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Variability assessment and association analysis for yield and nutritional traits in improved lentil (*Lens culinaris*) genotypes

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Abstract
The present study was conducted to assess the genetic variability parameters and associations among the yield, yield attributing and nutritional traits. Variation analysis revealed a narrow difference between PCV and GCV estimates for most of the characters except seed/pod, biological weight and seed yield per. All traits show high heritability coupled with high genetic advance for most of the traits suggesting the preponderance of additive gene action. Correlation coefficient study revealed that seed yield/plant shows significant & positive relationship with biological weight, pods/plant, harvest index, hundred seed weight & seed/pod. The result of association analysis revealed that biological yield per plant and harvest index were the most important components for getting higher yield. The lentil genotypes were also characterized for stem, flower, leaf, growth habit and seed traits as per PPV&FRA guidelines showing considerable variability for all characters studied.

Keywords: genetic variability, correlation analysis, path analysis, morphological characterization

Introduction
Lentil (*Lens culinaris*) is one of the most important Rabi pulse crop in India. It belongs to Leguminosae family (2n = 14). The lentils are an important source of essential amino acids, fatty acids and trace mineral (Zia-Ul-Haq *et al*., 2011) [23]. India is the world's leading producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Currently lentil is primarily grown in the developing world with a particular concentration in Asia (45%), where India (24%) and Turkey (07%) are the largest producing countries. Global production of lentil is 6.3 million ton. In the New World, Canada is the leading producer followed by the India and Australia. (FAOSTAT, 2019) [5]. All India lentil production of 1.61 Mt from an area of 1.55 MH. with average productivity of lentil is 1039 kg/ ha (Success report 2018-19, Farmer portal). In Chhattisgarh it has 0.16 lakh ha area under lentil with average production of 0.06 lakh tones and average productivity of 375 kg/ha (Success report 2018-19, Farmer portal). Yield is the resultant product of various morphological and biological components. For any yield improvement programme selection of superior parents are pre requisite. The knowledge about genetic variability and heritability is helpful to the breeder to articulate selection criteria for improvement of yield associated parameter. The genotype possessing better heritability and genetic advance for various characters may serve as a best parent for any crop improvement programme (Khan *et al*., 2004). Studies on the genotypic correlation of the yield components along with nutritional traits and their contribution to yield through path analysis provide information to design appropriate breeding strategy towards improvement of the crop. Moreover, for maintenance of genetic purity of varieties during seed production and certification programme there is an urgent need of identification and documentation of diagnostic features of released varieties with their accurate identification keys such as colour of stem, flower and foliage colour, plant habit, cotyledon and testa colour and testa mottling, giving detailed description on comparative basis with clear-cut features of distinctness.

Materials and Methods
Plant materials
The present research was conducted in the experimental field of Research cum Instructional farm, Department of Genetics and Plant Breeding, College of agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh, during the *Rabi* season of 2020-21 with 30

genotypes of lentil improved lines.

The experiment was carried out under Randomized block design with 3 replications. Each genotype was accommodated in 4 rows plot of 4m length with row-row and plant-plant distance of 22.5cm and 5 cm, respectively. Thirty improved genotypes along with four checks from various parts of India, were used for this study. The observation was recorded on five randomly selected plants from each of the plot in each replication, data on yield attributing and nutritional traits were obtained by averaging the values. The pre-harvest observations recorded were days to first flowering, days to 50% flowering, days to maturity, plant height (cm), height of first pod, no. of primary branches/plant, no. of pods/plant, no. of seeds/pod, biological yield/plant (g), Harvest index (%). The post-harvest observations recorded were 100-seed weight (g) & seed yield/plant (g), along with three nutritional traits that is, protein percentage, Fe content (mg/kg) & Zn content (mg/kg) . For statistical analysis, average data from the sampled plants with respect to various traits were used. The genotypic and phenotypic coefficients of variation and heritability in broad sense were estimated using procedure given by Robinson *et. al* (1966) whereas, genetic advance (GA) estimated as per Johnson *et al.*, (1955) [8]. Test of significance for correlation coefficient, the estimated values were compared with table values (Fisher and Yates, 1963) [6] at n-2 degree of freedom at 5% and 1% level of significance. Path analysis were performed as described by Dewey and Lu (1959) [4]. The results of path coefficient analysis are interpreted as per the following scale suggested by Lenka and Mishra (1973) [13]. Characterization is done according to DUS guideline, PPV&FRA, 2007.

Results and Discussion

Anova

Variability is the prerequisite for improvement of any character in breeding programme. Analysis of variance revealed highly significant differences among the 30 genotypes for all the studied characters (Table 1), hence experimental material could be further exploited in hybridization programme for trait improvement. This result is in close harmony with Sharma *et al.* (2018) [18], Sakthivel *et al.* (2019) [17].

