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Genetic divergence studies in lentil (*Lens culinaris* Medik) under different cropping systems in mid-hills of North Western Himalaya

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Abstract

Genetic diversity of 44 diverse genotypes of lentil was studied through D^2 statistic. The genotypes were grouped into 9, 11 and 7 clusters in monocropping, intercropping and combined over cropping systems, respectively. Genotypes from different geographical locations have been observed in same cluster and vice-versa indicating that clustering of populations does not follow their geographic or location distribution. The intra cluster distance was observed to be highest for cluster III in monocropping and intercropping system and cluster I in combined over system thereby indicating greater genetic divergence between the genotypes belonging this cluster. The maximum inter–cluster distance was observed between cluster I and IX in monocropping and cluster I and II in combined over system. The diversity among the cultivars measured by inter cluster distance was adequate for improvement of lentil by hybridization and selection. Seeds per plant, pods per plant, pod cluster per plant, biological yield per plant and seed yield per plant were the potential contributors towards genetic divergence in both the systems as well as combined over systems. This clearly indicated that the genotypes included in these clusters are having broad spectrum of genetic diversity and could be used in hybridization programme of lentil for obtaining desirable segregates through selection in the advanced breeding programme. Divergence study suggested that the crosses involving parents viz., L 1-27, Vipasha, 2104, 2116, 2119, L 1-3, L 1-26, 2127, 2129, 2136, 2142, 2144, 2153, 2157, 2167, 2170 and 2174 with Precoz like, L 1-24 and L-90-57 are likely to through desirable recombinants in succeeding generations.

Key words: Divergence, lentil, monocropping, intercropping.

Introduction

Lentil (*Lens culinaris* Medikus subsp. *culinaris*) was among the first crops domesticated and has become an important food legume crop in the farming and food systems of many countries globally. Its seed is a rich source of protein, minerals and vitamins for human nutrition, and the straw is a valued animal feed. Its ability in nitrogen and carbon sequestration improves soil nutrient status, which in turn provides sustainability in production systems. Systematic research on lentil started recently, compared to other early-domesticated crops. During the last two and a half decades, research progress has been made in various aspects of the crop. Large numbers of germplasm have been collected, evaluated and preserved at national and international levels, with the International Center for Agricultural Research in the Dry Areas (ICARDA) holding the largest collection of cultivated and wild germplasm accessions. To date, a total of 91 improved cultivars have been released globally, emanating from genetic material supplied by ICARDA. The primary product is the seed which has relatively higher contents of protein, carbohydrate and a calorie compared to other legumes and is the most desired crop because of its high average protein content and fast cooking characteristic in many lentil producing regions (Muehlbauer *et al.*, 1985). It can be used as a main dish, side dish, or in salads. Seeds can be fried and seasoned for consumption; flour is used to make soups, stews, purees, and mixed with cereals to make bread and cakes; and as a food for infants (Surayavansi *et al.*, 1985). Success in recombination breeding depends on the exploitation of genotypes as parents for high heterotic crosses and transgressive segregants. It is important to quantify the variability for parent selection. Genetic diversity is the first and foremost need for genetic improvement in any crop breeding programme. The D^2 statistics of Mahalanobis (1936) provides the means of grouping genotypes in topologically distinct clusters to arrange them in order of their relative distances from each other and cultivars are grouped into different clusters following Tocher's method as described by Rao (1952). Such a study is expected to be useful not only in the choice of parents based on relative merits of different genotypes/ varieties but also to serve as an index affecting selection.

Material and Methods

The present investigation was carried out at the Experimental Farm of the Department of Plant Breeding and Genetics, CSK HPKV, Palampur, situated at 1290.8 m above mean sea level and at

32°8' N latitude and 76°3' E longitude under two environments viz., I-monocropping of lentil and II-intercropping with linseed (1:1) during *rabi* 2002-2003. This region represents as sub-temperate mid hill zone of Himachal Pradesh having high annual rainfall (2500 mm). The soil is acidic in nature with pH ranging from 5.0 to 5.6. The experimental material comprised of 44 diverse genotypes of lentil, including one check (Vipasha) procured from different agencies, was grown in randomized complete block design with two replications under both the environments monocropping (E1) and intercropping (E2). The plot size consisted of single row of 2.25 m length of each genotype spaced 30 cm apart in each replication.

