA as % of mean	GA as % of mean (5%)
1.	Days to 50% flowering	61.82	1.59	4.64	3.05	2.04	3.48	0.34	1.52	2.46
2.	Days to maturity	99.45	2.61	5.81	3.20	1.63	2.42	0.45	2.23	2.24
3.	Plant height	40.15	6.54	11.37	4.83	6.37	8.40	0.57	3.99	9.96
4.	No. of secondary branches per plant	7.14	2.68	3.38	0.70	22.93	25.74	0.79	3.00	42.08
5.	No. of pods per plant	96.70	972.40	1032.97	60.57	32.25	33.24	0.94	62.33	64.45
6.	No. of seeds per pod	1.71	0.01	0.04	0.03	5.40	12.12	0.20	0.09	4.96
7.	No. of filled pods per plant	83.52	827.59	886.55	58.97	34.45	35.65	0.93	57.26	68.56
8.	100 Seed weight	2.37	0.15	0.15	0.00	16.58	16.59	1.00	0.81	34.13
9.	Grain yield per plant	3.47	1.40	1.50	0.10	34.05	35.27	0.93	2.35	67.71
10.	Biological yield per plant	6.99	4.02	4.88	0.87	28.67	31.62	0.82	3.74	53.56
11.	Harvest index	49.92	28.57	69.59	41.02	10.71	16.71	0.41	7.06	14.13

N= Normal sown condition; L= Late sown condition; ó²g =Genotypic variance; ó²p= Phenotypic variance; ó²e= Environmental variance; GCV=Genotypic coefficient of variation; PCV= Phenotypic coefficient of variation; h² bs= Heritibility (broad sense); GA= Genetic advance.

in broad sense was computed using the formula given by (5). Genetic advance as per cent of mean (GAM) for each trait was computed using the formula by (6).

Results and Discussion

The analysis of variance showed significant differences among the genotypes for eleven characters except the number of primary branches per plant, number of pods per cluster under late sown conditions which indicates adequate genetic variability in the experimental material. Estimates of phenotypic variance (??2??) and genotypic variance (??2??) were computed for all the characters. Under late sown conditions, the highest value of ??2p was observed for the number of pods per plant across the environment followed by the number of filled pods per plant, harvest index, and plant height. The lowest value was recorded for the number of seeds per pod. The highest value of genotypic variance, ??2g was recorded for the number of pods per plant across the environment followed by the number of filled pods per plant, harvest index, and plant height in late sown conditions. The lowest value was recorded for the number of seeds per pod. Thus, traits like the number of pods per plant, number of filled pods per plant, and harvest index show a high proportion of environmental variance which reveals higher environmental influence on these traits. Minimum difference between the respective estimates of ??2p and ??2g along with a higher value of ??2g with respect to environmental variance (??2e) was recorded for all the traits which tell us that the variability present among the genotypes for these traits were mainly due to genotype with the least influence of the environment and thus heritable.

The values of phenotypic coefficient of variation (PCV) were higher than that of genotypic coefficient of variation (GCV) for all the characters, which confirms that the variation is not only due to the genotypes but also due to the influence of the environment. The high values of PCV were recorded for the number of secondary branches per plant, number of pods per plant, filled pods per plant, grain yield per plant, and biological yield per plant. The characters which show high phenotypic coefficient of variation indicate more influence of environmental factors. Therefore, caution needs to be taken during the selection program as environmental variations are unpredictable in nature and may mislead in selection. Moderate estimate of PCV was observed for the number of seeds per pod, 100 seed weight, and harvest index. While traits like 100 seed weight and harvest index exhibited moderate GCV. The results in the context of phenotypic variability showed the presence of a great amount of variation under late sown conditions for the number of secondary branches per plant, total number of pods per plant, filled pods per plant, 100 seed weight, grain yield per plant, and biological yield per plant.

The presence of a large amount of variability indicates that there is a large scope of improvement for these traits through selection. Similar results were reported by (7, 8).