Variability analysis

Coefficient of variation studies indicated that the phenotypic coefficient variation (PCV) values were higher than those of genotypic coefficient variation (GCV) for most of the traits indicating the influence of environment to some extent on these traits both at vegetative and reproductive stage (Table 2). The study revealed that characters showed high genotypic coefficient variation (GCV) were seed yield/plant (29.93%) followed by seeds/pod (25.56%), biological yield (23.22%), hundred seed weight (22.58%) and number of primary branch (20.21%) respectively. High GCV for hundred seed weight and seed yield per plant were also reported earlier by Hissan *et al*., (2018). Similar finding was also confirmed by workers Sakthivel *et al*. (2019) [17] The high values of GCV for above characters indicate less manageable fluctuation; hence greater emphasis should be given on these traits while designing breeding programme with this material.

Heritability and Genetic advance

Estimation of broad sense heritability were found high for all the traits studied ranging from (80.06%) seeds/pod to (99.67%) for days to maturity mentioned. High heritability values showed that characters under investigation are less environmentally affected and have greater opportunity of genetic improvement through selection method. The results are quite in agreement with the findings of earlier workers Bhadru *et al*., 2012 [2] and Prajapati *et al*., 2011 [16].

High heritability coupled with high genetic advance as percent of mean was exhibited by traits *viz.*, seed yield/plant, hundred seed weight, pods/plant and biological yield/plant, suggesting that these traits are less influenced by the environment and are more stable and governed by additive gene action. Consequently have greater chance of improving these characters via simple selection method. The findings are in conformity with the previous workers Kumar *et al.* (2009) [11], Kumari *et al*. (2018) [12], Ghimire *et al*. (2019) [7] and Vanave *et al*. (2019) [21].

Association analysis

The genotypic and phenotypic correlation coefficients among the fifteen traits are presented in (Table 3a and 3b). The analysis revealed that yield/plant is significantly and positively correlated with biological weight (0.795**,0.818**) followed by pods/plant (0.695**, 0.690**), harvest index (0.623**,0.610**) hundred seed weight (0.463**, 0.425**) and seeds/pod (0.410**, 0.353**) at both level, respectively. It shows negative correlation with flowering period both at genotypic and phenotypic level also reported by Karadavut (2009) [9]; Tyagi and Khan (2010) [20]; Sharma *et al*. (2014) [19]. Among the other characters pods per plant was found to positively and significantly correlated by seeds per pod, biological yield per plant and harvest index whereas, protein percent was found significantly correlated by iron content. The correlation analysis revealed the association among the traits, thus relationship of various lentil traits would determine their relative significance for improving the yield.

Path analysis

The path coefficient analysis revealed that direct and indirect contribution of harvest index, biological yield per plant and pods per plant were maximum on seed yield per plant (Table 4). All the other characters showed their indirect influence primarily through biological yield per plant and harvest index. Thus, both correlation and path coefficient studies showed that these two characters were the most important components for getting higher yield. Higher direct effect of biological yield/plant was also reported by Younis *et al.*, (2008) [22], Sharma *et al.*, (2014) [19], Dalbeer *et al.*, (2015) [3], Pandey *et al.*, (2017) [15] and Sakthivel *et al.*, (2019) [17].

Morphological characterization

Thirteen different qualitative characters of 30 lentil genotypes were studied on the basis of DUS descriptors (PPV&FRA, 2007). Pod anthocyanin, leaf pubescence and cotyledon colour do not show any variation among varieties. Stem anthocyanin was present in fifty percent of the population. Foliage green colour intensity, growth habit and leaflet size are important visual parameter and variation was present in all form for above mentioned characters. Most of the varieties are medium duration and medium height *i.e.* 67% whereas, 33% of the population is short heighted and short duration. Only WBL-77 show white flower colour, rest all varieties fall under violet flower colour. 80% population shows the testa mottling. Seed size and testa colour are important stable character

which show variation in maximum category. Detailed description of characterization was present in Table no. 5 and graphical representation in Figure 1.

Table 1: Analysis of variance for nutritional and yield attributing traits in Lentil

Source of variation	df	DFF	D50%	DM	PH (cm)	FPH (cm)	PB	PPP	SP	BW (g)	HI (%)	100 SW (g)	SYPP (g)	P %	Fe (mg/kg)	Zn (mg/kg)
Replication	2	0.48	0.21	0.08	0.68	0.44	0.03	5.18	0.09	0.11	1.74	0.01	0.03	1.680*	1.740*	0.58
Treatment	29	165.69**	142.09**	92.34**	36.57**	8.71**	0.78**	183.05**	0.37**	2.13**	147.17**	1.33**	0.61**	6.82**	245.12**	210.41**
Error	58	0.546	0.498	0.1	0.643	0.147	0.012	2.160	0.028	0.11	0.684	0.003	0.026	0.412	0.433	0.421
*Significant at p=0.05% level, **Significant at p=0.01% level																

df	=	degree of freedom	PH	=	Plant height (cm)	SP	=	Seeds/pod	SYPP	=	Seed yield/plant
DFF	=	Days to first flowering	FPH	=	Height of first pod (cm)	BW	=	Biological weight	P%	=	Protein(%)
D50%	=	Days to 50% flowering	PB	=	Number of primary branches	HI(%)	=	Harvest index (%)	Fe	=	Iron content (mg/kg)
DM	=	Days to maturity,	PPP	=	Pods/plant	100 SW	=	100 Seed weight (g)	Zn	=	Zinc content (mg/kg)

