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STUDIES ON GENETIC VARIABILITY AND INTERRELATIONSHIP AMONG THE DIFFERENT TRAITS IN EXOTIC LINES OF LENTIL (*LENS CULINARIS* MEDIK)

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Abstract

Seventy one genetically diverse genotypes of lentil were studied at the Seed Breeding Farm, Department of Plant Breeding and Genetics, J.N.K.V.V., Jabalpur (M.P.), India; during *Rabi* season to observe their phenotypic variability and associations of different quantitative characteristics. High heritability estimate accompained by high genetic gain were observed for traits plant height, number of primary branches per plant, number of secondary branches per plant, total number of pods per plant, number of effective pods per plant, 100 seed weight, biological yield per plant, harvest index and seed yield per plant. Harvest index, number of effective pods per plant, total number of pods per plant and biological yield per plant were found to display significant positive relationships with seed yield. Harvest index, biological yield per plant, days to 50% flowering, days to maturity and number of primary branches per plant showed maximum and positive direct effect on seed yield per plant. Association analyses revealed that total number of pods per plant, biological yield per plant and harvest index showed positive and significant association with seed yield per plant as well as its have direct positive effect on seed yield. Thus, these traits might be considered for selecting the high yielding genotypes in lentil.

Key words : Correlation, path coefficient analysis, genetic variability, lentil.

Introduction

The lentil or Masoor dal (*Lens culinaris* Medik) is a bushy annual plant of the legume family, grown for its lens-shaped seeds. It is about 15 inches tall and the seeds grow in pods, usually with two seeds in each. With 26% protein, lentils have the third highest level of protein from any plant-based food after soybeans and hemp and is an important part of the diet in many parts of the world, especially in Indian subcontinent, which have large vegetarian populations. A variety of lentils exists with colors that range from yellow to red orange to green, brown and black. Red, white and yellow lentils are decorticated, that is, they have their skins removed. There are large and small varieties of many lentils. One of the primary objectives of lentil breeders is to increase the grain yield. Generally, yield represents the final character resulting from many developmental and biochemical processes which occur between germination and maturity. Before yield improvements can be realized, the breeder needs to identify the causes of variability in grain yield in any given environment. Since fluctuation in environment generally affects yield primarily through its components, many researchers have analyzed yield through its components (Adams, 1967; Mcneal *et al*., 1974; Ishaq *et al*., 2000; Esan and Omolaja, 2002). Grafius (1960) suggested that individual yield components may contribute valuable information in breeding for yield. Yield when viewed from the mechanistic or geometric point of view is a product of its components. Knowledge of genetic variability, heritability and the association between traits being improved *e.g.* yield and other traits in the population is desirable to a plant breeder. This will enable him to know how the selection pressure exerted by him on one trait will cause changes in other traits. Furthermore, the direction and magnitude of such changes could be made manifest. Traits associated with yield may be used either as indirect selection criteria or in a selection index for higher yield. Negative correlations are often found between morphological components of yield in crop plants. They probably arise primarily from developmentally-induced

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relationships (Tambal *et al*., 2000). The aim of this work was to identify variability, correlation and path coefficient estimates of economically important plant characteristics and to determine the characteristics contributing to seed yield in exotic lines of lentil.

Materials and Methods

The present study was carried out at the Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, Jabalpur (M.P., India) under Lentil Improvement Project during *Rabi* 2013-14.

Seventy one lentil genotypes received from ICARDA, Morroco were used as material and were planted in a randomized block design with three replications, in plots of 4 rows, each 3 m long and spaced 25 x 10 cm. Data were collected on days to 50% flowering, days to pod initiation, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, total number of pods per plant, number of effective pods per plant, number of seeds per pod, 100 seed weight, biological yield per plant, harvest index and seed yield per plant. The days to 50% flowering, days to pod initiation and days to maturity were recorded on a whole plot basis and other characters were recorded from a random sample of plants in each plot.

Standard statistical procedure were used for the analysis of variance, genotypic and phenotypic coefficients of variation (Burton, 1952), heritability (Hanson *et al*., 1956) and genetic advance (Johnson *et al*., 1955). The genotypic and phenotypic correlation coefficients were computed using genotypic and phenotypic variances and co-variances (Al. Jibouri *et al*., 1958). The path coefficient analysis was done according to the method by Dewey and Lu (1959).

