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Full Length Research Paper

Studies on genetic variability and interrelationship among the different traits in *Microsperma lentil* (*Lens culinaris* Medik)

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The genetic parameters, character association and path coefficient analysis between yield and yield contributing characters of 25 lentil genotypes were studied during 2007 - 2008 at Kisan (PG) College, Simbhaoil. The genotypes exhibited a wide range of variability for all the traits studied. High heritability accompained by moderate to high GCV and genetic gain were observed for number of pods plant^{-1}, number of branches plant^{-1}, 100 seed weight, seed yield plant^{-1} and harvest index. Correlation studies indicated that number of pods plant^{-1}, biological yield and harvest index were positively and significantly correlated with seed yield at both phenotypic and genotypic levels. Path coefficient analysis showed that harvest index, biological yield and number of pods plant^{-1} showed maximum and positive direct effect on seed yield.

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

INTRODUCTION

The lentil or daal 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. The plant originated in the Near East and has been part of the human diet since the aceramic (non-pottery producing) Neolithic times, being one of the first crops domesticated in the Near East. 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 (e.g., Masoor 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 geo-metric point of view is a product of its components. Know-ledge 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 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

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Table 1. List of genotypes.

1.	L-307	10.	L-4673	19.	L-415
2.	L-4595	11.	PKVL-1	20.	L-5194
3.	L-4674	12.	LC-59	21.	L-5214
4.	L-4676	13.	Schore74-3	22.	P-2141
5.	L-4618	14.	L-393	23.	P-2147
6.	L-4671	15.	L-308	24.	P-2237
7.	L-4076	16.	L-306	25.	L-830(check)
8.	L-617017.	L-309			
9.	L-466018.	L-395			

in lentil.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm of Kisan PG, College during 2007/2008 season. Twenty five lentil genotypes (Table 1) collected from NBPGR, New Delhi 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 30 x 10 cm. Data were collected on reproductive traits; germination %, days to 50% flowering, days to maturity, plant height, number of branches plant^{-1} , number of pods plant^{-1}, pod size, seed yield plant^{-1}, biological yield, 100 seed weight and harvest index. The days to flower and maturity were recorded on a whole plot basis and biological yield and seed yield plant^{-1}, plant height and pods plant^{-1} were recorded from a random sample of ten 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 co-efficient 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 2. The analysis of variance showed significant differences among genotypes for all the 12 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 plant^{-1}, number of branches plant^{-1}, 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 3.35 for days to maturity to 52.36 for pods plant^{-1}.

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 plant^{-1} and seed yield (Harer and Deshmukh, 1992; Jagtap and Mehetre, 1994).

Encouraging results were obtained with respect to the heritability of the characters studied except for pod size, plant height and seeds per pod. The heritability for most of the characters ranged from 0.775 to 0.984. The heritability estimates was highest for days to 50% flowering, 100 seed weight, branches plant-1, pods plant-1, germination percent, days to maturity and seed yield 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).

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 pods plant^{-1}, days to 50% flowering, harvest index and germination percent. High heritability coupled with high genetic advance over mean was observed for number of pods plant^{-1} , branches plant^{-1}, and 100-seed weight 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 and seed yield showed high heritability coupled with moderate genetic advance, while high heritability with low genetic advance were recorded for days to maturity and germination percent rendering them unsuitable for improvement through selection. Low heritability combined with low genetic advance as percentage of mean was noted for pod size and seeds pod^{-1} which indicates that the scope for improving such traits through selection is very much limited and this may be attributed to the non-additive

Table 2. Estimate of mean, components of variance, heritability (broad sense) and expected genetic advance in respect of 12 characters in lentil.

