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DETERMINATION OF ANCESTRAL RELATIONSHIP TOWARDS THE DEVELOPMENT OF ADVANCED BREEDING LINES OF LENTIL (*LENS CULINARIS* MEDIK) VARIETIES IN INDIA

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Abstract

Pedigree analysis was performed to assess the ancestral contribution of 58 varieties of lentil released in India and were traced back to 47 ancestors. The relative genetic contribution (RGC) from ancestors was also computed. Ludhiana local, a selection from local collection of Punjab was most frequently used parent followed by Bihar local, P 495, P 230, Precoz etc. On the pedigrees of 369 lentil advanced breeding lines (172 small seeded and 197 large seeded types) were tested in initial varietal trial on MULLaRP. They were traced back to 106 ancestors of small seeded and 98 of large seeded types. The mean genetic contribution of these ancestors revealed that Ludhiana local contributed maximum to the genetic base in small seeded entries of initial varietal trial followed by Bihar local, Precoz, Sehore 74-3 and P 495. Similarly, among large seeded types, Precoz contributed maximum followed by Ludhiana local, Sehore 74-3, P 230 and Bihar local. Extensive and repetitive use of superior genotypes with common ancestors explained why the genetic base of released varieties is narrow and the integration of new germplasm is of great importance for broadening the genetic base of released varieties of lentil.

Introduction

Lentil is among the oldest domesticated crops in the world. It is a cool season food legume playing a significant role in human and animal nutrition as well as soil fertility (Bhatty 1988, Abraham 2015). It can be grown in rotation to cereal crops which promote sustainable cereal-based production system. It is the most important crop because of high protein content and fast cooking characteristic. The major lentil growing countries are Canada, India, Turkey, Australia, USA, Nepal, China and Ethopia. Lentil is the second most important winter pulse crop in India. It is generally grown as rainfed crop during *rabi* season after rice, maize, pearl millet or *kharif* fallow. North-eastern region of the country has been the area of small seeded lentil. Several small seeded, lentil is also cultivated as paira crop with rice. Its cultivation is mainly concentrated in Uttar Pradesh, Bihar, Madhya Pradesh and West Bengal which together contribute more than 80 per cent of area and production. The crop has great promise in rice fallows of Assam, high yielding varieties resistant to rust have been released for northern region. Concerted efforts were also made to develop large seeded varieties suitable for central zone of India. These high yielding varieties have also shown tolerance to wilt. With the inception of All India Coordinated Pulses Improvement Project in sixties, this led to increase in area and production. But at the same time, this also laid to narrowing down of genetic base of lentil varieties through replacement of land races by improved varieties. As the diversity in species provides protection against the outbreak of insect-pest and diseases and also to varying climatic conditions, therefore, it is essentially required to examine the genetic diversity involved in lentil improvement programmes.

Ancestor-offspring relationship, being used for studying the changes of genetic diversity during the course of cultivars improvement, can be measured by relative genetic contribution (Lin 1991). It has been used as an indicator of genetic base in cereals (Cox *et al.* 1986, Lin 1991), pulses (Dixit and Katiyar 2004, 2006, Srivastava *et al.* 2017, Katiyar *et al.* 2007, 2008) and

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oilseeds (Gopal and Oyama 2005) to provide information about the ancestor relationship of the varieties. An attempt was made to (i) determine the number of ancestor present in at least once in the pedigree and (ii) estimate relative genetic contribution (RGC) of ancestors to lentil varieties released in India and lentil genotypes, Initial Varietal Trials (IVT) bred during the last ten years (2005-06 to 2014-15).

