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Genetic Variability and Selection Response for Yield and its Component Traits in Linseed (*Linum usitatissimum* L.)

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ABSTRACT

In the present investigation number of capsules per plant and seed yield per plant showed high PCV and GCV values in BC_2F_2 and BC_1F_3generations and also they exhibited high heritability coupled with high genetic advance as per cent of mean which showed the additive nature of gene effect and thus direct selection may be effective for these characters. At 20% selection intensity all the characters exhibited positive selection differential except days to 50% flowering while response to selection was found positive for all the characters. The predicted heritability in narrow sense in BC_1F_2generation was found high (more than 60 %) for all the characters except number of seeds per capsule which showed moderate heritability in narrow sense.

KEYWORD

Selection response, Standardized selection, differential and realized heritability

INTRODUCTION

Linseed (*Linum usitatissimum* L., 2n = 30) is a diploid, self-pollinated and homozygous species of Linaceae family. This genus comprises mostly herbs and shrubs in tropical and subtropical region. It is an important oilseed crop grown both for seed and fibre. It is an industrial oilseed crop and its each and every part has commercial and medicinal importance Linseed seed contains good percentage of oil varying from 33-45 and 24% crude protein in different varieties (Bhushan *et al.*, 2017). Its seed comprises complete protein (rich in eight essential amino acids), higher order linolenic acid (an essential poly unsaturated Omega-3 fatty acid) highest in plant kingdom.

Globally, its production is 26.54 lakh tones from an area of 26.25 lakh ha with an average productivity of 1011 kg/ha. India ranks third in area after Canada, Kazakhstan and China but goes down to fourth rank in case of total production. As far as productivity is concerned our national average of 496 kg/ha is surpassed by almost all major linseed growing countries viz., Canada (1405 kg/ha), USA (1323 kg/ha), China (1248 kg/ha) and Kazakhstan (755 kg/ha) (Anonymous, 2016). In our country the crop occupies 2.84 lakh ha with a production of 1.41 lakh tones culminating in low productivity of 496 kg/ha. India contributes about 10.81 % and 5.31 % to world area and production respectively. The major part of linseed growing area lies in the states of Madhya Pradesh., Chhattisgarh, Uttar Pradesh, Maharashtra, Bihar, Odisha, Jharkhand, West Bengal, Nagaland and Assam accounting for more the 97 % of the nation (Anonymous, 2016).

The total production could be enhanced either by making horizontal expansion in area, which is not possible owing to high population growth, so none of the option left other than vertical expansion, which could be done opting a suitable breeding method (Choudhary *et al.*, 2018). Genetic variability is a pre-requisite for successful selection of superior progenies from segregating generations for further selection. At the same time the early generation testing is one of the best option to reduce the amount of material to be handled in the segregating generations and also to retain the good recombinant lines for the traits under improvement. It is also enhanced by selection response which maximises either by selecting the best genotype available in the population or by increasing the rigour of selection. A very rigorous selection may not be desirable as it can eliminate some promising genotypes (Choudhary *et al.*, 2018).

Grain yield is a complex character and is the result of interaction of many variables due to different gene association that might exist in different population and might result in quite different relationships. It is also largely influenced by environment. Further genotype and environmental interaction reduces the effectiveness of early generation selection (Whan *et al*,. 1981 and Rahman *et al.*, 1986). Recognizing the importance of response to selection for advancing the segregating materials and importance of early generations' selection in plant breeding experiments, the main objective of present investigation was to validate response of selection in early segregating generations.

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MATERIALS AND METHODS

The present investigation was carried out during *Rabi* 2015-16 and 2016-17 using the experimental material consisting of parents as Sekhar and T-397 and backcross progenies of (Sekhar X T-397) X Sekhar. The BC_1F_2 and BC_1F_3 population was grown in the *Rabi* 2015-16 and 2016-17 respectively with spacing of 30 cm and 10 cm between and within the rows respectively with 4 meter row length. Recommended agronomic practices were followed throughout the crop growth period to raise a healthy crop in both the years. Observation on 500 randomly selected plants were taken for the characters, days to 50 % flowering, days to maturity, plant height (cm), primary branches per plant, capsules per plant, seeds per capsule, capsule diameter (mm), yield per plant (g) and 1000-seed weight (g) in BC_1F_2 base population and progeny rows of selects were grown next year and designated as BC_1F_3. Standard statistical procedures were used for the analysis of mean variance, genotypic and phenotypic coefficients of variation, heritability and genetic advance as suggested by Sharma (1998). Standardized selection differential, response to selection and realized heritability were estimated as per Falconer (1989) while predicted/expected selection differential, predicted/expected selection response (or genetic advance), predicted/expected generalized selection response and predicted heritability following Sharma (1998).