Results and Discussion

Genetic variability

Variability in the population, especially in respect to the characters for which improvement is sought, is a prerequisite for successful selection. Data on mean, variability, heritability and genetic advance as percentage of mean are presented in table 1. The analysis of variance showed significant differences among genotypes for all the 13 characters studied, which provides an opportunity for selecting suitable genotypes with better performance for the traits. The estimates of phenotypic coefficient of variation (PCV) in general, were higher than the estimates of genotypic coefficient of variation (GCV) for all the characters, which suggested that the apparent variation is not only due to the genotypes but also due to the influence of environment. The characters *viz.* number of pods per plant, number of branches per plant, seed yield and harvest index showed high GCV estimates. This is an indicative of less amenability of these traits to environmental fluctuations and hence, greater emphasis should be given to these characters, while breeding cultivars from the present material.

High GCV for seed yield and harvest index were also earlier reported by Younis *et al*. (2008) and Rasheed *et al*. (2008). The magnitude of PCV ranged from 5.43 for days to maturity to 58.0 for number of effective pods per plant. The characters with high phenotypic coefficient of variation indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection program because the environmental variations are unpredictable in nature and may mislead the results. Similar findings were reported for characters like plant height, number of pods per plant and seed yield (Harer and Deshmukh, 1992; Jagtap and Mehetre, 1994).

The heritability for most of the characters ranged from 0.673 to 0.982. The heritability estimates was high for 100-seed weight, followed by days to pod initiation, days to 50% flowering, days to maturity, total number of pods per plant, plant height, number of effective pods per plant, biological yield per plant, number of secondary branches per plant, seed yield per plant, harvest index and number of primary branches per plant, which suggested that the characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflects the genotypic ability of cultivars to transmit the genes to their off-springs.

Similar results were also reported by Bicer and Sarkar (2008), Younis *et al*. (2008), Rasheed *et al*. (2008), Rao and Yadav (1988), Chauhan and Singh (1998), Singh and Srivastava (2013). High heritability does not mean a high genetic advance for a particular quantitative character. Johnson *et al*. (1955) reported that heritability estimates along with genetic gain would be more rewarding than heritability alone in predicting the consequential effect of selection to choose the best individual. The expected genetic advance was high for number of effective pods per plant, total number of pods per plant, seed yield per plant, harvest index, number of secondary branches per plant, biological yield per plant, 100 seed weight, number of seeds per pod, number of primary branches per plant and plant height. High heritability coupled with high genetic advance over mean was observed for plant height, number of primary branches per plant, number of secondary branches per plant, total number of pods per plant, number of effective pods per plant, seeds per pod, 100 seed weight, biological yield per plant, harvest index and seed yield per plant, which suggested that these characters can be considered as favorable attributes for the improvement through selection and this may be due to additive gene action (Panse, 1957) and thus, could be improved upon by adapting selection without progeny testing. Similar results have also been reported by Yadav *et al*. (2003). Days to 50% flowering, days to pod initiation and days to maturity showed high heritability accompanied with moderate genetic advance. This reflects the presence of non-additive gene effects. Selection based on such traits may not be rewarding.

Correlation

The progresses in plant breeding depends upon effective selection scheme based on the correlated and non-correlated response. The seed yield in almost all the crops is referred as super trait which results from the multiplicative interactions of several other traits which are termed as yield components. Thus, genetic architecture of seed yield in lentil as well as other crops is based on balanced or overall net effect produced by various yield components directly with one another. Therefore, identification of important yield components and information about their association with yield and also with each other is very useful for selecting efficient genotypes for evolving high yielding varieties. In this respect, the correlation coefficient which provides symmetrical measurement of degree of association between two variables or characters, help us in understanding the nature and magnitude of association among yield and yield.

Knowledge of correlation is required when selection is to be made on several characters at a time through some simultaneous selection model (Singh, 1972). Even if, the objective is to make selection on a single trait, the knowledge of correlation is essential to avoid the undesirable correlated changes in other characters. In general, magnitude of genotypic correlation was higher than their corresponding phenotypic correlation coefficients in most of the characters suggesting that a strong inherent association exists for the traits studied and phenotypic selection may be rewarding. Higher magnitude of genotypic correlation helps in selection for genetically controlled characters and give a better response for seed yield improvement than that would be expected on the basis of phenotypic association alone (Robinson *et al*., 1951). The genotypic and phenotypic correlation coefficients between yield and yield attributes are given in Table 2. Harvest index, number of effective pods per plant, total number of pods per plant and biological yield

Table 1 : Estimate of mean, components of variance, heritability (broad sense) and expected genetic advance in respect of 13 characters.

