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Short Communication

Protein content in wild and cultivated taxa of lentil (*Lens culinaris* ssp. *culinaris* Medikus)

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Abstract

The protein contents in 72 diverse accessions of lentil ranged from 10.5 to 23.7 % with an average of 18.7 % in varieties/breeding lines, 14.5 to 27.1 % with an average of 22.4 % in landraces of Mediterranean origin and 18.1 to 32.7 % with an average of 22.6 % in wild species. Significantly high protein content (32.7 %) was recorded in accession ILWL 47 belonging to *Lens ervoides*. The coefficient of variation and standard deviation in Mediterranean landraces (18.1 %) showed high protein contents as compared to varieties/breeding lines (16.9 %) and wild species (17.8 %) . As per the Jaccard's similarity coefficient based on protein content 72 accessions were grouped into two main clusters. Cluster I possessed a solitary accession ILWL 47 while remaining accessions were grouped in cluster II, which was subdivided into sub cluster IIa with 48 genotypes and IIb comprising of 29 accessions of varieties/breeding lines, 16 of wild species and 3 landraces. The results indicated that Indian varieties/breeding lines are significantly different from Mediterranean landraces and wild species in respect of protein contents.

Key words: Lentil, protein content, Mediterranean landraces, wild species

Lentil (*Lens culinaris* ssp. *Culinaris* Medikus), is grown widely in cool-season under rainfed conditions. Globally, it occupies 3.74 mha area with an annual production of 3.40 mt and average yield of 915 kg/ha (Erskine et al. 2011; Kumar et al. 2012). Lentils are mainly produced in South Asia and China, Northern Great Plains in North America, West Asia and North Africa, Sub-Saharan Africa and Australia. India being the largest producer, in 2014-15, whereas the area under lentil was 1.48 mha with 1.01 mt of production (Anonymous 2016). Indian common diet is considered incomplete without the inclusion of pulses in any form because it is an important source of protein. India produces inadequate amount of pulses and therefore, the natural source of protein is affected leading to malnutrition in some parts of the country. Protein rich foods are required for maintaining the normal metabolic function of the body and the use of lentil can be one of the ways for improving the protein malnutrition among poor. There is a great need to develop the lentil cultivars with high yield higher concentration of protein. Although several studies on assessing protein contents in lentil have been conducted reporting a wide range in protein contents (Hamdi et al. 1991; Tyagi and Sharma 1995; Hedley et al. 2001; Wang et al. 2009; Burstin et al. 2011). Non significant differences for protein concentration in green and red lentils have been also been reported (Boyle et al. 2010). However most of these studies have been conducted among accessions belonging to cultivated species and screening of accessions of wild species has remained limited for protein content. Therefore, the present investigation has been focused on determination of protein content and genetic relationship among the diverse genotypes of lentil.

Seventy two diverse accessions of lentil including 32 released varieties, breeding lines, 15 landraces from Mediterranean region and 25 accessions of 6 wild species were analyzed. Details about these accessions including name, type of material, pedigree, source/origin and country are given in Supplementary Table 1. The accessions of wild species and Mediterranean landraces were procured from ICARDA, Morocco, whereas released varieties and breeding lines were taken from IIPR, Kanpur. The material was grown at Indian institute of Pulses Research Kanpur (268270N, 808140E; 152.4m amsl) following standard agronomic practices.

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Table 1. Protein contents (%) in lentil accessions, their pedigree, origin and source