Table 2: Genetic variability parameters for yield attributing & nutritional traits in lentil

Characters	Mean	Max	Min	SD	SE	GCV (%)	PCV	h^2 (%)	GA (%)
DFF	51.77	67.34	40.34	7.431	1.35	14.32	14.40	99.01	29.37
D50%	62.02	75.00	50.00	6.88	1.25	11.07	11.13	98.95	22.69
DM	105.80	116.34	97.00	5.54	1.01	5.24	5.24	99.67	10.77
PH (cm)	39.40	43.93	28.86	3.49	0.63	8.78	9.015	94.90	17.62
FPH (cm)	18.10	21.43	14.00	1.70	0.31	9.32	9.61	94.03	18.62
PB	2.51	3.36	1.86	0.50	0.09	20.21	21.88	85.35	38.47
PPP	39.30	55.73	23.13	7.81	1.42	19.75	20.10	96.54	39.98
SP	1.31	1.93	1.00	0.34	0.06	25.56	28.56	80.06	47.11
BW	3.52	5.54	2.36	0.84	0.15	23.22	25.19	84.95	44.10
HI (%)	41.50	55.51	30.61	7.00	1.27	16.83	16.95	98.61	34.45
100 SW(g)	2.95	3.90	1.63	0.74	0.13	22.58	22.67	99.26	46.37
SYPP (g)	1.46	2.46	0.97	0.45	0.08	29.93	31.89	88.10	57.87
P %	22.62	25.69	19.00	1.47	0.26	6.46	7.05	83.82	12.18
Fe (mg/kg)	74.43	90.80	54.40	14.14	2.58	12.13	12.16	99.47	24.92
Zn (mg/kg)	65.51	79.83	41.60	8.37	1.52	12.77	12.81	99.40	26.22

DFF	=	Days to first flowering	PB	=	Number of primary branches	100 SW	=	100 Seed weight(g)
D50%	=	Days to 50% flowering	PPP	=	Pods/plant	SYPP	=	Seed yield/plant
DM	=	Days to maturity	SP	=	Seeds/pod	P%	=	Protein (%)
PH	=	Plant height (cm)	BW	=	Biological weight	Zn	=	Zinc content (mg/kg)
FPH	=	Height of first pod (cm)	HI(%)	=	Harvest index (%)	Fe	=	Iron content (mg/kg)

Table 3(a): Genotypic correlation among fifteen traits in thirty varieties of lentil

	DFF	D50%	DM	PH (cm)	FPH (cm)	PB	PPP	SP	BW (g)	HI (%)	100 SW (g)	SYPP (g)	P %	Fe (mg/kg)	Zn (mg/kg)
DFF	1														
D50%	0.955**	1													
DM	0.745**	0.700**	1												
PH (cm)	0.050	-0.020	0.070	1											
FPH (cm)	0.234*	0.244*	0.103	0.302**	1										
PB	0.134	0.032	0.230*	-0.171	-0.023	1									
PPP	-0.407**	-0.515**	-0.340**	-0.060	-0.128	0.427**	1								
SP	-0.267*	-0.379**	-0.276**	-0.083	0.032	0.016	0.468**	1							
BW (g)	-0.318**	-0.366**	-0.425**	-0.044	-0.304**	0.291**	0.566**	0.205	1						
HI (%)	-0.675**	-0.729**	-0.250*	-0.053	-0.270*	-0.029	0.372**	0.326**	0.040	1					
100 SW(g)	-0.317**	-0.256*	-0.258*	0.247*	-0.148	-0.168	0.157	0.180	0.494**	0.200	1				
SYPP(g)	-0.644**	-0.720**	-0.488**	-0.052	-0.353**	0.173	0.695**	0.410**	0.795**	0.623**	0.463**	1			
P%	0.016	0.066	0.014	-0.118	-0.030	0.010	0.005	-0.046	-0.323**	0.087	-0.165	-0.206	1		
Fe (mg/kg)	0.003	0.006	-0.207	-0.050	0.282**	0.248*	0.242*	0.007	0.204	-0.045	0.108	0.118	0.239*	1	
Zn (mg/kg)	0.475**	0.460**	0.381**	0.017	-0.036	0.149	-0.103	-0.272**	0.006	-0.317**	-0.009	-0.197	0.079	-0.046	1
*Significant at p=0.05% level, **Significant at p=0.01% level															

DFF	=	Days to first flowering	FPH	=	Height of first pod (cm)	BW	=	Biological weight	P%	=	Protein (%)
D50%	=	Days to fifty percent flowering	PB	=	Number of primary branches	HI (%)	=	Harvest index (%)	Fe	=	Iron content (mg/kg)
DM	=	Days to maturity,	PPP	=	Pods/plant	100 SW	=	100 Seed weight(g)	Zn	=	Zinc content (mg/kg)
PH	=	Plant height (cm)	SP	=	Seeds/pod	SYPP	=	Seed yield/plant			

Table 3(b): Phenotypic correlation among fifteen traits in thirty varieties of lentil