The heritability (broad sense) estimated for the eleven quantitative characters range from 19.90 % (number of seeds per pod) to 99.90 % (100 seed weight) in late sown conditions. Higher heritability was recorded for the determinants like 100 seed weight (99.90 %) followed by the number of pods per plant (94.10%), number of filled pods per plant (93.30 %), grain yield per plant (93.20 %), biological yield per plant (82.20 %), number of secondary branches per plant (79.34 %) in late sown environments. Genetic advance for the traits under study ranged from 0.085 (number of seeds per pod) to

Table-2 : Estimation of phenotypic correlation coefficient for different quantitative traits in lentil (Late sown).

S. No.	Characters	Days to 50% flowering	Days to maturity	Plant height	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	No. of filled pods per plant	100 Seed weight	Biological yield per plant	Harvest index	grain yield per plant
1.	Days to 50% flowering		0.6163***	-0.0005	0.2191*	0.2103*	-0.1421	0.2381*	0.0773	0.1671	0.0678	0.1635
2.	Days to maturity			0.2225*	0.2109*	0.248**	0.2461 *	0.2675**	0.3292***	0.3815***	-0.0087	0.3580**
3.	Plant height				0.2018*	-0.185	0.0754	-0.1808	0.0719	-0.0819	-0.0422	-0.0924
4.	No. of secondary branches per plant					0.1092	-0.0992	0.1224	0.1384	0.0379	0.2146*	0.1252
5.	No. of pods per plant						-0.0588	0.9560***	-0.1449	0.6992***	0.2323*	0.7661**
6.	No. of seeds per pod							-0.0625	0.2649**	-0.0884	0.0202	-0.0697
7.	No. of filled pods per plant								-0.0895	0.7367***	0.2523**	0.8117**
8.	100 Seed weight									0.3114**	0.1478	0.3572**
9.	Biological yield per plant										-0.1089	0.8894**
10.	Harvest index											0.3383**

Table-3 : Direct (diagonal) and indirect effects of components traits attributing to grain yield per plant in lentil at phenotypic level (Late sown).

S. No.	Characters	Days to 50% flowering	Days to maturity	Plant height	No. of secondary branches per plant	No. of pods per plant	no. of seeds per pod	No. of filled pods per plant	100 Seed weight	Biological yield per plant	Harvest index
1.	Days to 50% flowering	-0.0488	-0.0301	0	-0.0107	-0.0103	0.0069	-0.0116	-0.0038	-0.0082	-0.0033
2.	Days to maturity	0.0222	0.036	0.008	0.0076	0.0089	-0.0089	0.0096	0.0118	0.0137	-0.0003
3.	Plant height	0	-0.0001	-0.0003	-0.0001	0.0001	0	0.0001	0	0	0
4.	No. of secondary branches per plant	-0.0012	-0.0011	-0.0011	-0.0053	-0.0006	0.0005	-0.0006	-0.0007	-0.0002	-0.0011
5.	No. of pods per plant	0.0018	0.0022	0.0016	0.0009	0.0087	0.0005	0.0083	0.0013	0.0061	0.002
6.	No. of seeds per pod	-0.0017	-0.003	0.0009	-0.0012	-0.0007	0.0121	-0.0008	-0.0032	-0.0011	0.0002
7.	No. of filled pods per plant	0.02	0.0225	-0.0152	0.0103	0.0804	-0.0053	0.0841	-0.0075	0.062	0.0212
8.	100 Seed weight	0.0022	0.0095	0.0021	0.004	-0.0042	-0.0076	-0.0026	0.0288	0.009	0.0043
9.	Biological yield per plant	0.1446	0.3301	-0.0709	0.0328	0.605	-0.0765	0.6375	0.2694	0.8653	-0.0943
10.	Harvest index	0.028	-0.0036	-0.0175	0.0888	0.0961	0.0084	0.1044	0.0611	-0.0451	0.4137
11.	Grain yield per plant	0.1635	0.358	-0.0924	0.1252	0.7661	-0.0697	0.8117	0.3572	0.8894	0.3383
	Partial R^2	-0.008	0.0129	0	-0.0007	-0.0067	-0.0008	0.0683	0.0103	0.7697	0.14

Table-4 : Composition of clusters based on Ward's Minimum Variance of 36 genotypes of lentil (Late sown).

