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ESTIMATION OF GENETIC PARAMETERS TO FORMULATE SELECTION STRATEGY FOR INCREASED YIELD IN LINSEED

M. Yasin Mirza, Mubashir A. Khan, M. Akmal, Akbar S. Mohmand, Malik S. Nawaz, Nazakat Nawaz and Najeeb Ullah*

ABSTRACT:- Genotypic differences among the genotypes in three seasons were statistically significant for plant height, number bolls plant^{-1}, 1000-seed weight and seed yield hectare^{-1}. These studies were conducted at National Agricultural Research Centre, Islamabad, Pakistan during *rabi* 2002-03, 2003-04 and 2004-05. Pooled genotypic and phenotypic variances were maximum for seed yield and minimum for 1000-seed weight. Genotypic coefficient of variation and phenotypic coefficient of variation were observed maximum for seed yield and minimum for plant height. Broad sense heritability estimates were high for all the traits during three years ranging from 63% for plant height and 97% for seed yield. High heritability pooled estimates of 89% for 1000-seed weight and seed yield ha^{-1} coupled with corresponding high estimates of genetic advance in percent of mean (17.23 and 18.33) for these traits indicated the predominance of additive gene effects. Mass selection based on these additively controlled traits is suggested for improvement of yield. Plant height, number of bolls plant^{-1} and 1000-seed weight showed genetic advance of 7.96, 8.85 and 17.23 % respectively with the prospects of improving seed yield up to the level of 18.33 %.

Key Words: Linseed; Genetic Parameters; Selection Strategy; Seed Yield; Pakistan.

INTRODUCTION

Linseed (*Linum usitatissimum* L.) also known as flax is cultivated for seeds and fibres. Its oil is largely of drying type and non-edible because of high amount of saturated fatty acids namely; palmitic acid and stearic acid alongwith unsaturated fatty acids viz., oleic, linoleic and linoleinic acids. Its oil content ranges from 33-45% with protein content of 24% (Gill, 1987). Singh and Marker (2006) 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 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 %).

In Pakistan average yield of linseed is quite low and the crop is only cultivated in Sindh and Punjab provinces. It was grown on 5432 ha and total production of 3656 kgha^{-1} with average yield of 673 kgha^{-1} during 2008-09 (Anonymous, 2008-09).

Pyramiding of favorable genes for variety development is an uphill task for a breeder and the success depends upon availability of large magnitude of genetic variability as the segregation patterns of yield and related traits are continuous and their phenotypic expressions are highly vulnerable to environmental influences. The genetic variability and the heritability of polygenic characters in a population are useful parameters for estimating expected response to selection. The major function of heritability is to provide information on transmission of trait(s) from parents to the offspring and facilitate the evaluation of genetic and environmental effects aiding in selection. Moreover, estimates of heritability can also be used to predict genetic advance under different schemes of selection and help in anticipating the genetic improvement of the crop.

Mahto and Rahman (1998), Popescu et

*Oilseeds Research Programme, Crop Sciences Institute, National Agricultural Research Centre, Islamabad, Pakistan.

al. (1998), Mishra and Yadav (1999), Payasi et al. (2000), Noor (2004), Zaheer (2007) and Tadesse et al. (2010) have also evaluated linseed genotypes based on estimated genetic parameters.

The objective of the present studies were to evaluate a collection of promising and improved linseed genotypes for their yield performance, and generating knowledge on different genetic parameters to formulate the selection strategy(s) for yield improvement of this crop.

MATERIALS AND METHODS

The experimental materials comprising populations of ten advanced/improved linseed lines namely; LS-24, LS-25, LS-26, LS-27, LS-29, LS-30, LS-31, LS-32, LS-33 and a check variety called Chandni were sown in randomized complete block design with four replications during *rabi* 2002-03, 2003-04 and 2004-05 at National Agricultural Research Centre, Islamabad, Pakistan. Experimental unit comprised four 5m long rows keeping row-to-row and plant-to-plant spacing at 45 cm and 10 cm, respectively. At physiological maturity, data were recorded on ten randomly selected plants for four yield components including plant height, number of bolls plant, 1000-seed weight and seed yield hectare^{-1}. The data collected were subjected to analysis of variance after Steel and Torrie (1980) for each year separately as well as on pooled basis over three years. Estimates of genotypic and phenotypic variances were computed following Singh and Chaudhry (1985). Genotypic and phenotypic coefficients of variation and broad sense heritability were estimated after Burton (1952). Heritability estimates were grouped as high (>50%), medium (20-50%) and low (<20%) as proposed by Stansfield (1986). Genetic advance at 10% selection intensity and genetic advance as percent of mean were computed using formula given by Johnson et al. (1955) and used by Allard (1960).

