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Study on genetic variability, heritability and genetic advance for grain yield and yield component traits (*Linum usitatissimum* L.)

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Abstract
The present investigation was carried out at Crop Research Center (Chirori), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, during *rabi* season 2016-17. The experimental material comprised of forty diverse linseed accessions were obtained from Project coordinating unit (Linseed), CSAUA&T, Kanpur. The experiment was conducted in Randomized Complete Block Design (RBD) in three replications, to estimate the relative high magnitude of phenotypic and genotypic coefficient of variation was observed for number of secondary branches per plant, seed yield per plant, number of primary branches per plant and biological yield per plant. Environmental influence was very meager on expression of these characters of the genetic material under study as it was evident by narrow gap between genotypic and phenotypic coefficient of variation. High estimates of genetic advance were observed for only one trait i.e. number of capsules per plant and moderately observed for plant height and harvest index. High heritability coupled with high genetic advance as percent of mean was observed for the traits *viz.*, number of secondary branches per plant, number of primary branches per plant, biological yield per plant and seed yield per plant, indicating that heritability may be due to additive gene action and simple selection based on these characters may be effective. High estimates of genetic advance as percentage of means were recorded for number of secondary branches per plant, seed yield per plant, number of primary branches per plant and biological yield per plant.

Keywords: Genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance

Introduction

Linseed (*Linum usitatissimum* L.) is also known as flax/alsi or tisi which is a member of the genus *Linum* in the family *Linaceae*. Linseed (*Linum usitatissimum* L) is the second most important winter (*rabi)* oilseed crop and stands next to rapeseed- mustard in area and production in India. Almost every part of the linseed plant is utilized commercially either directly or after processing. It is commercially cultivated for its seed, which is processed into oil and after extraction of oil, a high protein livestock feed is left (Sankari, 2000; Kurt and Bozkurt, 2006) [28, 17].

Its oil is largely of drying type and non-edible because of high amount of linoleinic acids. Its oil content ranges from 33-45% with protein content of 24% (Gill, K.S. 1987) [13]. 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) [29] 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 cake is a superior supplement for the dairy cattle due to its excellent palatability. Its meal contains 3% oil and 36% protein and serves as nutritious feed for milch cattle. It is a good source of calcium (170 $mg100g^{-1}$), phosphorus (370 $mg100g^{-1}$), potassium, manganese, waxes (0.012-0.450 %), sterols and phospholipids (0.11-0.21 %). It is also used as organic manure. It contains about 5% N, 1.4% P_2O_5 and 1.8% K_2O (Ahlawat, 2008) [1].

The important linseed growing countries are India, Canada, China, USA, Russia, Egypt and Ethiopia. Russian Federation ranks first in terms of area (0.71 mha) and production (0.67 mt) under linseed cultivation in the world. Kyrgyzstan ranks first in linseed productivity (2257.9 kg/ha) in the world. In technical oil production, it ranks first in the country. The area (0.29 mha) with production (0.12 mt) and productivity (426.6 kg/ha) of linseed in India, (FAOSTAT, 2016). In U.P. linseed productivity is 460 kg/ha and highest productivity (1013 kg/ha) is in Rajasthan (Anonymous- 2016) [3].

Flax is considered as a ''founder crops'' that has been providing raw materials for medicine, food and textiles for more than 8000 years and is of great importance to the human welfare (Zeist and Bakker-Heeres 1975) [34]. Flax seed is a good source of lignans that have anticancer properties (Westcott and Muir 2003) [32]. About 20% of the total linseed oil produced in India is used by the farmers and the rest about 80% goes to industries for the manufacture of paints, varnish, oilcloth, linoleum, printing ink etc. The flax fibre is widely used and serves as valuable raw material for textiles, thread/rope and packaging materials; the straw and short fibre is used for pulp to produce special papers for cigarettes, currency notes and artwork; and the wooden part serves as biomass energy or litter in cattle farming (Rowland, 1998; Mackiewicz-Talarczyk *et al*., 2008) [26, 19]. Linseed derivatives such as whole flax seed, flax meal and milled flax have been reported as a functional or nutraceutical food due to its health promoting or disease preventive properties (Fitzpatrick, 2007) [12]. Lignans is one of the major compounds in linseed hull which acts as an important antioxidant agent. Flax seed provides 800 times higher lignans than the seeds of other plants except sesame (Jhala and Hall, 2010) [14]. The amino acid pattern of linseed protein resembles that the pattern of soybean protein, which is considered to be one of the most nutritious plant proteins (Rabetafika *et al*., 2011) [25].

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 carried out at Crop Research Center (Chirori), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), during *rabi* season 2016-17. The site of experiment is at an elevation of about 297 meter above mean sea level with 29º01'N latitude and 77º75'E longitudes, representing the North Western Plain Zone. The meteorological data, obtained from dept. of Soil Science, SVPUA&T, Modipuram, Meerut. The experiment was laid out in Randomized Complete Block Design (RBD) with three replications during *rabi* season, 2016-17. The experiment was sown on 2nd December, 2016. Each treatment was grown in 3 m long double row plot spaced 30 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 forty genotypes for every character, in each replication, were used for the analysis of variance. The analysis of variance and covariance 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 (1967) [22]. The significance of the differences among all the genotypes was tested by F-test using the error variance. The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and environmental coefficient of variation (ECV) were computed, following Burton and Devane, (1952) [8] method. Heritability in broad sense h^2 (b) was calculated as a ratio of genotypic variance to phenotypic variance (Allard, 1960) [2]. The expected genetic advance under selection for the different characters was estimated as suggested by Allard, (1960) [2].

