



# **Study on Genetic Variability for Yield and Yield Contributing Traits in Linseed (*Linum usitatissimum* L.)**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The present study was conducted to estimate the extent of genetic variability, heritability and genetic advance. The experimental material comprising of 40 linseed genotypes were evaluated at Experimental Farm, Department of Genetics and Plant Breeding, College of Agriculture, Latur during *Rabi*-2023. The material was sown in Randomized block design with two replications with the spacing of 30 cm x 5 cm. Observations were recorded for ten characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, number of seed per capsule, 1000 seed weight (g), harvest index (%), oil content (%) and seed yield per plant (g). Analysis of variance showed substantial amount of

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genetic variability had been found for all the characters, which was indicated by significant differences among and between treatments. The magnitude of genotypic and phenotypic coefficients of variation was found to be high for the number of branches per plant, number of capsules per plant, harvest index and seed yield per plant. The highest broad sense heritability values were certainly found for all ten characters. High heritability coupled with high genetic advance as per cent of mean were associated with characters days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, 1000 seed weight, harvest index and seed yield per plant which indicated that heritability is most likely due to additive gene effects and simple phenotypic selection may be effective.

**Keywords:** Linseed; variability; heritability; genetic advance; GCV; PCV.

## 1. INTRODUCTION

“Linseed (*Linum usitatissimum* L.) commonly referred to as flax, is an annual plant belonging to the Linaceae family and the *Linum* genus. It is a diploid species ( $2n = 30$ ) and is widely known as “Alsi.” It is believed to have originated in Southwest Asia, with particular emphasis on India, according to Vavilov (1935). The genus name '*Linum*' comes from the word 'lin,' which translates to 'thread,' while the species name '*usitatissimum*' is a Latin term meaning 'most useful.' When harvested as an oilseed, it is commonly called flaxseed or linseed and when used for its fiber, it is referred to as fibre flax or simply flax, particularly in Europe.” (Vaisey-Genser and Diane, 2003).

“Linseed is an annual herbaceous plant that typically grows to a height of 30 to 120 cm (1 to 4 feet). It thrives in temperate climates. The optimal temperature range for the vegetative and reproductive phases is between “21-27°C”. Despite being a self pollinating crop, linseed can experience up to 2% cross-pollination” (Dilman, 1928). It thrives on fertile, medium-to-heavy, well-drained soils, particularly silty loam, clay loam and silty clays. During the flowering stage, high temperatures (over 32°C) combined with moisture stress limit the production of seeds. The plant features narrow, lance-shaped leaves and produces small, blue or white flowers. The seeds of linseed are small, flat and oval in shape with a hard outer shell that protects the inner oil-rich core. This crop is grown in three different ecosystems: irrigated, rainfed and uterine. Linseed is a versatile winter (*rabi*) oilseed crop, cultivated primarily for its oil.

Linseed is mainly cultivated for its seeds, which are processed to produce linseed oil and for its fibers, which are used in the production of linen. Linseed is a multipurpose resource with applications in the textile industry, manufacturing

and medicine. Beyond being an oilseed, it is available in various forms, including whole seeds, meals, flour and oil. It is incorporated into a wide range of commercial products, such as food, animal feed and non-food items. Linseed enhances the nutritional value and functionality of several food products including cereals, baked goods, snacks and beverages. Additionally, it improves the quality of animal feed, making it a valuable addition to livestock diets. Its versatility and nutritional profile have made it a valuable crop both for industrial uses like oil production, textile manufacturing and for its health benefits in food products. Linseed is the best source of omega-3 fatty acids, which are necessary because they cannot be manufactured by the body and must be obtained through food.

## 2. MATERIALS AND METHODS

### 2.1 Testing Location and Layout of Experiment

An experiment was conducted with 40 genotypes of linseed during *rabi*-2023 at Experimental farm of the Department of Genetics and Plant Breeding, College of Agriculture, Latur. The material of linseed genotypes for the present study were collected from Oilseed Research Station, Latur. The trail was carried out in Randomized block design with two replications having 30 cm x 5 cm spacing. The observations were recorded on days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, number of seed per capsule, 1000 seed weight (g), harvest index (%), oil content (%) and seed yield per plant (g).

