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Assessment of variability for agro-morphological traits in elite lentil (*Lens culinaris*) lines using multivariate analysis

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ABSTRACT

Genetic variability was assessed using multivariate analysis among elite lentil lines derived through hybridization between *macrosperma* and *microsperma* types. As per principal component analysis, first four principal components (PC) expressed 83.50% of total variation in which PC I, PC II, PC III & PC IV accounted for 34.73%, 27.14%, 11.94% and 9.69% of total variation, respectively. On the basis of cluster analysis, cluster III was found promising for yield and its major component traits as it had the highest mean values for number of pods per plant (69), 100 seed weight (1.81g), seed yield per plant (1.73g), biological yield per plant (5.0g), harvest index (35.13%) and maturity (159 days). The correlation study between yield and its components, traits *viz.*, biological yield per plant (r=0.70), number of pods per plant (r=0.55) and delayed maturity (r=0.40) were found major yield contributing traits and can be given due emphasis during development of improved genotypes of lentil for rainfed condition of Uttarakhand hills.

Key words: Cluster analysis, Genetic variability, Lentil (*Lens culinaris* Medikus), Principal Component Analysis (PCA).

INTRODUCTION

Lentil (*Lens culinaris* Medikus) is an important grain legume particularly, in the Indian sub-continent and South East Asia. Approximately, half of the world's area (48%) and 37% of production of lentil is contributed by South Asia. Among South Asian lentil growing countries, India alone accounts for 78.56% of acreage and 77.98% of production but lags well behind world's productivity of 966 Kg/ha (Rahman *et al.*, 2005). Poor yield level of lentil is mainly because it is grown on residual soil moisture under rainfed conditions by resource poor farmers with traditional cultivars. Traditionally grown Indian lentils are although, fairly adapted to the local environmental conditions but susceptible to many biotic and abiotic stresses (Kumar *et al*., 2009). In India, lentil occupies 1.56 m ha area, contributes 1.05 million tonnes production with 678 Kg/ha productivity (DAC, 2011-12) and about 65% of lentil area is under the varieties of *microsperma* (small seeded) type, mainly grown in Punjab, Haryana, Uttar Pradesh and Bihar whereas about 35% of area is under *macrosperma* (large seeded) type varieties grown mostly in Madhya Pradesh and adjoining districts of Uttar Pradesh (Tickoo *et al*., 2005). Traditionally cultivated *microsperma* type Indian lentils are more polymorphous, more pigmented, characterized by early flowering and maturity, low biological yield, short stature and small seeds (Erksine *et al.*, 1998) with *pilosae* traits *i.e.* pubescence on the vegetative organs and short/rudimentary tendril at the tip of leaf (Vandenberg and Slinkard, 1989). On the contrary, *macrosperma* lentil genotypes are adapted to long day conditions and possesses many desirable traits like upright growth habit, profuse foliage and large seed size but generally, yields lower than the small seeded ones (Majumdar, 2011; Tickoo *et al*., 2005). As the seed size increases, the number of seeds per pod and pods per plant decreases considerably which adversely affect the seed yield (Singh *et al*., 2009). Furthermore, small seeded lentils are better adapted to dry environments whereas large seeded varieties have greater cold tolerance (Erskine, 1996). Lentils of *microsperma* and *macrosperma* types have diverse geographical evolution as well as genetic makeup and judicious use of both of these in hybridization programmes can be helpful in developing high yielding, biotic and abiotic stress resistant genotypes with wider adaptability as well as advantageous in the broadening of the existing genetic base of lentil (Lal *et al.*, 2000; Chahota *et al*., 2007; Kumar *et al*., 2009).