Materials and Methods

The pedigree analysis was performed to quantify the ancestral contribution of 58 lentil varieties (25 large seeded and 33 small seeded) released by Central Variety Release Committee (CVRC) or State Variety Release Committee (SVRC) viz., Angoori (IPL 406), Arun (PL 77-12), Asha (B 77), B 177, BR 25, Garima (LH 82-6), Haryana Masar 1, HUL 57, IPL 316, Jawahar Lentil 3 (SLC 6), Jawahar Lentil 1, KLB 208-4 (Krati), KLS 218 (Azad Masar 1), KLS 09-3 (Krish), L 9-12, LL 56, LL 147, Lens 4076 (Shivalik), LL 699, LL 931, Malika (K 75), Markandey, NarendraMasoor 1 (NDL 92-1), Noori (IPL 81), Pant Lentil 6, Pant Lentil 4, Pant Lentil 7, Pant L 5, Pant L 639, Pant L 8, Pant L 406, Pant L 234, Priya (DPL 15), PusaMasoor 5 (L 4594), PusaVaibhav (L 4147), Ranjan (B 256), RVL 31, Sapna (LH 84-8), SalimarMasoor 1, Salimar M 2, Sheri (DPL 62), Shekhar 4, Shekhar 2, Shekhar 3 (KL 320), Subrata (WBL 58), T 8, T 36, VL 126, VL Masoor 1, VL Masoor 4, VL Masoor 514, VL Masoor 125, VL Masoor 133, VL Masoor 103, VL Masoor 507, VL Masoor 129, Vipasha (HPL 5) and WBL 77 (Moitree) released in India from 1956 to 2015. The study was carried out at Indian Council of Agriculture Research-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh, India.

Relative genetic contribution of different ancestors to a given variety was computed by partitioning the genetic constituents of each variety into theoretical percentages attributable to different ancestors assuming that every time a cross is made each parent transmits 50 per cent of its genes to the progeny with equal probability. The mean genetic contribution of a given ancestor was estimated by the mean of relative genetic contributions of this ancestor to all the released varieties. The cumulative genetic contribution of an ancestor was computed by assuming its RGC to all varieties. Apart from released varieties, the promising lentil genotype (IVT - Initial Varietal Trials entries) which entered in All India Coordinated Research Project during last 10 years (2005-06 to 2014-15) for multilocational testing across the country were also included in the study. Pedigree analysis of these IVT entries was conducted to identify the ancestors frequently used in the hybridization programme of lentil in India.

Results and Discussion

The pedigree analyses of all released lentil cultivars in India were performed to identify the ancestors. The pedigree of 58 varieties was traced back to 47 ancestors (Table 1) of which 29 appeared only once. Although these ancestors imparted little in mean relative genetic contribution, 18 of 29 contributed 25 per cent or more of genetic constituents of individual varieties. Further, the most frequently used parent in hybridization programme was Ludhiana local (14 times), followed by Bihar local (11 times), Precoz (6 times), P 230 (5 times), P 495 (4 times) etc. (Table 1). Ancestor Ludhiana local collected from Punjab was used in the development of L 9-12 variety in 1972. Similarly, Bihar local parent was used in the development of T 8 variety in 1967. Both these ancestors have wider adaptability. Further, L 9-12 and T 8 were crossed for the development of Pant L 639, which is the first variety developed through hybridization in 1980. In an earlier study on the pedigrees of total 35 lentil cultivars developed, Dixit and Katiyar (2004) have reported Ludhiana local and Bihar local parents to be the most utilized in lentil breeding where 22 ancestors were used with Ludhiana local being a common ancestor in 17.14 per cent of the varieties developed. Similarly, most of the other ancestors were used as donor parents of single gene for disease resistance, particularly rust, during the last one or two decades. Further, some of the exotic ancestors *viz.*, Precoz, EC 2216, EC 15734/382, EC 3109 and Exotic 1 were also used as a donor in breeding programme for different agronomic traits and biotic and abiotic stresses. Precoz was used as a donor for extra-large seed size and earliness in lentil breeding programme. As these ancestors were mainly involved as a source of one or few genes, the original contribution from these germplasm was diluted after several cycles of backcross and selection for promising recombinants. Limited geographical origins of the ancestors and almost negligible introductions suggest the narrow genetic base in the 58 Indian lentil varieties. Due to lack of proper documentation, it is possible that source of these ancestors might be related which may further narrow down the genetic base of lentil.

