RESEARCH PAPER

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Genetic variability, correlation and path analysis in linseed (*Linum usitatissimum* L.)

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A study was conducted to assess variability in 79 genotypes of linseed. Data were recorded on twelve characters. These genotypes showed considerable variability for all the parameters. Wide range of PCV and GCV were observed for number of capsules per plant, number of seeds per capsule and seed yield per plant. The heritability estimates ,were ranging between 30.20 per cent (number of seeds per capsule) to 99.7 per cent (days to maturity). The per cent mean genetic advance was high for number of branches per plant, seed yield per plant, days to flowering and number of capsules per plant. Seed yield per plant was positively and significantly correlated with number of branches per plant, number of capsules per plant and harvest index at both phenotypic and genotypic levels. Genotypic correlation coefficients, were higher than corresponding phenotypic one for most of character combinations. Path coefficient analysis revealed that harvest index exhibited highest positive direct effect on seed yield per plant followed by number of branches per plant. Indirect effects' of number of branches per plant and number of capsules per plant *via* harvest index was positive, but indirect effect was more than that of the direct effect on seed yield.

Key words : Variability, Correlation, Path analysis, Linseed, PVC, GCV

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INTRODUCTION

Linseed belongs to the family Linaceae and genus *Linum.* This genus is native to South West Asia and the Mediterranean region of Europe and is distributed in the tropical and temperate countries of world (Darlington, 1963). It is an unparalleled source for paints, varnishes, oil, cloths, lenolinum and lubricants. In addition, the oil cake is a most valuable feeding cake to both milch and flattering animals. The cake is also used as manure and is a very good source of nitrogen to soil. The main aim of plant breeding programme is to improve the plant traits for agronomic, economic and nutritional values. However, the important quantitative traits are under polygenic control and display a great variety of genotypes x environment interaction.

The knowledge about nature and extent of variability present in the germplasm collections is important in planning a sound breeding strategy. In addition to this information on various genetic parameters, association between traits will provide a strong insight into control of those traits. The evaluation of germplasm is a pre-requisite to identify the superior sources for various traits and for their efficient utilization. In the present study, an attempt has been made to assess the genetic parameters, such as variability, heritability, genetic advance, character association and path coefficient analysis in 79 accessions of linseed.

RESEARCH METHODOLOGY

The material for the present study comprised of 79 linseed genotypes. These genotypes were evaluated in the regional agricultural research station, Raichur, UAS, Dharwad, which is situated in North-Eastern Dry Zone (Zone-2) of Karnataka at 16° 12' N latitude and 77° 12' E longitude and 389 meters above mean sea level with average annual rainfall of 660 mm. The material for the present study comprised of 79 linseed genotypes. These genotypes were evaluated in the regional agricultural research station, Raichur, UAS, Dharwad, which is situated in North-Eastern Dry Zone (Zone-2) of Karnataka at 16° 12' N latitude and 77° 12' E longitude and 389 meters above mean sea level with average annual rainfall of 660 mm. The genotypes were grown in randomized block design in three replications. Data on 12 characters were recorded from 5 plants per replication and the average was taken for analysis. Observations were recorded on days to flowering, plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, seed length, seed breadth, 1000-seed weight, harvest index, days to maturity, oil content and seed yield per plant. Data were analyzed as per standard procedures. Genetic variability parameters, correlation and path analysis were analyzed as proposed by Johnson *et al.* (1955) and Dewey and Lu (1957) The statistical analysis was carried out using computer software SPAR(Indian Agricultural Statistical Research Institute, Delhi)

RESULTS AND ANALYSIS

The findings of the study have been discussed in detail as under:

Means and genetic variance:

The analysis of variance showed a wide range of variation and significant differences for all the character (Table 1). The coefficient of variation at phenotypic (PCV) and genotypic (GCV) levels were high for seed yield per plant, number of branches per plant and number of capsules per plant and medium to low for other nine characters. Absolute variability in different characters cannot be the decisive factor for deciding as to which character is showing the highest degree of variability.

The coefficient values indicated considerable amount of variability existing for all the characters except oil content (Table 2). Very low difference between phenotypic coefficient of variation values and genotypic coefficient of variation values were observed for days to flowering, seed breadth, days to maturity and oil content indicating a low level of environmental factors operating but the influence of extraneous factors was high for seed yield, number of branches per plant, 1000 seed weight and plant height (Mahto and Rahaman, 1998).