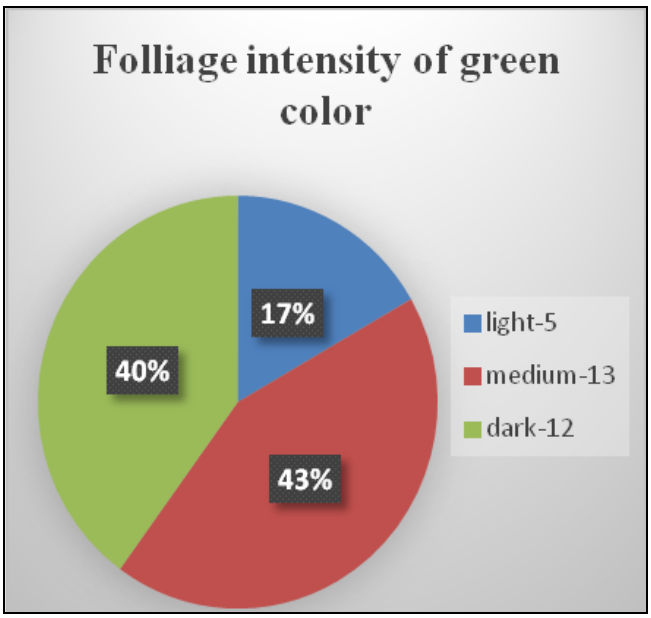
	DFF	D50%	DM	PH (cm)	FPH (cm)	PB	PPP	SP	BW (g)	HI (%)	100 SW (g)	SYPP (g)	P %	Fe (mg/kg)	Zn (mg/kg)
DFF	1														
D50%	0.936**	1													
DM	0.739**	0.694**	1												
PH (cm)	0.048	-0.017	0.065	1											
FPH (cm)	0.227*	0.239*	0.100	0.302**	1										
PB	0.122	0.028	0.213*	-0.135	-0.008	1									
PPP	-0.398**	-0.498**	-0.335**	-0.061	-0.127	0.395**	1								
SP	-0.237*	-0.335**	-0.244*	-0.082	0.003	-0.003	0.412**	1							
BW (g)	-0.296**	-0.328**	-0.395**	-0.038	-0.279**	0.247*	0.569**	0.191	1						
HI (%)	-0.667**	-0.716**	-0.249*	-0.052	-0.258*	-0.026	0.376**	0.282**	0.064	1					
100 SW (g)	-0.313**	-0.253*	-0.257*	0.242*	-0.146	-0.156	0.154	0.164	0.455**	0.197	1				
SYPP(g)	-0.605**	-0.665**	-0.461**	-0.045	-0.323**	0.153	0.690**	0.353**	0.818**	0.610**	0.425**	1			
P%	0.019	0.048	0.018	-0.097	-0.034	0.011	-0.001	-0.009	-0.290**	0.074	-0.149	-0.193	1		
Fe (mg/kg)	0.003	0.007	-0.206	-0.045	0.275**	0.230*	0.237*	0.006	0.190	-0.043	0.107	0.111	0.216*	1	
Zn (mg/kg)	0.470**	0.455**	0.380**	0.013	-0.034	0.132	-0.103	-0.250*	0.002	-0.315**	-0.008	-0.187	0.073	-0.045	1
*Significant at p=0.05% level, **Significant at p=0.01% level															

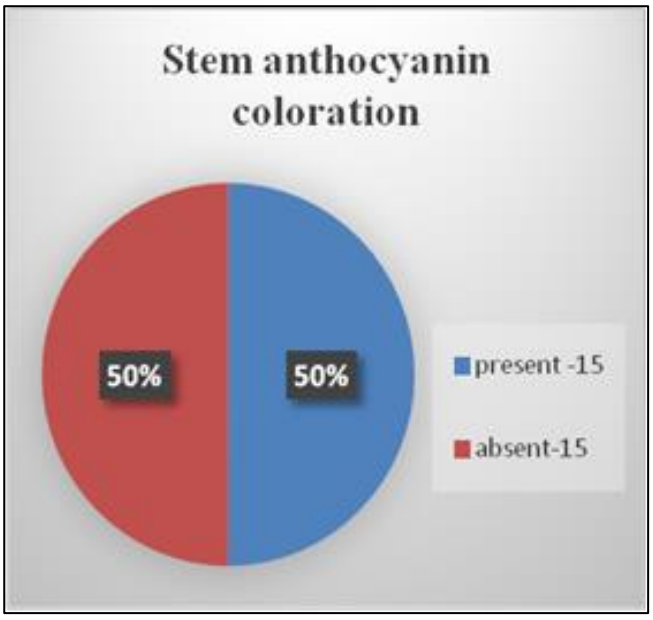
DFF	=	Days to first flowering	FPH	=	Height of first pod (cm)	BW	=	Biological weight	P%	=	Protein(%)
D50%	=	Days to fifty percent flowering	PB	=	Number of primary branches	HI(%)	=	Harvest index (%)	Fe	=	Iron content (mg/kg)
DM	=	Days to maturity,	PPP	=	Pods/plant	100 SW	=	100 Seed weight(g)	Zn	=	Zinc content (mg/kg)
PH	=	Plant height (cm)	SP	=	Seeds/pod	SYPP	=	Seed yield/plant			