Characters	Range		Mean	Variance		Coefficient of variation		h^2 B (%)	Genetic advance	GA (As % Mean)
	Min.	Max.		Phenotypic	Genotypic	Phenotypic	Genotypic			
Days to 50% flowering	52.67	83.33	74.44	41.58	40.11	8.66	8.51	96.50	12.81	17.21
Days to pod initiation	62.00	91.33	82.80	37.60	36.32	7.41	7.28	96.60	12.20	14.74
Days to maturity	99.33	124.33	115.96	39.84	38.43	5.44	5.35	96.50	12.54	10.82
Plant height (cm)	24.50	61.67	39.70	37.14	35.17	15.36	14.94	94.70	11.89	29.94
Number of primary branches per plant	2.17	6.57	3.01	0.60	0.47	25.66	22.86	79.40	1.26	41.94
Number of secondary branches per plant	3.23	16.77	7.30	5.81	5.37	33.00	31.72	92.40	4.59	62.82
Total number of pods per plant	20.40	96.17	46.37	395.46	374.96	42.89	41.76	94.80	38.84	83.77
Number of effective pods per plant	8.00	85.10	30.34	309.63	289.84	58.00	56.12	93.60	33.93	111.85
Number of seeds per pod	1.13	3.60	1.77	0.42	0.28	36.72	30.13	67.30	0.90	50.92
100 seed weight **(g)**	2.20	5.70	3.33	0.76	0.74	26.17	25.93	98.20	1.76	52.94
Biological yield per plant **(g)**	26.50	82.13	53.21	255.95	238.48	30.07	29.03	93.20	30.71	57.72
Harvest index **(%)**	1.13	6.50	3.13	2.09	1.76	46.26	42.48	84.30	2.51	80.36
Seed yield per plant (g)	0.50	3.47	1.58	0.51	0.45	45.20	42.74	89.40	1.31	83.25

Table 2 : Estimates of phenotypic (top figures) and genotypic (bottom figures) correlation coefficients.

Characters		**Days to 50% flowering**	**Days to pod initiation**	**Days to maturity**	**Plant height (cm)**	**Primary branches**	**Secondary branches**	**Number of pods per plant**	**Effective pods per plant**	**Number of seeds per pod**	**100 seed weight (g)**	**Biological yield/ plant (g)**	**Harvest index (%)**	**Seed yield/ plant (g)**
Days to 50% flowering	**P**	**1.000**												
	G	**1.000**												
Days to pod initiation	**P**	0.992**	**1.000**											
	G	0.996	**1.000**											
Days to maturity	**P**	0.689**	0.687**	**1.000**										
	G	0.699	0.696	**1.000**										
Plant height (cm)	**P**	0.298**	0.285**	0.287**	**1.000**									
	G	0.310	0.300	0.303	**1.000**									
Primary branches	**P**	-0.442**	-0.419**	-0.494**	-0.358**		**1.000**							
	G	-0.597	-0.483	-0.562	-0.419	**1.000**								
Secondary branches	**P**	-0.532**	-0.526**	-0.502**	-0.192**		0.749**	**1.000**						
	G	-0.559	-0.550	-0.526	-0.216	0.820	**1.000**							
Number of pods/plant	**P**	-0.255**	-0.264**	-0.419**	0.082	0.147*	0.159*	**1.000**						
	G	-0.263	-0.274	-0.429	0.082	0.159	0.167	**1.000**						
Effective pods/plant	**P**	-0.399**	-0.400**	-0.487**	-0.026	0.310**	0.297**	0.884**	**1.000**					
	G	-0.418	-0.422	-0.512	-0.038	0.357	0.313	0.910	**1.000**					
Number of seeds/pod	**P**	0.376**	0.362**	0.311**	0.109	-0.270**	-0.206**	-0.291**	-0.589**	**1.000**				
	G	0.454	0.450	0.372	0.142	-0.344	-0.268	-0.385	-0.656	**1.000**				
100 seed weight (g)	**P**	-0.008	-0.004	0.075	0.140*	-0.014	-0.065	0.100	0.061	-0.018	**1.000**			
	G	-0.012	-0.006	0.075	0.144	-0.011	-0.072	0.104	0.063	-0.026	**1.000**			
Biological yield/plant (g)	**P**	0.189**	0.170*	0.246**	0.311**		-0.216**	-0.181**	0.259**	0.217**	-0.220**	-0.009	**1.000**	
	G	0.205	0.187	0.269	0.324	-0.255	-0.204	0.268	0.216	-0.254	-0.005	**1.000**		
Harvest index (%)	**P**	-0.326**	-0.306**	-0.222**	-0.126	0.215**	0.217**	0.236**	0.295**	-0.160*	0.136*	-0.383**	**1.000**	
	G	-0.354	-0.335	-0.251	-0.122	0.242	0.242	0.265	0.335	-0.192	0.144	-0.372	**1.000**	
Seed yield/plant (g)	**P**	-0.209**	-0.204**	-0.012	0.104	0.091	0.112	0.411**	0.461**	-0.337**	0.123	0.277**	0.748**	**1.000**
	G	-0.214	-0.210	-0.010	0.123	0.093	0.116	0.444	0.496	-0.401	0.129	0.310	0.734	**1.000**

