Assessment of Genetic Variability, Heritability and Genetic Advance for Yield and Yield Attributes in Linseed (*Linum usitatissimum* L.)

Abstract

Linseed is recognized as an excellent source of essential minerals, nutrients, and is particularly rich in omega-3 fatty acids and alpha-linolenic acid (ALA), making it highly recommended for cardiovascular health. It is cultivated mainly for both linen, and oil production, which is used for production of paints, varnishes and linoleum paste. The present investigation was conducted using a Randomized Block Design with three replications among 75 linseed genotypes, including ten checks, to evaluate genetic variability, heritability, and genetic advance for yield and its attributes. Analysis of variance revealed significant variation across all studied traits. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) ranged from low to high, with the lowest GCV and PCV observed for days to maturity, number of seeds per capsule, and days to 50% flowering. Conversely, the highest GCV and PCV values were recorded for seed yield per plant (g), number of capsules per plant, number of secondary branches per plant, and plant height. All traits recorded the highest heritability. High heritability and genetic advance were recorded for seed yield per plant, number of capsules per plant, number of secondary branches per plant, plant height, thousand seed weight, number of primary branches and oil content, indicating the presence of additive gene action for these characters. Based on these results, the genotypes studied show significant genetic variation for yield and its attributes, which should be leveraged in future breeding programs.

Keywords: Genetic variability, heritability, genetic advance, linseed and seed yield.

INTRODUCTION

Linseed (*Linum usitatissimum* L.), an annual and self-pollinated species, belongs to the family Linaceae and has a chromosome number of 2n = 30 (Toor and Alka, 2023). It is believed to have originated in Southwest Asia, particularly India (Vavilov, 1935; Richharia, 1962). Linseed is primarily cultivated during the Rabi season, serving as both an oilseed and fiber crop. It is commonly known as "Alsi" in Hindi and "Aviselu" in Telugu. Linseed oil is widely used in the production of paints, inks, varnishes, wood treatments, soaps, linoleum, putty, and pharmaceuticals (Walsh, 1965). Additionally, it plays a significant role in the manufacturing of

specialty papers, including those used for cigarettes, currency notes, and artwork. Due to omega-3 fatty acids content, it is widely recommended for patients with cardiovascular disorders. In India it is cultivated in the states of Rajasthan, West Bengal, Karnataka, Orissa, Bihar, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Maharashtra and Punjab. In Uttar Pradesh, the Area, Production and Productivity of Linseed is 0.49 lakh hectares, 0.35 lakh tonnes and 716 kilograms per hectare, respectively (Anonymous 2023). The low productivity of linseed is primarily due to its cultivation under input-deficient conditions on marginal and sub-marginal lands, which are prone to risks and have poor soil fertility. Over 80% of the crop is grown in rain-fed areas, with primitive sowing methods like relay (utera) cropping still in use. Additionally, limited dissemination of advanced agronomic practices and a persistent shortage of essential inputs such as improved varieties, irrigation, fertilizers, and weed management contribute to the issue. However, by adopting improved cultivars and recommended production and protection technologies, linseed yields could increase by 2-3 times. Genetic variability refers to the extent to which individual genotypes within a population differ from one another. This variability is crucial for biodiversity, as it enables populations to adapt to changing environmental conditions, reducing the risk of extinction. Understanding genetic variation and the inheritance patterns of quantitative and qualitative traits is vital for designing effective breeding programs (Shah *et al*., 2015; Kumar *et al*., 2016). Genetic parameters such as the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are valuable tools for assessing the level of variability within germplasm (Kumar *et al*., 2019; Upadhyay *et al*., 2019). Evaluating variability in yield and its associated traits is crucial before developing a suitable breeding strategy for genetic enhancement (Kumar *et al*., 2019). Hence, the current study was conducted to identify genetic variability and heritability of key desirable traits in linseed genotypes for use in future breeding programs.