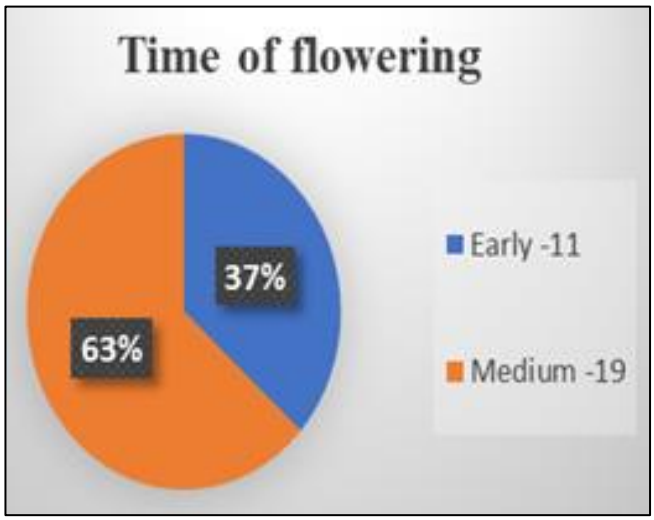
Table 4: Genotypic direct and indirect effects of nutritional and yield attributing traits on seed yield/plant (g) as dependent trait

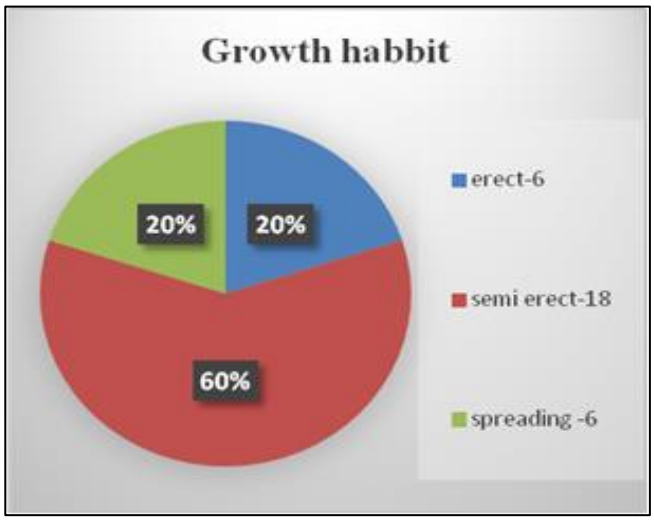
	DFF	D50%	DM	PH (cm)	FPH (cm)	PB	PPP	SP	BW (g)	HI (%)	100 SW (g)	P %	Fe (mg/kg)	Zn (mg/kg)	Genotypic correlation
DFF	0.1527	-0.1035	-0.0106	-0.0017	0.01329	-0.0080	-0.0395	-0.0014	-0.2331	-0.3836	-0.0168	-0.001	-0.0001	-0.0109	-0.644**
D50%	0.1459	-0.1084	-0.0100	0.00067	0.01389	-0.0019	-0.0499	-0.0021	-0.2689	-0.4142	-0.0136	-0.0001	-0.0002	-0.0105	-0.720**
DM	0.1138	-0.0758	-0.0142	-0.0023	0.00584	-0.0138	-0.0329	-0.0015	-0.3116	-0.1421	-0.0137	-0.0002	0.0093	-0.0087	-0.488**
PH(Cm)	0.0076	0.0022	-0.0010	-0.034	0.01717	0.0103	-0.058	-0.0004	-0.0326	-0.0303	0.01316	0.0018	0.0022	-0.0004	-0.052
FPH(Cm)	0.0357	-0.0264	-0.0014	-0.0102	0.05688	0.0014	-0.012	0.00018	-0.2235	-0.1532	-0.0078	0.0005	-0.013	0.0008	-0.353**
PB	0.0205	-0.0034	-0.0032	0.0058	-0.0013	-0.0602	0.0415	0.00009	0.21346	-0.0164	-0.0089	-0.0002	-0.0111	-0.0034	0.173
PPP	-0.0621	0.0557	0.0049	0.0020	-0.0072	-0.0257	0.0974	0.0026	0.4158	0.2115	0.00834	- 0.0001	-0.0108	0.0024	0.695**
SP	-0.0407	0.0411	0.0039	0.00283	0.00182	-0.009	0.0459	0.00555	0.15022	0.18535	0.00955	0.0007	-0.0003	0.0062	0.410**
BW(g)	-0.0485	0.0397	0.0061	0.00151	-0.0173	-0.0175	0.0550	0.00114	0.73415	0.02286	0.02626	0.00051	-0.0091	-0.0001	0.795**
HI(%)	-0.1031	0.0790	0.0036	0.00182	-0.0153	0.0175	0.0362	0.00181	0.02953	0.56837	0.01061	-0.0001	0.002	0.00727	0.623**
100 SW(g)	-0.0484	0.0278	0.0037	-0.0084	-0.0084	0.01014	0.0153	0.001	0.3626	0.11341	0.05317	0.0005	-0.0048	-0.0007	0.516**
P %	0.0024	-0.0071	-0.0002	0.00401	-0.0017	-0.005	0.0045	-0.0002	-0.2367	0.04923	-0.0015	-0.0015	-0.0107	-0.0018	-0.206
Fe (mg/kg)	0.0005	-0.0006	0.00295	0.0017	0.01604	-0.0149	0.0235	0.00004	0.14989	-0.0253	0.00576	-0.0003	-0.0448	0.0034	0.118
Zn (mg/kg)	0.0725	-0.0498	-0.0054	-0.0005	-0.0020	-0.0089	-0.0099	-0.0015	0.0042	-0.1801	0.0017	-0.001	0.0066	-0.0229	-0.197
*Significant at p=0.05% level, **Significant at p=0.01% level															