In the present investigation, elite lines of lentil derived through hybridization between *microsperma* and *macrosperma* followed by selection of desirable recombinants in segregating generations practicing pedigree method, were

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evaluated to compare the performance of genotypes under rainfed condition of mid altitudes of Uttarakhand hills.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2013-14 at Experimental Farm, VPKAS, Hawalbagh, Almora ($29^0$35'N & $79^0$39'E at an elevation of 1250 m asl) under rainfed condition of Uttarakhand hills of India. The experimental material comprised of 59 elite lines of lentil which were developed by crossing of *microsperma* and *macrosperma* type parents and segregating generations were subjected to pedigree method of selection up to F_6/F_7 generation. These lines were manually sown in augmented design with 2 checks *viz.,* VL *Masoor* 125 and VL *Masoor* 133. The plot size was 4 rows of 3 m length with 23cm row to row and 2.5cm plant to plant spacing. Recommended dose of fertilizer *i.e.,* 20, 40 and 20 kg/ha NPK was applied as basal dose. All other recommended crop management practices were followed to raise a healthy crop. The data were recorded on different agro morphological traits *viz.,* days to flowering, days to maturity, plant height (cm), number of pods per plant, pod length (cm), 100 seed weight (g), seed yield per plant (g) and biological yield per plant (g). Observations on principal phenological stages *viz.,* flowering and maturity were recorded at 50% of flowering and 80% maturity, respectively, on whole plot basis. Plant height (cm), number of pods per plant, seed yield per plant (g), and biological yield per plant (g) were recorded on 3 randomly sampled plants. Pod length (cm) was recorded on 10 pods sampled at random within each genotype. 100 seed weight (g) was recorded on random seed sample for each genotype and harvest index (HI) was calculated as economic yield expressed as percentage of total biological yield. Statistical analysis for seed yield, primary and secondary yield components and phenological traits were performed to determine simple statistical estimates, *i.e.,* mean, range, CV (%) (Singh and Chaudhary, 1985) and Principal Component Analysis (Rao, 1984). Correlation coefficient between Principal Component Axes scores and adjusted mean values of the traits were computed. First and second principal component axes scores were plotted to aid visualization of group difference within lentil genotypes. All the quantitative traits were analyzed with the help of SAS (9.3 version) and SYSTAT computer software.

RESULTS AND DISCUSSION

To determine the magnitude of genetic variation, morphological evaluation is an important step in description and classification of genotypes (Zubair *et al.,* 2007). Moderate to high variability was observed for majority of quantitative traits *viz.,* days to 50% flowering(101-127), plant height (21.33-36.33cm), number of pods per plant (21-99), biological yield per plant (2.09-8.65 g), harvest index (14.61-47.69 %) and seed yield per plant (0.54-2.85 g) (Table 1). This indicated that in this set of materials considerable genetic variability exists, which has great significance to the plant breeder as it plays a crucial role in framing a triumphant breeding programme as well as improvement of these traits through selection.

Transformation of quantitative traits into principal component yielded 9 eigen vectors and roots. First eigen vector expressed highest eigen value 3.13 and only first three of the nine Principal Component Axes (PCA) had given eigen value more than one. Only principal component with eigen value more than one were considered in determining the agro morphological variability in accessions (Kaiser, 1960) which suggest differentiation of the genotypes was because of relatively high contribution of few characters rather than small contribution from each character. Principal Component Analysis (PCA) reflects the importance of the largest contributor to the total variation at each axis of differentiation and also identifies plant traits that contribute most to the observed variation within group of genotypes. Afuape *et al.* (2011) advocated its practical application in the selection of parental lines for breeding purposes. The first four Principal

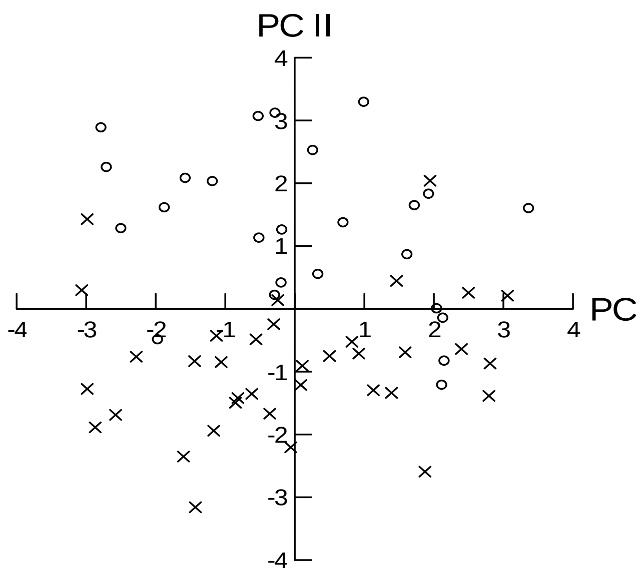
TABLE 1: Estimates of mean, range, CV (%), eigen value and variation (%) explained by each eigen root for 9 quantitative traits in elite lines of lentil.