CLUSTER I	FLIP 2011-17L, X 2011S-221, Noori, FLIP-2010-90L, Arun, X 2011S-212-1, Pusa Ageti, FLIP 2010-73L-2, LKH-1, X2011S-221-2, FLIP 2010-86L
CLUSTER II	FLIP 2010-90L-2, X 2011S-193-1, FLIP 2011-17L-2, X2011S-188-1, X 2011S-206-1, FLIP 2011-17L-1, FLIP 2011-62L, X 2011S-210-1, HUL-57, NDL-1, X 2011S-172-1, X2011S-208, X2011S-111-2, BRL-2, LKH-2, BRL-3, FLIP 2010-87L, X2011S-221-1
CLUSTER III	KLS-218, BRL-1, PL-8, Shivalik, PL-6
CLUSTER IV	Pusa Vaibhav
CLUSTER V	IPL-406

Table-5 : Percentage contribution of each character towards total genetic divergence in 36 lentil genotypes (Late sown).

S. No.	Source	Times Ranked 1st	Contribution %
1.	Days to 50% flowering	1	0.1587
2.	Days to maturity	2	0.3175
3.	Plant height	4	6349
4.	No. of secondary branches per plant	14	2.2222
5.	No. of pods per plant	48	7.619
6.	No. of seeds per pod	_	0.0001
7.	No. of filled pods per plant	5	0.7937
8.	100 Seed weight	546	86.667
9.	Grain yield per plant	7	1.111
10.	Biological yield per plant	3	0.4762
11.	Harvest index	_	0.0001

62.33 (number of pods per plant) in late sown conditions. High genetic advance was obtained for the total number of pods per plant (62.33) and filled pods per plant (57.26) in late sown conditions. High heritability with high genetic advance per se mean were noted for characters like 100 seed weight, grain yield per plant, biological yield per plant, number of pods per plant, number of filled pods per plant, number of secondary branches per plant under late sown environments. A trait with high heritability coupled with high genetic advance suggests maximum genetic response in selection. In pulses, environment and genotype × environment interactions contribute more than 70 % of total phenotypic variance as narrated earlier (9, 10, 11, 12).

Enhanced Understanding of Yield Improvement in Late Sown Conditions : The efficiency of indirect selection is quantified as a correlated response (Falconer, 1960). This involves the use of correlation coefficient analysis to assess the interrelationships among various vegetative and reproductive traits. The aim is to identify the traits that can be targeted for yield enhancement.

In the context of a second sowing, the grain yield per plant demonstrated a significant positive association with several factors: days to maturity (0.358**), total number of pods per plant (0.766**), filled pods per plant (0.812**), 100-seed weight (0.357**), biological yield per plant (0.889**), and harvest index (0.338*). This significant correlation suggests potential for improvement in these traits, leading to an increase in grain yield per plant. This is consistent with findings from various studies (8, 10, 13).

The grain yield per plant is influenced by a set of characteristics, which exhibit varying degrees of interrelationship. This is studied using the tool path coefficient. Phenotypic path coefficient analysis under late sowing conditions revealed that several factors had a positive direct effect on grain yield per plant: days to maturity, total number of pods per plant, number of seeds per pod, number of filled pods per plant, 100-seed weight, biological yield, and harvest index. Conversely, days to 50% flowering, plant height, and number of secondary branches per plant had a negative direct effect on grain yield per plant. These findings align with reports from various studies (8, 10, 11, 14).

A divergence study revealed significant differences among genotypes for eleven traits under late sown conditions, indicating the presence of a substantial amount of genetic variability. Assessment of clusters revealed heterogeneity within and between clusters based on major trait relationships. The inter-cluster distances were generally larger than intra-cluster distances, suggesting a wide diversity among the germplasm of different groups.