### 2.2 Experimental Materials

The experiment was conducted using 40 linseed genotypes namely; Meera, Mutant-02, LSL-01, FR-11, Neelam, RLC-04, T-397, EX-6-3, EC-

1474, EC-704, GS-27, GS-119, ES-1534, Divya, GS-111, EC-1386, GA-85, LSL-93, ES-1462, GS-109, GS-64, NL-94, EC-99001, GS-68, EC-41741, EC-41623, GS-15, GS-61, EC-1463, TL-99, ES-14230, FR-111, EC-1066, ES-1476, GS-40, GS-20, GS-82, EI-5511, JLS-395 and ES-1445.

### 3. RESULTS AND DISCUSSION

The improvement of the crop relies heavily on genetic variability. A key factor in successful breeding programs is understanding the type and extent of genetic variation within each crop species. A comprehensive understanding of this variation is essential for its effective application in crop improvement as genetic variation forms the basis for plant breeding, where selection is used to develop enhanced genotypes. The study of genetic advance is crucial as it measures the genetic gain resulting from selection for a specific trait. Therefore, examining heritability, genetic variability and genetic advance is essential for any crop improvement program that involves selection or hybridization.

#### 3.1 Analysis of Variance

The analysis of variance revealed that there are highly significant differences between genotypes for all ten variables examined in (Table 1). Days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, 1000 seed weight, harvest index, oil content and seed yield per plant all showed a significant difference between genotypes. This suggests that there is a broad range of variability across genotypes for yield and its contributing attributes and that selection can be beneficial for another trait in relation to the genotypes studied. Similar outcome was earlier reported by Choudhary et al. (2017), Meena et al. (2020), Terfa and Gurm (2020), Patil et al. (2023) and Paliwal et al. (2024).

#### 3.2 Mean Performance

While analyzing the data, the mean performance of 40 linseed genotypes for ten characters shows. The promising genotypes RLC-04 and LSL-93 exhibited early flowering and short plant height. The genotypes EC-1476 and ES-1534 have a late maturity day. The trait number of seeds per capsule was highest for genotypes GS-15, ES-14230 and JLS-395 whereas, ES-

1445 and GS-61 showed a high 1000 seed weight. Mutant-2, GS-68, GS-27 and FR-111 were found to be the highest performers in terms of seed yield per plant with their respective features. These results indicated that, these genotypes possess a desirable combination of yield potential, making it an ideal for selection and future breeding programs.

#### 3.3 Genotypic and Phenotypic Coefficient of Variation

The amount of differences in quantitative characteristics is measured and expressed as a variance. The total quantity of observed variation or phenotypic variation in character does not accurately represent variation that can be fixed in subsequent generations, whereas genotypic variation is the number of fixable differences from one generation to the next. The environmental variance changes from one location to another and so cannot be fixed.

In general (Table 2), the phenotypic variance was greater than the genotypic variances for the characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, number of seed per capsules, 1000 seed weight (g), harvest index (%), oil content (%) and seed yield per plant (g).

The genotypic coefficients of variance ranged from 5.39% to 20.15%. The highest genotypic coefficient of variation (GCV) was for seed yield per plant (20.15%) followed by harvest index (19.06%), number of branches per plant (18.43%), number of capsules per plant (18.25%), 1000 seed weight (12%), days to maturity (11.62), days to 50 per cent flowering (11.56%) and plant height (10.14%). The lowest genotypic coefficients of variation were found in the number of seeds per capsule (6.36%) and oil content (5.39%).

The phenotypic coefficients of variance ranged from 5.72 % to 21.32%. The highest phenotypic coefficient of variation (PCV) was for seed yield per plant (21.32%) followed by harvest index (19.61%), number of branches per plant (19.27%), number of capsules per plant (18.67%), 1000 seed weight (12.24%), days to maturity (11.70%), days to 50 per cent flowering (11.70 %) and plant height (10.32 %). The lowest phenotypic coefficients of variation were found in the number of seeds per capsule (7.18%) and oil content (5.72%).