Ten competitive plants were selected randomly from each genotype in each replication to record observations for traits viz., days to 50 per cent flowering, days to 75 per cent maturity, plant height (cm), primary branches per plant, pod clusters per plant, pods per plant, pods per cluster, seeds per plant, 100-seed weight (g) biological yield per plant (g), seed yield per plant (g), harvest index (%) and prevalent disease, under both the environments. Mean values were used for standard statistical analysis and estimation of diversity by using Mahalanaobis's D^2 statistic (Rao, 1952).

Results and Discussion

The analysis of variance revealed highly significant mean sum of squares for all the traits in monocropping and intercropping thereby indicating higher amount of variability among the genotypes. Based on the relative magnitude of D^2 values, the forty four (44) genotypes of lentil were grouped into 9, 11 and 7 clusters in monocroping, intercropping and combined over cropping systems, respectively (Table 1). Genotypes from different geographical locations have been observed in same cluster and vice-versa indicated that clustering of populations do not follow their geographic or location distribution. Similar observations have also been recorded by Suryavanshi *et al.* (1985). Bhatt (1970) reported that the process of genetic drift and selection in different environments can produce greater genetic diversity than can the factor of geographical distance. Therefore, it is suggested that parents should be selected on the basis of total divergence for the characters used for an overall improvement in the yield. Sinha *et al.* (1977) has also observed that better combiners are generally derived from distantly related parents.

Table 1. Distribution of 44 genotypes of lentil among clusters on the basis of D^2 analysis in Environments 1, II and combined over

Cluster	No. of genotypes	Genotypes
I(E1)	15	L1-27, Vipasha, 2104, 2116,2119,2127,2129,2136,2142,2144,2153,2157.2167,2170,2174
E2	6	PL406, PL639, LI-28, L-4147, Fasciated mutant, 2147
E3	15	L1-27, Vipasha, 2104,2116, 2119,2127,2129,2136,2142,2144,2153,2157,2167,2170,2174
II(E1)	6	L1-25, L-4147, L-4634, PL639, Pusa-4, Fasciated mutant
E2	14	Vipasha, 2104,2116,2119, 2127,2129, 2136,2142, 2144, 2153, 2157, 2167,2170,2174
E3	11	L1-5, L1-6, L1-8, L1-24, L1-29, L1-50, L-65, L-207, DPL-58, DPL-61, DPL-62
III(E1)	09	L1-28, L1-29, L-65, L-207, L-4600, DPL-15, DPL-62, PL-406, L-2147
E2	14	L1-5, L1-6, L1-8, L1-29, L1-50, L-65, L-207,L-4634, L-4600, DPL-15, DPL-58, DPL-61, DPL-62, L9-104
E3	08	L1-25, L1-28, L-4147, L-4600, PL-406, PL-639, 2147, Fasciated mutant
IV(E1)	7	L1-5, L1-6, L1-8, L1-50, DPL-58, DPL-61, L9-104
E2	02	Precoiz like, L-4149
E3	03	L1-3, L1-26, Pusa-4
V(E1)	02	L1-3, L1-26
E2	01	L1-27
E3	04	L-4149, L-90-57, L-9-104, Precoz like
VI(E1)	01	EC1
E2	02	L1-26, Pusa-4
E3	02	L-4634, DPL-15
VII(E1)	01	L-90-57
E2	01	L1-3
E3	01	L1-3
VIII(E1)	01	L-4149
E2	01	L-90-57
E3	-	-
IX(E1)	02	Precoz like, L1-24
E2	01	L1-24
E3	-	-
X(E1)	-	-
E2	01	EC1
E3	-	-
XI(E1)	-	-
E2	01	L1-25
E3	-	-

