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Genetic variability in lentil (*Lens culinaris* M.) genotypes for seed and seedling characteristics

Sonu Get, DK Gothwal, Ramesh Chand Choudhary and Komal Shekhawat

Sonu Get
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Rajasthan, India

DK Gothwal
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Rajasthan, India

Ramesh Chand Choudhary
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Rajasthan, India

Komal Shekhawat
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner

Correspondence
Sonu Get
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Rajasthan, India

Abstract
In this study, thirty genotypes of lentil (*Lens culinaris* M.) were evaluated in randomized block design with three replications during 2017-18 in laboratory of Department of Plant Breeding and Genetics, SKN college of agriculture, Jobner to determine genetic variability, heritability and genetic advance for seed and seedling characteristics. Observations were recorded on 100 seed weight, seed volume, true density, bulk density, porosity, water absorption capacity, water absorption index germination, seedling length, seedling fresh weight, seedling dry weight and seedling vigour index. The analysis of variance indicated significant difference among genotypes and considerable variability with respect to all the characters except germination percentage. The highest PCV and GCV expressed as percentage was observed for porosity followed by seed volume, seedling length and seedling vigour index, whereas low for bulk density and water absorption index. The estimates of heritability were high for all the characters ranging from 61.39 to 97.37. The estimate of very high heritability with high genetic advance was observed for seed weight, seed volume, water absorption capacity and seedling dry weight whereas high heritability with low genetic advance was recorded for bulk density.

Keywords: Genetic variability, physical properties, seedling, water absorption, lentil, selection, porosity

Introduction
Lentil (*Lens culinaris* M.) was one of the earliest cultivated crop in the world with archeological evidence from the early Stone Age. Lentil belongs to family Fabaceae (Leguminosae) and subfamily Papilionaceae. Among the different taxa of wild lentils *L. orientalis* is considered to be the progenitor of the cultivated lentil and is now generally classified as *L. culinaris* subsp. *orientalis*. According to Ladizinsky (1979) [12] lentil has been originated in Southern Turkey. It is cultivated in semi-arid regions of the world particularly in the Indian sub-continent and the dry areas of Middle East (Malik, 2005) [15]. Lentil is divided into two sub-species including macrosperma (broad and large seeds with a diameter of 9-6 mm) and microsperma (concave shaped tiny seeds with a diameter of 6-2 mm) (Rathore, 2002) [19]. Lentil is known as poor man's meat. Nutritionally lentil seeds are valued for their high protein content (as much as 30%) and good source of vitamins and other important minerals (K, P, Fe, Mg, Zn), low in fat and cholesterol free. Lentils have second highest ratio of protein per calorie of any legume, after soybean. Physical characteristics of seed play an important role in equipment design for plant cultures, storage, harvest, transportation and yield. Therefore it seems to achieve these basic scientific information about these characteristics is necessary. Genetic variability, heritability and genetic advance for different types of physical properties of seeds have been reviewed by other researchers such as Amin *et al.* (2004) [3] and Cetin (2007) [5], Makkawi *et al*. (2008) [14], Adewale *et al*. 2010[1], Malik *et al*. (2011) [16], Latha (2014) [13], Altuntas *et al*. (2005) [2] and Hadi *et al.* (2016) [7].

Material and Method
In order to investigate the seed and seedling characteristics of lentil genotypes, the experiment was carried out in the Laboratory of Department of Plant Breeding and Genetics, Sri Karan Narendra College of Agriculture, Jobner (SKNAU, Jobner, Rajasthan) during the period from October, 2017 to April, 2018. This work was done in a randomized complete block design with three replications. For this purpose 30 lentil genotype were obtained from AICRP on MULLaRP at Rajasthan Agricultural Research Institute, Durgapura, Jaipur. Seed and seedling characteristics like 100 seed weight, seed volume, true density, bulk density, porosity, water absorption capacity and water absorption index, seedling length, seedling fresh weight, seedling dry weight, and seedling vigour index was measured. Uniformly selected seeds were sterilized with 0.1% mercuric chloride for 1 minute and then washed repeatedly for two to

three times under running tap water followed by washing with distilled water.