**Table 1. Analysis of variance for yield and yield related traits in linseed**

Sr. No.	Characters	Mean Sum of Squares		
		Replication	Treatments	Error
	d.f.	1	39	39
1	Days to 50 per cent flowering	5.00	76.20**	1.82
2	Days to maturity	15.31	266.36**	3.95
3	Plant height (cm)	6.05	73.05**	2.48
4	Number of branches per plant	0.14	0.80**	0.06
5	Number of capsules per plant	31.50	200.76**	8.74
6	Number of seed per capsule	0.02	0.61**	0.13
7	1000 seed weight (g)	0.09	1.78**	0.06
8	Harvest index (%)	1.10	46.34**	2.57
9	Oil content (%)	1.09	7.48**	0.82
10	Seed yield per plant (g)	0.06	2.82**	0.08

Results of genetic variability parameters indicated that the estimates of phenotypic coefficient of variation were greater than the genotypic coefficient of variation (Fig. 1.) for the majority of the characters that indicating the influence of environment on the traits under study (Table 2). Similar results were reported by Paul and Kumari (2018), Thakur et al. (2022) and Singh et al. (2019). However, genotypic and phenotypic variances for days to 50 per cent flowering and days to maturity are nearly equal and hence environment did not exert masking influence on the expression of genetic variability for these traits. These findings are consistent with previous reports of Dandigadasar et al. (2011), Singh et al. (2015) and Dhirhi and Mehta (2019).

High values of PCV and GCV were obtained for traits viz., number of branches per plant, number of capsules per plant, harvest index and seed yield per plant. Similar findings were reported by Krishnan et al. (2012), Meena et al. (2020), Dogra et al. (2020), Terfa and Gurmu (2020), Patil et al. (2023), Shankar et al. (2024). Whereas, the lowest PCV and GCV values were observed for the traits Number of seed per capsule (7.18 and 6.36 % respectively) and oil content (5.72 and 5.39 % respectively). It suggests that limited genetic variability and is heavily influenced by the environment. Similar results were observed by Thakur et al. (2022), Shankar et al. (2024), Yadav et al. (2024), Meena et al. (2020) and Thakur et al. (2020).

### 3.4 Heritability and Genetic Advance as Per Cent of Mean

“Heritability indicates the proportion of phenotypic variation attributable to genetic factors, while genetic advance shows how much improvement we can expect through selection. Knowing both helps plant breeders plan better

ways to develop improved crop varieties. Broad-sense heritability provides an idea about the portion of observed variability attributable to genetic differences. Genetic advance, which predicts improvement in the succeeding generations through selection, is a highly effective method for managing breeding material and enhancing genetic gain. Genetic advance, which predicts improvement in the succeeding generations through selection, is a highly effective method for managing breeding material and enhancing genetic gain” (Dogra et al. (2020).

The broad sense heritability high for the all the ten characters (Table 2). The highest heritability estimates were observed for days to maturity (98.52 per cent), days to 50 per cent flowering (97.61 per cent), plant height (96.60 per cent), 1000 seed weight (96.17 per cent), number of capsules per plant (95.65 per cent), harvest index (94.46 per cent), number of branches per plant (91.47 per cent), seed yield per plant (89.38 per cent), oil content (88.92 per cent) and number of seed per capsule (78.53 per cent).

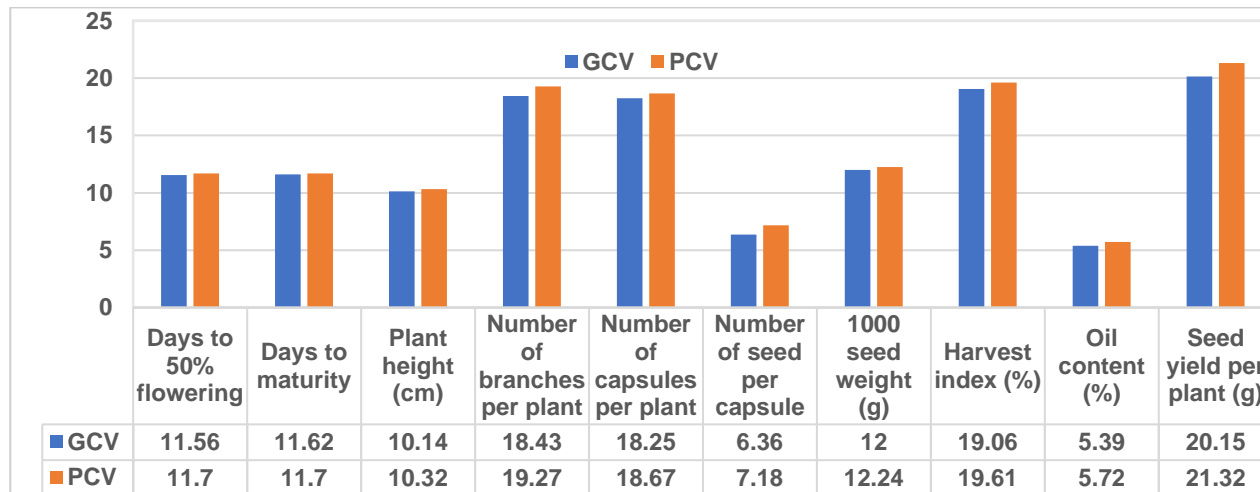
Genetic advance as percent of mean exhibited higher values for seed yield per plant (39.26%) followed by harvest index (38.17%), number of capsules per plant (36.78%) and number of branches per plant (36.31%), 1000 seed weight (24.25%), days to maturity (23.76%), days to 50 per cent flowering (23.54%) and plant height (20.54%) showed medium values for the traits, number of seed per capsule (11.62%) and oil content (10.48%).

