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Variability, Heritability and Genetic Advance Studies of Linseed (*Linum usitatissimum* L.) Genotypes at Vindhya Region of Madhya Pradesh, India

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A B S T R A C T

Linseed genotypes were grown in Completely Randomized Block Design (CRBD) at AKS University, Satna, during *Rabi* season on November 2022. The ten quantitative characters of 15 linseed cultivars studied, data were collected and estimated for variance, genetic variability, heritability and genetic advance. The design of the experiment indicated highly significant differences for all the characters due to treatments. The analysis of variance of fifteen genotypes of linseed, indicated the existence of sufficient amount of variability among genotypes for all the studied characters. PCV was higher than GCV for all the studied characters. The maximum GCV and PCV were observed for viz., seed yield per plant followed by biological yield per plant, number of capsules per plant, test weight and plant height. Higher estimates (h^2b) >80% were observed for all the characters except harvest index, branches per plant, number of seed per capsule and biological yield per plant. High heritability coupled with high genetic advance observed for test weight, seed yield per plant and plant height indicating, these characters could be prominently governed by additive gene action. So the selection and improvement of these traits could be more effective and will help in improving the seed yield in linseed.

Introduction

India is one of the leading oilseeds producing country in the world with 19 per cent of world area and 10 percent of world production. Linseed (*Linum usitatissimum* L.) belonging to family Linaceae is one of the important oil and fiber yielding crop of India which comprises about 14 genera. The genus Linum comprising more than 230 species, viz,. *Linum alatum*, *Linum allredii*, *Linum arenicola*, *Linum aristatum*, *Linum austral*, etc., exhibits great diversity in Karyotypic, morphological and biochemical attributes. The somatic chromosome number in other species of the genus Linum is reported to vary from 16 to 80 (Ray, 1944; Darlington and Wylie, 1956; Gill, 1966; Harris, 1968). Two theories have attempted to explain the origin of *Linum usitatissimum*.

The first holds that flax was developed from wild species through human selection. *L. angustifolium* Huds., a wild species prevalent throughout the Mediterranean region, is

the most likely progenitor and readily crosses with *L. usitatissimum*. The second holds that cultivated flax arose from polyphyletic activities (Vavilov, 1926). Madhya Pradesh is the leading state both in area and production followed by Jharkhand and Uttar Pradesh (Anonymous, 2020-21).

It has nutritional, medicinal and industrial uses. Because of the high linolenic acid content in seed oil, it is used as drying oil in the paints and varnish industry (Mc Hughen, 1992). Linseed oil is also utilized in the process of cementing of roads in the USA (Weiss, 2000).

The seed yield per hectare in India is very low due to the cultivation of marginal/sub-marginal lands. Therefore, it is necessary to evaluate the reason of low results and measures to improve outcomes.

Genetic variability is important for all crop improvement because presence of existing variability is very important to produce improved plant types. Therefore, assessment of the genetic resource in the current context is very important for selection of donor parents for the traits to be improved in breeding programme.

Materials and Methods

The present investigation was conducted during *Rabi,* 2022-23 at Research farm, Genetics and Plant Breeding, AKS University, Sherganj, Satna, Madhya Pradesh. The material consists of 15genotypes of Linseed (*Linum usitatissimum* L.) germplasm comprising indigenous cultivars, evaluated in Completely Randomized Block Design. The entire experimental field divided in 3 blocks of equal size and each block had 15 plots.

Each plot was consisted of four rows 1.5 meters length, following row to row spacing of 30 cm. and plant to plant spacing of 15 cm. These genotypes exhibiting wide spectrum of variability for various agronomic and morphological characters were collected from different places of M.P., U.P. and Chhattisgarh.

Ten observations on yield and yield contributing characters were recorded and estimated for different parameters viz., variability, (GCA and SCA) heritability and genetic advance. From each plot, five competitive plants were randomly selected for recording observations for various ten quantitative characters, which were recorded on the per plot basis. The analysis of variance for the design of the experiment was carried out according to the procedure outlined by Panse and Sukhatme (1967). The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and environmental coefficient of variation (ECV) was estimated by the formula suggested by Burton and de Vane (1953).

Heritability in broad sense (h^2b) was estimated using the formula suggested by Burton and de Vane (1953). Genetic advance was calculated by the method suggested by Johnson *et al.,* (1955).

