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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 3011-3015

www.thepharmajournal.com
Received: 02-12-2022
Accepted: 05-02-2023

Ashok Kumar Meena
Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Kota, Rajasthan, India

Sandhya Kulhari
Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Kota, Rajasthan, India

Manoj Kumar
Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Kota, Rajasthan, India

Corresponding Author:
Ashok Kumar Meena
Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Kota, Rajasthan, India

Genetic variability, heritability and correlation coefficient in linseed (*Linum usitatissimum* L.)

Ashok Kumar Meena, Sandhya Kulhari and Manoj Kumar

Abstract
The experiment was conducted using Randomized Complete Block Design (RBD) in three replications and the trail was totally consisted thirty six genotypes. The experimental materials were obtained from IIPR Kanpur. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the character studied. GCV and PCV were highest for number of capsules per plant followed by number of primary branches per plant. Heritability was high for all the character except number of seeds per capsule, protein content and seed yield per plant. Greater magnitude of heritability coupled with high to moderate genetic advance as percent of mean was observed for number of capsules per plant, number of primary branches per plant, plant height, seed yield per plant and 1000 seed weight. Seed yield per plant had positive and significant correlation with plant height, number of capsules per plant 1000 seed weight and protein content, while highly correlate with number of capsules per plant. Path coefficient analysis revealed that number of capsules per plant has strong positive direct effect on seed yield per plant. Based upon genetic variability, heritability, genetic advance as percent of mean, correlation and path coefficient analysis, it was concluded that number of capsules per plant, number of primary branches per plant, 1000 seed weight and plant height are most important yield components in linseed breeding programme.

Keywords: Linseed, GCV, PCV, heritability, genetic advance, correlation coefficient

Introduction

Linseed (*Linum usitatissimum* L.) is one of the most important *Rabi* oilseed crop after rapeseed and mustard. It originated in Mediterranean and the southwest Asian regions (Vavilov, 1935) [14]. Linseed is an annual herbaceous self-pollinated crop. It belongs to the order Malpighiales, genus Linum and family Linaceae. The botanical name *Linum usitatissimum* was given by Linnaeus in his book "Species Plantarum". The Latin species name *usitatissimum* means "most useful" (Linnaeus, 1857) [15]. Its oil is largely of drying type and non-edible because of high amount of linolenic acids. Its oil content ranges from 33-45% with protein content of 24%. Recent advances in neuro biology have established that it is best herbal source of Omega-3 and Omega-6 fatty acids which helps in regulating the nervous system. Singh and Marker (2006) [20] reported that its oil is high in omega-3 fatty acid which is believed to be helpful in lowering cholesterol level when included in the diet chain.

Linseed fiber is known as flax fiber. It is strong, non-lignified, soft, flexible, lustrous, shining, pale yellow colour and contains high water absorbency quality." Flax contains "80-90 percent cellulose." It is valued for its "strength and durability excelling cotton and stronger than cotton, rayon or wool." Flax is grouped, as natural, cellulose, bast, multi-cellular fiber. It is a good source of calcium (170 mg 100 per gram), phosphorus (370 mg 100 per gram), potassium, manganese, waxes (0.012-0.450 percent), sterols and phospholipids (0.11-0.21 percent). It is also used as organic manure. It contains about 5 percent N, 1.4 percent P_2O_5 and 1.8 percent K_2O (Ahlawat, 2008) [2].

The important linseed growing countries are India, Canada, China, USA, Russia, Egypt and Ethiopia. Russian Federation ranks first in terms of area and production under linseed cultivation in the world. The area (19.65 mha) with production (12.96 mt) and productivity (666 kg/ha) of linseed in India, (DAC& FW, 2021). In terms of Rajasthan total area of growing linseed is nearby 0.25 million hectare with production 0.34 million tonnes and productivity 1351 kg per ha. (Annual Report AIRCP Linseed, 2020-21).

So the study of genetic variability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA%) are necessary to start efficient breeding programme.

The genotypic coefficient of variation ensures the range of variability available in a crop and enables to utilize the amount of variability present in different characters. The phenotypic expression of the character is the result of interaction between the genotype and environment. A relative comparison of heritability and expected genetic advance gives an idea about the nature of gene governing a particular character. Moreover, estimates of heritability can also be used to predict genetic advance under selection, so that the plant breeder can anticipate improvement from different types and intensities of selection.