Seed characteristics

Seed volumes was measured by liquid displacement technique (Shepherd, 1986) [20]. For each lentil genotype 100 seeds were weighed and put into a 100 ml measuring cylinder containing 15 ml (initial reading) of water. Seed volume was recorded as (final reading-initial reading)/100 (Mohsenin, 1986) [18] and expressed as (µl/seed). To measure the true density, individual seed weight (g) was divided by its volume which was measured already in cm^3 and it was expressed as g/cm^3. To determine the bulk density of seed, the mass of seed (g) was divided by volume of container (cm^3) by using following formulae suggested by Khattak *et al*., 2006 [10]:

$$\text{Bulk density } (g/cm^3) = \frac{M}{V}$$

Where,

M = Mass of seed (W_2 - W_1) in grams

V = Volume of container in cm^3

To calculate the water absorption capacity, 100 seeds from each replication were weighted, soaked in water and was maintained at a temperature of 22 °C for 12 hours. The seeds were then removed from water and the excess moisture on the seed surface was removed with filter paper and seeds were weighted. Water absorption capacity in terms of grams per seeds was obtained by dividing the difference between these two values multiplied by100 (Mohsenin, 1986) [18].

$$\text{WAC (mg/seed)} = \frac{\text{Weight after soaking - Weight before soaking}}{100}$$

Where,

WAC = Water absorption capacity

Water absorption index was obtained by dividing the water absorption capacity of a single seed by its size/weight (Williamsa *et al*., 1983) [23].

$$\text{Water absorption index} = \frac{\text{Water absorption capacity (mg/seed)}}{\text{Original seed size (g)}}$$

The porosity (ε) of bulk seed was computed from the values of true density (ρ_t) and bulk density (ρ_b) using the following formula (Singh and Goswami, 1996) [21]:

$$\text{Porosity (\%)} = \{1 - \frac{\rho b}{\rho t}\} \times 100$$

Seedling characteristics

Germination paper was used as a matrix for seed germination. Then the germination papers were sterilized at 15 psi and 121 °C for 20 in autoclave. A seed was considered to have germinated at the emergence of both radicle and plumule up to 2 mm length (Chartzoulakis and Klapaki, 2000) [6]. The number of germinated seeds was recorded 7^{th} day after planting in petridishes and the germination percentage was determined by using the following formula (Aniat *et al.*, 2012) [4]:

$$\text{Germination Percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds planted}} \times 100$$

The seedling length of germinated seeds was recorded on 11^{th} day of planting in petridishes. Five seedlings from each petridish were randomly selected from each replication and seedling length was measured by using a measuring scale in centimeter and averaged. The fresh weight of seedling from the five seedlings from each replication was measured in milligram by using a sensitive electronic balance and averaged. After taking fresh weight of seedlings, these were kept in oven at 65 °C for 48 hours for drying. After drying, the dried seedlings were weighed using sensitive electronic balance in milligram and average was recorded. The seedling vigour index was determined by multiplying the seedling length with concerned germination percentage by the following formula (Iqbal and Rahmati, 1992) [8]:

$$\text{Seedling Vigour Index (SVI)} = \text{(SL) X (GP)}$$

Table 1: List of genotypes used in the experiment

S. No.	Genotype	S. No.	Genotype
1	RLG - 43	16	RLG - 257
2	RLG - 191	17	RLG - 258
3	RLG - 223	18	RLG - 234
4	RLG - 224	19	RLG - 195
5	DPL - 58	20	RLG - 255
6	RLG - 147	21	RG - 254
7	RLG - 48	22	RLG - 5
8	RLG - f8(3)	23	Sapna
9	RLG - 245	24	RLG - 273
10	RLG - 261	25	RLG - 279
11	DPL - 62	26	RLG - 270
12	LG - 262	27	RLG - 283
13	RLG - 250	28	RLG - 274
14	RLG - 256	29	RLG - 281
15	RLG - 266	30	RLG - 276

Table 2: Mean sum of squares for various characters in lentil

S. No.	Characters	Replications	Genotypes		Error
1	100 seed weight (g)	0.0161	0.5167	**	0.0079
2	Seed volume (µl/seed)	0.7111	56.2284	**	1.2398
3	True density (g/cm3)	0.0017	0.0276	**	0.0025
4	Bulk density (g/cm3)	0.0003	0.0013	**	0.0001
5	Porosity (%)	0.7498	92.1571	**	8.0808
6	Water absorption capacity (mg/seed)	0.1597	42.1086	**	0.5531
7	Water absorption index	0.0016	0.0041	**	0.0008
8	Germination (%)	9.3817	17.8612		17.0461
9	Seedling length (cm)	3.3105	6.5993	**	1.1439
10	Seedling fresh weight (mg)	35789.6413	127058.6508	**	29945.7383
11	Seedling dry weight (mg)	84.0884	3640.0117	**	32.5013
12	Seedling vigour index	29145.0226	62066.7193	**	12794.0533