Results and Discussion

The analysis of variance for the design of the experiment involving 15 linseed genotypes was evaluated in for the ten quantitative characters. The design of the experiment (MSS) indicated highly significant differences for all the characters suggesting the presence of appreciable genetic variability among the experimental material of linseed under study. Table 1. The highest variances due to treatment also found for number of capsules per plant (444.52**).

Non-significant differences due to replications were observed for all the characters. Thus, there is enough of area and scope for advancement of different polygenic and oligogenic traits through selection. Similar results were reported by Upadhyay and Mehta (2019); Dabalo *et al.,* (2020); Dogra *et al.,* (2020); Terfa and Gurmu, (2020); Prameela *et al.,* (2022); Thakur *et al.,* (2022); Meena *et al.,* (2023); Patel *et al.,* (2023); Patel *et al.,* (2023); Patil *et al.,* (2023).

The mean performance of 15 genotypes and range for 10 characters are presented in Table 2. The grand means, range, GCV, and PCV of 15 genotypes of linseed for 10 quantitative traits are presented in Table3. The genotypes showing very high performance in desirable direction for various characters listed in Table 4 can serve as suitable donors for improving the traits of linseed for which they had high mean performance.

The magnitude of phenotypic coefficients of variation (PCV) was slightly higher than corresponding genotypic coefficients of variation for all the parameters due to the environmental influence. The magnitude of GCV ranged from lowest branches per plant (0.862) to highest seed yield per plant (22.708). The magnitude of PCV ranged from days of 50% flowering (8.561) to harvest index (22.912).

The high GCV and PCV were recorded for seed yield per plant (24.907) followed by biological yield per plant (21.893), number of capsules per plant (19.852), test weight (17.619) and plant height (13.608). This is an indicative of less amenability of these characters to environmental fluctuations and hence, greater emphasis should be given to these traits.

The traits with high environmental coefficient of variation (ECV) indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection programme because the environmental variations are unpredictable in nature and may mislead the results.

Earlier researchers also observed high amount of PCV and GCV values viz., Upadhyay and Mehta (2019); Dabalo *et al.,* (2020); Dogra *et al.,* (2020); Terfa and Gurmu (2020); Prajapati *et al.,* (2022); Prameela *et al.,* (2022); Thakur *et al.,* (2022); Meena *et al.,* (2023); Patel *et al.,* (2023); Patel *et al.,* (2023) and Patil *et al.,* (2023) in their respective studies.

The major function of heritability estimates is to provide information on transmission of characters from parents to the progeny. Heritability estimates are used to predict expected advance under selection so that breeders are able to anticipate improvement from different of selection intensity.

Burton and De Vane (1953) suggested that the GCV along with heritability estimate could provide better picture of the genetic advance to be expected by phenotypic selection. Heritability h^2 (Broad Sense), Genetic Advancement, Genetic Advance as % of Mean 5%, was estimated for all the studied characters of linseed and has been presented in Table: 5.

Among the characters studied, higher estimates (h^2b) >80% were observed for all the characters except harvest index (51.1%), branches per plant (62.76%), number of seed per capsule (64.18%) and biological yield per plant (75.8%). The heritability value ranged from (51.1%) percent for harvest index to (99.9%) for test weight.

High heritability estimates were found for test weight (99.9%) followed by plant height (98.4%), days to maturity (93.2%), days to 50 % flowering (92.4%), seed yield per plant (83.1%) and number of capsules per plant (81.77%) suggested that the characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflect the genotypic ability of strains to transmit the gene to their progenies. Similar findings were reported by Upadhyay and Mehta (2019); Terfa and Gurmu (2020); Prameela *et al.,* (2022); Thakur *et al.,* (2022); Meena *et al.,* (2023); Patel *et al.,* (2023) and Patil *et al.,* (2023) in their studies.

Genetic advance is a measure of genetic gain under selection which depends upon main factors viz., genetic variability, heritability, and selection index Allard (1960). The expected genetic advance in percent of mean ranged from lowest branches per plant (0.148%) to highest seed yield per plant (42.649%).

High estimate of expected genetic advance were found for High estimate of expected genetic advance were found for seed yield per plant (42.649%) followed by test weight (36.273%), biological yield per plant (34.186%) and plant height (27.571%).

