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CORRELATION AND PATH ANALYSIS IN LINSEED (*Linum usitatissimum* L.) FOR SEED YIELD AND YIELD ATTRIBUTING TRAITS

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ABSTRACT

This study assessed genetic variability, genotypic and phenotypic correlations, and path coefficients for seed yield and yield attributing traits in linseed genotypes under irrigated conditions. Genotypic correlations exceeded phenotypic ones, highlighting strong genetic control over trait associations, with environmental factors attenuating phenotypic expressions. Days to 50% flowering positively correlated with plant height and 1000-seed weight but negatively with maturity and seeds per capsule. Plant height, technical height, secondary branches, and capsules per plant showed highly significant correlated with grain yield. Path analysis at the genotypic level identified seeds per capsule, secondary branches, and capsules per plant as exerting the highest positive direct effects on grain yield, while days to maturity had a negative direct effect.
***Keywords* :** Seed yield kg/ha, path coefficient analysis, genotypic correlation, phenotypic correlation, linseed germplasm, yield components.

Introduction

Linseed (*Linum usitatissimum* L.) is one of the oldest cultivated oilseed crops and holds significant agricultural and industrial importance worldwide. It is also known as flax. In India, it is a major Rabi oilseed crop grown under diverse agro-ecological conditions, largely in rainfed and marginal environments. The crop is valued for its multipurpose utility, as its seeds are rich in oil (35–45%) and protein, while its straw provides high-quality fibre. Linseed oil is extensively used in industrial applications such as paints, varnishes, inks, linoleum, and adhesives, and is also nutritionally important due to its exceptionally high content of omega-3 fatty acids, particularly alpha-linolenic acid. Despite these advantages, linseed productivity remains low, mainly due to the cultivation of traditional varieties with limited yield potential and poor adaptation to varied environments. In order to enhancing yield and quality traits through genetic improvement is therefore a major breeding objective. Effective selection for yield improvement requires a clear understanding of the genetic variability present in the crop and the relationships among yield and its component traits. Correlation analysis provides insights into the association between traits, while path coefficient analysis helps to partition these relationships into direct and indirect effects, enabling precise identification of key yield-contributing characters. The combined use of these biometrical tools is essential for formulating efficient breeding strategies aimed at developing high-yielding and well-adapted linseed varieties.

Materials and Methods

A field trial of Linseed was conducted during the Rabi season of 2024–25 at Ranchi-6 (Jharkhand) Research farm of Birsa Agricultural University. The experimental site is located at 23°25′47.3″ N latitude and 85°18′48.3″ E longitude, at an elevation of 634 m above mean sea level, and experiences a subtropical climate during the Rabi season. There were 30 varieties of Linseed including five check varieties (National, Zonal, and Local checks), laid out in a Randomized Block Design with three replications. Linseed wads sown was done on 5 December 2024, with each genotype planted in a length of 4 m row at 30 cm row spacing, and each plot consisted of six rows covering 4.0 × 1.8 m². Observations were recorded from ten randomly selected plants per genotype in each replication. The traits included days to 50% flowering, days to maturity, plant height, technical height, number of primary branches, number of secondary branches, capsules per plant, seeds per capsule, capsule size, 1000-seed weight, and grain yield per hectare. These traits collectively provided a comprehensive assessment of genetic variability and performance among the thirty linseed genotypes.

The mean data recorded for all traits were subjected to analysis of variance (ANOVA) following the standard procedure for RBD to determine the significance of differences among genotypes. Estimates of genotypic and phenotypic coefficients of variation (GCV and PCV) were calculated according to Burton (1952). Heritability in the broad sense and genetic advance as a percentage of the mean were estimated using the methods proposed by Johnson *et al*. (1955) to assess the extent of genetic variability and predict the expected genetic gain from selection and to assess the interrelationships between seed yield per plant and its component traits, correlation coefficients were calculated. Additionally, path analysis was analysed to estimate the direct and indirect effects of these yield-contributing characters. Correlation coefficient was estimated by Johanson and path analysis was calculated as suggested by Dewey and Lu (1959).

Results and Discussion

Correlation Analysis

Correlation analysis at both genotypic and phenotypic levels revealed important associations among seed yield and its contributing traits in linseed. In general, genotypic correlation coefficients were higher than their phenotypic counterparts, indicating that genetic factors played a dominant role in governing trait associations, while environmental influences reduced the magnitude of phenotypic correlations. Days to 50% flowering showed positive genotypic correlations with plant height and 1000-seed weight, but negative associations with days to maturity and seeds per capsule, suggesting genetically controlled trade-offs between phenology and reproductive traits, as also reported by Verma *et al*. (2016). Plant height and technical height exhibited significant positive correlations with primary and secondary branches, capsules per plant, and grain yield at both levels, emphasizing their structural importance in yield formation (Kant, 2011; Patel *et al*., 2020). Secondary branches and capsules per plant showed strong positive correlations with grain yield, while days to maturity was negatively associated with yield, indicating the advantage of relatively early maturing genotypes under irrigated conditions.