Genotype	Pedigree	Origin/source	Protein content(%)	Genotype	Pedigree	Origin/source	Protein content(%)
Varieties/cultivars				IG 2159	'' ''	Iran, ICARDA	26.5
DPL-15	PL406 × L 4076	IIPR, Kanpur	23.6	IG 2226	'' ''	Turkey, ICARDA	24.9
DPL-62	JL 1 × LG 171	IIPR, Kanpur	21.3	IG 4365	'' ''	Jordan, ICARDA	23.8
IPL-81	K 75 × PL 639	IIPR, Kanpur	18.9	IG 4448	'' ''	Syria, ICARDA	22.9
IPL-406	DPL 35 × EC 157634/382	IIPR, Kanpur	22.9	IG 5187	'' ''	Jordan, ICARDA	27.1
PL-02	PL 4 × DPL 55	GBPUAT, Pant Nagar	19.5	IG 5320	'' ''	Jordan, ICARDA	24.5
PL-04	UPL 175 × (PL 184 × P 288)	GBPUAT, Pant Nagar	20.6	IG 5360	'' ''	Jordan, ICARDA	26.1
PL-05	L 4606 × LG 171	GBPUAT, Pant Nagar	23.7	IG 112108	'' ''	Moracco, ICARDA	23.5
Pant L-639	L 9-12 × TYPE 8	GBPUAT, Pant Nagar	21.1	IG 112128	'' ''	Moracco, ICARDA	14.5
K-75	Local selection from Bundelkhand, UP	CSAUAT, Kanpur	21.5	IG 134327	'' ''	Iran, ICARDA	16.5
T-36	Local selection from Budaun, UP	CSAUAT, Kanpur	20.5	IG 134356	'' ''	Iran, ICARDA	21.9
VL-1	Local selection from UP hills	VPKAS, Almora	22.1	IG 129214	'' ''	Lebanon, ICARDA	14.5
VL-4	Local selection from UP hills	VPKAS, Almora	16.7	**Wild taxa**			
L-9-12	Local Selection from Punjab	PAU, Ludhiana	15.7	ILWL 118	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	24.5
JL-1	Local Selection from Sehore, MP	JNKVV, Jabalpur	16.5	ILWL - 203	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	19.9
JL-3	Local Selection from Sagar , Mp	JNKVV, Jabalpur	20.7	ILWL 248	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	26.7
Ranjan	Mutant of B77	Berhampur, WB	14.5	ILWL - 312	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	27.7
NDL-1	PL 406 × PRECOZ	NDUAT, Faizabad	16.1	ILWL - 326	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	27.5
WBL 77	ILL7723 × BLX 84176	Berhampur, WB	19.9	ILWL - 447	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	26.6
WBL-58	JLS 2 ×T 36	Berhampur, WB	16.9	IG - 135395	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	24
IPL 316	Sehore 74-3 × DPL-58	IIPR, Kanpur	16.1	ILWL - 339	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	24.2
IPL 526	DPL-62 × DPL-58	IIPR, Kanpur	16.7	ILWL - 344	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	18.3
Breeding lines				IG - 135415	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	20.5
IPL-313	ILL7659× DPL 58 × KL 178	IIPR, Kanpur	17.8	ILWL - 367	*Lens culanaris* sp. *orientalis*	ICARDA, Morocco	25.7
IPL-315	PL 4 × DPL 62	IIPR, Kanpur	20.1	ILWL - 169	*Lens culanaris* sp. *odemensis*	ICARDA, Morocco	19.7
IPL 319	ILL6458 X DPL-58	IIPR, Kanpur	20.5	ILWL - 72	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	20.1
IPL-520	DPL 58 × LH 90-11	IIPR, Kanpur	17.3	ILWL - 80	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	26.9
DPL-58	PL 639 × PRECOZ	IIPR, Kanpur	14.1	ILWL-47	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	32.7
IPLS-09-14	Selection from Masan	IIPR, Kanpur	10.5	ILWL-44	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	26.5
IPLS-9-24	ILL8072 × ILL6037	IIPR, Kanpur	19.6	ILWL - 269	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	19.2
IPLS-9-07	L 4603 × PRECOZ	IIPR, Kanpur	20.3	IG - 136620	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	18.9
IPLS-09-19	ILL7947 × ILL1005	IIPR, Kanpur	12.5	ILWL - 443	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	19.8
Landrace				IG - 136622	*Lens culanaris* sp. *ervoides*	ICARDA, Morocco	19.8
EC-208355	Unknown	NBPGR, India	18.1	IG - 136651	*Lens culanaris* sp. *nigricans*	ICARDA, Morocco	18.3
Mediterranean landraces				IG - 136628	*Lens culanaris* sp. *nigricans*	ICARDA, Morocco	20.5
IG 539	*Lens culinaris* subsp. *culinaris*	Turkey, ICARDA	22.6	IG - 136623	*Lens culanaris* sp. *nigricans*	ICARDA, Morocco	19.8
IG 842	'' ''	Lebanon, ICARDA	23.9	ILWL - 338	*Lens culanaris* sp. *tomentosus*	ICARDA, Morocco	19.4
IG 843	'' ''	Lebanon, ICARDA	23.1	ILWL - 337	*Lens culanaris* sp. *tomentosus*	ICARDA, Morocco	18.1

The crude protein in grinded samples was determined using Kjeldahl method (AOAC, 1998) (Make: Pelican Kelplus-Classic DX-VATS). All measurements were recorded in triplicates and the average protein in per cent was obtained by multiplying the % nitrogen value (calculated as per following equation) with 6.25 being the Protein Factor:

$$\% \text{ Nitrogen} = \frac{14 \times (\text{normality of acid}) \times (\text{Titrant Value})}{\text{Sample weight} \times 1000} \times 100$$

First order statistical analyses including mean, range and coefficient variation (CV) in per cent were calculated using Excel software. The significant differences between the means of protein contents among the accessions were tested using *t*-test following two-sample assuming unequal variances method at the significance level of p = 0.05. Cluster analysis was performed using Euclidean distances based on the protein to compute the similarity between the genotypes and dendogram was constructed using unweighted pair group method with arithmetic average (UPGMA) in the NTSYS pc-2.11x software (Rolf 1998).