Results & Discussion

The ultimate objective of most of the plant breeding programmes is to develop high yielding superior genotypes/lines better than existing ones through the manipulation of genetic constellation at Crop Research Center (Chirori), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), during *rabi* season 2016-17. Among various oilseed crops, linseed (*Linum usitatissimum* L.) is an important *rabi* oilseed crop grown in India and in other developing countries of the world.

Looking to the above aspects, the present investigation was undertaken subject to different genetical studies *viz*., genetic variability, heritability and genetic advance. On the basis of these studies and assessment, ranking of genotypes can be done and superior genotypes can be identified and tested in multilocation to be used in further breeding programmes. The results obtained from the present investigation are discussed below.

The analysis of variance indicated that the highly significant mean differences were observed for all the eleven quantitative characters under study *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 seeds per capsule, biological yield per plant (g), seed yield per plant (g), harvest index (%) and 1000 seed weight (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 yield components *viz.*, days to 50% 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, biological yield per plant, seed yield per plant, harvest index and 1000 seed weight. 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 nonheritable variation. It is apparent from the table 2 that the phenotypic coefficient of variation (PCV) was little 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. Similar to these findings Paul *et al.* (2017) [24] 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 secondary branches per plant, seed yield per plant, number of primary branches per plant, biological yield per plant,. In addition harvest index exhibited high value of PCV. Moderate values of PCV (10-20%) were obtained for capsules per plant, 1000 seed weight and plant height, while the harvest index, capsules per plant, 1000 seed weight and plant height exhibited moderate values of GCV. Earlier worker Basavaraj *et al.* (2011) [5], Tewari *et al.* (2012) [30], Asgarinia *et al.* (2014) [4], Yadav and Singh (2016) [33] were reported high PCV and GCV for number of capsules per plant, number of seeds per capsule and yield per plant. In addition to above investigation, several other workers, Chauhan *et al.* (2012) [9], Kanwar *et al.* (2014) [16], Pali and Mehta (2015) [21] and Paul *et al.* (2017) [23] also reported high PCV and GCV for characters they studied. The difference among the GCV and PCV values for different characters indicates that the influence of environment in expressing the variability with characters. If this difference least, means the environment is much affecting in the variable performance of the characters, but if the difference is more, means there is much influence of environment in the expression of the characters.

Heritability is the important parameters for selecting genotypes that permits greater effectiveness of selection by separating out environmental 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 78.10% to 97.30%. The characters *viz*., 1000 seed weight, number of secondary branches per plant and days to 50% flowering exhibited very high estimates of broad sense heritability and rest traits showed high estimates of broad sense heritability. These results are in accordance with the findings of Chauhan *et al.* (2012) [9] observed high heritability along with high genetic advance for plant height (cm), seeds per capsule, capsules per plant, number of primary branches per plant and number of secondary branches per plant. Tewari *et al.* (2012) [30] showed high heritability with high genetic advance for capsules per plant and seed yield per plant. Belete, Y.S. and Yohannes, (2013) [6] observed high heritability along with high genetic advance for number of seeds per plant. Bibi *et al*. (2013) [7] found high heritability for days to flower initiation, days to flower completion, days to maturity, 1000-grain weight, capsules per plant and harvest index. Maximum genetic advance was observed for seed yield per hectare followed by seed yield per plot, capsules per plant, plant height and seeds per capsule. Kanwar *et al.* (2014) [16] observed high heritability coupled with high genetic advance for number of capsules per plant, seed yield per plant, biological yield, plant height and number of primary branches per plant. Nizar and Mulani (2015) [20] recorded high heritability coupled with high genetic advance (GA) for number of capsules per plant and seed yield per plant and low heritability and GA was recorded for oil content. Pali and Mehta (2015) [21] observed high heritability coupled with high genetic advance for capsules per plant and branches per plant. Choudhary *et al.* (2016) [10] recorded high heritability combined with high genetic advance for capsules per plant. Sahu and Sahu (2016) [27] revealed that high heritability with high genetic advance were recorded for the characters *viz.*, seed yield per plant, followed by harvest index, seed weight, days to maturity, biological yield. Yadav and Singh (2016) [33] recorded high heritability in broad sense for all the characters except days to maturity which showed moderate heritability. Genetic advance was a high for number of capsules per plant. Other characters showed moderate to low genetic advance. Paul *et al.* (2017) [23] observed high heritability and high genetic advance for harvest index.