Materials & Methods

The present investigation was undertaken at Department of Genetics and Plant Breeding, College of Agriculture, Kota during *Rabi* 2019-2020. The site of experiment is at an elevation of about 271 meter (889 ft) above mean sea level with 25.18°N latitude and 75.83°E longitude. The standard week wise meteorological data for the period of this investigation recorded at the Meteorological Observatory, Agricultural Research Station, Ummedganj, Agriculture University, Kota. The experiment was laid out in Randomized Complete Block Design (RBD) with three replications during *Rabi* season, 2019-20. Each genotype was grown in 3 m long plot spaced 20 cm apart. The plant to plant distance was maintained at 10 cm. All advocated agronomic practices and plant protection measures were followed during the crop growth period. The mean values of thirty six genotypes for every character, in each replication, were used for the analysis of variance. The analysis of variance for individual characters and for the character pairs respectively, were carried out using the mean values of each plot following the method given by Panse and Sukhatme (1985) [16]. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed, following Burton and Devane, (1952) [6] method. Heritability in broad sense h^2 (broad sense) was calculated as a ratio of genotypic variance to phenotypic variance (Allard, 1960) [3]. The expected genetic advance under selection for the different characters was estimated as suggested by Johnson *et al*. (1955) [11]. To determine the degree of association of various characters with yield and also among the yield components, the correlation coefficients were calculated. The correlation was calculating using the formula given by fisher (1918). The direct and indirect effects were estimated using path coefficient analysis as suggested by Wright (1921) [21] and elaborated by Dewey and Lu (1959) [9].

Results & Discussion

The analysis of variance indicated that the highly significant mean differences were observed for all the eleven characters under study *viz*., days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 1000 seed weight (g), harvest index (%), protein content (%), oil content (%), seed yield per plant (g). This indicates that substantial variability was present in the linseed accessions selected for study and were suitable for further genetic and selection parameters. This variability can be utilized for selection of promising lines of linseed. Therefore, these parameters were analysed (Table 1) and their implications are discussed above.

The estimation of results, a wide range of variability was observed for yield and its attributing traits *viz*., days to 50 percent flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, harvest index and 1000 seed weight protein content and oil content. The obtain a clear picture about the variability in all the genotypes; the variability was further splited into phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). The estimation of phenotypic and genotypic components of variation is of primary importance to get an idea of relative extent of heritable and non-heritable variation. It is apparent from the (table 2) that the phenotypic coefficient of variation (PCV) was slightly higher than genotypic coefficient of variation (GCV) for all the characters under study, which suggests that the traits considered under the present study are less influenced by the environment. Ashok *et al*. (2017) also observed that the PCV values were greater than the GCV values for all the traits studied. The study high values of PCV and GCV were obtained for similar traits *viz*., number of primary branches per plant, number of capsules per plant. Moderate PCV and GCV (10–20%) values for plant height (cm), number of seeds per capsule, 1000 seed weight (g), seed yield per Plant (g). Low PCV and GCV (<10) observed for days to 50 percent flowering, days to maturity, harvest index (%), protein content (%) and oil (%). Earlier worker Kaur and Kumar (2018) [12] were reported high GCV and PCV for number of capsule per plant.

Heritability is the most important parameter for selecting genotypes that permits greater effectiveness of selection by separating out environment influence from the total variability. Therefore, these parameters were analysed (Table 2) and their implications are discussed below. The study, all the characters showed high to very high estimates of broad sense heritability ranging from 44.80% to 97.40%. The characters *viz*., 1000 seed weight, number of primary branches per plant, number of capsule per plant, days to 50% flowering, plant height (cm) and oil content exhibited very high estimates of broad sense heritability and traits like days to maturity and harvest index (%) showed high estimates of broad sense heritability. These results are in accordance with the findings of Vipin *et al*. (2019) observed high heritability along with high genetic advance for number of capsule per plant and number of primary branches per plant. Maximum genetic advance was observed for number of capsules per plant followed by number of primary branches per plant, plant height (cm), seed yield per plant (g) and 1000 seed weight (g) Kanwar *et al*. (2014) [13].

The estimation of highest genetic advance was observed in only one trait *i.e*. Number of capsules per plant. Moderate genetic advance were observed in only one traits i.e. Plant height (cm**)**, while characters days to maturity, days to 50 percent flowering, oil (%), number of primary branches per plant, Protein (%), harvest index (%), seed yield per plant (g) showed low estimates of genetic advance. In present investigation, the traits showed high estimates of genetic advance as percentage of means e.g. number of capsules per plant followed by number of primary branches per plant, plant height (cm), seed yield per plant (g), 1000 seed weight (g). Days to maturity and protein (%) exhibited low estimates of genetic advance as percentage of mean. Earlier workers such as Ashok *et al*. (2017). Genetic advance as percent of mean was high for days to 50 percent flowering, plant height, number of primary branches per plant, number of capsules per plant, harvest index, 1000 seed weight and seed yield per plant. Therefore, these parameters were analysed (Table 2) and their implications are discussed above. These characters representing high values of heritability, genetic advance and genetic advance as percent of mean emerge as ideal traits for improvement through selection due to high variability and transmissibility.