MATERIALS AND METHODS

The current investigation was conducted in a Randomized Blocked Design with using of 75 linseed genotypes including ten checks in three replications for variability studies for traits viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of secondary branches per plant, number of primary branches per plant, oil content (%), thousand seed weight (g) and seed yield per plant (g) at Oilseeds Research Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, (India) during Rabi season 2019-20. The crop was maintained in healthy and good condition by using recommended agronomic practices. Sowing was done with a maintained space of 30 cm × 7 cm. For taking observations on the above traits, five equally competitive plants were tagged. The parameters, genotypic coefficient (GCV)

and phenotypic coefficient of variation (PCV) were calculated by the formula given by Burton (1952), heritability (Allard, 1960), and genetic advance as percentage of mean (GAM) (Johnson *et al*., 1955). Sivasubramanian and Madhavamenon (1973) categorized (both phenotypic and genotypic) coefficients in range of 20%: High, 10-20%: Moderate, and <10%: Low. Johnson *et al*., (1955) classified heritability (h^2) estimates as Low: 0-30%, Medium: 30-60% and High: Above 60%. The categorization of genetic advance as percentage of mean estimates as <10%: Low, 10-20%: Moderate and >20%: High by Johanson *et al*., (1955). Statistical analysis was carried out by using R- software.

RESULTS AND DISCUSSION

Analysis of variance for the randomized block design (RBD) with respect to 75 genotypes of linseed revealed significant differences among the material used in the present investigation for all the ten characters (Table 1) studied viz., days to 50 % flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seed per capsule, 1000-seed weight (g), seed yield per plant (g), indicating wide spectrum of variation among the genotypes. Similar results were reported by (Bibi *et al*., 2013; Paul *et al*., 2016; Sharma and Paul, 2016; Tyagi *et al*., 2014). The results are displayed in Table 1.

Range and Mean of Ten Traits

The range values of mean among 75 genotypes for ten quantitative traits viz., days to 50 per cent flowering (52-89) with the mean of 70.01 days. The results were presented in Table 2. For days to maturity, the range values from 119-145 with a mean value is 132.12. The mean value of number of primary branches per plant is 4.52 with a range (3-8). The number of secondary branches per plant recorded as a mean of 17.77 with ranges from 8-31. Plant height recorded range values from 43-118 with a mean of 64.70. The range values of mean from 36-202 were recorded for the number of capsules per plant with a general mean of 110.04. On the other hand, the range values of mean for number of seeds per capsule (7-10), thousand seeds weight (4.18-9.7), oil content (24.85-45.50) and seed yield per plant (2.53-12.47) with mean values of 8.70, 7.23, 36.45 and 6.63, respectively. Similar type of were reported by Ahmad *et al*., (2014) for days to 50% flowering and days to maturity. Tyagi *et al*. (2014) observed the mean performance of several yield traits viz., plant height, primary and secondary branches, leaf area, number of capsules, seeds per capsule, stem diameter, flowering duration, maturity, biological yield per plant, grain yield per plant, and harvest index, which indicated variability among 31 genotypes.

Phenotypic and genotypic coefficient of variability

The genetic variability parameters for different traits viz., genotypic coefficient of variation (GCV) and phenotypic coefficient variances (PCV) are displayed in (Table 2 and Figure 1). Results indicated that the phenotypic coefficient of variation is slightly higher than the genotypic coefficient of variation (GCV) for all the characters studied, it reveals that the traits under study were less influenced by environment. Similar results on linseed were also reported by (Kumar *et al*., 2016; Paul *et al*., 2017). If the values of GCV and PCV are higher than 20 % then it is considered as highest variability among the traits. The highest (GCV) and (PCV) values were found particularly for seed yield per plant (36.49% and 36.84%), number of capsules per plant (28.75% and 28.84%) and number of secondary branches (28% and 29.16%) respectively (Table 2). Similarly (Kumar *et al*., 2019; Upadhyay *et al*., 2019) reported the highest GCV and PCV value for seed yield per plant and number of capsules per plant. Moderate GCV and PCV were recorded for test weight (17.26% and 17.47%) and oil content (12.17% and 12.25%) respectively. Moderate GCV and high PCV (19.57% and 23.65% respectively) were revealed number of primary branches, this indicates as the trait more influenced by environment. Low GCV and PCV for days to maturity (4.43% and 4.53%) (Terfa *et al*., 2020), number of seeds per capsule (5.39% and 6.62%) and days to 50 per cent flowering (9.54% and 9.68%) respectively, indicating less variability exist in these characters. Moderate to low variability indicates the need for improvement of base population.