RESULTS AND DISCUSSION

Genetic variability is a pre-requisite for successful selection of superior progenies from segregating generations for further selection. Genetic variability can be created by hybridization or mutation. F_2 is an ideal generation in which segregation and recombination are maximum for imposing selection. F_3 generation is equally important in the process of selection. The magnitude of recombination potential depends on the genetic diversity of the parents. A population is said to be superior when it shows high mean coupled with high variability (Savitha and Usha, 2015).

In the present (Table 1) investigation a very small differences between GCV and PCV was seen indicating little environmental influence on manifestation of studied characters showing its governance by additive genes; corroborating the findings of previous workers (Kumar *et al.*, 2012 and Kumar *et al.*, 2015). Number of capsules per plant and seed yield per plant showed high PCV and GCV values in both the generations. Sahu *et al.* (2014), Tyagi *et al.* (2014) and Choudhary *et al.* (2016) also reported high values of PCV and GCV for above mentioned traits. In both the populations i.e., BC_2F_2 base population/generation and BC_1F_3 progeny population/generation high heritability coupled with high genetic advance as per cent of mean was observed for number of capsules per plant and seed yield per plant representing the additive nature of gene effect and direct selection may be effective for these characters which is supported by the results of Rajanna *et al.* (2014) and Kumar *et al.* (2017).

Early generation testing helps breeder to increase the breeding efficiency by choosing superior genotypes and eliminating inferior lines from heterozygous population. Heterozygosity, which is highest at F_2 stage decreases in F_3 generation, as with every advance in generation, it decreases by 50% in a population (Acquaah, 2012). Therefore, in F_2 generation selection is applied on individual plant while at F_3 stage it is applied within the F_3 line. Selection increases the population genotypic mean for a particular trait. The increase in means results in positive value of selection differential and selection response in next generation

At 20% selection intensity (Table 2), all the characters exhibited positive selection differential (S/rS) except days to 50% flowering which was found to have negative selection differential. Positive selection differentials resulted due to the the increase in mean phenotypic value whereas negative selection differentials due to decrease. Standardized selection differential was the highest for seed yield per plant,

Table 1 Estimates of variability, heritability and genetic advance for different characters in BC_1F_2 and BC_1F_3 population of cross-(Shekhar X T-397) X Shekhar

Parameters / Characters	σ^2p		σ^2g		PCV (%)		GCV (%)		Heritability (%) broad sense		Genetic advance		GAM (%)	
	BC_1F_2	BC_1F_3	BC_1F_2	BC_1F	BC_1F_2	BC_1F_3	BC_1F_2	BC_1F	BC_1F_2	BC_1F_3	BC_1F_2	BC_1F_3	BC_1F_2	BC_1F_3
Days to 50 % flowering	3.09	12.96	2.89	12.71	2.64	5.23	2.55	5.18	93.54	98.07	2.30	4.94	3.46	7.40
Days to maturity	12.67	21.90	10.87	14.10	3.13	3.81	2.89	3.05	85.79	64.38	4.28	4.22	3.72	3.53
Plant height	39.19	30.69	32.29	21.04	14.12	10.04	12.81	8.31	82.39	68.55	7.22	5.32	15.66	10.08
No. of primary branches	1.32	1.56	0.82	0.31	49.69	29.63	39.19	13.25	62.19	20.00	1.00	0.35	28.12	7.73
No. of capsules per plant	242.42	1061.46	202.32	935.41	44.95	46.99	41.06	44.11	83.45	88.12	18.19	40.19	33.13	52.38
No. of seeds per capsule	2.25	1.61	1.25	1.21	21.71	14.84	16.18	12.86	55.55	75.20	1.17	1.34	14.84	14.59
Capsule diameter	0.27	0.12	0.17	0.07	8.08	5.19	6.49	3.89	64.38	56.39	0.47	0.27	7.29	4.03
Seed yield per plant	0.88	3.28	0.81	3.00	60.65	50.84	58.24	48.69	92.23	91.71	1.21	2.32	41.01	60.52
1000-seed weight	1.59	0.34	1.43	0.23	21.12	7.65	19.88	6.31	90.27	68.19	1.59	0.55	22.49	7.04

^2p = Phenotypic variance, ^2g= Genotypic variance, PCV=Phenotypic co-efficient of variability, GCV= Genotypic co-efficient of variability, GAM= Genetic advance as percent of mean

Table-2 Estimates of standardized selection differential, standardized selection response and realized heritability of different traits for cross (Sekhar X T-397) X Sekhar at 20% selection intensity.

