Determination 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 the production of paints, varnishes, and linoleum paste. The objective of the present investigation was to evaluate genetic variability, heritability, and genetic advance for yield and its attributes among 75 linseed genotypes including ten checks using Randomized Block Design with three replications at Oilseeds Research Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, (India) during *Rabi* season 2019-20. 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. In conclusion, 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

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.), an annual and self-pollinated species, belongs to the family Linaceae and has a chromosome number of 2n = 30 (Paliwal et al., 2023; Toor and Alka, 2023). It is believed to have originated in Southwest Asia, particularly India (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 (Ronika et al., 2020; 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 (Dash et al., 2016; Reddy et al., 2013). 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 (Amin *et al*., 2015). Over 80% of the crop is grown in rain-fed areas, with primitive sowing methods like relay (utera) cropping still in use (Srivastava, 2009). 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. Yield is a complex quantitative trait that is governed by polygenes and it is continuously influenced by the environment (Solanki et al., 2016). However, by adopting improved cultivars and recommended production and protection technologies, linseed yields could increase by 2-3 times (Leelavathi and Mogali, 2018). A significant challenge with dual-purpose varieties lies in the differing maturity rates for fiber and seed. To enhance linseed traits, it is crucial to investigate the available genetic resources, pinpoint promising lines, and explore their potential for broadening trait variability (Chandrawati et al., 2016). 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 (Shah et al., 2015). 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). “Heritability is a good indicator of the transmission of characters from parents to their progeny. The estimates of heritability along with genetic advance mean percentage help the plant breeder in the effective selection of genotypes for a particular character from diverse genetic populations” (Chandrawati et al., 2016; Thakur et al., 2020). “Evaluating variability in yield and its associated traits is crucial before developing a suitable breeding strategy for genetic enhancement” (Kumar *et al*., 2019; Laskar et al., 2015). Hence, the objective of the present study is to identify genetic variability and heritability of morphological and seed quality traits of linseed genotypes for use in future breeding programs.

2. MATERIALS AND METHODS

2.1 Location of study

The current investigation was conducted at Oilseeds Research Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, (India) during *Rabi* season 2019-20.

2.2 Experiment Design and procedure

A total of 75 linseed genotypes including 10 checks (T-397, Shekhar, Parvathi, Rajan, Gaurav, Surya, Ruchi, Meera, Rashmi, and Shikha) were sown in a Randomized Blocked Design with three replications for genetic 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). RBD design enhances the reliability of the findings by minimizing the effects of confounding variables. Experimental materials were sown in 2 lines with 5m length. The crop was maintained in healthy and good condition by using a recommended package of practices. Sowing was done with a maintained space of 30 cm × 7 cm for each plant per hill by thinning after 15 days of sowing. For taking observations on the above traits, five equally competitive plants were tagged. The oil content (%) was estimated by using the NMR method.

2.2 Statistical analysis

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 a percentage of the mean (GAM) (Johnson *et al*., 1955). Sivasubramanian and Madhavamenon (1973) categorized (both phenotypic and genotypic) coefficients in the 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). All statistical analyses were performed by using R-software.

3. RESULTS AND DISCUSSION

3.1 Analysis of variance

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 Banjare et al., (2019), Paul *et al*., (2016); Sharma and Paul, (2016); Tyagi *et al*., (2014). The results are displayed in Table 1.

3.2 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 was 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 the 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 the 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. Comparable results were found in the study by Ahmad *et al*., (2014) for days to 50% flowering and days to maturity. Dikshit and Sivaraj (2015), Kaur et al., (2018) and Samantara,(2020) for days to 50 per cent flowering, days to maturity, seeds per capsule and thousand seed weight, and 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.

3.3 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), Ranjana *et al*. (2018), Upadhyay *et al*., (2019) and Paliwal et al., (2024) 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) revealed the number of primary branches, which indicates that the trait is more influenced by the environment. Low GCV and PCV for days to maturity (4.43% and 4.53%) (Leelavathi and Mogali, 2018; 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%) (Leelavathi and Mogali, 2018; Manhar, 2021) respectively, indicating less variability exists in these characters. Moderate to low variability indicates the need for improvement of the base population.