Table 1. Ancestors and frequency of their occurrence in the pedigree of 58 lentil varieties developed in India.

Ancestor		Ancestor	
Ludhiana local	(14)*	LH 90 - 103	(1)
Bihar local	(11)	LL 608	(1)
Precoz	(6)	NP 21	(1)
P 230	(5)	PL 284 - 67	(1)
P 495	(4)	Pithoragarh local	(1)
JLS 2	(3)	P 4	(1)
Jorhat local	(3)	PKVL 1	(1)
Badaun local	(3)	PL 77 -2	(1)
LG 171	(3)	P 237	(1)
Bundelkhand local	(3)	Sehore local	(1)
Almora local	(2)	Sehore 74-3	(1)
UPL 175	(2)	Shajahpur local	(1)
VL 101	(2)	VHC 2776-1	(1)
Sagar local	(2)	No. 4	(1)
PL 184	(2)	BLX 84176	(1)
P 285	(2)	L 32-1	(1)
LG 362	(2)	L 3875	(1)
JLS 1	(2)	L 4126	(1)
EC 2216	(1)	L 460	(1)
EC 15734/382	(1)	LL 498	(1)
EC 3109	(1)	L 830	(1)
IL 7978	(1)	Pusa 2	(1)
IL 7723	(1)	Exotic 1	(1)
KLS 133	(1)		

*Figure in parenthesis is the frequency of occurrence of ancestor.

The ten most important contributors of 58 Indian lentil varieties are presented in Table 2. These 10 ancestors collectively comprised more than 51 per cent of germplasm released in the time period of 1956 to 2015. The mean genetic contribution revealed that the ancestor Ludhiana local contributed maximum to the genetic base followed by Bihar local, P 495, P 230, Precoz, Bundelkh and local, Almora local, Baduan local, Sagar local and JLS 2. Ancestors Ludhiana local and Bihar local collected from Punjab and Bihar state, respectively have been used widely in the breeding programmes due to its wider adaptability and, therefore, more suitable for unfavourable environmental conditions. These ancestors are small seeded types. Bihar local is semi-spreading types with grey mottled seeds. Ancestor Ludhiana Local was used in the development of varieties like L 9-12, KLS 9-3, LL 56, Narendra Masoor 1, Pant L 639, Sapna (LH 84-8), Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7, Priya (DPL15), Pusa Masoor 5 and Haryana Masar 1. Similarly, Bihar local was used in the development of varieties like T 8, Pant L 639, Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7, Priya (DPL 15), Pusa Masoor 5, Haryana Masar 1 and Arun (PL 77-12).Further, among Indian lentil varieties developed through hybridization and mutation, Ludhiana local had been involved in more than 24 per cent of the released varieties followed by Bihar local (> 18%), Precoz (>10%), P 230 (> 8%), P 459 (> 6%), Badaun local (> 5%), JLS 2 (> 5%) and Sagar local (> 3%). P 495 has been used in the development of Pant L 406 through direct selection and is small seeded type and resistant to rust. Ancestor P 230 has been used in the development of the varieties Pant L 234 directly and indirectly in the development of PL 7, Lens 4076, DPL 15 and Haryana Masar1, is a compact dwarf type, with many branches and having small seed size. An exotic macrosperma source Procoz used as a donor for large seed size has been involved in the development of more than 10 per cent Indian varieties of large seeded types. Bundelkh and local is large seeded type while Almora local is small seeded type and seeds are black in colour. Ancestor Badaun local originated from Uttar Pradesh is semi-spreading type with grey mottled seed and has been used in the development of T 36 through direct selection. Similarly, ancestor JLS 2 is large seeded type and ancestor Sagar local involved in the development of Jawahar Lentil 1 directly, is having early maturity and medium large seed size. The study clearly showed extensive use of few ancestors that has led the narrowing the genetic base and thus has increased its vulnerability to the climate change. Further, limited utilization of variability led in reduction in pace of development of widely adopted varieties with resistance to biotic and abiotic stresses.