E1-Monocropping, E2- Intercropping and E3-Combined over environments

The composition of the clusters differed with cropping systems. This indicated that D^2-statistic is influenced by the variation in the cropping system resulting in inconsistent clustering of some genotypes. Similar observation has also been recorded earlier by Singh and Gupta (1977)

At genotypic level, the maximum contribution to the divergence has been shown by seeds per plant followed by seed yield per plant, biological yield per plant, pods per plant, pod clusters per plant, primary branches per plant and 100-seed weight in both the individual cropping as well as combined over systems. However, at inter-cluster level seeds per plant, pods per plant, pod cluster plant, biological yield per plant and seed yield per plant have been observed to be potential contributors towards genetic divergence in both the systems as well as combined over systems. The traits *viz.,* seeds per plant, pod cluster per plant, biological yield per plant, pods per plant and seed yield per plant have shown significant contribution towards genetic divergence at both genotypic level and inter-cluster level. Thereby showing their importance in genetic diversity of lentil genotypes. Suryavanshi *et al.* (1985) have also reported that days from flowering to maturity, seed yield and harvest index were chiefly responsible for genetic divergence in lentil.

The intra-cluster distance was observed to be highest for cluster III in monocropping (218.15) and intercropping system (316.12) and cluster I in combined over systems (144.48). The lowest intra-cluster distance has been observed for cluster V (11.90), VI (11.08) and IV (22.09) in monocropping, intercropping and combined over systems, respectively (Table 2). The maximum intra-cluster distance observed for cluster III is perhaps because of wide genetic diversity among its genotypes. The chance of getting better segregants by crossing the genotypes of the same cluster showing low intra-cluster distance are very low. Therefore, it would be logical to attempt crosses between the genotypes of cluster separated by large inter cluster distances.

The maximum inter-cluster distance was recorded between cluster I and IX (2076.62) followed by cluster V and IX (1490.73) in monocropping and cluster VII and VIII (1504.66) followed by cluster II and VIII (1255.28) in intercropping and cluster I and II (708.09) followed by cluster I and V (679.64) in combined over systems. This clearly indicates that the genotypes included in these clusters are having broad spectrum of genetic diversity and could very well be used in hybridization programme of lentil for improving seed yield.

The closest proximity has been observed between cluster III and VII (83.35) followed by cluster III and IV (88.54) in monocropping, between cluster VI and VII (65.61) followed by cluster II and V (70.56) in intercropping and between cluster II and V (49.98) followed by cluster III and VI (53.14) in combined over systems.

The lowest inter-cluster distances indicated that the genotypes of these clusters have close relationship and hence, may not be emphasized upon to be used in hybridization programme. Crosses involving parents belonging to most divergent clusters would be expected to manifest maximum heterosis and also wide variability of genetic architecture. In the monocropping, thus, crosses between the genetically diverse genotypes of cluster I viz., L 1-27, Vipasha, 2104, 2116, 2119, 2127, 2129, 2136, 2142, 2144, 2153, 2157, 2167, 2170 and 2174 and genotypes of cluster IX comprising Precoz like and L 1-24 are likely to produce new recombinants with desired traits. Similarly, L 1-3 and L 1-26, two genotypes which are included in cluster V could be crossed with the genotypes of cluster IX.

In intercropping, cluster VII represented by L 1-3, the only genotype could be crossed with L-90-57, the only genotype forming cluster VIII and maximum heterosis could be expected in hybrid progeny. Similarly, mating between genotypes of cluster II viz.. Vipasha, 2104, 2116, 2119, 2127, 2129, 2136, 2142, 2144, 2153, 2157, 2167 and 2170 and L90-57, the only genotype of cluster III to develop high yielding segregants.

In combined over system, cluster I represented by L 1-27, Vipasha, 2104, 2116, 2119, 2127, 2129, 2136, 2142, 2144, 2153, 2157, 2167, 2170 and 2174 could be used in hybridization programme with genotypes of cluster II viz., L 1-5, L 1-6, L 1-8, L 1-24, L 1-29, L 1-50, L-65, L-207, DPL-58, DPL-61 and DPL-62 would likely to produce new combination with desired traits. Likewise, crosses between the genotypes belonging to cluster I and cluster V (L-4149, L-90-57, L9-104 and Precoz like) would exhibit higher heterosis and also results in segregants with higher yield.