* & ** significant at 5% and 1% probability, G = Genotypic correlation coefficient, P = Phenotypic correlation coefficient.

per plant exhibited significant and positive correlation with Seed yield per plant.

The degree of association was highest between days to pod initiation and days to 50% flowering. It was followed by number of effective pods per plant and total number of pods per plant. Hamdi *et al.* (2003) also reported that seed yield was positively and significantly correlated with pod numbers, harvest index and negatively with flowering duration. High positive correlation of number of effective pods per plant with seed yield may be attributed to the increased sink strength (Nakaseko, 1984). Diaz Carrasco *et al*. (1985) also suggested that yield could be raised by selecting for earliness, tallness and more pods per plant, which is evident in the present study.

Amongst the other characters, harvest index showed positive and highly significant correlation with number of effective pods per plant, total number of pods per plant, number of secondary branches per plant and number of primary branches per plant, suggesting that increased harvest index is associated with more production of pods and number of branches.

Number of effective pods per plant also exhibited highly significant and positive correlation with seed yield per plant, harvest index, number of primary branches per plant, number of secondary branches per plant, total number of pods per plant and biological yield per plant.

Days to 50% flowering and days to pod initiation exhibited highly significant negative correlation with number of secondary branches per plant, number of primary branches per plant, number of effective pods per plant, harvest index, total number of pods per plant and seed yield per plant. As per the plant height is concerned, it showed the positive correlation with biological yield per plant, 100 seed weight, days to 50% flowering, days to pod initiation and days to maturity. Negative correlation of plant height with number of primary branches per plant and number of secondary branches per plant. The results obtained by Esmail *et al*. (1994), Begum and Begum (1996), Vir *et al*. (2001), Kishore and Gupta (2002), Naji *et al*. (2003), Al-Ghzawi *et al*. (2011) and Tadesse *et al*. (2014) were the agreement with the present findings.

Path coefficient analysis

Knowledge of correlation alone is often misleading as the correlation observed may not be always true. Two characters may show correlation just because they are correlated with a common third one. In such cases, it becomes necessary to study a method which takes into account the causal relationship between the variables in

Table 3 : Direct effects (diagonal) and indirect contribution of different characters towards seed yield.