Table 2. Mean genetic contribution and frequency of occurrence of 10 important ancestors of lentil varieties developed in India.

Ancestor	Mean genetic contribution	Cumulative genetic contribution	Frequency of occurrence in pedigrees
Ludhiana local	0.1064	0.1064	0.2414
Bihar local	0.0851	0.1915	0.1897
P 495	0.0479	0.2394	0.0690
P 230	0.0479	0.2872	0.0862
Precoz	0.0426	0.3298	0.1034
Bundelkhand local	0.0426	0.3723	0.0517
Almora local	0.0426	0.4149	0.0345
Badaun local	0.0372	0.4521	0.0517
Sagar local	0.0319	0.4840	0.0345
JLS 2	0.0266	0.5106	0.0517

Ludhiana Local and Bihar Local were also used directly or indirectly as ancestors for the development of varieties and their involvement as male or female parent in hybridization programme. Ludhiana Local was used directly in the development of varieties like L 9-12, KLS 9-3, LL 56, Narendra Masoor 1, Pant L 639 and Sapna (LH 84-8) and indirectly in hybridization *viz.* Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7 (2 times), Priya (DPL15), Pusa

Masoor 5 and Haryana Masar1; and 13 times as a female viz. Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7 (2 times), Priya (DPL 15), Pusa Masoor 5, Haryana Masar 1, L 9-12, Pant L 639, Sapna (LH 84-8), KLS 09-3, LL 56 and once as a male in Narendra Masoor 1. Similarly, Bihar local was used directly in the development of T 8, Pant L 639 and Arun and indirectly in hybridization *viz.* Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7 (2 times), Priya (DPL 15), Pusa Masoor 5 and Haryana Masar 1 and 9 times as a male *viz.* Lens 4076 (Shivalik), LL 699, Noori (IPL 81), Pant Lentil 7 (2 times), Priya (DPL15), Pusa Masoor 5,Haryana Masar 1 and Pant L 639 and as a female was used in T 8 and Arun.

The mean genetic contribution of Ludhiana local for small seeded varieties was 0.0621 with occurrence of 15.30 per cent and for large seeded varieties was 0.0443 with occurrence of 8.84% (Table 3). Likewise Bihar local for small seeded varieties was 0.0535 with occurrence of 12.87 per cent and for large seeded varieties was 0.0316 with occurrence of 7.10 per cent. The small seeded varieties like KLS 09-3, Narendra Masoor1, LL 56, Pant L 639, Haryana Masar1 and LL 699 and large seeded varieties *viz.*, Sapna, LH 84-8, Arun, PL 77-12, Pant Lentil 7, Noori (IPL 81), Priya (DPL15), Lens 4076 (Shivalik) and Pusa Masoor 5 were developed using Ludhiana local. Using ancestor Bihar local small seeded cultivars *viz.*, Pant L 639 and Haryana Masar1 and large seeded cultivars *viz.* Arun, PL 77-12, Lens 4076 (Shivalik), Priya (DPL15), Noori (IPL 81), Pant Lentil 7 and Pusa Masoor 5 were developed.

Table 3. Involvement of Ludhiana local and Bihar local in small and large seeded lentil varieties development in India.

Type	Mean genetic contribution		% of occurrence	
	Ludhiana local	Bihar local	Ludhiana local	Bihar local
Small seeded (*Microspera* type)	0.0621	0.0535	15.30	12.87
Large seeded (*Macrosperma* type)	0.0443	0.0316	8.84	7.10

Involvement of ancestors Ludhiana local and Bihar local (since the time of development) in different time period is shown in Table 4. Mean genetic contribution of Ludhiana local and Bihar local was maximum in 1976-1985 time period. Ludhiana local was cytoplasmic source of 25 per cent varieties (Pant L 639 and LL 56) developed during 1976-1985; 30 per cent varieties *viz.*, Sapna (LH 84-8), Lens 4076 (Shivalik), Priya (DPL 15) developed during 1986-1995; more than 17 per cent varieties (Narendra Masoor1, Noori, LL 699, Haryana Masar1) developed in 1996-2005; and more than 22 per cent varieties (Pusa Masoor 5, Pant Lentil 7, KLS 09-3) developed in 2006-2015 time period.