Table 2. Average intra (diagonal) and inter-cluster average D2 among different clusters in Environment I, Environment 2 and Environment 3

Cluster		I	II	III	IV	V	VI	VII	VIII	IX	X	IX
I	**E1**	**189.25**	429.01	1043.25	1463.61	155.59	1141.75	802.84	1130.20	2076.24	-	-
	E2	**94.64**	395.71	208.24	316.51	189.97	117.62	302.73	572.43	299.14	339.98	170.28
	E3	**144.53**	708.17	337.72	124.74	679.46	374.95	595.10	.....	.....	.....	.....
II	**E1**		**139.38**	209.68	420.15	133.99	336.50	137.08	298.28	844.97	-	-
	E2		**261.21**	711.64	782.09	70.50	192.39	168.83	1255.08	1043.92	753.20	531.26
	E3		**84.81**	133.52	427.19	50.04	83.52	85.00	.....	.....	...	...
III	**E1**			**218.15**	88.53	542.76	109.03	83.31	98.59	302.76	-	-
	E2			**316.01**	72.33	480.60	493.25	828.27	142.06	101.90	102.56	242.37
	E3			**104.76**	123.24	154.54	53.20	186.67	.....	.....	....	.....
IV	**E1**				**146.60**	873.22	108.09	166.33	102.41	140.33	-	-
	E2				**37.40**	554.17	632.01	969.06	104.09	115.96	131.83	261.25
	E3				**22.12**	440.71	200.70	453.51	.....	.....	.....	.....
V	**E1**					**11.87**	733.05	381.60	676.51	1490.52	.....	.....
	E2					72.24	102.23	971.97	706.28	577.75	100.95	.....
	E3					**56.25**	89.48	117.10	.....	.....	.....	.....
VI	**E1**						–	202.40	122.28	288.77	.....	.....
	E2						**11.06**	65.69	1044.61	692.04	653.63	164.13
	E3						**31.38**	109.38	.....	.....	.....	.....
VII	**E1**							–	90.29	437.03	....	.....
	E2							–	1504.07	1066.36	1011.36	293.35
	E3								–	.....	.....	.....
VIII	**E1**								–	275.59	....	.....
	E2								–	119.33	143.43	560.51
	E3								-	-	-	-
IX	**E1**									37.02	....	....
	E2									–	183.07	331.78

Values bolded are intra-cluster distance, E1-Environment1, E2-Environment 2 and E3-Environment 3

Table 3. Cluster means of different clusters for different characters in Environment I, Environment 2 and Environment 3