Heritability (H^2 b) and Genetic Advance per mean

Heritability is a good indicator of transmission of characters from parents to its progeny. The estimates of heritability help the plant breeder in selection of genotypes from diverse genetic population. Therefore, high heritability helps in effective selection for a particular character. All the traits presented in (Table 2 and Figure 2.) recorded the highest heritability. The genetic advance is a useful indicator of the effective and efficient selection progress that can be expected as result of exercising selection on the base population. In present study high heritability and genetic advance as percentage of mean (>20) was recorded for seed yield per plant, number of capsules per plant, number of secondary branches per plant, plant height, thousand seed weight, number of primary branches and oil content, indicating the predominance of additive gene action for these characters (Tadesse *et al*., 2010; Terfa *et al*., 2020; Toor and Alka, 2023). This shows that selection is effective in improving these traits. On the other hand, high heritability with low genetic advance as percentage of the mean was revealed for days to maturity and number of seeds per capsule

which indicates these traits were governed by non-additive genes. Similar findings were also reported by Dash *et al*., (2016). Oil content and days to 50 per cent flowering were recorded with high heritability and moderate Genetic advance as percentage of the mean suggests that these traits were heritable can be improved by selective breeding efforts. Pali and Mehta (2013) also reported high heritability with moderate genetic advance for oil content and all other fatty acid components.

Conclusion

In conclusion, the present study reveals that there is a significant amount of variability among all the genotypes for all the traits studied. The highest GCV and PCV values were recorded for seed yield per plant (g), number of capsules per plant, number of secondary branches per plant and plant height. Low GCV and PCV were recorded for days to maturity, number of seeds per capsule and days to 50 per cent flowering. High heritability coupled high genetic advance as percentage of mean were observed for seed yield per plant, number of capsules per plant, number of secondary branches per plant, plant height, thousand seed weight, number of primary branches and oil content, indicating the predominance of additive gene action for these characters and effective in selection for breeding.

Table 1. Mean sum of squares and their significance from analysis of variance (ANOVA) of ten plant characters in linseed.

Characters	Mean sum of squares		
	Replication	Treatment	Error
	2	74	148
Days to 50 % flowering	3.45	137.83**	4.17
Number of primary branches per plant	1.89	3.43**	1.08
Number of secondary branches per plant	0.13	80.65**	6.31
Plant height	2.45	512.60**	4.76
Number of capsules per plant	12.72	3023.87**	18.89
Number of seeds per capsule	0.41	0.99**	0.33
Days to maturity	2.15	107.47**	4.74
Oil content	0.18	59.85**	0.72
Thousand seed weight	0.34	4.80**	0.11
Seed yield per plant	1.46	17.93**	0.33

*Significant at 5% level **Significant at 1% level

Table 2. Estimation of genetic variability parameters for various traits in Linsee

Character	Mean ± SE	Range		Coefficient of variation		Heritability (H^2 b) (%)	Genetic Advance	Genetic advance in percent of mean (%)
		Minimum	Maximum	PCV (%)	GCV (%)			
Days to 50% flowering	70.01±1.18	52	89	9.68	9.54	97	13.54	19.33
Number of Primary branches	4.52±0.60	3	8	23.65	19.57	68	1.50	33.35
Number of Secondary branches	17.77±1.45	8	31	29.16	28.00	92	9.84	55.37
Plant height (cm)	64.70±1.26	43	118	20.20	20.10	99	26.67	41.23
Number of capsules per plant	110.04±2.50	36	202	28.84	28.75	99	64.99	59.05
Number of seeds per capsule	8.70±0.33	7	10	6.62	5.39	66	78.85	9.05
Days to maturity	132.12±1.25	119	145	4.53	4.43	95	11.78	8.92
Seed yield per plant (g)	6.63±0.33	2.53	12.47	36.84	36.49	98	4.94	74.46
1000 seed weight (g)	7.23±0.19	4.18	9.7	17.47	17.26	97	2.54	35.14
Oil content (%)	36.45±0.49	24.85	45.50	12.25	12.17	98	9.08	24.93