Correlation coefficient analysis revealed that seed yield per plant exhibited significant and positive correlation both at genotypic and phenotypic level with plant height, number of capsules per plant and 1000 seed weight. Hence, direct selection for these traits would therefore be most effective in the improvement of linseed genotypes (Table 3). Similar results were reported by Ankit *et al*. (2019) [5]; Rajanna *et al.* (2014) [17].

Table 1: Analysis of variance for yield and its attributing traits in Linseed genotypes

Source of Variation	D.f.	MEAN SUM OF SQUARES										
		Days to 50% flowering	**Days to maturity**	**Plant height (cm)**	**Number of primary branches per plant**	**Number of capsules per plant**	**Number of seeds per capsule**	**1000 Seed weight (g)**	**Harvest index (%)**	**Protein content (%)**	**Oil content (%)**	**Seed yield per Plant (g)**
Replication	2	0.287	0.176	8.413	0.170	81.788	0.420	0.043	1.056	0.067	0.562	0.901
Genotypes	35	39.628**	17.920**	159.470**	5.390**	3061.367**	2.085**	1.891**	26.745**	1.944**	13.189**	2.228**
Error	70	1.611	1.938	9.326	0.089	68.129	0.476	0.016	2.378	0.565	0.605	0.336

** Significant at 1% level

* Significant at 5% level

Table 2: Genetic parameters of variation for seed yield and its contributing characters in linseed genotypes

S. No.	Characters	Genetic parameters							
		Grand Mean	**Range**		**PCV (%)**	**GCV (%)**	**h^2 (bs) (%)**	**Genetic advance**	**Genetic advance as% mean**
			Minimum	**Maximum**					
1	Days to 50% flowering	68.16	61.67	77.33	5.55	5.22	88.70	6.90	10.13
2	Days to maturity	129.23	124	134	2.09	1.79	73.30	4.07	3.16
3	Plant height (cm)	58.56	42.53	76.30	13.16	12.08	84.30	13.40	22.86
4	Number of primary branches per plant	5.08	3.27	8.67	26.80	26.14	95.20	2.67	52.54
5	Number of capsules per plant	101.94	46.67	174.67	32.03	30.99	93.60	62.96	61.76
6	Number of seeds per capsule	7.48	6.30	10.00	13.45	9.79	53.00	1.10	14.68
7	1000 Seed weight (g)	7.35	5.80	8.77	10.90	10.76	97.40	1.61	21.89
8	Harvest Index (%)	33.68	28.56	39.97	9.62	8.46	77.40	5.16	15.33
9	Protein content (%)	20.32	18.16	21.42	4.98	3.34	44.80	0.94	4.60
10	Oil content (%)	38.66	34.40	43.14	5.67	5.30	87.40	3.94	10.20
11	Seed yield per Plant (g)	6.13	4.50	7.97	16.19	13.14	65.90	1.35	21.97

Table 3: Genotypic and phenotypic correlation coefficients between different traits in linseed genotypes

Sr. No.	**Character**	**r**	**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**Number of primary branches per plant**	**Number of capsules per plant**	**Number of seeds per capsule**	**1000 seed weight (g)**	**Harvest index (%)**	**Protein content (%)**	**Oil content (%)**	**Seed yield per plant (g)**
1	Days to 50% flowering	r_g	1.000	0.225*	-0.021	0.241*	-0.038	-0.110	-0.289**	-0.255**	-0.021	0.173	-0.094
		r_p	1.000	0.143	-0.016	0.240*	-0.046	-0.074	-0.261*	-0.207*	-0.072	0.153	-0.093
2	Days to maturity	r_g		1.000	0.002	0.085	-0.274**	0.263*	-0.081	-0.393**	-0.124	-0.065	-0.406**
		r_p		1.000	-0.072	0.052	-0.198*	0.138	-0.078	-0.300**	-0.060	-0.055	-0.303**
3	Plant height (cm)	r_g			1.000	-0.080	0.283**	-0.068	0.476**	0.270**	0.059	-0.124	0.280**
		r_p			1.000	-0.059	0.235*	-0.054	0.438**	0.231*	0.045	-0.103	0.259**
4	Number of primary branches per plant	r_g				1.000	0.359**	-0.331**	-0.215*	0.022	0.035	-0.208*	-0.089
		r_p				1.000	0.327**	-0.233*	-0.206*	0.002	-0.012	-0.206*	-0.088
5	Number of capsules per plant	r_g					1.000	-0.389**	0.144	0.172	-0.037	-0.085	0.484**
		r_p					1.000	-0.278**	0.130	0.138	-0.004	-0.065	0.385**
6	Number of seeds per capsule	r_g						1.000	0.221*	0.181	-0.118	0.174	-0.143
		r_p						1.000	0.173	0.165	-0.168	0.082	-0.023
7	1000 seed weight (g)	r_g							1.000	-0.002	-0.172	-0.048	0.273**
		r_p							1.000	-0.014	-0.134	-0.061	0.220*
8	Harvest index (%)	r_g								1.000	-0.162	-0.092	0.009
		r_p								1.000	-0.040	-0.097	0.046
9	Protein content (%)	r_g									1.000	-0.048	0.191*
		r_p									1.000	-0.001	0.102
10	Oil content (%)	r_g										1.000	0.099
		r_p										1.000	0.041
11	Seed yield per plant (g)	r_g											1.000
		r_p											1.000