High heritability coupled with high genetic advance observed for test weight, seed yield per plant and plant height indicating that these characters could be prominently governed by additive gene action. So the selection of these traits could be more effective for desired genetic improvement.

Similar findings were observed by Dabalo *et al.,* (2020); Dogra *et al.,* (2020); Terfa and Gurmu (2020); Prameela *et al.,* (2022); Thakur *et al.,* (2022); Meena *et al.,* (2023); Patel *et al.,* (2023); Patel *et al.,* (2023) and Patil *et al.,* (2023) in their studies.

In the focus of above results it may be concluded that wide spectrum of exploitable variability in the material studied with respect to seed yield per plant and its component characters.

As per mean performance the maximum yield was recorded by varieties/genotypes viz., Priyam, GP-IIPR 1153-C, JLS 95, Shekhar, GP-IIPR 1249-B and GP IIPR-1249-C.

The maximum GCV and PCV were observed for viz., seed yield per plant followed by biological yield per plant, number of capsules per plant, test weight and plant height. Higher estimates (h^2b) >80% were observed for all the characters except harvest index, branches per plant, number of seed per capsule and biological yield per plant.

Table.1 Analysis of variance for ten quantitative characters in Linseed

Traits	Replicate (df=2)	Treatments (df=14)	Error (df=28)
Days to 50 % flowering	4.571556	91.509841**	6.972508
Branches per plant	0.600889	0.95327**	0.946603
Days to maturity	0.480222	46.773746**	3.186413
Plant height	0.344	228.201524**	3.756381
Number of capsules per plant	133.92955	444.518508**	380.243841
Number of seed per capsule	1.176	0.710095**	0.654095
Test weight	0.002889	2.894984**	0.001698
Biological yield per plant	31.330667	39.78381**	9.628048
Harvest index	12.744667	25.057714**	12.243952
Seed yield per plant	3.002889	3.114984**	0.525746

*Significant at 5% probability level. **Significant at 1% probability level.

Table.2 Mean performance of 10 characters of linseed genotypes

S.N.	Genotypes	Days to 50 % flowering	Branches/ plant	Days to maturity	Plant height	Number of capsules per plant	Number of seed/capsule	Test weight	Biological yield/ plant	Harvest index	Seed yield/ plant
1	RLC 92	68.93	6.60	137.27	72.80	89.07	7.60	6.20	18.37	22.90	4.17
2	Garima	64.53	5.00	137.07	76.47	64.80	7.20	4.67	10.40	23.37	2.43
3	Shekhar	53.27	5.20	133.80	56.87	50.20	7.40	6.27	17.67	26.70	4.67
4	Padmini	60.60	4.87	131.80	57.67	65.47	7.40	5.50	14.30	28.93	4.07
5	Priyam	54.20	4.47	132.00	52.53	62.67	6.73	4.50	21.37	26.00	5.63
6	Ruhi	53.80	5.87	129.47	58.53	43.93	7.67	4.70	9.10	23.70	2.10
7	JLS 95	51.00	5.53	129.13	64.33	67.20	6.80	6.97	20.20	23.73	4.83
8	GP-IIPR 1153-A	59.60	5.33	134.07	64.07	64.53	7.13	4.53	17.33	24.57	4.23
9	GP-IIPR 1153-B	62.53	5.13	136.30	77.13	52.80	8.20	4.20	18.47	18.37	3.40
10	GP-IIPR 1249-A	54.13	4.87	135.07	62.27	63.93	8.07	6.00	15.17	27.70	4.20
11	GP-IIPR 1249-B	61.07	5.73	136.13	76.60	55.30	7.07	6.97	20.03	23.03	4.60
12	GP-IIPR 1249-C	52.93	5.60	121.87	59.73	77.20	7.67	4.37	16.43	27.90	4.60
13	GP-IIPR 1218	55.93	5.80	133.27	56.00	50.80	7.20	6.33	18.93	24.17	4.53
14	GP-IIPR 1153-C	52.20	5.93	132.40	54.20	67.47	8.27	6.23	19.13	27.87	5.23
15	GP-IIPR 1072-A	64.60	6.13	134.60	72.20	44.40	8.00	6.20	12.60	20.97	2.67

Table.3 Mean, Range, Genotypic, Phenotypic, and CV for 10 quantitative characters in linseed

