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Association Analysis in Linseed (*Linum usitatissimum* L.)

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Correlation and path coefficients were studied in F_1 and F_2 populations of twenty one crosses of linseed (*Linum usitatissimum* L.). Seed yield per plant showed strong positive correlation with capsules per plant in F_2 and seed weight in F_1 and F_2. Tillers per plant and seeds per capsule also had moderate correlation with yield in both generations. Conversely, plant height in F_2 and capsule diameter in F_1 and F_2 showed negative association with yield. However, more favourable and effective character association developed in F_2 than F_1 with yield. Path coefficient analysis revealed that capsules per plant and seed weight had the maximum direct positive effect on yield in F_1 than F_2. Although the direct effect of tillers per plant and seeds per capsule were low in F_2 but their contribution through capsules per plant were considerable.

Character associations are ordinarily explained on the basis of linkage and pleiotropy. In F_2, linkages are broken and new recombination are produced which cause deviation in correlation study as compared to non-segregating generation (F_1). Accordingly, segregating populations offer greater scope for selection for yield through positive improvement in its components. An attempt has, therefore been made to study correlation and path coefficients in non-segregating and segregating populations of linseed

MATERIAL AND METHODS

Seven varieties, namely, T 397, LC 205, 'Neelam', R 4, 'Hira' 'Mukta, and EC 77909 were crossed in all possible combinations without reciprocals. The parents and 21 F_1s in one row plots and 21 F_2s in five row plots were grown in randomized block design with three replications at college Farm during *rabi* 1979. The row length was 3.0 m with inter and intra-row spacing of 30 and 15 cm, respectively. Data on 10 and 50 plants from non-segregating and segregating generations, were recorded for plant height, tillers per plant, capsule diameter, capsules per plant, seeds per capsule, seed weight (1,000-seed) and seed yield per plant. Correlation coefficients were calculated using the means of F_1 and F_2 plants and path coefficient effects were estimated with the help of procedure outlined by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The estimates of correlation coefficients between all possible pairs of characters in both generations are presented in Table 1. Genotypic correlation coefficient value revealed that capsules per plant in F_2 and seed weight in F_1 and F_2 had strong positive correlation with seed yield whereas capsules per plant in F_1, tillers per plant and seeds per capsule in

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both generations showed moderate correlation. High and significant positive correlation of yield with capsules per plant and seeds per capsule are also on record (Patil *et al.*, 1980). Conversely, plant height in F_1 and capsule diameter in each generation revealed negative correlation with yield. Among yield components, tillers with capsule diameter and plant height with seeds per capsule in both generations discerned strong positive and negative correlations, respectively. The correlation of capsules per plant with seed weight was found stronger in F_1 than F_2.

Examination of correlations indicated that degree of associations were altered from F_1 to F_2 and more favourable and effective character asssociations developed in F_2 progenies with seed yield. Further F_2 analysis suggested that a suitable plant of linseed should be characterised by large number of capsules per plant followed by seed weight, tillers per plant and seeds per capsule. But the seeds per capsule which is positively correlated with yield is negatively associated with seed weight. This would mean that it is not possible to select for large seed size without affecting seeds per capsule with the help of suitable breeding procedures.

Path analysis (Table II) revealed that capsules per plant and seed weight consistently had the maximum direct positive effect in both the populations. The tillers per plant and seeds per capsule also had a positive direct effect on yield but the indirect effects *via* capsules per plant were a little higher than their direct effect in F_2 generation. Incidently, all these traits had positive correlation at F_1 as well as F_2 levels. Thus correlated response is to be expected when selection is applied for any one of them keeping yield improvement as the ultimate objective. The high direct positive effects of pods per plant in segregating populations of gram crosses have also been reported by several workers (Singh *et al.*, 1976 Chandgi Ram *et al.*, 1980). In contrast, the contribution of plant height in F_2 and capsule diameter in F_1 and F_2 was negative but the indirect effect of the former *via* capsules per plant and that of latter *via* tillers and seeds per capsule was positive. Though these results are generally similar to those reported with varietal collections of linseed but the F_2 analysis offered greater scope for selection than F_1 population. Thus an ideal plant type would have high capsule number with heavy and more seeds per capsule and medium to dwarf in height. The number of capsules per plant can be increased by increasing the tillers with many branches. Badwal *et al.* (1970) and Patil *et. al.* (1980) reported that capsules per plant, 1,000-seed weight, seeds per capsule and number of branches are the major factors which directly contribute to seed yield and are in close agreement with the results of the present findings.