The present study also included the pedigree analysis of the advanced breeding lines which were developed during last 10 years (2005-06 to 2014-15) and tested in Initial Varietal Trials in All India Coordinated Programmes (Table 5). Total of 369 IVT entries were tested in the multi-locational trials during the period under review, out of which 172 entries tested were small seeded types and 197 were large seeded types. The pedigree of 172 small seeded types was traced back to 106 ancestors and the mean genetic contribution of these ancestors revealed that Ludhiana local contributed maximum to the genetic base in small seeded type entries of IVT followed by Bihar local, Precoz, Sehore 74-3 and P 495. Similarly, among large seeded types, the pedigree of 197 IVT entries were traced back to 98 ancestors and the mean genetic contribution depicted that Precoz contributed maximum followed by Ludhiana local, Sehore 74-3, P 230 and Bihar local. The results are in conformity with those reported earlier by Dixit and Katiyar (2004). Among the

369 entries tested in IVT during 2005-06 to 2014-15, seven varieties of small seeded types *viz.*, KLS 218, HUL 57, VL 126, WBL 77, Pant L 6, Haryana Masar 1 and KLS 09-3 and nine varieties of large seeded types *viz.*, VL 507, IPL 406, Pant L 7, IPL 316, Markanday, SalimarMasoor 2, RVL 31, KLB 2008-4 and Shekhar 4 were developed.

Table 4. Involvement of Bihar local and Ludhiana local in different time period in development of lentil varieties.

Year	Total no. of varieties developed	No. of varieties where ancestors used (directly/ indirectly)		Varieties % where ancestors involved directly/indirectly		Mean genetic contribution		Varieties % with cytoplasm of			
		Ludhiana local	Bihar local	Ludhiana local	Bihar local	Ludhiana local	Bihar local	Ludhiana local	Others	Bihar local	Others
1976-85	8	2	1	25.00	12.50	0.125	0.062	25	75	-	100
1986-95	10	3	2	30.00	20.00	0.054	0.023	30	70	-	100
1996-05	17	4	3	23.50	17.64	0.045	0.025	17.64	82.36	-	100
2006-15	18	4	3	23.20	16.60	0.029	0.014	22.22	77.78	-	100

Table 5. Mean genetic contribution and frequency of occurrence of a few ancestors of advanced breeding lines (IVT - Initial varietal trial entries) of last ten years (2005-06 to 2014-15) in lentil.

Ancestor	Mean genetic contribution	Cumulative genetic contribution	Frequency of occurrence in pedigrees
Small seeded type			
Bihar local	0.0926	0.0926	0.3910
Ludhiana local	0.0902	0.1828	0.3462
Precoz	0.0590	0.2417	0.1282
Sehore 74-3	0.0519	0.2936	0.0705
P 495	0.0495	0.3432	0.0705
Large seeded type			
Precoz	0.0918	0.0918	0.2873
Ludhiana local	0.0899	0.1818	0.3710
Sehore 74-3	0.0561	0.2379	0.0775
P 230	0.0561	0.2940	0.1549
Bihar local	0.0517	0.3457	0.2610