Env. No.		No. of genotypes	Days to 50% flowering	Days to 75% maturity	Plant height (cm)	Primary branches/ plant	Pod cluster/ plant	Pods/ plant	Pods/ cluster	Seeds/ plant	100-seed weight (g)	Biological yield/ plant (g)	Seed yield/ plant (g)	Harvest index (%)
I	E1	15	144.87**	179.77	27.46	2.07	13.49	25.87	1.73	31.41	3.12	2.67	0.87	31.45*
	E2	6	111.83	173.83	27.06	1.95	25.38	46.68	1.79	79.13	1.78*	3.11	1.42	45.83
	E3	15	145.52**	179.07	27.54	1.92	13.69	24.31	1.69	30.29	3.38	2.77*	0.88	31.36
II	E1	6	111.58	171.42	26.58	2.22	25.12	47.23	1.84**	76.25**	2.08	3.36	1.47	42.85
	E2	14	146.71**	181.18	27.83	1.74	13.13	24.81	1.67	29.57	3.59	2.96	0.92	30.88
	E3	11	93.40*	173.25	27.06	1.61*	21.93	36.43	1.62	46.97	3.00	3.00	1.34	44.34
III	E1	9	101.01	170.83	27.00	1.76	23.93	42.31	1.73	64.39	2.49	3.33	1.52	45.09
	E2	14	97.29	175.21	24.88	1.58	20.51	33.54	1.55	41.11	3.15	2.75	1.19	43.45
	E3	11	93.40*	173.25	27.06	1.61*	21.93	36.43	1.62	46.97	3.00	3.00	1.34	44.34
IV	E1	7	92.79	170.42	27.62	1.71	23.53	39.10	1.66	54.53	3.14	3.50	1.59	44.58
	E2	2	94.75	171.00*	21.48	1.65	18.75	28.40	1.37	38.10	3.58	3.42	1.35	37.54
	E3	3	133.40	173.33	27.63	2.07**	27.78**	50.35**	1.85**	82.41**	2.00	3.24**	1.48	45.64**
V	E1	2	134.00	172.25	26.34	1.60	23.10	40.90	1.83	67.18	1.87*	2.65	1.23	45.79**
	E2	1	138.50	177.50	24.50	1.40*	12.20*	18.80*	1.48	23.60*	2.42	1.42*	0.51*	36.76
	E3	4	94.19	169.13*	25.30*	1.68	18.61	28.65	1.42*	35.25	3.78**	3.30	1.35	38.33
VI	E1	1	95.50	180.00**	29.75**	2.10	13.20*	22.30*	1.66	25.90*	3.33	2.62	0.83	31.75
	E2	2	130.75	175.50	28.50	2.20**	31.15	57.20**	1.86**	92.20**	2.12	3.75**	1.74**	45.94
	E3	2	109.13	175.50	26.00	1.88	22.35	38.25	1.63	52.40	3.09	3.31	1.50**	45.15
VII	E1	1	109.50	167.00	23.00*	1.50*	17.90	30.10	1.54	33.80	4.07**	3.08	1.41	43.89
	E2	1	143.00	173.50	28.65	1.90	25.40**	42.30	1.77	74.10	2.35	2.72	1.24	46.45**
	E3	1	95.75	182.00**	29.45**	1.90	13.50*	21.90*	1.56	25.35*	3.08	2.97	0.80*	27.10*
VIII	E1	1	103.00	170.00	27.00	2.40**	29.30**	53.40**	1.72	69.30	3.25	6.30**	2.78**	35.68
	E2	1	82.00*	177.00	23.20	1.41	17.00	25.40	1.44	28.80	3.96**	2.63	1.18	45.14
	E3	-	-	-	-	-	-	-	-	-	-	-	-	-
IX	E1	2	80.75*	165.50*	27.10	1.85	16.30	23.00	1.41*	26.75	3.63	2.16*	0.78*	36.82
	E2	1	86.00	172.50	20.70	1.42	19.90	25.70	1.36*	41.40	2.00	1.86	0.80	43.64
	E3	-	-	-	-	-	-	-	-	-	-	-	-	-
X	E1	-	-	-	-	-	-	-	-	-	-	-	-	-
	E2	1	96.00	184.00**	29.15**	1.70	13.80	21.50	1.46	24.80	2.84	3.32	0.77	22.46*
	E3	-	-	-	-	-	-	-	-	-	-	-	-	-
XI	E1	-	-	-	-	-	-	-	-	-	-	-	-	-
	E2	1	122.00	174.50	18.85*	1.80	17.20	28.60	1.69	44.60	2.23	2.26	1.10	45.42
	E3	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	E1		108.18	171.91	26.88	1.91	20.87	36.02	1.68	49.95	2.99	3.29	1.39	39.77
	E2		113.53	175.97	24.98	1.70	19.49	32.08	1.59	47.04	2.73	2.75	1.11	40.32
	E3		111.97	143.44	27.02	1.86	19.98	34.86	1.62	49.58	2.90	3.10	1.25	39.51
Range	E1	Minimum	80.85	165.50	23.00	1.50	13.20	22.30	1.41	25.90	1.87	2.16	0.78	31.45
	E2		82.00	171.00	18.85	1.40	12.20	18.80	1.36	23.60	1.78	1.42	0.51	22.46
	E3		93.40	169.13	25.30	1.61	13.50	21.90	1.42	25.35	1.96	2.77	0.80	27.10
	E1	Maximum	144.87	180.00	29.75	2.40	29.30	53.40	1.84	76.25	4.07	6.30	2.78	45.79
	E2		146.71	184.00	29.15	2.20	25.40	57.20	1.86	92.20	3.96	3.75	1.74	46.45
	E3		145.52	182.00	29.45	2.07	27.78	50.35	1.85	82.41	3.78	3.24	1.50	45.64

