



ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating 2017: 5.03
TPI 2017; 6(8): 310-314
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www.thepharmajournal.com
Received: 05-06-2017
Accepted: 06-07-2017

Amit Kumar
Department of Genetics & Plant
Breeding, S.V.P.U.A. & T-
Meerut, Uttar Pradesh, India

SA Kerkhi
Department of Genetics & Plant
Breeding, S.V.P.U.A. & T-
Meerut, Uttar Pradesh, India

Rohit Kumar
Department of Genetics & Plant
Breeding, S.V.P.U.A. & T-
Meerut, Uttar Pradesh, India

Studies on heritability, genetic advance & character association analysis in Linseed (*Linum usitatissimum* L.)

Amit Kumar, SA Kerkhi and Rohit Kumar

Abstract

High heritability coupled with high genetic advance as percent of mean was observed for the characters, capsules per plant and biological yield per plant while high heritability coupled with moderate genetic advance in percent of mean was recorded for days to 50% flowering and plant height. Seed yield revealed significant positive correlation with days to 50% flowering, capsules per plant, biological yield per plant, harvest index, plant height and seeds per capsule. Thus, it could be inferred that by improving these traits through selection either alone or in combination, will result in improvement of yield in linseed. Path coefficient analysis (Genotypic and Phenotypic) of grain yield and its contributing characters revealed that biological yield per plant had the high positive direct effect on grain yield per plant followed by harvest index and capsules per plant.

Keywords: additive, correlation, direct effects, direct effects, dominance, genotype, genetic advance, heritability, phenotype and path

1. Introduction

Linseed (*Linum usitatissimum* L.) commonly known as *Alsi*, belongs to the genus *Linum* of the family Linaceae having 13 genera. Out of these only *Linum usitatissimum* (with diploid chromosome $2n=30$) is the only cultivated species of genus *Linum*. However, about 20% of the total oil produces from linseed is also under human consumption in different states of India. Linseed oil cakes are very nutritious and is under use as feed for milch cattles Linseed is widely cultivated in Russia, U.S.A., Argentina, Uruguay, India, Pakistan, China, Japan, Morocco, Australia, Ireland, Scotland, Poland, and a few other European countries. The major linseed growing states in the country are Madhya Pradesh, Chhattisgarh, Maharashtra, Uttar Pradesh and Orissa which all together contributes more than 83 percent of total linseed area under production. The total area, production and productivity of linseed are 284 thousand hectare, 153 thousand tones and 539 Kg per hectare respectively in India and the total area, production and productivity are 25 thousand hectare, 14 thousand tones and 560 Kg per hectare in U.P. respectively (Directorate of Economics and Statistics, Ministry of Agriculture and farmers Welfare. 2014-15) [7].

2. Material & Methods

The present experiments were involving thirty-five genotypes of linseed was undertaken to examine the genetic variability, heritability, genetic advance, correlation coefficient, path coefficient analysis and genetic divergence. Thirty five genotypes of linseed were sown in a Randomized Complete Block Design with three replications during *rabi* season 2015-16 at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP). Each genotype was sown in 3 rows plot of 3 meters length, spaced 20 cm apart with plant to plant distance of 5-6 cm. All recommended agronomic practices and plant protection measures were followed to raise the good crop. Observations were recorded for days to 50 per cent flowering, plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule, days to maturity, biological yield per plant (g), seed yield per plant (g), harvest index (%) and 1000 seed weight. The analysis of variance was done as per the procedure described by Panse and Sukhatme, (1969). The heritability & genetic advance for different characters was estimated as suggested by Allard (1960) [1]. The analysis of path coefficient was estimated by following the procedure as suggested by Wright, (1921) [21] and as elaborated by Dewey and Lu, (1959) [6].

Correspondence
Amit Kumar
Department of Genetics & Plant
Breeding, S.V.P.U.A. & T-
Meerut, Uttar Pradesh, India

3. Results & Discussion

The mean sum of squares for seed yield and its component traits are presented in Table-1. The analysis of variance revealed highly significant differences among the genotypes for all the characters viz; days to 50% flowering, plant height, primary branches per plant, number of capsules per plant, number of seeds per capsule, days to maturity, biological

yield per plant, seed yield per plant, harvest index and 1000 seed weight which showed wide spectrum of variation among present set of material when it was tested against 'F' test. Similar findings were also observed by Chaudhari *et al.* (2015) [3], Chauhan *et al.* (2015) [4] and Siddiqui *et al.* (2016) [19].