Characteristics	Mean	Range	CV (%)	Eigen value	Variation (%) explained by each eigen root
Days to 50% flowering	113	101-127	5.74	3.13	34.73
Plant height (cm)	27.87	21.33-36.33	12.56	2.44	27.14
Number of pods per plant	47.9	21-99	43.74	1.08	11.94
Pod length (cm)	1.03	0.93-1.13	3.88	0.87	9.69
Days to maturity	156	152-164	2.06	0.57	6.37
Biological yield per plant (g)	4.88	2.09-8.65	28.07	0.38	4.2
Seed yield per plant(g)	1.48	0.54-2.85	35.14	0.31	3.47
100 seed weight (g)	1.81	1.24-2.60	17.78	0.21	2.33
Harvest Index (%)	30.53	14.61-47.69	25.75	0.01	0.13

Component Axes (PCA), together accounted for 83.50% of total variance and PC I, PC II, PC III and PC IV accounted for 34.73%, 27.14%, 11.94% and 9.69% of total variation, respectively. Highly significant positive correlation of PCI was observed with harvest index (0.471) followed by number of pods per plant (0.462), days to maturity (0.451), seed yield per plant (0.413) and days to 50% flowering (0.379) (Table 2). The traits with highly significant positive weight on PC II were biological yield per plant (0.507), plant height (0.467), pod length (0.424) and 100 seed weight (0.405). PCA III had highly significant positive correlation with pod length (0.558) and 100 seed weight (0.376) whereas, highly significant negative correlation was recorded for seed yield per plant (0.383) and biological yield per plant (0.498). PC IV had highly significant positive correlation with plant height (0.456) and days to 50% flowering (0.420) whereas, significant negative association was observed for 100 seed weight (0.665) and harvest index (0.270). Principal Component Analysis showed maximum contribution of pods per plant, days to 50% flowering, plant height and days to maturity to total diversity among the studied accessions (Kumar and Solanki, 2014). The first two principal components PCI and PCII contributed 61.87 % of total variation were plotted graphically to represent variability among genotypes (Figure 1). Two distinct groups were formed with slight overlapping between genotypes. Dispersion pattern clearly demarcated the lentil genotypes possessing high (>5g/ plant) and low (<5g/plant) biological yield per plant. Twenty seven lentil landraces belonging to the two different seed morphological groups were characterized using Principal Component Analysis (PCA) and cluster analysis by Cristobal *et al*., 2014.

Lentil genotypes under study were grouped into 3 distinct groups based on cluster analysis. Cluster analysis is a statistical technique that can be applied to data that exhibit “natural” groupings. Cluster analysis sorts through the raw data and groups them into clusters (Kayan and Adak, 2012). Maximum number of genotypes were grouped in cluster I (34) followed by cluster II (21) and III (6). Mean values of three different clusters (Table 2) revealed that, cluster I is having least mean values for days to 50% flowering (110) and days to maturity (154) whereas, cluster III had genotypes with most delayed maturity (159 days) with highest mean values for the traits *viz*., number of pods per plant (69), 100 seed weight (1.81 g), seed yield per plant (1.73) biological yield per plant (5g) and harvest index (35.13%). Cluster analysis revealed that genotypes from these two clusters (I & III) can be used further in hybridization in order to get early maturing and productive recombinants which may produce higher amount of heterotic expression.

Grain yield is a complex trait and interplay of various yield contributing traits. The estimates of the inter relationship between grain yield and other yield attributes as well as among themselves would facilitate effective selection schemes to



*Biological yield per plant >5g (o) and <5g(x)

FIG 1: Scatter diagram based on Principal Components (PCI & PCII) scores of elite lentil lines

TABLE 2: Cluster means, correlation coefficient among Principal Components and 9 quantitative traits of elite lentil lines