Path Analysis

Path coefficient analysis provided deeper insight into the cause–effect relationships among traits. At the genotypic level, seeds per capsule exerted the highest positive direct effect on grain yield, followed by secondary branches and capsules per plant, confirming their primary role in yield determination. In contrast, days to maturity and some structural traits showed negative direct effects, though their overall correlations with yield were often positive due to substantial indirect effects through branching and capsule traits. Phenotypic path analysis similarly identified capsules per plant, secondary branches, and technical height as major contributors to yield, with environmental factors moderating the expression of phenological traits. These results agree with earlier findings in linseed (Kant *et al*., 2008; Paliwal *et al*., 2024) and suggest that selection for secondary branches, capsules per plant, and seeds per capsule would be most effective for improving seed yield under irrigated conditions.

Conclusion

The study revealed significant genetic variability among linseed genotypes for seed yield and its component traits under irrigated conditions. Genotypic correlations were generally higher than phenotypic correlations, indicating strong genetic control over yield-associated traits. Correlation and path analyses identified secondary branches, capsules per plant, and seeds per capsule as key contributors to grain yield due to their strong positive direct effects. Days to maturity showed a negative direct influence on yield, suggesting the advantage of early maturing genotypes. Overall, selection based on branching and capsule-related traits would be effective for improving linseed yield under irrigated conditions.

Table 1 : List of thirty Linseed entries used in present investigation list

S. No.	Name of Entries	Developed by
1	RLC-207	RARI, Durgapura (Rajasthan)
2	BLK-2023-1	BAU, Kanke
3	BLK-2023-2	BAU, Kanke
4	BAU-2022-03	BAU, Kanke
5	RUCHI	CSAUA&T, Kanpur
6	SABOUR-TISI-2	BAU, Sabour
7	BLK-2023-3	BAU, Kanke
8	BLK-2023-4	BAU, Kanke
9	BLK-2023-5	BAU, Kanke
10	BLK-2023-6	BAU, Kanke
11	MUKTA	CSAUA&T, Kanpur
12	NEELUM	CSAUA&T, Kanpur
13	BLK-2023-7	BAU, Kanke
14	J 23	JNKVV, Jabalpur
15	SLS-155	SVPUAT, Meerut
16	BLK-2023-8	BAU, Kanke
17	INDU	CSAUA&T, Kanpur
18	BLK-2023-9	BAU, Kanke
19	BLK-2023-12	BAU, Kanke
20	BLK-2023-14	BAU, Kanke
21	UMA	CSAUA&T, Kanpur
22	TL-99	BARC, Mumbai
23	RAJAN	CSAUA&T, Kanpur
24	NL-421	MPKV, Rahuri (MH)
25	KIRAN	IGKV, Raipur
26	T-397 (NC)	CSAUA&T, Kanpur
27	SHEKHAR (ZC)	CSAUA&T, Kanpur
28	DIVYA (LC)	BAU, Kanke
29	BIRSA-TISI-2 (LC)	BAU, Kanke
30	JLS-95 (NC)	JNKVV, Sagar (MP)

Table 2 : Analysis of variance (mean sum squares) for yield attributing characters

Source of variation	Days to 50% flowering	Days to maturity	Plant height (cm)	Technical height (cm)	No. of Primary branches / plant	No. of secondary branches / plant	1000 seed weight (g)	No. of capsules/ plant	No. of seeds/ capsule	Capsule size	Grain yield (Kg/ha)
Replication d.f (2)	9.011	30.178	7.730	2.423	0.001	0.056	0.191	42.582	0.015	0.011	15,536.843
Treatment d.f (29)	40.890**	17.023*	328.688**	171.035**	2.23**	2.52**	2.323**	470.28**	1.403**	0.53**	62339.936**
Error d.f (58)	2.310	9.764	8.280	15.006	0.219	1.176	0.111	13.657	0.343	0.061	11730.550

** = Significant at 1 % and * = Significant at 5 % level of significance

Table 3 : Correlation Matrix (Above diagonal Genotypic and below diagonal Phenotypic)