The characters days to 50 per cent flowering (97.61, 23.54 per cent respectively), days to maturity (98.52, 23.76 per cent respectively), plant height (96.60, 20.54 per cent respectively), number of branches per plant (91.47 per cent, 36.31 per cent respectively), number of capsules per plant (95.65 per cent, 36.78 per cent

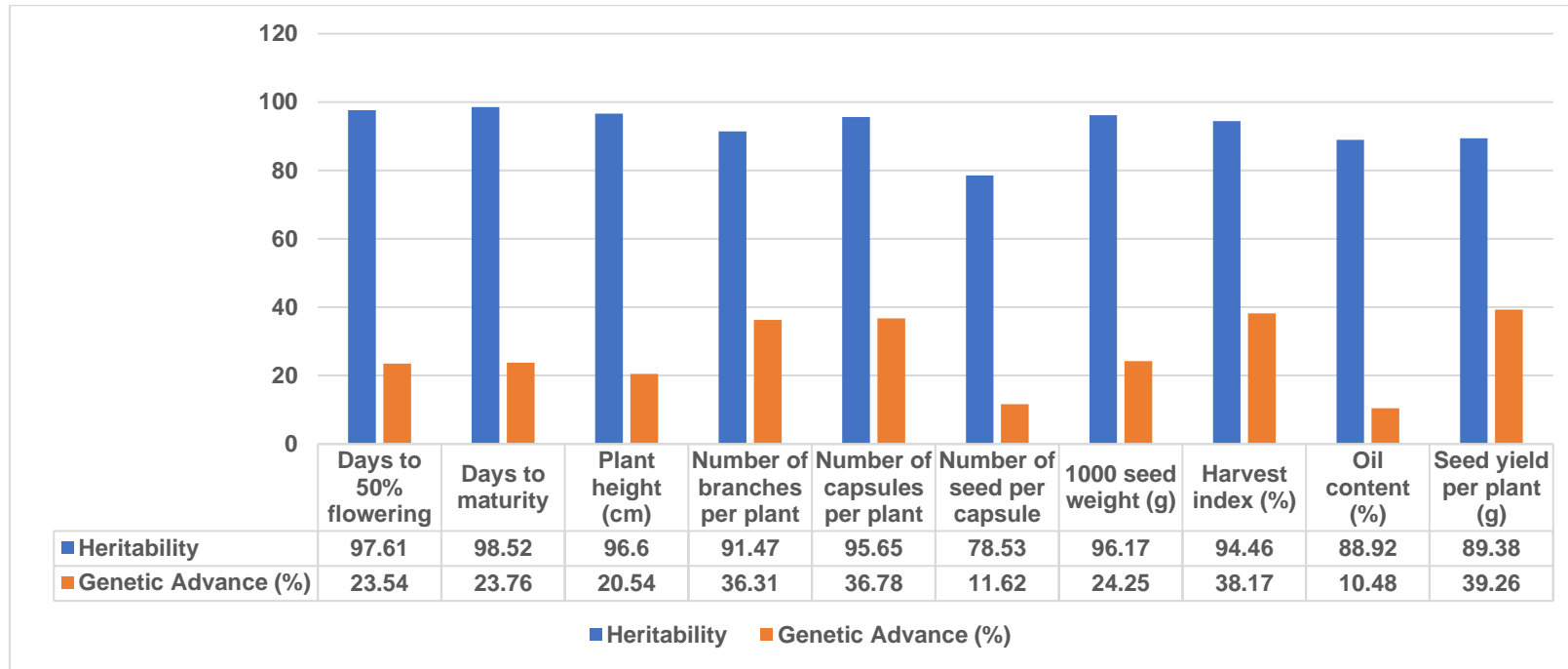
**Table 2. Genetic parameters of variability for different traits in linseed**