S. No.	Characters	Grand mean	Range		GCV	PCV	ECV	C.V. @ 5%
			Min.	Max.				
1	Days to 50 % flowering	57.96	51.00	68.93	9.159	9.53	4.556	4.42
2	Branches per plant	5.47	4.47	6.60	0.862	10.303	17.783	1.65
3	Days to maturity	132.95	121.87	137.27	2.867	2.97	1.343	2.99
4	Plant height	64.09	52.53	77.13	13.495	13.608	3.024	3.24
5	Number of capsules per plant	61.32	43.93	89.07	7.549	19.852	31.801	1.56
6	Number of seed per capsule	7.49	6.73	8.27	1.823	6.493	10.793	1.87
7	Test weight	5.58	4.20	6.97	17.614	17.619	0.739	0.07
8	Biological yield per plant	16.63	9.10	21.37	19.061	21.893	18.655	5.19
9	Harvest index	24.66	18.37	28.93	8.381	11.72	14.19	5.85
10	Seed yield per plant	4.09	2.10	5.63	22.708	24.907	17.723	1.21

Table.4 Most desirable linseed genotypes identified for different traits

S. No.	Traits	Genotypes
1	Days to 50 % flowering	JLS 95, GP-IIPR 1153-C, GP-IIPR 1249-C, Shekhar, Ruhi, GP-IIPR 1249-A and Priyam.
2	Branches per plant	RLC 92, GP IIPR-1072-A, GP-IIPR 1153-C, Ruhi and GP-IIPR 1218.
3	Days to maturity	GP-IIPR 1249-C, JLS 95, Ruhi and Padmini.
4	Plant height	Priyam, GP-IIPR 1153-C, Shekhar, GP-IIPR 1218, Padmini, Ruhi and GP-IIPR 1249-C.
5	Number of capsules per plant	RLC 92, GP-IIPR 1249-C, GP-IIPR 1153-C, JLS 95 and Padmini.
6	Number of seed per capsule	GP-IIPR 1153-C, GP-IIPR 1153-B, GP-IIPR 1249-A, GP-IIPR 1072-A, Ruhi and GP-IIPR 1249-C.
7	Test weight	GP-IIPR 1249-B, JLS 95, GP-IIPR 1218, Shekhar, GP-IIPR 1153-C, GP-IIPR 1072-A and RLC 92.
8	Biological yield per plant	Priyam, JLS 95, GP-IIPR 1249-B, GP-IIPR 1153-C, GP-IIPR 1218, GP-IIPR 1153-B and RLC 92.
9	Harvest index	Padmini, GP-IIPR 1249-C, GP-IIPR 1153-C, GP-IIPR 1249-A, Shekhar and Priyam.
10	Seed yield per plant	Priyam, GP-IIPR 1153-C, JLS 95, Shekhar, GP-IIPR 1249-B and GP-IIPR 1249-C.

Table.5 Heritability (%) in broad sense, Genetic advance and genetic advance as % of mean (5%) for 10 quantitative characters in Linseed

S. No.	Characters	Heritability (h^2b)	Heritability (h^2b %)	Genetic Advance	Gen. Adv. as % of Mean 5%
1	Days to 50 % flowering	0.924	92.4	10.51	18.135
2	Branches per plant	0.6276	62.76	0.008	0.148
3	Days to maturity	0.932	93.2	7.58	5.701
4	Plant height	0.984	98.4	17.671	27.571
5	Number of capsules per plant	0.8177	81.77	3.626	5.913
6	Number of seed per capsule	0.6418	64.18	0.079	1.055
7	Test weight	0.999	99.9	2.022	36.273
8	Biological yield per plant	0.758	75.8	5.686	34.186
9	Harvest index	0.511	51.1	3.044	12.346
10	Seed yield per plant	0.831	83.1	1.745	42.649

High heritability coupled with high genetic advance observed for test weight, seed yield per plant and plant height indicating, these characters could be prominently governed by additive gene action. So the selection and improvement of these traits could be more effective and will help in improving the seed yield in linseed.

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Author Contribution

Satyadev Kol: Investigation, formal analysis, writing—original draft. Brindaban Singh: Validation, methodology, writing—reviewing. Ayodhya Prasad Pandey:—Formal analysis, writing—review and editing. Rajbeer Singh Gaur: Investigation, writing—reviewing. Vivek Dehariya: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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