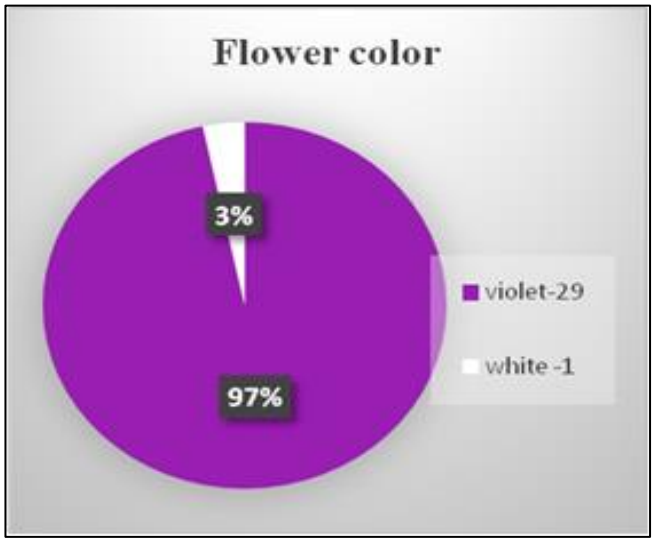
DFF	=	Days to first flowering	FPH	=	Height of first pod (cm)	BW	=	Biological weight	P%	=	Protein (%)
D50%	=	Days to fifty percent flowering	PB	=	Number of primary branches	HI (%)	=	Harvest index (%)	Fe	=	Iron content (mg/kg)
DM	=	Days to maturity,	PPP	=	Pods/plant	100 SW	=	100 Seed weight(g)	Zn	=	Zinc content (mg/kg)
PH	=	Plant height (cm)	SP	=	Seeds/pod	SYPP	=	Seed yield/plant			