RESULTS AND DISCUSSION

Analysis of variance for each season as well as on pooled basis indicated statistically significant differences ($P \leq 0.01$) among the genotypes for all the traits studied. Results are in line with those of Payasi et al. (2000). Coefficient of variation for these traits ranged from 2 to 9 % showing the accuracy of the experimental design and randomization as supported by Gomez and Gomez (1984).

Agronomic Performance

Mean performance of the promising genotypes against the check (Chandni) for three years separately and pooled over the years is presented (Tables 1 and 2). Character wise results are discussed to identify the superior genotype(s) out of tested ones.

Plant Height

On pooled mean basis, eight genotypes were dwarf with plant height ranging from 102 cm (LS-24) to 113 cm (LS-27) as against the check with value of 115 cm. However, six genotypes viz., LS-24, LS-25, LS-26, LS-30, LS-31 and LS-32 were dwarf and had short plant height in each season as against the check variety.

Number of Bolls Plant

It is believed that high number of bolls plant^{-1} reflect the yield potential of a crop variety. In our study, the values of pooled means over three seasons showed that all the lines except LS-29 with 94 bolls plant^{-1}, possessed more number of bolls plant^{-1} ranging from 99(LS-27) to 108 in LS-26 as compared to Chandni having 96 bolls plant^{-1}. LS-25, LS-26, LS-30, LS-32 and LS-33 possessed large number of bolls plant^{-1} in each season as against the check.

1000-seed weight

Seed weight is an important yield component, hence needs particular emphasis for improving the yield of any crop. In this study, LS-25, LS-27, LS-29, LS-30, LS-31 and LS-33 were high in 1000-seed weight with values of 7.92, 7.56, 7.63, 8.94, 8.08 and 7.13 g, respectively as against the check (7.09 g) indicated by pooled mean values. Season wise data depicted that in 2002-03 all 9 entries; in 2003-04 five entries (LS-25. LS-29, LS-30, LS-31 and LS-33) with seed weight of 8.0 to 10.95 g; and in 2004-05 six entries including LS-24, LS-25, LS-27, LS-30, LS-31 and LS-32 had higher 1000-seed weight than check variety.

Seed Yield

It is an outcome of intricate relationship of several contributing characters. Consistency in yield performance over the years is an important measure of ranking for developing commercial varieties. Results indicated that LS-24, LS-25, LS-26, LS-31, LS-32 and LS-33 showed consistent high yield performance than check in each season. LS-24 produced maximum seed yield of 2251 kg ha^{-1} followed by LS-33 (2022 kg ha^{-1}) in 2002-03. LS-32 followed by LS-27 produced maximum yield of 1698 and 1631 kg ha^{-1} in 2003-04. While LS-25 and LS-33 produced high yield of 1272 kg ha^{-1} in 2004-05 as compared to check. Moreover, the pooled mean data also elucidated that all the varieties out yielded the check (1188 kg) with seed yield hectare^{-1} ranging from 1293 kg (LS-29) to 1626 kg (LS-24). These results are in conformity with those of Noor (2004) and Zaheer (2007).

Genetic Parameters

Statistical measures such as genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, broad sense heritability, genetic advance and genetic advance as percent of mean

Table 1. Mean performance for plant height (cm) and number of bolls plant^{-1} and estimates of genetic parameters in linseed genotypes over three years

	Plant height (cm)				Number of bolls plant^{-1}			
Genotypes	Years			Pooled	Years			Pooled
	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean
LS-24	99	100	108	102	66	165	88	106
LS-25	113	110	110	111	78	159	77	105
LS-26	109	106	109	108	83	163	79	108
LS-27	113	115	111	113	72	137	87	99
LS-29	116	116	114	115	69	132	81	94
LS-30	108	111	111	110	87	154	75	105
LS-31	105	109	105	106	74	150	79	101
LS-32	99	109	107	105	81	152	79	104
LS-33	105	115	117	112	79	151	86	105
Chandni (C)	116	114	114	115	74	152	63	96
Mean	108	111	111	110	76	151	79	102
Range	99-116	100-116	105-114	102-115	66-87	132-165	63-88	94-108
LSD (5%)	4.96	7.45	3.65	3.22	9.83	11.12	4.92	5.59
CV (%)	3.16	4.64	2.28	2.02	8.87	5.06	4.28	3.76
Genotypic Mean square	153.71**	97.47**	57.39**	77.12**	172.00**	453.93**	209.54**	91.60**
Genetic Parameters								
GV	35.5	17.77	12.76	18.05	31.54	98.81	49.51	19.19
PV	47.2	44.16	19.1	22.97	77.4	157.52	61.02	34.02
GCV (%)	5.52	3.8	3.22	3.86	7.39	6.58	8.91	4.3
PCV (%)	6.36	5.99	3.94	4.35	11.58	8.31	9.89	5.72
h (%)	87	63	82	89	64	79	90	75
GA	12.27	8.68	7.36	8.75	11.57	20.48	14.49	9.02
GA (%)	11.37	7.82	6.63	7.96	15.22	13.56	18.35	8.85