The coefficient of variation reveals the extent of variability present for different characters and it does not indicate the heritable portion. To obtain the knowledge of heritable portion of the variability it is essential to know the heritability estimates of the different characters. Practically, heritability estimate is of greater value to the breeder, since they indicate the degree of dependence of genotypic value on phenotypic value. The effectiveness of selection for any character depends not only on the amount of phenotypic and genotypic variability, but also on the magnitude of heritability. In the present study, broad sense heritability was used and it includes both additive and non-additive gene effects (Hanson *et al.,* 1956).

Table 1 : Analysis of variance

Sr. No.	Characters	Mean sum of square		CV (%)
		Genotypic	Error	
1.	Days of flowering	84.54 **	0.83	2.36
2.	Plant height (cm)	50.81 **	4.68	6.08
3.	Number of branches per plant	1.52 **	4.69	5.38
4.	Number of capsules per plant	37.99 **	7.62	12.08
5.	Number of seeds per capsule	0.77 **	0.33	7.04
6.	Seed length (mm)	0.17 **	0.006	1.75
7.	Seed breadth (mm)	0.07 **	0.0003	0.81
8.	1000 Seed weight (g)	0.02 **	0.004	1.27
9.	Harvest index	14.89 **	1.75	4.25
10.	Days to maturity	121.28 **	0.13	2.34
11.	Oil content (%)	2.61 **	0.25	1.28
12.	Seed yield per plant	0.18 **	0.03	16.28

* and ** indicate significance of values at p=0.05 and 0.01, respectively

Table 2 : Genetic parameters for twelve characters in linseed (*Linum usitatissimum* L.)

Sr. No.	Characters	Range			Coefficient of variation		Heritability (%)	Genetic advance (GA)	Genetic advance as per cent mean GAM)
		Min.	Max.	Mean	notypic (PCV)	Genotypic (GCV)			
1.	Days to flowering	30	50	38.74	13.84	13.64	97.10	10.72	27.67
2.	Plant height (cm)	28.27	48.33	35.60	12.58	11.01	76.60	7.07	19.85
3.	Number of branches per plant	3.00	6.40	4.02	18.25	17.43	91.30	1.38	34.32
4.	Number of capsules per plant	15.93	31.13	22.84	18.44	13.92	57.00	4.95	21.67
5.	Number of seeds per capsule	6.93	9.40	8.23	8.43	4.62	30.20	0.43	5.24
6.	Seed length (cm)1	3.93	4.97	4.44	5.55	5.26	90.00	0.46	10.36
7.	Seed breadth (mm)	1.83	2.53	2.25	6.97	6.92	98.70	0.32	14.22
8.	1000 Seed weight (g)	5.25	5.66	5.40	1.84	1.33	52.20	0.11	2.03
9.	Harvest index	26.30	37.05	31.14	7.95	6.73	71.40	3.64	11.68
10.	Days to maturity	96.00	123.0	107.43	5.93	5.92	99.70	13.07	12.16
11.	Oil content (%)	37.27	41.67	39.68	2.57	2.23	75.20	1.58	3.98
12.	Seed yield per plant	0.69	1.81	1.10	26.09	20.39	61.00	0.36	32.72

Heritability was high for all the characters studied except number of capsules per plant, number of seeds per capsule and 1000 seed weight which showed moderate heritability. The character exhibited high heritability indicated less influence of environment and are governed by non-additive gene effect. Selection may be considerably difficult or virtually impractical due to the masking effect of environment on genotypic effect *(*Singh *et al.,* 1998).

Heritability estimates along with genetic advance are normally helpful in predicting the gain under selection than heritability alone. Hence, heritability estimate along with genetic advance over mean were determined to get a clear picture of scope of improvement -in various characters through selection. Days to flowering, plant height, number of branches per plant and seed yield. per plant showed high heritability coupled with high genetic advance, which indicated the presence of high additive gene action making these characters to respond better for selection. High heritability coupled with moderate genetic advance was observed for harvest index and seed breadth, these characters indicate that the variability is due to both additive and non-additive interaction of gene. Which suggest that simple selection method alone will not be effective. Hence, hybridization followed by selection would be a better choice for linseed improvement.