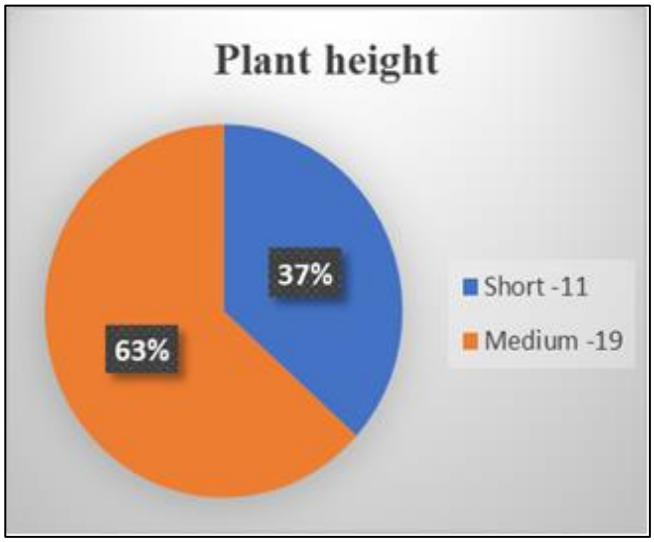


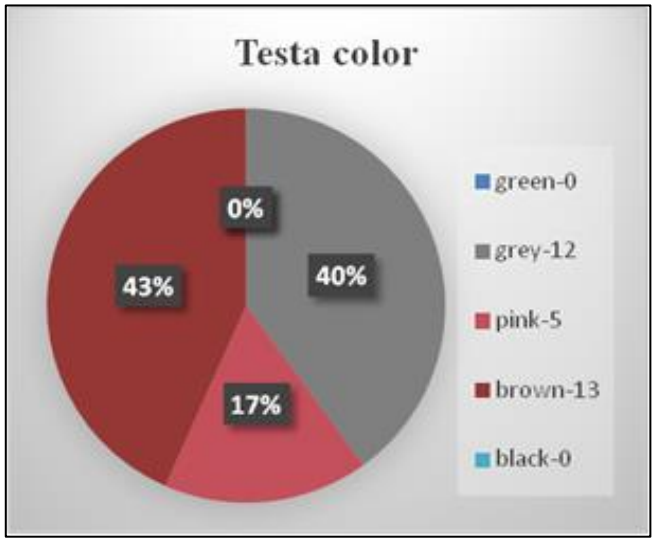


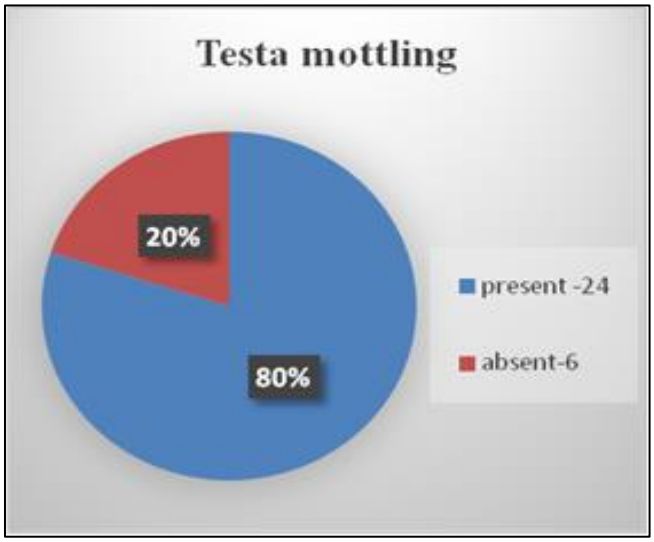

Time of flowering
37%
63%
Early -11
Medium -19


Growth habbit
20%
20%
60%
erect-6
semi erect-18
spreading -6


Flower color
3%
97%
violet-29
white -1


Plant height
37%
63%
Short -11
Medium -19


Testa color
0%
40%
43%
17%
green-0
grey-12
pink-5
brown-13
black-0


Testa mottling
20%
80%
present -24
absent-6

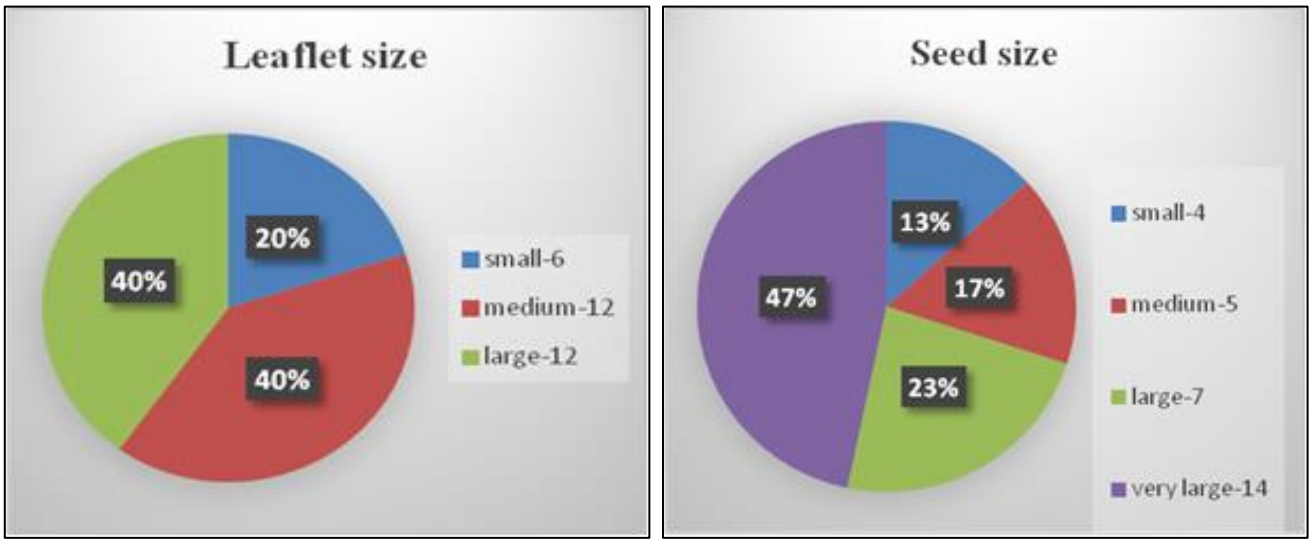


Fig 1: Graphical representation of different morphological characters.

Table 5: Characterization of different morphological characterization on the basis of DUS guideline PPV& FRA, 2007