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

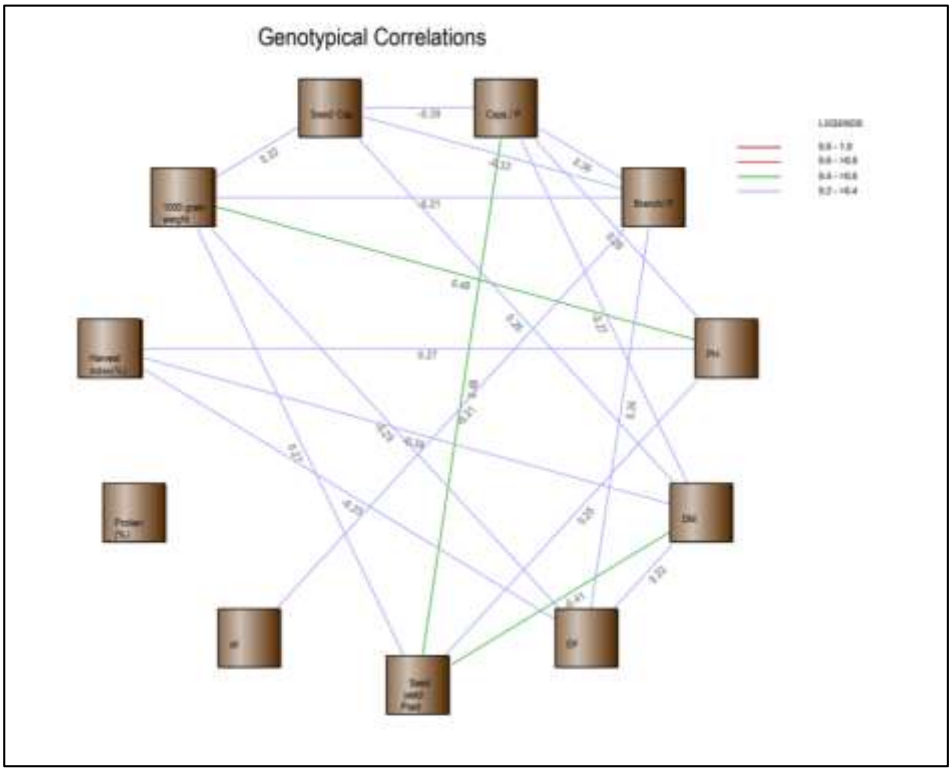

Fig 1: Genotypic correlation coefficients diagram between different traits in linseed genotypes

Conclusion

The results of the present investigation the presence of adequate genetic variability within and among the genotypes, which suggests scope for further genetic improvement in linseed. High heritability coupled with high genetic advance were observed for the traits like number of capsules per plant, plant height, number of primary branches per plant and 1000 seed weight with positive direct effect as revealed by phenotypic and genotypic path coefficient making these character desirable for selection. In addition based on correlation coefficient analysis study it was inferred that number of capsules per plant had high significant association and also show high positive direct effect on seed yield. Hence, in the improvement programme importance may be given for this trait to improve genetic yield potential in linseed. Therefore, induced genetic variability can be successfully utilized to develop new cultivars of linseed.

Acknowledgement

The author is thankful to the Dr. Sandhya, Assistant professor, Department of Genetics and Plant Breeding, Agriculture University, Kota for her untiring help and assistance during the experiment and preparation of manuscript.

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