*and **represent significant at 5% and 1% level of significance, respectively

Table 3: The general mean, range, GCV, PCV, Hbs, GA etc for different characters

Parameters	Mean	SE	Min.	Max.	σ^2g	σ^2p	GCV	PCV	h^2 (%)	GA (%)
100 seed weight (g)	3.12	0.05	2.19	3.68	0.17	0.18	13.20	13.51	95.55	26.59
Seed volume (µl/seed)	26.98	0.64	19.00	35.00	18.33	19.57	15.87	16.40	93.66	31.64
True density (g/cm3)	1.16	0.03	0.98	1.36	0.01	0.01	7.85	8.95	77.01	14.20
Bulk density (g/cm3)	0.78	0.01	0.75	0.82	0.00	0.00	2.52	2.94	73.65	4.46
Porosity (%)	32.34	1.64	21.78	43.75	28.03	36.11	16.37	18.58	77.62	29.71
Water absorption capacity (mg/seed)	29.28	0.43	19.00	34.22	13.85	14.40	12.71	12.96	96.16	25.67
Water absorption index	0.94	0.02	0.86	1.02	0.00	0.00	3.56	4.63	59.09	5.63
Germination (%)	97.70	2.38	91.11	100.00	0.27	17.32	0.53	4.26	1.57	0.14
Seedling length (cm)	9.05	0.62	6.50	12.55	1.82	2.96	14.91	19.03	61.39	24.06
Seedling fresh weight (mg)	1455.03	99.91	1163.53	2040.93	32370.97	62316.71	12.37	17.16	51.95	18.36
Seedling dry weight (mg)	261.16	3.29	170.33	325.47	1202.50	1235.00	13.28	13.46	97.37	26.99
Seedling vigour index	883.68	65.30	636.08	1196.50	16424.22	29218.28	14.50	19.34	56.21	22.40

Table 4: The overall rank of different genotypes in lentil

S. No.	Variety	SW	SV	TD	BD	Por	WAC	WAI	Germ	SL	SFW	SDW	SVI	Total	Overall Rank
1	RLG - 43	29	29	18	7	21	29	24	13	3	13	21	2	209	23
2	RLG - 191	27	28	4	2	4	25	1	13	15	5	28	16	168	11
3	RLG - 223	19	11	20	24	17	21	26	1	27	29	13	27	235	29
4	RLG - 224	15	11	13	13	15	17	21	22	21	20	7	21	196	19
5	DPL - 58	7	3	27	28	25	13	28	13	9	10	9	9	181	15
6	RLG - 147	24	20	22	21	22	24	4	13	10	15	26	10	211	27
7	RLG - 48	3	2	24	1	28	12	30	1	13	2	2	13	131	1
8	RLG - f8(3)	5	4	25	19	24	6	23	1	20	16	12	17	172	13
9	RLG - 245	26	21	23	14	26	26	7	22	7	12	18	8	210	26
10	RLG - 261	22	21	16	5	19	22	9	1	6	6	25	6	158	9
11	DPL - 62	1	5	19	26	16	3	20	25	2	1	20	3	141	2
12	LG - 262	30	30	17	3	20	30	29	22	12	28	30	11	262	30
13	RLG - 250	21	18	11	8	14	20	18	1	4	7	15	4	141	2
14	RLG - 256	4	9	10	23	7	4	19	1	24	25	10	24	160	10
15	RLG - 266	20	16	14	18	12	18	13	13	19	24	14	19	200	21
16	RLG - 257	14	16	7	12	8	14	10	1	18	19	16	15	150	6
17	RLG - 258	12	11	8	16	5	15	25	30	14	4	6	23	169	12
18	RLG - 234	9	24	1	20	2	7	14	25	28	30	19	28	207	22
19	RLG - 195	23	26	3	30	1	23	8	28	11	21	23	12	209	23
20	RLG - 255	2	7	15	29	10	2	15	13	17	14	5	18	147	5
21	RG - 254	28	27	26	27	23	28	3	1	8	18	29	7	225	28
22	RLG - 5	25	24	21	25	18	27	10	1	5	9	27	5	197	20
23	Sapna	18	18	5	11	6	19	22	25	1	3	22	1	151	7
24	RLG - 273	16	14	12	14	13	16	16	1	16	11	11	14	154	8
25	RLG - 279	11	21	2	5	3	8	12	13	22	8	17	20	142	4
26	RLG - 270	13	14	6	10	9	11	17	13	30	26	3	30	182	17
27	RLG - 283	8	1	30	22	30	1	2	1	26	22	4	25	172	13
28	RLG - 274	10	5	28	3	29	5	6	13	25	23	8	26	181	15
29	RLG - 281	6	10	9	9	11	10	27	28	29	17	24	29	209	23
30	RLG - 276	17	7	29	17	27	9	5	1	23	27	1	22	185	18