Parameters / Characters	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of capsules per plant	No. of seeds per capsule	Capsule diameter (mm)	Seed yield per plant (g)	1000 seed weight (g)
Population mean	66.71	113.92	44.35	2.31	34.64	6.91	6.42	1.55	6.02
Mean of selected plants	66.62	114.92	46.12	3.56	54.92	7.86	6.43	2.96	7.08
σp	1.76	3.56	6.26	1.15	15.57	1.5	0.52	0.94	1.26
S or rS	-0.09	1.00	1.77	1.25	20.28	0.95	0.01	1.41	1.06
(S/σ p)	-0.05	0.28	0.28	1.08	1.30	0.63	0.02	1.5	0.84
Progeny mean	68.79	122.98	55.19	4.22	69.33	8.56	6.55	3.36	7.58
R	2.08	9.06	10.84	1.91	34.69	1.65	0.13	1.81	1.56
(R/σp)	1.18	2.55	1.73	1.66	2.23	1.10	0.25	1.93	1.24
(R/S)	-22.63	9.03	6.12	1.53	1.71	1.74	13.00	1.28	1.47
$\sigma^2 e$	0.20	1.80	6.90	0.50	40.10	1.00	0.10	0.07	0.15
pS	2.46	4.98	8.76	1.61	21.79	2.10	0.73	1.32	1.76
pR %	3.46	3.72	15.66	28.12	33.13	14.84	7.29	41.01	22.49
pgR	1.31	1.20	1.15	0.87	1.17	0.78	0.90	1.29	1.26
phNS	0.94	0.86	0.82	0.62	0.83	0.56	0.64	0.92	0.90

p=Phenotypic standard deviation, S=Selection differential or rS=Realized selection differential, (S/σ p)=Standardized selection differential, R=Selection response, (R/σp)=Standardized selection response, R/S= Realized heritability, ^{2}e=Environmental variance, pS=Predicted/expected selection differential, pR=Predicted/expected selection response (or Genetic advance) , pR% = % proportion of pR in selected plants (or GAM %), pgR=Predicted/expected generalized selection response, phNS=Predicted heritability in narrow sense.

followed by number of capsules per plant, number of primary branches per plant, 1000-seed weight, number of seeds per capsule, days to maturity and plant height. Days to 50% flowering recorded negative value which is desired in case of earliness.

The response to selection (R) was found positive for all the characters although for characters viz., days to 50% flowering, days to maturity and plant height negative value is desired when selection is being made for earliness and short stature plant height. Selection results in increase in the frequency of certain alleles and elimination of others leading to changes in genotypic and phenotypic values of the offsprings which exhibit better performance than their parents (Ahmad *et al.*, 2017). Maximum standardized selection response was obtained for days to maturity, followed by number of capsules per plant, seed yield per plant, plant height, number of primary branches per plant, 1000-seed weight, days to 50% flowering and number of seeds per capsule. The realized heritability was found high for all the characters, the highest being for days to 50% flowering followed by capsule diameter, days to maturity, plant height, number of seeds per capsule, number of capsules par plant, number of primary branches per plant, 1000-seed weight and seed yield per plant indicating that the offspring of the selected parents differ from the original population almost as much as the selected parents do.

The predicted/expected selection differential (pS) in BC_1F_2 was found highest in number of capsules per plant followed by plant height, days to maturity, days to 50% flowering, number of seeds per capsule, 1000-seed weight, number of primary branches per plant and seed yield per plant. These values define the probable size of realized selection differential (rS) in BC_1F_3 generation. Non-realization of full magnitude of predicted selection differential may result from several genetic and non-genetic factors.

The predicted/expected selection response (pR) or (genetic advance) in BC_1F_2 was seen highest for number of capsules per plant followed by plant height, days to maturity, days to 50% flowering, 1000-seed weight, number of seeds per capsule, seed yield per plant and number of primary branches per plant. These values define the probable size of realized selection response (rR) in BC_1F_3 generation. A number of factors may be responsible for fuller realization of pR or for ensuring the speed of advance under selection.

The realized or predicted response (rR or pR) can be generalized by dividing them with phenotypic standard deviation of the same generation of the base population to compare relative response to selection which is given by predicted or expected generalized selection response (pgR) in next generation. It was maximum for days to 50% flowering followed by seed yield per plant, 1000-seed weight, days to maturity, number of capsules per plant, plant height, capsule diameter, number of primary branches per plant and number of seeds per capsule.

A decreasing trend was observed for realized response to selection (R or rR) to predicted or expected generalized selection response (pgR) for all the characters except capsule diameter and 1000-seed weight, confirming the findings of Chatterjee and Jha (1990) which might be due to the greater homozygosity and homogeneity with the advancement of generation in a self-pollinated crop goes on decreasing

resulting in lower scope for further improvement for selection.

CONCLUSION

The predicted heritability in narrow sense (phNS) in BC_1F_2 generation was found high (more than 60 %) for all the characters except number of seeds per capsule which showed moderate heritability in narrow sense. The high value of phNS and pR% for characters such as number of primary branches per plant, number of capsules per plant, 1000-seed weight and seed yield per plant exhibited the preponderance of additive gene action and further selection for these characters would be rewarding while for plant height and number of seeds per capsule the high phNS and moderate pR%, and moderate phNS with moderate pR% respectively represented existence of both additive and non-additive gene action direct selection may be misleading (Sharma, 1998).

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