* - Minimum value, ** - Maximum value, E1-Environment I, E2- Environment 2 & E3- Environment 3

On the basis of cluster means in monocropping the genotypes of cluster VIII which have shown the maximum cluster means for pod clusters per plant, pods per plant, biological yield per plant and seed yield per plant (Table3); the genotypes of cluster II for maximum cluster means of pods per cluster and seeds per plant; genotypes of cluster V for maximum cluster means of harvest index should be involved in crossing for improvement of these traits, while the genotypes of cluster IX which have recorded minimum cluster mean values for days to 75 per cent maturing should be involved in crossing for early maturing segregants of lentil.

In intercropping system, the genotypes of clusters which have exhibited maximum cluster mean values viz., cluster VI for pods per plant, pods per cluster, seeds per plant, biological yield per plant and seed yield per plant cluster VII for pod cluster per plant and harvest index should be involved in crossing for getting desirable segregants for these traits while genotypes of cluster VIII and cluster IV should be involved in crossing for improvement in earliness. Combined over systems, the genotypes of cluster IV, cluster VI and cluster VII should be involved in crossing for improvement of traits viz., pods per plant, pod clusters per plant, biological yield per plant, seed yield per plant, seeds per plant and harvest index while the genotypes of cluster V and cluster II should be involved in crossing to improve earliness.

Thus the present study suggests that genotypes from cluster I, II, III and IV may yield better recombinants. Besides, pods per plant, pods per cluster, seeds per plant, pod cluster per plant were found important traits for selecting better yielding genotypes.

References

Bahl PN, Lal S and BM Sharma 1993. An overview of the production and problems in southeast Asia. p. 1-10. In: W. Erskine and M.C. Saxena (eds.), Lentil in South Asia. Proceedings of the seminar on lentils in south Asia. ICARDA, Aleppo, Syria.

Bhatt GM 1970. Multivariate analysis approach to selection of plants for hybridization aiming at yields improvement in self-pollinated crops. Australian J. Agri. Res. **21**:1-7.

Mahalanobis PC 1936. On the generalized distance in statistics. Proc. Nat. Acad. Sci. India **2**:49-55.

Muehlbauer FJ, Cubero JI and RJ Summerfield 1985. Lentil (*Lens culinaris* Medic.). p 266-311. In: R.J. Summerfield and E.H. Roberts (eds.), Grain Legume Crops. Collins, 8 Grafton Street, London, UK.

Rao CR 1952. *Advance Statistical Methods in Biometrical Research.* John Wiley, New York.

Sharma PC and Luthra SK 1987. Genetic divergence in lentil. Genetica-Agraria **41**:349-59.

Singh PK and Gautam PL 1987. Genetic divergence in durum wheat germplasm. Narendra Deva J. Agri. Res. **2**: 45-49.

Singh SP and Gupta RK 1979. Genetic divergence in pearl millet. Indian J. Gen. and Pl.Br. **32**: 210-15.

Sinha MK, Enerjea SP and Seetharam R 1977. Genetic divergence and evolutionary trends in cultivated Rice.II Rassegnatrimenstrale di studi anno ventisimettemo **26**:23-24.

Surayavansi RK, Rao SK and Singh CB 1985. Genetic diversity in lentil. Lens Newsl. **12**:28-31.

Williams PC and U Singh 1988. Quality screening and evaluation in pulse breeding. p 445-57. In: R.J. Summerfield (ed.), World Crops: Cool Season Food Legumes.