Results and Discussion

The results showed the maximum and the minimum value of the coefficient of variation was dedicated to seedling vigour index (12.80%) and bulk density (1.15%) respectively. In a study on three lentil genotypes, wide differences were reported for physical properties that the maximum value of the coefficient of variation was dedicated to the 100 seed weight trait with 32.2% (Hadi *et al*., 2016) [7]. In another study, wide differences were reported for physical characteristics such as 100 seed weight, seed volume, water absorption capacity and water absorption capacity among these cultivars (Malik *et al*., 2011) [16].

Mean squares for different source of variation for different characters are given in table-2. The data were analysed and analysis of variance revealed that there was significant difference among the genotypes for different seed and seedling characteristics *viz*., 100 seed weight (g), seed volume (µl/seed), true density (g/cm^3), bulk density (g/cm^3), porosity (%), water absorption capacity (mg/seed), water absorption index, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg) and seedling vigour index except germination per cent. The results were in partial confirmation with the results of Tizazu and Emire (2010) [22], Latha (2014) [13], Kumar *et al*. (2014) [11], Mekonnen *et al.* (2014) [17], Khan *et al*. (2015) [9] and Hadi *et al.* (2016) [7].

The mean performance, range, genotypic variation, phenotypic variation, genotypic coefficient of variation, phenotypic coefficient of variation, heritability in broad sense and genetic advance are presented in the table-2. Wide range of differences for GCV was observed which varied from 16.37% (porosity) to 2.52% (bulk density), whereas PCV ranged from 19.34% (seedling vigour index) to 2.94% (bulk density). The GCV and PCV were moderate in100 seed weight, water absorption capacity, seedling fresh weight and seedling dry weight. The lower magnitude of GCV and PCV were found for true density, bulk density and water absorption index. The magnitude of phenotypic coefficient of variation is higher than genotypic coefficient of variation for all the characters in the present study with small difference between these two genetic parameters. These results are in agreement with Makkawi *et al*. (2008) [14], Malik *et al*. (2011) [15], Mekonnen *et al*. (2014) [17] and Hadi *et al*. (2016) [7].

In this study, the estimates of broad sense heritability were high for all the characters ranging from 61.39% (seedling length) to 97.37% (SDW). Seedling fresh weight (51.95%), seedling vigour index (56.21%) and water absorption index (59.09%) showed moderate estimates of heritability. High heritability values for quantitative characters are always preferred by the breeders as characters with high heritability estimates enable them to base their selection on the basis of expression of these characters.

The expected genetic advance expressed as percentage of mean was observed to be higher for seed volume, porosity, seedling dry weight, water absorption capacity, 100 seed weight, seedling length and seedling vigour index ranging from 22.40% to 31.64%, which are in accordance with the earlier reports of Makkawi *et al*. (2008) [14] and Malik *et al*. (2011) [16]. Low genetic advance was observed for bulk density (4.46%) and water absorption index (5.63%), whereas moderate genetic advance was observed for true density (14.20%) and seedling fresh weight (18.36%). The present findings are in agreement with earlier reports of Makkawi *et al*. (2008) [14] and Malik *et al*. (2011) [16].

High heritability (broad sense) coupled with high genetic advance as percentage of mean was observed for the characters *viz*., 100 seed weight, seed volume, porosity, water absorption capacity, seedling length and seedling dry weight, which is in agreement with earlier reports of Makkawi *et al*. (2008) [14], Adewale *et al*. (2010) [1] and Malik *et al*. (2011) [16], while true density showed high heritability with moderate genetic advance. The high heritability and low genetic advance was recorded for bulk density. Low heritability and low genetic advance was found for WAI. The rank total of different genotypes also done based on character wise rank which was presented in

Conclusions

The study concluded, that selection based on high 100 seed weight, seed volume, water absorption capacity, true density, porosity, seedling length, seedling fresh weight, seedling dry weight and seedling vigour index may play an important role in lentil for designing desirable machines and equipments to be used during harvesting, seed processing, storing and transportation of the seed. Based upon the rank analysis the genotypes RLG-48, DPL-62, RLG-250, RLG-279 and RLG-225 were found to be most desirable for breeding purpose in respect to all the characters studied.

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