Among thousands of accessions available, only a small number was utilized in the breeding programme meant for varietal development. Extensive use of parents like Ludhiana local, Bihar local, P495, P 230, Precoz etc. in the lentil improvement programme of India led to genetic erosion and narrowing of genetic base as evident from not significant superiority of the recently released varieties of lentil. The present study quantifies the genetic base of improved varieties and breeding lines that provide indirect information about the relatedness of the varieties and breeding lines. To breed new varieties for facing the effects of global climate change, the new gene pool of varieties must be broad end by introducing wild species, land races and exotic germplasm into breeding programme. Accordingly, breeders have to make efforts to include diverse parents in the hybridization to develop high yielding varieties with broad genetic base so that vulnerability to emerging biotic and abiotic stresses can be minimized. The effectiveness of the selection in any crop depends upon the extent and nature of phenotypic and genotypic variability present in different traits of the population (Arora 1991). With the advent of modern breeding tools and techniques including various molecular biology tools it has become possible to incorporate genes from various divergent sources systematically in less time. Further, knowledge of the degree of relationship among advanced breeding lines and varieties is useful in choosing superior yet genetically diverse parents for mating that would generate transgressive segregants in later generations.

Widening of existing genetic base of lentil (*Lens culinaris*) is key to its yield enhancement. Extra-bold and extra-early genotypes with good phenological adaptation have to developed. Biochemical and molecular techniques have to be used for biodiversity evaluation and assessment of genetic structure of germplasm accessions in the genus *Lens* summarized by Ferguson and Robertson (1966), Abo-elwafa *et al.* (1995) and Sharma *et al.* (1995). Precoz, an early flowering macrosperma line has been extensively used in hybridization programme by Indian breeders. Further, *Lens nigricans* from secondary gene pool has to be crossed with cultivated species (*Lens culinaris*) through embryo rescue. Efforts should also be made to introgress some useful genes from wild species. *Lens orientalis* shows fairly good degree of chromosome homology with *Lens culinaris* forming maximum of five bivalents and thus can be used to incorporate useful genes in the latter.

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References

Abo-elwafa A, Marai K and Shimada T 1995. Intra- and interspecific variations in *Lens* revealed by RAPD markers. Theoratical & Applied Genetics **90**: 335-340.

Abraham R 2015. Lentil (*Lens culinaris* Medik) current status and future prospect of production in Ethiopia. Adv. Plants Agric. Res. **2**(2): 00040. DOI: 10.15406/apar. 2015.02.00040.

Arora PP 1991. Genetic variability and its relevance in chickpea improvement. International Chickpea Newsletter **25**: 9-10.

Bhatty RS 1988. Compositoion and quality of lentil (*Lens culinaris* Medik) : A review. Canadian Institute of Food Sciences and Technology **21**(2): 144-160.

Cox TS, Murpy JP and Rodgers DM 1986. Changes in genetic diversity in the red winter wheat regions of the United States. Proceedings of National Academy of Science, USA. **83**: 5583-6.

Dixit GP and Katiyar PK 2004. Genetic base of lentil varieties and breeding lines developed in India. Indian J. Agric. Sci. **74**(11): 625-627.

Dixit GP and Katiyar PK 2006. Genetic base of Indian fieldpea varieties and breeding lines. Indian J. Genet. **66**(4): 316-318

Ferguson M and Robertson LD 1996. Genetic diversity and taxonomic relationships within the genus *Lens* as revealed by allozyme polymorphism. Euphytica **91**: 163-172.

Gopal J and Oyama K 2005. Genetic base of Indian potato selection as revealed by pedigree analysis. Euphytica **142**: 23-31

Katiyar PK, Dixit GP and Singh BB 2007. Ancestral relationship of greengram advance breeding lines developed in India. Indian J. Agric. Sci. **77(9)**: 579-582.

Katiyar PK, Dixit GP and Singh BB 2008. Genetic base of advanced urdbean breeding lines developed in India as revealed by pedigree analysis. Indian J. Genet*.* **68(3)**: 324-326.

Lin MS 1991. Genetic base of japonica rice varieties released in Taiwan. Euphytica **56**: 43-46.

Sharma SK, Dawson IK and Waugh R 1995. Relationships among cultivated and wild lentils revealed by RAPD analysis. Theoretical & Applied Genetics **91**: 647-654.

Shrivastava AK, Chaturvedi SK and Singh NP 2017. Genetic base of Indian chickpea (*Cicer arietinum* L.) varieties revealed by pedigree analysis. Legume Research **40**(1): 22-26.

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