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Role of genetic variability for seed yield and its attributes in linseed (*Linum usitatissimum* L.) improvement

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Abstract
The present investigation was carried out with twenty five genotypes consisting of $6F_1s$, $6F_2s$, $6F_3s$, 5 parents and two check varieties which were evaluated during *Rabi* 2017-18 at the Experimental Farm of the Department of Plant Breeding and Genetics, BAU, Ranchi to examine the nature and magnitude of genotypic and phenotypic variability, heritability and genetic advance. The analysis of variance revealed highly significant difference among twenty five genotypes the studied characters. Highest PCV and GCV were expressed by number of capsules per plant and seed yield per plant. High heritability with high genetic advance as percentage of mean was recorded for technical height, plant height, number of capsules per plant, seed yield per plant, 1000-seed weight and oil content (%), indicating predominance of additive gene action for these characters.

Keywords: Linseed, genetic variability, heritability, genetic advance

Introduction
Linseed (*Linum usitatissimum* L. 2n=30) is an important *Rabi* oilseed crop and one of the oldest crops under cultivation. It is an annual, self-pollinating plant species belonging to the Linaceae family commonly known as "Alsi" and is presumed to be originated in southwest Asia particularly in India (Vavilov, 1935 [1] and Richharia, 1962 [2]). Two morphologically distinct cultivated species of linseed are recognized, namely Flax and Linseed. The flax types are commercially grown for the extraction of fibres, whereas the linseed is meant for the extraction of oil from seeds. The seed of linseed contain about 33-45 per cent oil and has been used for centuries as a drying oil. 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, linoleum, printing ink etc. But recently it has gained a new interest in the emerging market of functional food due to its high content of fatty acids, alpha linolenic acid (ALA), an essential Omega-3 fatty acid and lignin oligomers which constitute about 57% of total fatty acids in linseed (Reddy *et al.*, 2013) [3]. It's medicinal and nutraceutical properties have paved the way for its diversified uses and value addition in various forms. Recent advances in neuro-biology have established that it is the best herbal source of Omega-3 fatty acids which helps in regulating the nervous system (Anonymous, 2017) [4]. The average productivity is very low as compared to other countries, hence, there is an urgent need to increase the productivity by breaking the present yield barrier and developing high yielding varieties. A character which has higher range of genetic variability, high heritability and high genetic advance would be an effective tool to improve economic yield (Aytac and Kinaci, 2009) [5]. Morphological traits have been used to assess the genetic variation and relationships among populations of different oilseed species, Assessment of variability for yield and its component characters becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful in detecting the amount of variability present in the germplasm. Heritability coupled with high genetic advance would be more useful tool in predicting the resultant effect in selection of the best genotypes for yield and its attributing traits. It helps in determining the influence of environment on the expression of the genotypic and reliability of characters. With the above background information the present investigation was undertaken to study the genetic parameters among the twenty five linseed genotypes.

Materials and Methods

The experimental materials comprising of twenty five genotypes consisting of $6F_1$s, $6F_2$s, $6F_3$s, 5 parents and two check varieties were evaluated in Randomized Block Design with three replications, during *Rabi* season 2017-18 at Experimental Farm of the Department of Plant Breeding and Genetics, BAU, Ranchi with a spacing of 30 cm and 10 cm between and within the rows respectively with 3 meter row length. The non-segregating generations (Parents, F_1s and Checks) were grown in 3 rows, the segregating F_2 generations were grown in 10 rows and F_3s were grown in 20 rows. The observations were recorded from 10 randomly selected plants from P_1, P_2, F_1s and check, 20 plants from F_2s and F_3s from each plots and generation for days to 50% flowering, days to maturity, technical height (cm), plant height (cm), number of primary branches per plant, number of capsules per plant, capsule diameter (mm), number of seeds per capsule, 1000-seed weight (g), oil content (per cent). The data were analyzed statistically by analysis of variance as per randomized block design method given by Panse and Sukhatme (1966) [6]. The coefficient of variability was calculated following Burton (1952) [7]. Heritability and genetic advance under selection for these attributes were calculated according to (Lush, 1940) [8] and (Johnson *et al.* 1955) [9] respectively.

Result and Discussion

The analysis of variance (Table-1) revealed highly significant differences among twenty five genotypes for all the studied characters which are supported by Khorgade and Pillai (1994) [10] for number of capsules per plant, Savita (2006) [11] for days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and seed yield per plant. Rajanna *et al.* (2014) [12] and Bindra and Paul (2016) [13] also found a wide range of genetic variability of economically relevant traits which are in confirmation with the results of the present study.