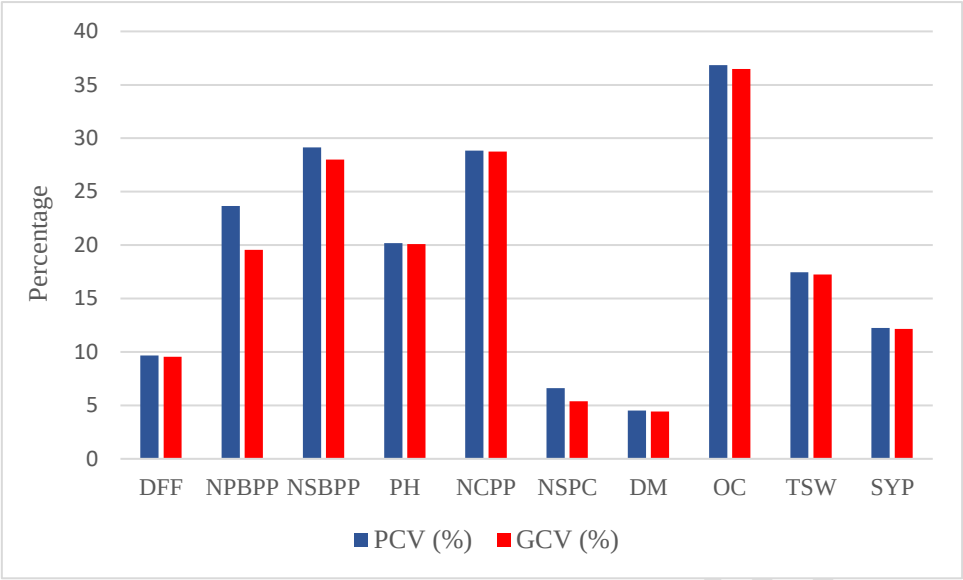

Figure 1. Phenotypic and Genotypic coefficient of variation of ten quantitative traits in linseed.

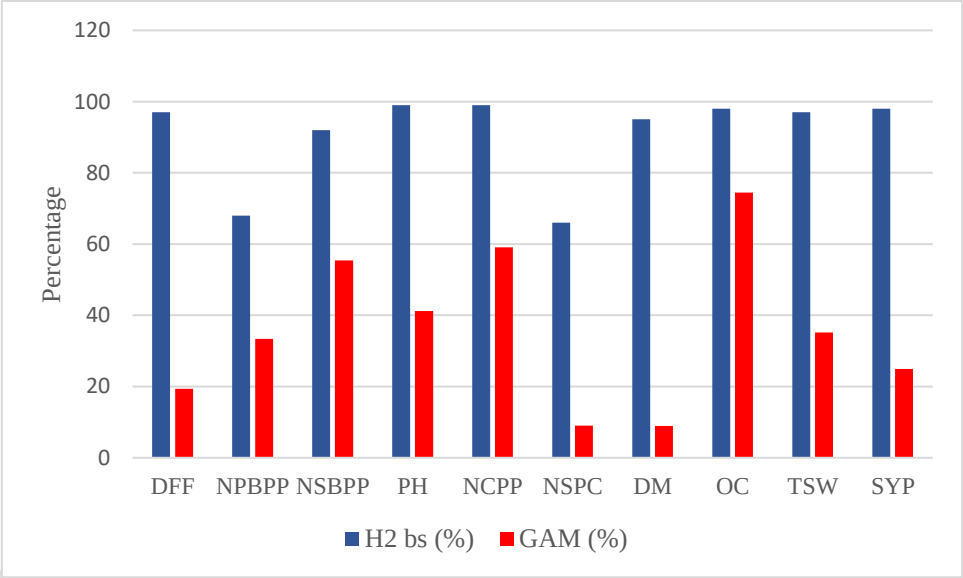

Figure 2. Heritability (broad sense) and Genetic advance as percentage of the mean for ten quantitative traits in linseed.

DFF: Days to 50 % flowering; NPBPP: Number of primary branches per plant; NSBPP: Number of secondary branches per plant; PH: Plant height; NCPP: Number of capsules per plant; NSPC: Number of seeds per capsule; DM: Days to maturity; OC: Oil content; TSW: Thousand seed weight; SYP: Seed yield per plant.

References

Ahmad R, Ibrar D, Mirza M.Y, Mahmood T, Ahmad Khan M, Iqbal M. Sh, Ahmad M. Genetic variability, heritability and genetic advance in some genotypes of linseed (*Linum usitatissimum* L.) Journal of Agricultural Research, 2014;52 (1):43–52.

Allard RW. Principles of plant breeding. John Wiley and Sons Inc., New York. 1960;145-147.

Bibi T, Talat M, Yasin M, Tariq M and Hasan E. Correlation studies of some yield related traits in linseed (*Linum usitatissimum* L.). Journal of Agricultural Science, 2013; 51: 121-132.

Burton GW, De Vane DE. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. Agronomy Journal, 1952;45 (10):478-481.

Dash J, Naik B.S, Mohapatra U.B. Variability, correlation and path-coefficient analysis in linseed (*Linum usitatissimum* L.) under late sown conditions in the north central plateau zone of Odisha in India. International Journal of Advanced Research, 2016;4 (1):799–811.