Character association and path analysis:

Genotypic correlation indicates the true genetic performance of genes actually governing the characters, whereas phenotypic correlations do not indicate the magnitude and direction of genetic correlation. The correlation studies (Table 3) showed higher estimates of genotypic correlation coefficient than. the corresponding phenotypic. Low phenotypic correlation values can be explained due to masking or modifying effects of environment on genetic association between the characters

Table 3 : Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficient between different traits in linseed

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
X_1	1	0.257**	0.105	0.079	0.184	0.008	0.065	0.007	0.051	0.959**	-0.005	0.077
X_2	0.301**	1	0.307**	0.176	0.055	-0.045	0.038	0.052	0.135	0.326**	0.002	0.144
X_3	0.109	0.354**	1	0.700**	0.040	-0.152	-0.122	0.005	0.464**	0.097	0.044	0.456**
X_4	0.088	0.2	0.881**	1	-0.016	-0.150	-0.083	-0.028	0.583	0.074	-0.017	0.545**
X_5	0.350**	-0.029	0.032	0.077	1	-0.235*	-0.207	0.035	0.197	0.152	-0.106	0.227*
X_6	0.007	-0.052	-0.166	-0.202	-0.410**	1	0.623**	-0.045	0.088	0.033	0.183	-0.008
X_7	0.066	-0.039	-0.126	-0.114	-0.370**	0.673**	1	-0.141	-0.102	0.108	0.208	0.056
X_8	0.003	0.029	-0.002	-0.042	0.069	-0.097	-0.212	1	-0.071	-0.001	-0.015	-0.086
X_9	0.057	0.113	0.525**	0.772**	0.243*	-0.117	-0.116	-0.157	1	0.048	-0.139	0.853**
X_{10}	0.975	0.372**	0.104	0.095	0.284**	0.036	0.109	0.004	0.059	1	0.023	0.081
X_{11}	-0.001	-0.006	0.042	-0.027	-0.293**	0.225**	0.227**	-0.089	-0.194	0.025	1	-0.073
X_{12}	0.096	0.141	0.564**	0.737**	0.196	0.014	0.083	-0.178	0.920**	0.098	-0.072	1

* and ** indicate significance of values at p=0.05 and 0.01 respectively

X_1 – Days to flowering, X_2 – Plant height, X_3 – Number of branches per plant, X_4 - Number of capsules per plant, X_5 – Number of seeds per capsule, X_6 – Seed length, X_7 – Seed breadth, X_8 – 1000 seed weight, X_9 – Harvest index X_{10} – Days of maturity, X_{11} – Oil content, X_{12} – Seed yield per plant

(Kumar and Chauhan, 1979). Seed yield showed significant positively correlated with number of branches per plants, capsules per plant and harvest index at both genotypic and phenotypic levels. Number of branches per plant showed significant positive correlation with plant height, number of capsules per plant and harvest index. This indicates that selecting for these characters would increase the yield. Positive significant association of number of branches per plant with capsules per plant was observed by Kapoor and Chawla (1983). Ajit (2006) reported significant positive correlation of number of branches per plant with plant height, number of capsules per plant and harvest index. Positive association of plant height positive association with days to flowering, number of branches per plant and days to maturity suggesting that taller plants with more number of branches per plant would result in higher seed yield. Chawla and Singh (1983) observed positive significant correlation of plant height with days to flowering. Positive significant association of plant height with days to maturity and number of branches per plant was reported by Mahto and Mahto (1997) and Ajit (2006). Harvest index had significant association with number of branches per plant, number of capsules per plant and number of seeds per capsule. Positive significant correlation of harvest index with capsules per plant was also reported by Chawla and Singh (1983) and Malik and Singh (1995). Ajit (2006) reported positive correlation of harvest index with number of branches per plant and number of capsules per plant. In the present study, number of branches per plant, number of capsules per plant and harvest index showed significantly positive association with yield. Correlation among different character can be taken for further improvement in the seed yield of linseed.