Conclusion

Under late sown conditions, the analysis of genetic variability parameters revealed that the total number of pods per plant, filled pods per plant, 100-seed weight, and biological yield per plant could be crucial parameters for improving lentil genotypes for seed yield. Moreover, the biological yield per plant showed the maximum and

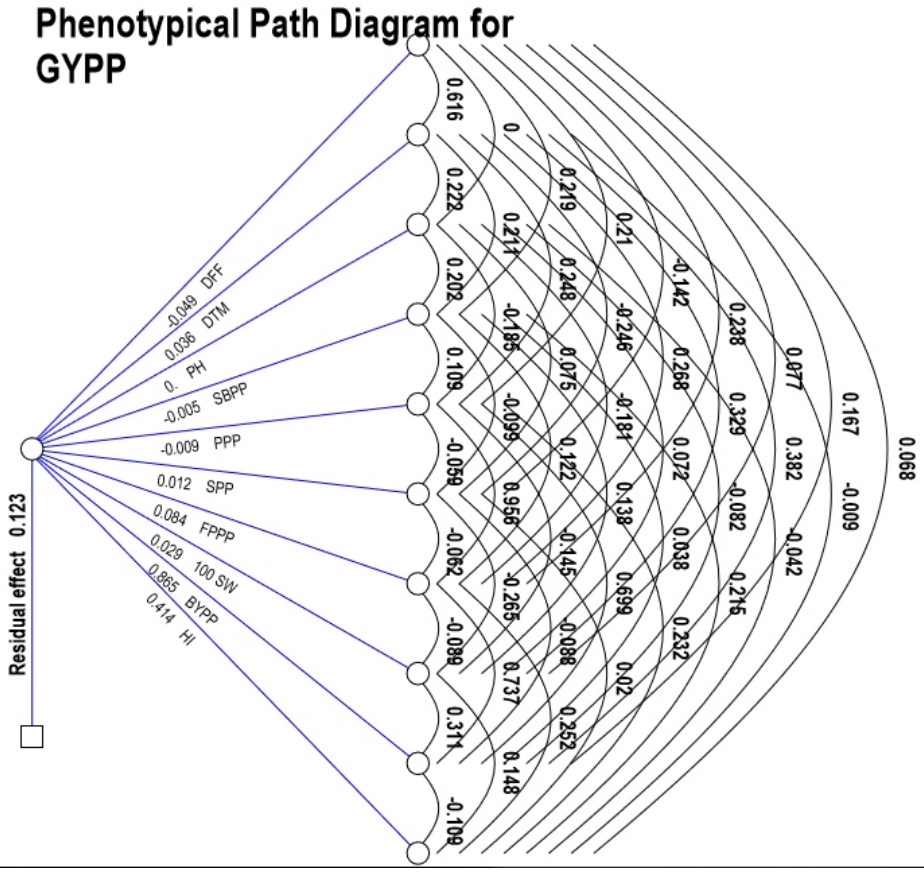

Fig.-1 : Phenotypic path diagram for grain yield per plant under late sown condition.

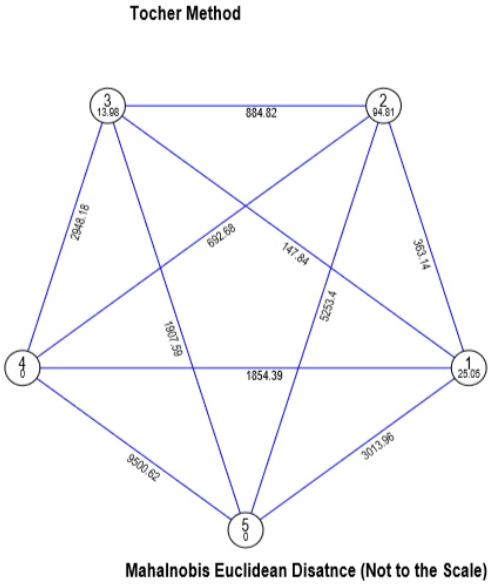

Fig.-2 : Euclidean 2 distances under late sown condition.

positive direct effect on grain yield per plant, followed by harvest index, number of filled pods per plant, and days to maturity. Therefore, these traits should be the primary focus for yield improvement in lentil.

Acknowledgment

Authors are grateful to the Bihar Agricultural University, Sabour, Bhagalpur, India for providing the required facilities for the experimental work.

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