Characters	Range		Mean	Coefficients of variation		Heritability (bs)	Genetic advance (GA)	Expected genetic advance (% of mean)
	Minimum	Maximum		Phenotypic (PCV)	Genotypic (GCV)			
Germination (%)	79.67	99.67	92.06	6.05	5.72	0.885	10.20	11.07
50% flowering (days)	71.67	105.33	88.18	11.75	11.65	0.984	21.00	23.51
Days to maturity	119.67	132.67	126.56	3.35	3.15	0.884	7.71	6.09
Plant height (cm)	26.85	46.17	36.65	13.12	12.02	0.539	8.823	22.7
Branches plant^{-1} (no)	26.23	101.01	54.62	40.78	40.38	0.981	45.00	82.38
Pods Plant^{-1} (no.)	20.93	112.00	76.00	52.36	51.66	0.973	35.10	39.80
Pod Size (cm)	1.03	1.30	1.17	8.06	5.29	0.430	0.08	6.38
Seeds Pod^{-1} (no.)	1.00	2.23	1.98	13.38	9.91	0.549	0.29	15.18
Biological yield (g)	22.45	38.10	29.63	14.73	12.97	0.775	6.97	23.57
Seed yield (g)	6.85	14.43	10. 54	19.81	18.15	0.839	3.61	34.25
100-seed wt.(g)	1.40	3.7	2.35	21.91	21.69	0.980	1.04	44.25
Harvest index (%)	23.43	46.14	35.79	17.52	15.95	0.829	10.7	29.89

gene action (Johnson et al., 1955).

Correlation

The study of inter-relationship among various characters in the form of correlation is, in fact, one of very important aspects in selection programme for the breeder to make an effective selection based on the correlated and uncorrelated response. Knowledge of nature and magnitude of associations among different characters are important on three counts. Indirect selection is important when desirable characters have low heritability measure in one sex only. The efficiency of indirect selection is measured as a correlated response (Falconer, 1960). 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. Similar results were also reported by Pathak et al. (1986). 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 3. The table revealed that pods plant^{-1}, biological yield and harvest index exhibited significant and positive correlation with seed yield both at genotypic and phenotypic level. The degree of association was highest between harvest index and seed yield. It was followed by pods plant^{-1} and harvest index. 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 pods plant^{-1} 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 plant^{-1}, which is evident in the present study. Amongst the other characters, harvest index showed positive and significant correlation with pods plant^{-1} and number of branches plant^{-1} suggesting that increased harvest index is associated with more production of pods and number of branches.

Table 3. Phenotypic (below diagonal) and genotypic (above diagonal) correlation coefficients among 12 characters in 25 genotypes of lentil

Characters	Germination	50% flowering	Days to maturity	Plant height	Branches plant^{-1}	Pods Plant^{-1}	Pod Size	Seeds Pod^{-1}	Biologicalyield	Seed yield	100-seed wt.	Harvest index
Germination	1.000	0.204	-0.011	0.439*	0.168	0.102	0.147	-0.168	0.278	0.323	0.107	0.149
50% flowering	0.180	1.000	0.205	-0.112	0.136	-0.137	-0.047	-0.162	-0.150	-0.158	-0.112	0.070
Days to maturity	-0.028	0.191	1.000	-0.109	0.531**	0.539**	-0.085	0.442*	-0.072	-0.316	0.072	-0.301
Plant height	0.357	-0.081	-0.070	1.000	-0.099	0.407*	0.079	-0.018	0.118	0.334	0.257	0.299
Branches plant^{-1}	0.147	0.139	0.500*	-0.077	1.000	-0.153	-0.155	-0.228	0.167	-0.338	0.435*	0.508**
Pods Plant^{-1}	0.100	-0.137	0.511**	0.376	-0.015	1.000	0.190	0.119	0.174	0.667**	-0.064	0.565**
Pod Size	0.087	-0.031	-0.067	0.052	-0.114	0.084	1.000	0.097	-0.335	-0.093	0.196	0.197
Seeds Pod^{-1}	-0.185	-0.115	-0.280	-0.004	-0.174	0.088	-0.014	1.000	-0.163	-0.046	-0.032	0.064
Biological yield	0.263	-0.127	-0.080	0.111	0.141	0.167	-0.189	-0.062	1.000	0.486*	-0.184	-0.248
Seed yield	0.271	-0.330	-0.248	0.319	-0.301	0.608**	-0.034	0.012	0.460*	1.000	0.076	0.720**
100-seed wt.	0.990	-0.104	0.069	0.246	0.428*	-0.068	0.146	-0.270	-0.164	0.089	1.000	0.221
Harvest index	0.102	-0.055	-0.216	0.276	0.447*	0.496*	0.133	0.055	0.293	0.069	0.225	1.000

*, ** = Significant p = 0.05% and p = 0.01% levels, respectively.