The estimation of highest genetic advance were observed in only one trait i.e. number of capsules per plant, moderate genetic advance were observed in two traits i.e. plant height (cm) and harvest index (%), while characters number of secondary branches per plant, days to 50% flowering, days to maturity, biological yield per plant, seed yield per plant, 1000 seed weight, number of primary branches per plant and number of seeds per capsule showed low estimates of genetic advance. In present investigation, most of the traits showed high estimates of genetic advance as percentage of means e.g. number of secondary branches per plant followed by seed yield per plant, number of primary branches per plant, biological yield per plant, number of capsules per plant, harvest index, 1000 seed weight and plant height. Days to 50% flowering, number of seeds per capsule and days to maturity exhibited low estimates of genetic advance as percentage of mean. Earlier workers such as Basavaraj *et al.* (2011) [5] estimated percent mean genetic advance was high for number of branches per plant, seed yield per plant, days to flowering and number of capsules per plant. Choudhary *et al.* (2015) calculated genetic advance as percent of mean was highest for plant height followed by number of capsules per plant and 1000-seed weight. 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 percentage of mean emerge as ideal traits for improvement through selection due to high variability and transmissibility.

Table 1: Analysis of variance (ANOVA) for eleven characters of forty genotypes in linseed (*Linum usitatissimum* L.).

Source of variations	**d.f.**	**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**Primary branches per plant**	**Secondary branches per plant**	**Capsules per plant**	**Seeds per capsule**	**Biological yield per plant (g)**	**Seed yield per plant (g)**	**Harvest index (%)**	**1000 seed weight (g)**
Replication	2	1.008	0.433	4.926	0.296	0.452	7.739	0.019	3.835	0.478	14.778	0.047
Treatments	39	70.435**	43.825**	207.259**	2.265**	74.169**	1016.536**	0.560**	37.460**	7.754**	144.340**	3.704**
Error	78	1.692	2.253	8.371	0.107	0.948	67.668	0.025	2.143	0.471	12.350	0.034

**Significant at 1% level

Table 2: Estimates of general mean, range, S.E., C.D., GCV, PCV, ECV, heritability h^2 % (BS), genetic advance and genetic advance as percentage of mean for eleven characters in linseed (*Linum usitatissimum* L.).

Parameters\Characters	**General Mean**	**Range**		**S.E.±**	**C.D. 5%**	**GCV (%)**	**PCV (%)**	**ECV (%)**	**Heritability h^2 % (BS)**	**Genetic Advance (GA)**	**GA as % of mean**
		Lowest	**highest**								
Days to 50% flowering	83.008	76.333	97.333	0.751	2.114	5.767	5.976	1.567	0.931	9.516	11.464
Days to maturity	131.467	123.667	139.333	0.866	2.440	2.832	3.053	1.142	0.860	7.112	5.410
Plant height (cm)	57.799	44.133	81.480	1.670	4.703	14.087	14.950	5.006	0.888	15.805	27.345
Primary branches per plant	3.668	2.067	7.000	0.189	0.533	23.120	24.791	8.950	0.870	1.629	44.415
Secondary branches per	16.925	10.850	36.000	0.562	1.582	29.190	29.752	5.753	0.963	9.985	58.997

plant										
Capsules per plant	102.266	64.300	144.800	4.749	13.371	17.390	19.161	8.044	0.824	33.251	32.515
Seeds per capsule	8.630	7.300	9.300	0.092	0.259	4.893	5.230	1.847	0.875	0.814	9.430
Biological yield per plant (g)	15.732	10.150	23.979	0.845	2.380	21.809	23.712	9.307	0.846	6.501	41.322
Seed yield per plant (g)	5.873	2.118	10.272	0.396	1.116	26.532	28.994	11.691	0.837	2.937	50.016
Harvest index (%)	37.525	20.577	52.110	2.029	5.712	17.676	20.004	9.365	0.781	12.074	32.176
1000 seed weight (g)	7.080	4.090	9.160	0.107	0.302	15.624	15.843	2.627	0.973	2.247	31.740

Conclusion

In present investigation the phenotypic coefficient of variation (PCV) ranged between (number of secondary branches per plant) to (days to maturity) whereas genotypic coefficient of variation (GCV) ranged between (number of secondary branches per plant) to (days to maturity). The highest magnitude of phenotypic coefficient of variation was observed for number of secondary branches per plant followed by seed yield per plant, number of primary branches per plant, biological yield per plant, harvest index, number of capsules per plant, 1000 seed weight, plant height and days to 50% flowering. Whereas the highest magnitude of genotypic coefficient of variation was observed for number of secondary branches per plant followed by seed yield per plant, number of primary branches per plant, biological yield per plant, harvest index, number of capsules per plant, 1000 seed weight, plant height, days to 50% flowering, number of seeds per capsule and days to maturity. High magnitude of heritability in broad sense was recorded for most of the characters. The highest genetic advance as percentage of mean was exhibited by eight characters *viz.*, number of secondary branches per plant, seed yield per plant, number of primary branches per plant, biological yield per plant, number of capsules per plant, harvest index, 1000 seed weight, and plant height. Moderate magnitude of genetic advance was obtained for one character only i.e. days to 50% flowering. However two character showed low genetic advance *viz.*, seeds per capsule and days to maturity.

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