*GV=Genotypic variance, PV=Phenotypic variance, GCV%=Genotypic coefficient of variation %, PCV%= Phenotypic coefficient of variation %, h=Heritability, GA=Genetic advance, GA%=Genetic advance as percent of mean** = Highly significant at 1% level of probability* provide precise estimates of genetic variation for quantitative characters in any crop (Yadav and Dalal, 1972). In the present studies, the values of variances were found maximum for seed yield and minimum for 1000-seed weight for three years separately as well as for pooled means over the years. In genotypic and phenotypic coefficients of variations, maximum values (17.06% and 17.59% respectively) were observed for seed yield whereas minimum values (3.22% and 3.94%, respectively)or plant height during 2004-05 (Tables 1 and 2). Similar trend was observed on pooled means basis with maximum and minimum values of GCV and PCV for seed yield (8.90% and 10.01%) and for plant height (3.86% and 4.35%) respectively. Present findings corroborate with those of Mishra and Yadav (1999) and Payasi et al. (2000) who reported high GCV and PCV for yield in linseed. Tadesse et al. (2010) reported high GCV and PCV for seed yield and low for plant height in linseed.

Relative amount of heritable portion of variance can be assessed through heritability estimation. Results demonstrated that broad sense heritability estimates were high for all the traits during each year separately as well as on pooled means basis ranging from 63% for plant height in 2003-04 to 97% for seed yield in 2004-05. The higher estimates indicated that large proportion of the total variance was explicitly due to the high genotypic variance and less environmental influence resulting in high heritable variation. The findings are in agreement with those of Mahto and Rahman (1998) who reported high heritability values for number of bolls per plant, 1000-seed weight and seed yield. Popescu

Table 2. Mean performance for 1000 seed weight (g) and seed yield (kgha^{-1}) and estimates of genetic parameters in linseed genotypes over three years

	1000-seed weight (g)				Seed yield (kg ha^{-1})			
Genotypes	Years			Pooled	Years			Pooled
	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean
LS-24	6.73	6.6	7.14	6.82	2251	1458	1169	1626
LS-25	6.8	8.52	8.43	7.92	1818	1466	1272	1519
LS-26	6.7	7.9	6.48	7.03	1867	1624	1061	1517
LS-27	7.56	7.42	7.7	7.56	1938	1631	883	1484
LS-29	7.15	9.57	6.48	7.63	1491	1569	818	1293
LS-30	8.12	10.95	7.76	8.94	1902	1596	885	1461
LS-31	7.6	8.6	8.03	8.08	1856	1474	1251	1527
LS-32	7.03	7.52	6.66	7.07	1671	1698	1205	1525
LS-33	6.76	8	6.63	7.13	2022	1531	1272	1608
Chandni (C)	6.64	7.97	6.65	7.09	1543	1125	896	1188
Mean	7.11	8.31	7.2	7.54	1836	1517	1071	1475
Range	6.64-8.12	6.6-10.95	6.48-8.43	6.82-8.94	1543-2251	1125-1698	818-1272	1188-1626
LSD (5%)	0.39	1.08	0.7	0.47	222.8	191.4	66.43	97.97
CV (%)	3.82	8.98	6.71	4.29	8.36	8.7	4.27	4.58
Genotypic Mean square	0.98**	6.02**	2.10**	1.70**	202445**	101408**	135673**	73469**
Genetic parameters								
GV	0.23	1.41	0.47	0.4	44717.71	21001.29	33394.26	17227.41
PV	0.3	1.97	0.70	0.51	68292.29	38404.71	35490.44	21786.84
GCV (%)	6.71	14.29	9.50	8.36	11.52	9.55	17.06	8.9
PCV (%)	7.67	16.89	11.60	9.45	14.23	12.92	17.59	10.01
h (%)	87	85	82	89	81	74	97	89
GA	0.98	2.45	1.41	1.3	435.62	298.53	376.45	270.38
GA (%)	13.82	29.44	19.56	17.23	23.73	19.68	35.15	18.33