Germplasm	Grain yield (Kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	Technical height (cm)	No. of Primary branches/ plant	No. of secondary branches/ plant	1000 seed weight (g)	No. of capsules/ plant	No. of seeds/ capsule	Capsule size
Grain yield (Kg/ha)	1.000	**0.075**	**-0.444****	**0.212***	**0.371****	**0.291****	**0.931****	**0.295****	**0.913****	**0.355****	**0.151**
Days to 50% flowering	0.002	1.000	-0.856**	0.298**	-0.048	-0.110	-0.055	0.460**	0.073	-0.370**	0.127
Days to maturity	-0.171	-0.101	1.000	-0.264*	-0.243*	-0.070	-0.643**	-0.409**	-0.275**	0.434**	-0.536**
Plant height (cm)	0.203	0.278**	-0.075	1.000	-0.005	0.309**	0.289**	0.247*	0.381**	-0.205	0.040
Technical height (cm)	0.417**	-0.044	-0.046	0.024	1.000	-0.253*	0.393**	-0.097	0.258*	0.357**	-0.052
No. of Primary branches	0.241*	-0.064	0.009	0.306**	-0.106	1.000	0.342**	-0.103	0.328**	-0.064	0.114
No. of secondary branches	0.482**	-0.066	-0.245*	0.135	0.251*	0.207	1.000	0.187	0.641**	-0.086	-0.005
1000 seed weight (g)	0.192	0.401**	-0.157	0.253*	-0.083	-0.050	0.011	1.000	0.271**	-0.085	0.261*
No. of capsule/ plant	0.677**	0.075	-0.111	0.357**	0.241*	0.262*	0.323**	0.246*	1.000	0.082	0.061
No. of seed/ capsule	0.105	-0.224*	0.154	-0.160	0.174	0.007	0.029	-0.080	0.055	1.000	0.177
Capsule size	0.103	0.119	-0.116	0.002	-0.055	0.068	0.005	0.165	0.033	0.057	1.000

** = Significant at 1 % and * = Significant at 5 % level of significance

Table 4 : Path coefficient analysis showing direct (diagonal) and indirect effects (off diagonal) at genotypic and phenotypic level

		Days to 50% flowering	Days to maturity	Plant height (cm)	Technical height (cm)	No. of Primary branches/ plant	No. of secondary branches/ plant	1000 seed weight (g)	No. of capsules/ plant	No. of seeds/ capsule	Capsule size	Grain yield per plot Correlation (r)
Days to 50% flowering	G	**0.095**	0.295	-0.028	0.021	0.018	-0.039	-0.046	0.040	-0.260	-0.022	0.075
	P	**-0.036**	0.004	-0.018	-0.011	-0.007	-0.015	0.042	0.038	-0.004	0.009	0.002
Days to maturity	G	-0.081	**-0.345**	0.024	0.106	0.012	-0.449	0.041	-0.151	0.305	0.093	-0.444**
	P	0.004	**-0.035**	0.005	-0.012	0.001	-0.055	-0.017	-0.056	0.003	-0.009	-0.171
Plant height (cm)	G	0.028	0.091	**-0.092**	0.002	-0.052	0.201	-0.025	0.209	-0.144	-0.007	0.212*
	P	-0.010	0.003	**-0.065**	0.006	0.033	0.031	0.027	0.181	-0.003	0.000	0.203
Technical height (cm)	G	-0.005	0.084	0.000	**-0.436**	0.042	0.274	0.010	0.141	0.251	0.009	0.371**
	P	0.002	0.002	-0.002	**0.258**	-0.011	0.057	-0.009	0.122	0.003	-0.004	0.417**
No. of Primary branches	G	-0.011	0.024	-0.029	0.110	**-0.167**	0.238	0.010	0.179	-0.045	-0.020	0.291**
	P	0.002	-0.000	-0.020	-0.027	**0.107**	0.047	-0.005	0.133	0.000	0.005	0.241*
No. of secondary branches	G	-0.005	0.222	-0.027	-0.171	-0.057	**0.697**	-0.019	0.350	-0.061	0.001	0.760**
	P	0.002	0.008	-0.009	0.065	0.022	**0.227**	0.001	0.164	0.000	0.000	0.547**
1000 seed weight (g)	G	0.044	0.141	-0.023	0.042	0.017	0.130	**-0.100**	0.148	-0.060	-0.045	0.295**
	P	-0.014	0.005	-0.016	-0.021	-0.005	0.002	**0.106**	0.125	-0.001	0.012	0.192
No. of capsule/ plant	G	0.007	0.095	-0.035	-0.112	-0.055	0.447	-0.027	**0.547**	0.058	-0.011	0.913**
	P	-0.003	0.004	-0.023	0.062	0.028	0.073	0.026	**0.507**	0.001	0.002	0.677**
No. of seed/ capsule	G	-0.035	-0.150	0.019	-0.156	0.011	-0.060	0.008	0.045	**0.703**	-0.031	0.355**
	P	0.008	-0.005	0.010	0.045	0.001	0.007	-0.008	0.028	**0.016**	0.004	0.105
Capsule size	G	0.012	0.185	-0.004	0.023	-0.019	-0.003	-0.026	0.033	0.124	**-0.174**	0.151
	P	-0.004	0.004	-0.000	-0.014	0.007	0.001	0.017	0.017	0.001	**0.073**	0.103

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