Estimation of different genetic parameters is presented in Table-2. The result indicated that the PCV values were greater than the corresponding GCV values for all the traits studied indicating that the apparent variation is not only due to genotypes but, also due to the influence of environment. Therefore, caution has to be exercised in making selection for these characters on the basis of phenotype alone as environmental variation is unpredictable in nature. High estimates of PCV and GCV (>20%) were obtained for seed yield per plant and number of capsules per plant. Moderate PCV and GCV (10-20%) values were seen for technical height, plant height, 1000-seed weight and oil content (%) which indicated the presence of moderate genetic variability for these characters in linseed. Low estimates of (< 10%) were seen for days to 50% flowering, days to maturity, number of seeds per capsule and capsule diameter. (Akbar *et al*. (2003) [14], Khan *et al*. (2007) [15], Kumar *et al*. (2012) [16] and Manggoel *et al*. (2012) [17] supported the above findings.

Heritability is classified as low (below 30%), medium (30-60%) and high (above 60%) whereas genetic advance as percentage of mean (GAM) is classified as high (above20%), medium (10-20%) and low (below10%). Heritability estimate gives as idea about the heritable variation which is passed to the offspring from their parents. But heritability alone is not enough to judge the true heritable variation. Genetic advance or genetic grain is a more powerful estimate.

In the present investigation high heritability coupled with high genetic advance as percent of mean was obtained for technical height, plant height, number of capsule per plant, seed yield per plant, 1000-seed weight and oil content which indicated that most likely the heritability might be due to additive gene effect and selection may be effective in segregating generations confirming the findings of Mirza *et al.*(1996) [18], Pradhan *et al.* (1999) [19], Tewari *et al.* (2012) [20], Kumar *et al*. (2012) [16], Kanwar *et al.* (2014) [21], Pali and Mehta (2015) [22], Siddiquii *et al.* (2016) [23] and several other workers for seed yield per plant and number of capsules per plant, Reddy *et al.* (2013) [3], Rajanna *et al.* (2014) [12], Tyagi *et al.* (2014) [24], Kanwar *et al.* (2014) [21] and others for number of capsules per plant, seed yield per plant and 1000-seed weight. High heritability with low genetic advance as percent of mean was seen for days to maturity and capsule diameter indicating the presence of non-additive gene action and selection for such traits may not be rewarding confirming the finding of Rajanna *et al.* (2014) [12]. Moderate heritability with high genetic advance as percent of mean was seen for number of primary branches per plant which indicated the preponderance of additive gene action and selection pressure could profitability be applied on these characters for yield improvement which is supported by most of the workers as Pradhan *et al.* (1999) [19], Kumar *et al.* (2012) [16], Reddy *et al.* (2013) [3], Tyagi *et al.* (2014) [24] and Kanwar *et al.* (2014) [21] reported high heritability and high genetic advance as percent of mean. Similarly, low heritability accompanied with low genetic advance as percent of mean was observed for number of seeds per capsule indicating that the character is highly influenced by environmental effects and selection would be ineffective which is in agreement with the result of Kanwar *et al*. (2014) [21]. Important economic traits *viz*., technical height, plant height, number of capsule per plant, seed yield per plant, 1000-seed weight and oil content indicated that most likely the heritability might be due to additive gene effect and selection may be effective in segregating generations.

Table 1: Analysis of variance (MSS) for different yield and yield attributing characters in linseed.

Sl. No	Characters	Treatment (df=24)	Replication (df=2)	Error (df=48)
1	Days to 50% Flowering	23.44**	6.76	5.03
2	Days to maturity	122.11**	3.04	7.73
3	Technical height (cm)	74.82**	0.05	7.47
4	Plant height (cm.)	197.24**	1.94	7.91
5	No. of primary branches/ plant	1.99**	0.75	0.51
6	No. of capsules/ plant	4093.72**	1112.52	676.98
7	No. of seeds/ capsule	1.01**	0.14	0.19
8	Capsule diameter (mm.)	0.52**	0.13	0.06
9	Seed yield/ plant (g.)	17.76**	3.10	2.13
10	Test weight (g.)	4.47**	0.01	0.05
11	Oil content (%)	43.59**	0.61	0.60

*, ** -- Significant at 5% and 1% level of significance respectively.

Table 2: Estimates of variability, heritability and genetic advance for eleven traits in linseed.

Parameters Characters	PCV (%)	GCV (%)	Heritability (%)	Genetic Advance	Genetic Advance as per cent of mean
Days to 50% flowering	4.44	3.29	54.92	3.78	5.03
Days to maturity	4.91	4.48	83.13	11.59	8.41
Technical height (cm)	19.40	16.80	75.03	8.45	29.98
Plant height (cm)	14.60	13.77	88.86	15.42	26.73
No. of primary branches/ plant	20.08	14.02	48.80	1.00	20.18
No. of capsules/ plant	30.26	23.96	62.72	55.05	39.10
No. of seeds/ capsule	8.28	6.35	58.85	0.82	10.03
Capsule diameter (mm)	6.87	5.75	70.27	0.67	9.94
Seed yield/ plant (g)	33.96	28.60	70.89	3.95	49.60
Test weight (g)	15.77	15.51	96.72	2.46	31.43
Oil content (%)	10.20	10.00	95.97	7.63	20.18

PCV=Phenotypic co-efficient of variability, GCV= Genotypic co-efficient of variabilit

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