Anonymous (2023). Selected State-wise Area, Production and Productivity of Linseed in India (2022-23). https://www.indiastat.com/table/agriculture/selected-state-wise-area-production-productivity-l/1456968#. Accessed on September 19th 2024.

Johnson HW, HF Robinson, RE Comstock. Estimation of genetic and environmental variability in soya beans Agronomy Journal,1955; 47 : 314—318.

Kumar N, Paul S, Patial R. Study on Genetic variability, heritability and genetic advance for agromorphological traits of linseed (*Linum usitatissimum* L.). Research in Environment and Life Sciences, 2015; 9: 16–18.

Kumar N, Paul S, Singh D.R. Study on genetic variability, heritability and genetic advance for agro-morphological traits of linseed (*Linum usitatissimum* L.). Research in Environment and Life Sciences, 2016, 9 (1): 16–18.

Kumar S, Ram S, Chakraborty M, Ahmad E, Verma N, Lal H.C, Prasad Y, Kumar K, Bhushan S, Choudhary A.K. Role of genetic variability for seed yield and its attributes in linseed (*Linum usitatissimum* L.) improvement. Journal of Pharmacognosy and Phytochemistry, 2019; 266–268pp.

Kumar S, Ram S, Chakraborty M, Ahmad E, Verma N, Lal H.C, Prasad Y, Kumar K, Bhushan S, Choudhary, A.K. Role of genetic variability for seed yield and its attributes in linseed (*Linum usitatissimum* L.) improvement. Journal of Pharmacognosy and Phytochemistry, 2019: 266–268pp.

Pali V, Meheta N. Studies on genetic variability, correlation and path analysis for yield and its attributes in linseed (*Linum usitatissimum* L.). *Plant Archives*, 2013;13 (1) : 223—227.

Paul S, Kumari A, Sharma D. Estimation of phenotypic divergence in linseed (*Linum usitatissimum* L.) For yield-related traits under changed climate in mid-hills of north-west himalayas. Bangladesh Journal of Botany, 2016, 45(5): 1163-1171.

Paul S, Kumar N, Kumar A. Characterization and genetic variation study among linseed (*Linum usitatissimum* L.) genotypes for seed yield and related traits in midhills of north-west himalayas. Plant Archives 2017;17 (1): 407–411.

Richharia RH (1962) Linseed. The Indian Central Oilseeds committee. Hyderabad, India.

Shah K.A, Farhatullah, Shah L, Ali A, Ahmad Q, Zhou L. Genetic variability and heritability studies for leaf and quality characters in flue cured Virginia tobacco. Academia Journal of Agricultural Research, 2015; 3:044-048.

Sharma D. and Paul S. Genotype × environment interaction and phenotypic stability analysis of linseed (*Linum usitatissimum* L.) in mid-hills of North-West Himalayas. Journal of Applied and Natural Science, 2016; 8(4): 2040-2048.

Siva Subramanian V, Madhava MP. Path analysis for yield eld and yield components of rice. Madras Agricultural Journal, 1973; 60 : 1217—1221.

Tadesse T, Parven A, Singh H, Weyessa B. Estimates of variability and heritability in linseed germplasm. International Journal of Sustainable Crop Production, 2010; 5 (3) : 8—16. ISSN-1991-3036 (Online).

Terfa G.N. and Gurmu G.N. Genetic variability, heritability and genetic advance in linseed (*Linum usitatissimum* L) genotypes for seed yield and other agronomic traits. *Oil Crop Science*, 2020; *5*(3), pp.156-160.

Toor A.K. and Alka A.K. Genetic Variability and Character Association in Linseed (*Linum usitatissimum* L) Genotypes for Yield. *Environment and Ecology*, 2023; 41(4C), pp.2928-2938.

Tyagi A K, Sharma M K, Surya, Mishra S K, Kerkhi S A. and Chand P. Estimates of genetic variability, heritability and genetic advance in linseed (Linum usitatissinumL.) germplasm. Progressive Agriculture, 2014; 14(1): 37-48.

Upadhyay S, Nandan M, Ashish K.T. Assessment of variability among flax type linseed genotypes (*Linum usitatissimum* L.) of Chhattisgarh plains. International Journal of Current Microbiology and Applied Sciences, 2019; 8 (6): 2633–2637. https://doi.org/10.20546/ ijcmas.2019.806.316.

Vavilov NI (1935) Studies on the origin of cultivated plants. Bul Bot Plant Breeding, 16: 39-145.

Walsh RJ. Linseed oil protection for New York State Thruway bridges, Civil Engineering, 1965; 15(2):39-41.