Path coefficient is a tool, which provides an effective measure of direct and indirect cause of association and depicts the negative importance of each factor involved in contributing to the final yield. Path coefficient analysis revealed (Table 4) that harvest index was the single major character, which exhibited highest positive direct effect on seed yield per plant followed by number of branches per plant. Branches per plant showed direct positive effect on seed yield. However, indirect effect of branches per plant was more than direct effect through harvest index (Akbar *et al.,* 2003 and Ajit, 2006). In the present study, all these characters were found to have high significant and positive correlation with seed yield. From the above discussion, it can be concluded that due emphasis should

Table 4: Direct (diagonal) and indirect (above and below diagonal) effects of nine characters on seed yield in linseed at phenotypic level (Genotypic path values in parenthesis)

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	Correlation coefficient of yield
X_1	-0.034	0.002	0.007	0.004	0.020	0.000	0.011	0.000	0.040	0.026	0.000	0.077
	(0.018)	(-0.008)	(0.041)	(-0.033)	(0.018)	(0.000)	(0.016)	(0.000)	(0.059)	(-0.015)	(0.000)	(0.096)
X_2	-0.009	0.009	0.021	0.009	0.006	0.000	-0.007	0.000	0.106	0.009	0.000	0.144
	(0.005)	(-0.025)	(0.134)	(-0.076)	(-0.001)	(0.002)	(-0.009)	(0.001)	(0.118)	(-0.006)	(0.000)	(0.141)
X_3	-0.004	0.003	0.068	0.036	0.004	0.001	-0.021	0.000	0.365	0.003	0.000	0.456**
	(0.002)	(-0.009)	(0.378)	(-0.335)	(0.002)	(0.005)	(-0.030)	(0.000)	(0.550)	(-0.002)	(0.003)	(0.564)
X_4	-0.003	0.002	0.048	0.052	-0.002	0.001	-0.014	0.000	0.459	0.002	0.000	0.545**
	(0.002)	(-0.005)	(0.333)	(-0.380)	(0.004)	(0.006)	(-0.027)	(-0.001)	(0.808)	(-0.001)	(-0.002)	(0.737**)
X_5	-0.006	0.000	0.003	-0.001	0.107	0.001	-0.035	0.000	0.155	0.004	-0.000	0.227
	(0.006)	(0.001)	(0.102)	(-0.029)	(0.052)	(0.013)	(-0.087)	(0.001)	(0.255)	(-0.004)	(-0.022)	(0.196)
X_6	0.000	0.000	-0.010	-0.008	-0.025	-0.005	0.108	0.000	-0.069	0.001	0.002	-0.008
	(0.000)	(0.001)	(-0.063)	(0.077)	(-0.021)	(-0.031)	(0.158)	(-0.002)	(-0.122)	(-0.001)	(0.017)	(0.014)
X_7	-0.002	0.000	-0.008	-0.004	-0.022	-0.003	0.171	0.001	-0.081	0.003	0.002	0.056
	(0.001)	(0.001)	(-0.048)	(0.043)	(-0.019)	(-0.021)	(0.235)	(-0.005)	(-0.0122)	(-0.002)	(0.017)	(0.083)
X_8	0.000	0.000	0.000	-0.001	0.004	0.000	-0.024	-0.008	-0.056	0.000	0.000	-0.086
	(0.000)	(-0.001)	(-0.001)	(0.016)	(0.004)	(0.003)	(-0.050)	(0.021)	(-0.164)	(0.000)	(-0.007)	(-0.178)
X_9	-0.002	0.001	0.032	0.030	0.021	0.000	-0.018	0.001	0.787	0.001	-0.000	0.853**
	(0.001)	(-0.003)	(0.199)	(-0.293)	(0.013)	(0.004)	(-0.027)	(-0.003)	(1.047)	(-0.001)	(-0.015)	(0.920**)
X_{10}	-0.032	0.003	0.007	0.004	0.016	0.000	0.018	0.000	0.038	0.028	0.000	0.081
	(0.017)	(-0.009)	(0.039)	(-0.036)	(0.015)	(-0.001)	(0.026)	(0.000)	(0.061)	(-0.015)	(0.002)	(0.098)
X_{11}	0.000	0.000	0.003	-0.001	-0.011	-0.001	0.036	0.000	-0.110	0.001	0.010	-0.073
	(0.000)	(0.000)	(0.016)	(0.010)	(-0.015)	(-0.007)	(0.054)	(-0.002)	(-0.203)	(0.000)	(0.075)	(-0.072)

X_1 – Days to flowering, X_2 – Plant height, X_3 – Number of branches per plant, X_4 - Number of capsules per plant,
X_5 – Number of seeds per capsule, X_6 – Seed length, X_7 – Seed breadth, X_8 – 1000 seed weight, X_9 – Harvest index,
X_{10} – Days of maturity, X_{11} – Oil content, X_{12} – Seed yield per plant

be given to the characters *viz.,* number of branches per plant and harvest index making selection.

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