Characteristics	Cluster mean values			Correlation coefficients with Principal Components			
	C I	C II	C III	PCI	PCII	PC III	PC IV
Days to 50% flowering	110	114	116	0.379**	-0.264	0.175	0.420**
Plant height (cm)	29	27	27	-0.169	0.467**	0.065	0.456**
Number of pods/ plant	31	53	69	0.462**	0.014	-0.134	-0.004
Pod length (cm)	1.03	1.03	1.03	0.088	0.424**	0.558**	0.252*
Days to maturity	154	157	159	0.451**	0.023	0.311*	0.121
Biological yield/plant (g)	4.77	4.55	5	0.101	0.507**	-0.498**	0.112
Seed yield/ plant(g)	1.27	1.42	1.73	0.413**	0.312*	-0.383**	-0.101
100 seed weight (g)	1.8	1.78	1.81	-0.001	0.405**	0.376**	-0.665**
Harvest Index (%)	26.77	31.44	35.13	0.471**	-0.117	0.055	-0.270*

*, **: Significant at 5% and 1% probability levels, respectively.

TABLE 3: Correlation coefficients among 9 quantitative traits in elite lentil lines

Characteristics	X1	X2	X3	X4	X5	X6	X7	X8	X9
Days to 50% flowering (X1)	1.00								
Plant height (X2)	-0.35**	1.00							
Number of pods/ plant(X3)	0.39**	-0.23	1.00						
Pod length (X4)	0.02	0.46**	0.06	1.00					
Days to maturity (X5)	0.52**	-0.13	0.65**	0.25	1.00				
Biological yield/plant (X6)	-0.21	0.45**	0.20	0.29*	0.04	1.00			
Seed yield/plant (X7)	0.23	0.08	0.55**	0.21	0.40**	0.70**	1.00		
100 seed weight (X8)	-0.35**	0.24	-0.05	0.44**	0.08	0.26*	0.20	1.00	
HI % (X9)	0.56**	-0.38**	0.54**	0.00	0.54**	-0.12	0.60**	0.02	1.00

*, **: Significant at 5% and 1% probability levels, respectively.

improve the yield. Information on nature and magnitude of association among different traits can be helpful in indirect selection of desirable traits with low heritability, simultaneous selection of several traits (Singh, 1972) and to avoid undesirable correlated changes in desirable traits during selection (Tyagi and Khan, 2010). Strong significant positive correlation of seed yield per plant was observed with biological yield per plant (0.70), number of pods per plant (0.55) and days to maturity (0.40) (Table 3) and this could be used as important selection index for high yielding genotype under rainfed hill conditions. Significant positive association between 100 seed weight with pod length (0.44) and biological yield per plant (0.26) indicated that success could be achieved in combining the seed size with seed yield per plant by attempting crosses in lentil (Kishore and Gupta, 2002). Days to 50% flowering was found to be highly significantly correlated with harvest index (0.56), days to maturity (0.52) and number of pods per plant (0.39) whereas, highly significant negative association observed with plant height (0.35) and 100 seed weight (0.35). Days to maturity had highly significant positive correlation with number of pods per plant (0.65) and days to 50% flowering (0.52) suggest development of genotypes with longer duration for rainfed conditions in hills. Plant height also had highly significant positive association with pod length (0.46) and biological yield per plant (0.45) whereas harvest index (0.38) had highly significant association in negative direction. Harvest index had highly significant positive correlation with days to 50% flowering (0.56), number of pods per plant (0.54), days to maturity (0.54) and seed yield per plant (0.60) and highly significant negative association with plant height (0.38). Correlation study among different yield contributing traits and yield indicate that more biological yield, higher number of pods per plant and delayed maturity are major yield contributing traits which can be considered during development of improved genotypes for rainfed condition of North-Western Himalayan hills. Mahajan *et al*. (2006) suggested the development of tall plant type with delayed maturity in lentil genotypes for mid-altitudes of North-Western Himalayas.

CONCLUSION

In the present investigation, considerable genetic variability exist in elite lentil lines especially for days to 50% flowering, plant height, number of pods per plant, biological yield per plant and harvest index which is of high value for their further exploitation in breeding programmes. On the basis of PCA scores, dispersion of elite lines was found based on biological yield and correlation studies also suggest that traits *viz*., more biological yield, higher number of pods per plant and delayed maturity can be considered during development of improved genotypes for rainfed condition of North-Western Himalayan hills.

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