In the present study, the effect of residual factors over yield was 0.586 in F_1 and 0.447 in F_2. This suggests that there might be few more components other than the six studied in this investigation which might have been

responsible to influence the seed yield per plant.

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Table 1 Correlation coefficients of yield attributes in linseed

Character	Tillers / plant		Capsule diameter		Capsules / plant		Seeds / Capsule		Seed weight		Seed yield/plant	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Plant G	0.035	− 0.092	0.156	0.189	0.142	0.158	−0.482*	0.584**	0.127	0.134	0.071	−0.012
height P	0.034	− 0.090	0.154	0.188	0.141	0.156	− 0.481*	−0.578**	0 125	0.133	0.070	− 0.010
Tillers/ G			0.436*	0.476*	0.322	0.405	0.370	0.431	0.233	0.145	0.341	0.378
plant P			0.434*	0.473*	0.323	0.399	0.370	0.428	0.231	0.144	0.340	0.374
Capsule G					−0.057	− 0.069	0.093	0.068	0.128	0.066	− 0.027	−0.014
diameter P					− 0.067	− 0 068	0.093	0.066	0,125	0.064	−0.022	−0.012
Capsules/G							−0.033	0.244	0.512*	0.406	0 338	0,564**
plant P							−0.030	0.243	0 510*	0.403	0,331	0.559**
Seed G									−0.055	− 0.031	0.293	0.249
capsule P									−0.052	− 0.030	0.240	0.247
Seed G											0.504*	0.521*
weight P											0.501*	0.513*

* Significant at 5% level.

** Significant at 1% level.

G — genotypic; P — phenotypic.

TABLE II Direct and indirect effects of six quantitative characters in F_1 and F_2 populations of linseed

Character		Plant height	Tillers/ plant	Capsule diameter	Capsules/ plant	Seeds/ capsule	Seed weight	Genotypic of traits	correlatio with yiel
Plant height	F_1	*0.197*	0.008	-0.028	0.029	−0.132	0.007		0.071
	F_2	*−0.054*	−0.013	−0.012	0.079	−0.005	−0.007		−0.012
Tillers/ plant	F_1	0.006	*0.231*	−0.077	0.067	0.101	0.013		0.341
	F_2	0.005	*0.200*	−0.029	0.205	0.004	−0.007		0.378
Capsule diameter	F_1	0.029	0.100	*- 0.177*	−0.012	0.026	0.007		−0.027
	F_2	−0.010	0.096	*−0.062*	−0.035	0.001	−0.003		−0.014
Capsules/ plant	F_1	0.026	0.074	−0.010	*0.208*	−0.009	0.029		0.338
	F_2	−0.009	0.081	0.004	*0.506*	0.002	−0.021		0.564**
Seeds/ capsule	F_1	−0.090	0.085	- 0.015	−0.007	*0.274*	−0.003		0.243
	F_2	0.032	0.086	−0.004	0.124	*0.009*	0.002		0 249
Seed weight	F_1	0.024	0.054	−0.023	0.107	−0.015	*0.357*		0.504
	F_2	−0.047	0.029	−0.014	0.205	−0.013	*0.361*		0.521*

Residual effect $F_1 = 0.0586$, $F_2 = 0.447$

Under lined values denote the direct effect.

* Significant at 5% level.

** Significant at 1% level.