The protein content estimated among 72 accessions of lentil (Table 1) ranged from 10.5 % to 23.7 % with an average of 18.7% in varieties/breeding lines; 14.5 to 27.1 % with an average of 22.4% in Mediterranean landraces and 18.1 to 32.7 % with an average of 22.6% in wild species indicating that a large amount of genetic variability is available for this trait. The range of protein content was comparatively higher as compared to values reported earlier by Tyagi and Sharma (1995) in 32 lentil genotypes and in 3663 germplasm accessions analysed by Hamdi et al. (1991). The mean, standard deviation, standard error of mean and coefficient of variation for protein content in Indian varieties/breeding lines, Mediterranean landraces and accessions of wild species is presented in Table 2 and the average of three groups is depicted in Fig. 1. The average protein content of Mediterranean landraces did not differ significantly from wild species (Table 3; p = 0.88). However, highly significant differences were observed between the means of Mediterranean landraces and varieties/breeding lines (p = 0.004) and between the means of wild species and varieties/breeding lines (p= 0.0001) (Table 3). The coefficient of variation (16.9 %) and standard deviation (3.1) in varieties/breeding lines was lower as compared to Mediterranean landraces (18.1 % and 4.0, respectively) and wild species (17.8 % and 4.0, respectively) suggesting that both landraces and wild species have similar range of genetic variability for protein content, but their genetic variability is

Table 2. Mean, range, standard deviation and standard error of mean and coefficient of variation for protein content in breeding lines/varieties, land races and wild species of lentil

Type of material	Mean	Range	Standard deviation	SE of mean	Coefficient of variation (%)
Breeding lines and varieties	18.7	10.5-23.7	3.1	0.6	16.9
Mediterra-nean land races	22.4	14.5-27.1	4.0	1.1	18.1
Wild species	22.6	18.1-32.7	4.0	0.8	17.8

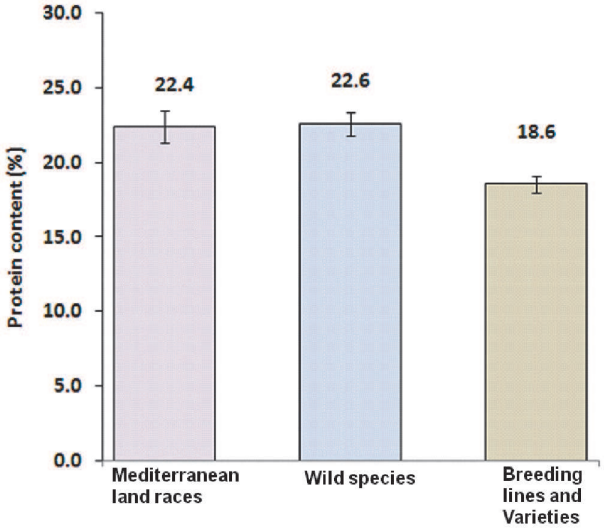

Fig. 1. The average content of protein in Mediterranean landraces, wild species and varieties/breeding

Table 3. Significance differences between the means of Mediterranean land races, wild species and breeding lines/varieties for protein content analysed in present study

Type of material	Breeding lines/ varieties	Mediterranean land races
Mediterranean land races	** (P = 0.004)	-
Wild species	** (P = 0.0001)	NS (P = 0.88)

**significant at P< 0.05

significantly higher than varieties/breeding lines. Kumar et al. (2016) reported 22.8% to 31.75%, protein in green and red lentils over the years. Therefore, it is presumed that wild and Mediterranean landraces are carrying useful genes for the higher protein content and hence are valuable genetic resources for developing high yielding varieties with high concentration of protein contents. The highest amount of protein content observed in accession ILWL 47 belongs to *L. ervoides* classified under secondary gene pool and has no cross compatibility with cultivated species. However, species has been successfully exploited for disease resistance to improve cultivated lentil through embryo rescue technique (Tullu et al. 2006).

The Jaccard's similarity coefficient based on protein content facilitated the clustering of 72 genotypes into two main groups. Cluster I possessed a solitary accession of wild species (ILWL 47) while remaining accessions were grouped in cluster II. Cluster II was subdivided into sub clusters, IIa and IIb. The sub-cluster IIa consisted of 48 accessions comprising of 29 accessions of varieties/breeding lines, 16 belonged to wild species and 3 landraces were of Mediterranean origin. The sub-cluster IIb contained 12 Mediterranean landraces, 9 accessions of wild species and 3 cultivars. Thus >90% accessions of Indian varieties/breeding lines and 80 % of Mediterranean landraces were grouped separately sub-clusters IIa and IIb, while wild species were distributed over these two sub-clusters. These results indicated that genetic makeup of Indian varieties/breeding lines for protein content is significantly different from Mediterranean landraces, some of which showed significantly higher amount of protein content in their seeds.

Significant genetic variability for protein content was recorded in the studied materials indicating enough scope to develop cultivars dense with high concentration of proteins. So far a limited focus has been made to improve the lentil cultivars with higher amount of protein content. As protein content is inherited quantitatively in lentil, therefore, concerted and systematic efforts should be made to improve cultivars with high protein content in lentils, which is expected to alleviate protein malnutrition through the protein rich diet.

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Declaration

The authors declare no conflict of interest.

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