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GENETIC VARIABILITY, HERITABILITY, AND GENETIC ADVANCE FOR YIELD AND COMPONENT TRAITS IN LINSEED

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ABSTRACT

Linseed (*Linum usitatissimum* L.) is a vital oilseed crop with significant nutritional and industrial value. This study evaluated 90 linseed genotypes for genetic variability, heritability, and genetic advance at BAU, Kanke, during the Rabi season of 2023-24 using an augmented block design. The analysis of variance revealed significant differences among genotypes for all studied traits, indicating substantial genetic variability. Secondary branches per plant (30.27% PCV, 26.80% GCV), capsules per plant (21.12% PCV, 19.12% GCV), and yield per plot (22.88% PCV, 20.52% GCV) exhibited the highest genetic variation, suggesting strong selection potential. Traits like 1000-seed weight (95.96%), days to maturity (88.14%), and days to 50% flowering (85.67%) showed high heritability, indicating strong genetic control. Genetic advance analysis revealed that secondary branches per plant (GA: 11.34, GAM: 48.94%) and yield per plot (GA: 19.63, GAM: 37.95%) offer promising breeding potential. The findings provide valuable insights for linseed improvement programs aimed at developing high-yielding and stress-tolerant varieties, ensuring enhanced productivity.

Keywords **:** Variability, heritability, genetic advance, linseed, PCV, GCV.

Introduction

Linseed, botanically referred to as *Linum usitatissimum* L. also known as flaxseed, plays a vital role in India's oilseed sector, contributing significantly to global production. Despite being a major producer, India struggles to meet domestic demand, necessitating imports. Linseed originated in West Asia and the Mediterranean region. It is a self-pollinated crop (2n = 30) belonging to the family Linaceae.

India cultivates linseed across diverse agro-climatic zones, primarily under rainfed conditions (63%) with additional utera (20%) and irrigated (17%) areas (Rokade *et al.*, 2015). Major producing states include Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Jharkhand and Bihar. The total cultivation area is approximately 2.1 lakh hectares, yielding 1.32 lakh tons with an average productivity of 6.59 q/ha (Ministry of Agriculture & Farmers Welfare, 2021-22).

Linseed is valued for its high oil content (35-45%), rich in omega-3 fatty acids, and protein (20-25%). It has diverse applications in food, industry, and traditional medicine. However, challenges such as delayed sowing due to long-duration paddy crops, moisture limitations, and irrigation constraints affect yield. Research focuses on breeding improved varieties with traits such as drought resistance, disease tolerance, and high oil content to enhance productivity.

Genetic and agro-morphological characterization is essential for crop improvement, ensuring germplasm conservation and superior cultivar development. Morphological traits provide insights into genetic diversity, aiding breeders in selecting high-yielding, disease-resistant, and climate-resilient varieties.

Linseed's nutritional and industrial significance underscores the need for ongoing research in genetic diversity and morphological characterization. Identifying superior genotypes will contribute to sustainable cultivation, ensuring both agricultural and industrial needs are met.

Materials and Methods

The experimental materials consisted of 90 linseed (*Linum usitatissimum* L.) entries obtained from the Indian Institute of Oilseed Research (IIOR) Hyderabad. These genotypes were assessed for genetic variability heritability and genetic advance at the western section of research farm BAU, Kanke. during the Rabi season of 2023-24. The experiment was conducted using Augmented block design with five blocks and five checks replicated randomly in each block. Each entry was sown in 1 row of 2m length, maintaining a row-to-row spacing of 30cm with 1m path gap between each block. To ensure optimal crop growth, the recommended package of practices was followed. Observations were recorded from five randomly selected plants per entries, assessing key agronomic traits such as days to 50% flowering, days to maturity, capsule size, number of primary and secondary branches per plant, number of capsules per plant, number of seeds per capsule, yield per plot and 1000-seed weight. The collected data were analyzed using the R Studio software. Genetic parameters, including phenotypic, genotypic and environmental coefficients of variation, were assessed based on the methods proposed by Burton and De Vane (1953) and Johnson *et al*. (1955). Heritability (h^2) was estimated as the ratio of genotypic variance to the total variance, which includes both genotypic and environmental components. Additionally, the expected genetic advance for various traits was calculated according to the procedures suggested by Burton and De Vane (1953) and Johnson *et al*. (1955).

Result and Discussion

The ANOVA is a set of statistical models designed to examine differences between group means and their associated variations, both within and among groups. It was developed by R.A. Fisher. Seed yield, being a highly variable and complex quantitative trait influenced by environmental factors, results from the cumulative effects of multiple components. ANOVA helps partition this variation into distinct components, including replications, treatments/genotypes, and error, allowing for a more precise evaluation of genetic and environmental influences on yield.

The analysis of variance for various yield and yield-related traits in linseed, presented in Table 1, showed that the mean sum of squares due to genotypes was significant for all studied traits. This indicates substantial variability among the selected genotypes, providing a strong basis for selecting different quantitative and qualitative traits for yield improvement in linseed. These findings align with previous studies conducted by Bibi *et al*. (2013), Kumar *et al*. (2015), Paul *et al*. (2015), Dabalo *et al*. (2020), Terfa *et al*. (2020) and Thakur *et al*. (2020).

Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) are crucial indicators of variability in linseed, reflecting the extent of variation influenced by genetic and environmental factors. The table 2 highlights that no. of secondary branch (30.27% PCV, 26.80% GCV), No. of primary branch (28.40% PCV, 22.33% GCV), No of capsules per plant (21.12% PCV), and yield per plot (22.88% PCV, 20.52% GCV) \ exhibited the highest variation among the studied traits. Similar trends were reported by Thakur *et al*. (2022), Toor *et al*. (2024), Dogra *et al*. (2020) and Tadesse *et al*. (2010). Conversely, days to 50% flowering (5.06% PCV, 4.68% GCV), days to maturity (4.07% PCV, 3.82% GCV), and seeds per capsule (9.38% PCV, 6.94% GCV) exhibited the low variation, indicating their stability across different genotypes. These findings are aligned with those of Meena *et al*. (2020) and Kumar *et al*. (2017). Moderate PCV and GCV values were observed for 1000 seed weight (g) (17.63% PCV, 17.27% GCV) aligning with findings of Prajapati *et al*. (2022) and Dabalo *et al*. (2020). High heritability was recorded for characters such as 1000 seed weight (95.96%), Days to maturity (88.14%), Days to 50% flowering (85.67), No. of capsules per plant (81.95%) and Yield per plot(g) (80.42%). Moderate heritability was observed for characters such as No. of secondary branch (78.35%), Capsule size (78.32%), No. of primary branch (61.84%) and No. of seeds per capsule (54.67%). These findings align with studies by Shankar *et al*. (2024), Meena *et al*. (2020) and Thakur *et al*. (2020). The estimates of genetic advance showed considerable variation across the traits studied. The highest genetic advance was observed for seed yield per plot (19.63) followed by the number of capsules per plant (17.91), number of secondary branches (11.34), days to maturity (9.50), days to 50% flowering (6.16). 1000 seed weight (2.37), number of primary branches (1.23), number of seeds per capsule (0.87). The lowest genetic advance was noted for capsule size (0.80). Genetic advance as per cent of mean ranged from 7.40% (days to maturity) to 48.94% (number of secondary branches). High genetic advance as percent of mean were found for traits such as seed yield per plot (37.95), number of primary branches (36.23%), number of capsules per plant (35.71%) and 1000 seed weight (34.90%). Moderate genetic advance as percent of mean were observed for capsule size (12.02%) and number of seeds per capsule (10.58). The low genetic advance as per cent of mean was recorded for days to 50% flowering (8.94%) and days to maturity (7.40%) similar findings has been observed in the study by Shankar *et al*. (2024), Ankit *et al.* (2019), Sahu *et al.* (2016) and Vardhan *et al*. (2012).

Conclusion

The study highlights significant genetic variability among 90 linseed genotypes, with key traits such as no. of primary and secondary branches per plant, no. of capsules per plant, and yield per plot showing high PCV, GCV, and genetic advance. High heritability estimates for traits like 1000-seed weight and days to maturity indicate strong genetic control, making them suitable for selection-based breeding. The results emphasize the potential for improving linseed productivity through targeted breeding strategies, ultimately contributing to sustainable agricultural practices and enhanced oilseed production.

Table 1 : Analysis of variance for different quantitative characters in linseed

S. No	Source	Treatment (ignoring Blocks)	Treatment: Check	Treatment: Test	Treatment: Test vs. Check	Block (eliminating Treatments)	Residuals
	df	94	4	89	1	4	16
1	Days to 50% Flowering	11.58 **	1.84 ns	12.14 **	1.01 ns	3.64 ns	1.74
2	Days to Maturity	35.84 **	224.34 **	27.31 **	41.07 **	3.44 ns	3.24
3	No. of Seeds/ Capsule	0.62 *	0.43 ns	0.60 *	2.85 **	0.62 ns	0.27
4	Capsule Size (mm)	0.26 **	0.54 **	0.25 **	0.00 ns	0.16 *	0.05
5	No. of Primary Branch	1.00 *	2.53 **	0.94 *	0.41 ns	0.53 ns	0.36
6	No. of Secondary branch	61.53 **	304.63 **	49.19 **	187.42 **	14.31 ns	10.65
7	No. of Capsules per plant	116.22 **	131.59 **	112.26 **	407.40 **	31.81 ns	20.26
8	1000 seed weight (g)	1.56 **	4.72 **	1.43 **	0.26 ns	0.10 ns	0.06
9	Yield/ plot (g)	150.85 **	389.94 **	140.03 **	157.46 *	24.33 ns	27.42
*= significant at 5%; **= significant at 1%							

Table 2 : Estimation of Genetic parameters for nine quantitative characters in Linseed

S. No.	Trait	Mean	Range	GCV (%)	PCV (%)	h^2	GA	GAM
1	Days to 50% Flowering	68.85	61-79	4.68	5.06	85.67	6.16	8.94
2	Days to Maturity	128.41	113-134	3.82	4.07	88.14	9.50	7.40
3	No. of Seeds/Capsule	8.26	6-10	6.94	9.38	54.67	0.87	10.58
4	Capsule Size (mm)	6.66	5.61-8.05	6.58	7.44	78.32	0.80	12.02
5	No. of Primary Branch	3.41	1-7	22.33	28.40	61.84	1.23	36.23
6	No. of Secondary branch	23.17	8-41	26.80	30.27	78.35	11.34	48.94
7	No. of Capsules per plant	50.16	27-75	19.12	21.12	81.95	17.91	35.71
8	1000 seed weight (g)	6.78	4.60-9.71	17.27	17.63	95.96	2.37	34.90
9	Yield/ plot (g)	51.72	25.95-73.71	20.52	22.88	80.42	19.63	37.95

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