Characters	States	No. of varieties	Name of varieties
Foliage color intensity	Light	5	L 4727, RVL-11-6,LH-89-48, LL 1373, WBL 77
	Medium	13	RVL-31,RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR -1, L-4076, DPL -15, IPL 81,IPL 406, IPL 220, NARENDRA MASOOR 2,LH-84-8, LH-82-6
	Dark	12	RVL-13-5, HVL-57, RLG-5, L-4717, L-4147, LH-84-8, LL 931, DPL 62, IPL 316, PANT L 7, PANT L 8, NARENDRA MASOOR 1
Stem anthocyanin coloration	Absent	15	RVL-11-6, RVL-31, RVL-13-7, JL-3, L-4717, LH-84-8, LH-82-6, DPL-15, DPL-62, IPL-220, IPL-316, IPL-406, KOTA MASOOR-1, LL-931, PANT-L-7
	Present	15	RVL-13-5, HUL-57, KOTA MASOOR-2, RLG-5, L-4076, L-4727, L-4147, LH-89-48, LL-699, LL-1373 IPL-81, WBL-77, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
Time of flowering	Early (<60) days	11	RVL-11-6, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4717, L-4076, WBL-77, PANT- L-7
	Medium (60-80) days	19	RVL-13-5, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-1373, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-406, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
Leaf pubescence	Present	30	RVL-11-6, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4717, L-4076, WBL-77, PANT- L-7, RVL-13-5, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-1373, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-406, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
Leaflet size	Small	6	HVL-57, L-4147, LH-89-48, LL 699, IPL 220,PANT L 8
	Medium	12	RVL-31, KOTA MASOOR-2, RLG-5, L-4717,LH-84-8,LL 1373,LL 931,DPL 62,IPL 81,WBL 77,NARENDRA MASOOR 1,NARENDRA MASOOR 2
	Large	12	RVL-11-6,RVL-13-5, RVL-13-7, JL-3, KOTA MASOOR -1, L 4727, L-4076,LH-82-6,DPL -15,IPL 406, IPL 316,PANT L 7
Growth habit	Erect	6	DPL-15, L-4717, LH-82-6, LL-699, IPL-220, WBL-77
	Semi erect	18	DPL-62, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4076, PANT-L-7, HUL-57, L-4147, LH-89-48, LH-84-8, LL-1373, LL-931, IPL-316, IPL-406 NARENDRA MASOOR-1, NARENDRA MASOOR-2
	Spreading	6	RVL-11-6, RVL-13-5, RLG-5, L-4727, IPL-81, PANT-L-8
Flower color	White	1	WBL-77
	Violet	29	RVL-11-6, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4717, L-4076, PANT- L-7, RVL-13-5, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-1373, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-406, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
Plant height	Short (<40 cm)	11	RVL-31, RVL-13-7, JL-3, L-4727, L-4717, L-4147, LH-89-48, LL-1373, DPL-15, DPL-62, IPL-220
	Medium (40-60 cm)	19	RVL-11-6, RVL-13-5, HUL-57, KOTA MASOOR-2, KOTA MASOOR-1, RLG-5, L-4076, LH-84-8, LH-82-6, LL-699, LL-931, IPL-81, IPL-316, IPL-406, WBL-77, PANT-L-8, PANT-L-7, NARENDRA MASOOR-1, NARENDRA MASOOR-2
	Absent	30	RVL-11-6, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4717, L-4076, WBL-77, PANT- L-7, RVL-13-5, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-1373, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-406, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
Seed size	Small(<2g)	4	L-4717, PANT L 8, LH-89-48, L-4147
	Medium (2-	5	LL 699, HUL-57, IPL 220, NARENDRA MASOOR 1, NARENDRA MASOOR 2

	2.5g)		
	Large(2.6-3g)	7	RVL-13-5, KOTA MASOOR -1, IPL 81, IPL 316, WBL 77, LH-84-8, RLG-5
	Very large (>3g)	14	RVL-11-6, RVL-31, RVL-13-7, KOTA MASOOR-2, L 4727, LH-82-6, L-4076, JL-3, LL 1373, DPL 62, DPL -15, LL 931, IPL 406, PANT- L-7, LH-82-6
	grey	12	RVL-11-6, RVL-13-7,L 4727, LH-89-48,LH-82-6,LL 699, DPL -15, IPL 220,PANT L 8,NARENDRA MASOOR 1,NARENDRA MASOOR 2
	pink	5	HVL-57,LL 931,DPL 62,IPL 81,WBL 77
	brown	13	RVL-13-5, RVL-31, JL-3, KOTA MASOOR-2,KOTA MASOOR -1,RLG-5, L-4717, L-4076, LH-84-8, LL 1373, IPL 406,IPL 316,PANT L 7
Testa mottling	Present	24	RVL-31, RVL-13-7, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4076, WBL-77, PANT- L-7, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2
	Absent	6	RVL-11-6,RVL-13-5,JL-3,L-4717,LL-1373,IPL-406,
	orange	30	RVL-11-6, RVL-31, RVL-13-7, JL-3, KOTA MASOOR-2, KOTA MASOOR-1, L-4727, L-4717, L-4076, WBL-77, PANT- L-7, RVL-13-5, HUL-57, RLG-5, L-4147, LH-89-48, LH-84-8, LH-82-6, LL-699, LL-1373, LL-931, DPL-15, DPL-62, IPL-81, IPL-316, IPL-406, IPL-220, PANT-L-8, NARENDRA MASOOR-1, NARENDRA MASOOR-2

Conclusion

The knowledge on available traits variability and their relationships is important to understand and its potential use in breeding programs of lentil crops. The present study generally implied the presence of significant genetic variability among the tested genotypes. Higher estimates of heritability and genetic advance were observed for seed yield/plant, hundred seed weight, pods/plant and biological yield/plant indicating that these characters are mainly controlled by additive genes and selection of such traits might be effective for the improvement of seed yield. Phenotypic correlation revealed that biological weight, pods/plant , harvest index , hundred seed weight and seeds/pod have their relative significance for improving the yield. The result of association analysis revealed that biological yield per plant and harvest index were the most important components for getting higher yield. The phenotyping of lentil genotypes at seed and plant levels helps in the identification and discrimination of varieties along with their maintenance of genetic purity during seed production and certification programme.

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