Number of pods plant^{-1} also exhibited significant positive association with plant height. Days to 50% flowering revealed non-significant correlation with all the traits both at phenotypic and genotypic levels. Similarly, germination percent and pod size revealed no significant correlation with any trait at the phenotypic level.

However, at the genotypic level germination percent revealed positive significant correlation with plant height. Days to maturity showed positive significant correlation with branches plant^{-1} and pods plant^{-1} at both phenotypic and genotypic levels. The results are in line with Arshad et al. (2004). As per the plant height is concerned, it showed the positive correlation with seed yield, pods plant^{-1} and harvest index. Positive correlation of plant height with seed yield has also been reported by Kumar et al. (2004). Similarly, branches plant^{-1} revealed significant correlation with 100-seed weight at both levels.

Similar results were also reported by Luthra and Sharma (1990).

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 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 4) for seed yield revealed that the traits like harvest index and biological yield showed highest positive direct effect towards seed yield. 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 have also been reported by Jain et al. (1996). Positive direct effect of number of pods plant^{-1} and indirect positive effect via germination percent, days to 50% flowering, branches plant^{-1} and harvest index were the main reason for strong positive correlation of this character with seed yield (0.608**). Similar results were reported by Chauhan and Sinha (1982) and Dixit and Dubey (1984).

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

Table 4. Direct effects (diagonal) and indirect contribution of different characters towards seed yield in 25 genotypes of lentil.

Characters	Germination (%)	50% flowering (days)	Days to maturity	Plant height (cm)	Branches plant^{-1} (no.)	Pods Plant^{-1} (no.)	Pod Size (cm)	Seeds Pod^{-1} (no.)	Biological yield (g)	100-seed wt. (g)	Harvest index (g)	Genotypic Correlation with seed yield
Germination	0.007	0.002	-0.002	-0.014	-0.004	0.010	-0.002	-0.002	0.187	0.002	0.008	0.271
50% flowering	0.001	0.008	0.011	0.003	-0.004	-0.014	0.001	-0.001	-0.090	-0.002	-0.047	-0.330
Days to maturity	0.000	0.002	0.058	0.003	-0.014	-0.052	0.002	-0.004	-0.057	0.001	-0.187	-0.248
Plant height	0.002	-0.001	-0.004	-0.040	0.002	0.039	-0.001	0.000	0.079	0.004	0.239	0.319
Branches plant^{-1}	0.001	0.001	0.029	0.003	-0.027	-0.015	0.003	-0.002	0.100	-0.007	-0.387	-0.301
Pods Plant^{-1}	0.014	0.011	-0.030	-0.015	0.014	0.103	-0.002	0.001	-0.118	-0.001	0.429	0.608**
Pod Size	0.001	0.000	-0.005	-0.002	0.003	0.009	-0.023	0.000	-0.134	0.002	0.115	-0.034
Seeds Pod^{-1}	-0.001	-0.001	-0.016	0.000	0.005	0.009	0.000	0.013	0.044	0.000	0.048	0.012
Biological yield	0.002	-0.001	-0.005	-0.004	-0.004	0.017	0.004	-0.001	0.708	-0.003	-0.254	0.460*
100-seed wt.	0.001	-0.001	0.004	-0.010	0.012	-0.007	-0.003	0.000	-0.116	0.015	0.195	0.039
Harvest index	0.001	0.000	-0.013	-0.011	0.012	0.051	-0.003	0.001	-0.207	0.003	0.865	0.699**

contribution of pods plant^{-1} was positive germination percent, days to 50% flowering, branches plant^{-1}, pods plant^{-1} and biological yield and also ciation with seed yield was positive and significant. Similarly, the indirect contribution of harvest index was positive via branches plant^{-1} and pods plant^{-1}. Plant height contributed positive indirect effect towards seed yield through pods plant^{-1} and biological yield.

The path coefficient analysis revealed that direct and indirect contribution of harvest index; biological yield and pods plant^{-1} were maximum on seed yield. 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 pods plant^{-1}. All the above characters exhibited their indirect effect mostly through number of pods plant^{-1}, harvest index and biological yield. Hence, it may be concluded that harvest index and pods plant^{-1} 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 asso- components that are contributing towards seed yield.

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