Characters	Mean	Range		GV	PV	GCV (%)	PCV (%)	h <sup>2</sup> (bs)	GA	GAM (%)
		Min.	Max.							
Days to 50 per cent flowering	52.73	39.00	63.50	37.19	38.10	11.56	11.70	97.61	12.41	23.54
Days to maturity	98.56	72.50	113.00	131.20	133.18	11.62	11.70	98.52	23.42	23.76
Plant height (cm)	58.53	40.00	70.00	35.28	36.52	10.14	10.32	96.60	12.02	20.54
Number of branches per plant	3.29	1.90	4.20	0.36	0.40	18.43	19.27	91.47	1.19	36.31
Number of capsules per plant	53.66	35.50	72.00	96.01	100.38	18.25	18.67	95.65	19.74	36.78
Number of seed per capsule	7.75	6.9	8.80	0.24	0.30	6.36	7.18	78.53	0.90	11.62
1000 seed weight (g)	7.73	6.10	9.25	0.86	0.89	12.00	12.24	96.17	1.87	24.25
Harvest index (%)	24.53	17.24	32.66	21.88	23.16	19.06	19.61	94.46	9.36	38.17
Oil content (%)	33.79	30.09	37.43	3.32	3.74	5.39	5.72	88.92	3.54	10.48
Seed yield per plant (g)	3.01	1.85	4.25	0.36	0.41	20.15	21.32	89.38	1.18	39.26

GV- Genotypic variance, PV- Phenotypic variance, GCV- Genotypic Coefficients of variation, PCV- Phenotypic coefficient of variation, h<sup>2</sup>(bs)- heritability (broad sense), GA- Genetic advance, GAM- Genetic advance as per cent of mean



**Fig. 1. GCV and PCV for yield and yield contributing characters in linseed**



**Fig. 2. Heritability and Genetic Advance (%) for yield and yield contributing characters in linseed**

respectively), 1000 seed weight (96.17, 24.25 per cent respectively), harvest index (94.46 per cent, 38.17 per cent respectively) and seed yield per plant (89.38 per cent, 39.26 per cent respectively) showed high heritability coupled with high genetic advance as per cent of mean which indicated that heritability is most likely due to additive gene effects and simple phenotypic selection may be effective. Similar results were obtained by Gauraha et al. (2011), Krishnan et al. (2012), Kumar et al. (2012), Kanwar et al. (2014) and Kumar et al. (2015).

Number of seed per capsule (78.53 per cent, 11.62 per cent respectively) and oil content (88.92 per cent, 10.48 per cent respectively) recorded high heritability coupled with moderate genetic advance as per cent of mean (Fig. 2.) which indicated the presence of non-additive gene action. High heritability is due to favorable influence of environment rather than genotype and selection for such trait may not be rewarding. Similar result was obtained by Naik and Satapathy (2002), Tadesse et al. (2010), Krishnan et al. (2012) and Patil et al. (2023).

#### 4. CONCLUSION

Genetic variability study demonstrated that the material used in the current research had significant variability which provided a suitable basis for selection. Higher values of phenotypic coefficient of variation than genotypic coefficient of variation for a trait indicate that the traits are influenced by their environment. While there was a close correspondence between GCV and PCV for the majority of the characters, environmental factors had less influence on the appearance of these characters. The GCV and PCV were reported to be high for seed yield per plant, harvest index, number of capsules per plant and number of branches per plant indicate the good scope for genetic improvement of these characters by selection. High heritability with high genetic advance as per cent of mean observed for the characters such as days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, 1000 seed weight, harvest index and seed yield per plant are most likely governed by additive genes suggesting that simple selection may effectively improve them.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image

generators have been used during the writing or editing of this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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