Characters	**Days to 50% flowering**	**Days to pod initiation**	**Days to maturity**	**Plant height (cm)**	**Primary branches**	**Secondary branches**	**Number of pods per plant**	**Effective pods per plant**	**Number of seeds per pod**	**100 seed weight (g)**	**Biological yield per plant (g)**	**Harvest index (%)**
Days to 50% flowering	**0.426**	0.4242	0.298	0.132	-0.212	-0.238	-0.112	-0.178	0.193	-0.005	0.088	-0.157
Days to pod initiation	-0.507	**-0.509**	-0.3547	-0.153	0.246	0.280	0.139	0.215	-0.229	0.003	-0.095	0.170
Days to maturity	0.147	0.147	**0.215**	0.064	-0.118	-0.112	-0.090	-0.108	0.078	0.016	0.057	-0.053
Plant height (cm)	0.018	0.018	0.018	**0.060**	-0.025	-0.013	0.005	-0.002	0.008	0.009	0.019	-0.007
Number of primary branches per plant	-0.066	-0.064	-0.075	-0.056	**0.133**	0.109	0.021	0.048	-0.046	-0.001	-0.034	0.032
Number of secondary branches per plant	0.028	0.027	0.026	0.011	-0.041	**-0.050**	-0.008	-0.016	0.013	0.004	0.010	-0.012
Total number of pods per plant	-0.023	-0.024	-0.038	0.007	0.014	0.015	**0.089**	0.080	-0.034	0.009	0.024	0.024
Number of effective pods per plant	0.015	0.016	0.019	0.001	-0.013	-0.012	-0.034	**-0.037**	0.024	-0.002	-0.009	-0.012
Number of seeds per pod	-0.035	-0.035	-0.029	-0.011	0.027	0.021	0.030	0.051	**-0.079**	0.002	0.020	0.015
100 seed weight **(g)**	0.000	0.000	-0.003	-0.006	0.000	0.003	-0.004	-0.002	0.001	**-0.039**	0.000	-0.006
Biological yield per plant **(g)**	0.120	0.109	0.157	0.190	-0.149	-0.119	0.156	0.126	-0.149	-0.003	**0.584**	-0.218
Harvest index **(%)**	-0.337	-0.318	-0.239	-0.116	0.231	0.230	0.252	0.319	-0.183	0.137	-0.355	**0.952**
Seed yield per plant (g)	-0.214	-0.210	-0.010	0.123	0.093	0.116	0.445	0.496	-0.401	0.129	0.310	0.734
Partial R^2	-0.091	0.107	-0.002	0.007	0.012	-0.006	0.039	-0.018	0.031	-0.005	0.181	0.699

Residual effect G = 0.2122

addition to the degree of such relationship. Path coefficient analysis measures the direct influence of one variable upon the other and permits separation of correlation coefficients into components of direct and indirect effects. Portioning of total correlation into direct and indirect effects provide actual information on contribution of characters and thus form the basis for selection to improve the yield.

Path coefficient analysis (table 3) for seed yield revealed that the traits like harvest index, biological yield per plant, days to 50% flowering, days to maturity and number of primary branches per plant showed highest positive direct effect on seed yield per plant. These results agree with the earlier reports of Priti *et al*. (2003). It means a slight increase in any one of the above traits may directly contribute towards seed yield. Similar results were observed by Vir *et al*. (2001) for harvest index, biological yield per plant and days to maturity, Kumar *et al*. (2004b) for harvest index, biological yield and days to 50% flowering, Singh *et al*. (2009) and Tyagi and Khan (2010) for harvest index, biological yield and pods per plant.

However, number of effective pods per plant, 100 seed weight, number of secondary branches per plant, number of seeds per pod and days to pod initiation showed negative direct effect. Similar findings were observed by Tadesse *et al*. (2014) for 100 seed weight. For days to maturity, the direct effect was positive while, its association with seed yield was observed to be negative, indicating the importance of restricted selection model for exploitation of the direct effect noticed. The indirect effect of number of primary branches per plant, number of secondary branches per plant, total number of pods per plant, number of effective pods per plant and 100 - Seed weight, was positive on seed yield *via* harvest index. The correlation between seed yield and harvest index was mainly due to direct positive effect of harvest index on seed yield. It shows that direct selection for this trait may improve seed yield per plant.

The path coefficient analysis revealed that direct and indirect contribution of harvest index; biological yield per plant and number of pods per plant were maximum on seed yield.

Conclusion

The above findings revealed that whatever, may be the character chosen for increasing the seed yield, the improvement could be achieved only through number of harvest index and number of pods per plant. All the above characters exhibited their indirect effect mostly through number of pods per plant, harvest index and biological yield. Hence, it may be concluded that harvest index and number of pods per plant are the main traits which are responsible for manipulation of seed yield in lentil. The residual effect was found to be moderate which indicates that there may be some more its assocomponents that are contributing towards seed yield.

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