GV=Genotypic variance, PV=Phenotypic variance, GCV%=Genotypic coefficient of variation %, PCV%=Phenotypic coefficient of variation %, h= Heritability, GA=Genetic advance, GA%=Genetic advance as percent of mean
*** = Highly significant at 1% level of probability*

et al. (1998) found large heritability estimates for plant height, bolls m^{-2} and seed yield. Mishra and Yadav (1999) also reported similar results for bolls $plant^{-1}$; whereas Payasi et al. (2000) reported high heritability value for seed yield; Noor (2004) for bolls $plant^{-1}$, 1000-seed weight and seed yield and Zaheer (2007) for bolls $plant^{-1}$ and 1000-seed weight in linseed. Tadesse et al. (2010) also reported that heritability estimates were high for seed yield, number of bolls $plant^{-1}$ and 1000-seed weight. These characters showing high heritability, therefore, may respond effectively to phenotypic selection.

Moreover, less difference between GCV and PCV and corresponding high heritability estimates were observed for all the characters studied (Tables 1 and 2), indicating less environmental influence on these characters and suggesting use of direct selection for their improvement. Popescu et al. (1998), Mishra and Yadav (1999), Noor (2004) and Zaheer (2007) reported similar findings in their studies conducted on linseed crop. Tadesse et al. (2010) who reported highest GCV and PCV for seed yield which are in line with our results.

High heritability *per se* is no index of high genetic gain, hence should be accompanied by high GA% when describing the genetic parameters in any crop as cautioned by Kadir et al. (1996). In current studies, bolls $plant^{-1}$, 1000-seed weight and seed yield ha^{-1} during three years as well as on pooled means basis showed heritability of 75, 89 and 89%, respectively. Plant height in 2002-03, showed high heritability (87%) coupled with high values of GA% (11.37), indicating that these traits are under control of additive genes and are helpful for selection based on phenotypic performance. Mahto and Rahman (1998) reported high heritability along with high GA% values for bolls $plant^{-1}$, 1000-seed weight and seed yield supporting that the expression of these traits was additively controlled. Popescue et al. (1998) also reported that plant height, bolls m^{-2} and seed yield were controlled by additive gene effects. Mishra and Yadav (1999) found high heritability and GA% for number of bolls $plant^{-1}$ indicating the preponderance of additive gene action. Payasi et al. (2000) reported additive gene effects controlling seed yield. Noor (2004) also found that additive gene action governed the expression of bolls $plant^{-1}$ and seed yield. Similarly, Zaheer (2007) investigated additive gene effects for bolls per plant and 1000-seed weight.

The aforementioned estimates of broad sense heritability, genetic advance and genotypic variances were high for plant height, number of bolls $plant^{-1}$, 1000-seed weight and seed yield $hectare^{-1}$. Therefore, mass selection based on these additively controlled traits is suggested for yield improvement in this crop. Mahto and Rahman (1998) reported that phenotypic selection made on the basis of bolls $plant^{-1}$, 1000-seed weight and seed yield would be effective for the improvement of yield. Moreover, Mishra and Yadav (1999) also emphasized the selection for high number of bolls $plant^{-1}$ to develop linseed varieties with high yield potential. These results also revealed that the characters with high genotypic coefficient of variation possessed high genetic advance irrespective of heritability estimates and vice versa, showing the preponderance of genetic influence and the findings are in line with those of Ali et al. (2000) who investigated that genetic advance in percent of mean is a function of heritability and genotypic coefficient of variation. However, the later parameter was more important than the earlier.

Mean values of genetic advance in percent over the years indicated that genetic improvement for plant height, number of bolls $plant^{-1}$, 1000-seed weight and seed yield can be achieved through selection up to the level of 7.96, 8.85, 17.23 and 18.33% respectively within the perspective of tested materials. Zaheer (2007) also mentioned that 16-32% improvement in yield of linseed could be achieved by selecting indirectly for the number of bolls per plant and 1000-seed weight. Tadesse (2010) reported genetic advance in percent of mean was high for seed yield and 1000-seed weight and are in agreement with our findings.

In conclusion, progress from selection is realized only to the extent of identification of superior genotypes. Information on the relative magnitudes of different sources of variance provides a guide towards this objective. From the results achieved in these studies, it is recommended that plant height, number of bolls plant^{-1}, 1000-seed weight and seed yield provide a good selection base as they had high values of heritability coupled with genetic advance. Emphasis should be placed on these characters for formulating selection strategy for the development of high yielding linseed varieties.

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