3.4 Heritability (H^2 b) and Genetic Advance per Mean

Heritability is a good indicator of the transmission of characters from parents to their progeny. The estimates of heritability help the plant breeder in selection of genotypes from diverse genetic population. Therefore, high heritability helps in the effective selection of 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 a result of exercising selection on the base population. In this study, high heritability and genetic advance as a percentage of the mean (>20) 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 predominance of additive gene action for these characters. Similar results were matched with Bhushan et al., (2019), Meena et al., (2020), Tadesse *et al*., (2010), Terfa *et al*., (2020), Thakur et al., (2020), Triveni et al., (2024), 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 (Paliwal et al., 2024) were recorded with high heritability and moderate Genetic advance as percentage of the mean indicating the significance of dominance and epistatic effects in the inheritance of these characters and selection for these traits would be less effective (Rajanna et al., 2014). It suggests that these traits 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.

4. 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 with high genetic advance as a percentage of mean was 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 the crop improvement.

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1.

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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

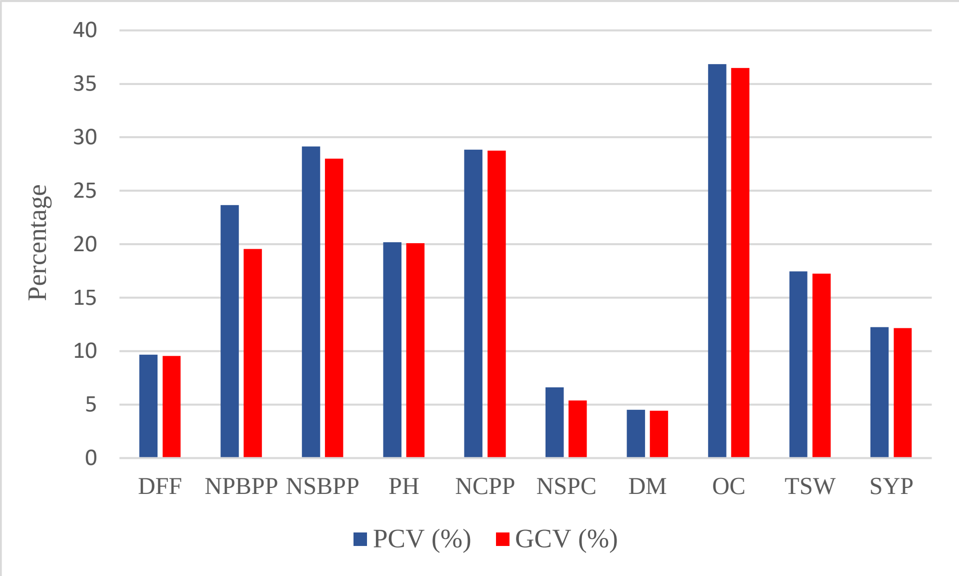

Figure 1. Phenotypic and Genotypic coefficient of variation of ten quantitative traits in linseed.

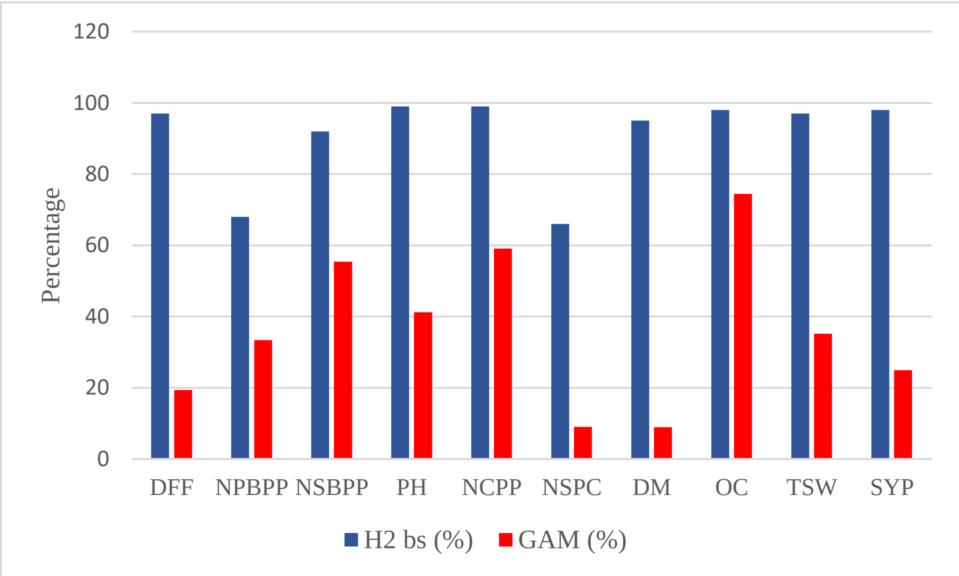

Figure 2. Heritability (broad sense) and Genetic advance as percentage of the mean for ten quantitative traits in linseed.

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.

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