Table 1: Analysis of variance for ten characters of 35 genotypes in linseed (*Linum usitatissimum* L.).

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Primary branches per plant	Capsules per plant	Seeds per capsule	Days to maturity	Biological yield per plant (g)	Seed yield per plant (g)	Harvest index (%)	1000 seed weight (g)
Replication	2	2.866	7.408	0.559	163.936	1.804	26.866	3.076	1.398	5.479	0.118
Treatment	34	98.887**	52.502**	1.941**	2855.421**	0.971**	7.419**	70.068**	7.409**	61.889**	1.186**
Error	68	1.327	2.635	0.422	146.183	0.192	1.650	3.437	0.961	20.911	0.313

** Significant at 1% level

The estimates of heritability in broad sense (H^2) were worked out for all the ten characters and the estimated values are given in Table-2. The estimates of heritability (in broad sense) were arbitrarily categorized in three major groups, i.e. high heritability (above 80 %), moderate heritability (60 to 80 %) and low heritability (Less than 60 %). The perusal of data revealed that highest H^2 was recorded for days to 50% flowering (96.10) and the lowest (39.50) for harvest index. High heritability (in broad sense) estimates were obtained for days to 50% flowering (96.10) followed by biological yield per plant (86.60), plant height (86.30), capsules per plant (86.10). Moderate heritability was recorded for seed yield per plant (69.10). However low H^2 was recorded in seeds per capsule (57.40) followed by primary branches per plant (54.50), days to maturity (53.80), 1000 seed weight (48.10)

and harvest index (39.50). The expected genetic advance expressed as per cent of mean varied from 1.548 (days to maturity) to 37.176 (capsules per plant). High genetic advance in percentage of mean (> 20%) was observed for the characters, capsules per plant (37.176), biological yield per plant (36.707), seed yield per plant (28.623). Moderate genetic advance in percentage of mean (10- 20%) was recorded for primary branches per plant (17.419), days to 50% flowering (15.951), harvest index (13.217), 1000 seeds weight (12.529) and plant height (12.330). However low (<10%) genetic advance in percentage of mean was recorded for seeds per capsules (8.664) and days to maturity (1.548). Similar findings were also observed by Fida *et al.* (2015) [8] and Dash *et al.* (2016) [5].

Table 2: Grand mean, range, GCV, PCV, heritability H^2 (%) and genetic advance of ten characters in linseed.

Characters	GM	Range		S.E.±	CD 5%	GCV	PCV	Heritability in broad sense in %	GA	GA as percent of mean
		Lowest	highest							
Days to 50% flowering	72.190	63.00	80.00	0.665	1.877	7.899	8.059	96.10	11.515	15.951
Plant height (cm)	63.285	53.40	74.20	0.973	2.645	6.442	6.934	86.30	7.803	12.330
Primary branches per plant	6.214	4.73	7.93	0.375	1.059	11.452	15.510	54.50	1.082	17.419
Capsules per plant	154.487	84.20	221.26	6.980	19.699	19.452	20.968	86.10	57.432	37.176
Seeds per capsule	9.183	8.26	10.00	0.253	0.714	5.550	7.323	57.40	0.796	8.664
Days to maturity	135.361	132.00	138.66	0.741	2.093	1.024	1.397	53.80	2.095	1.548
Biological yield per plant (g)	24.612	15.86	34.40	1.070	3.020	19.148	20.576	86.60	9.034	36.707
Seed yield per plant (g)	8.770	6.00	12.06	0.566	1.597	16.716	20.109	69.10	2.510	28.623
Harvest index (%)	36.208	25.07	44.65	2.640	7.450	10.207	16.238	39.50	4.786	13.217
1000 seed weight (g)	6.150	5.37	7.82	0.323	0.912	8.770	12.645	48.10	0.771	12.529

A close examination of Table-3 showed highly significant and positive correlations between characters such as days to 50% flowering with plant height (0.251**), capsules per plant (0.494**), seeds per capsule (0.279**), biological yield per plant (0.436**) and with seed yield per plant (0.325**); plant height with biological yield per plant (0.531**), capsules per plant (0.430**) and number of primary branches per plant (0.336**); number of primary branches per plant with capsules per plant (0.386**) and biological yield per plant (0.353**); capsules per plant with biological yield per plant (0.636**) and seed yield per plant (0.564**); biological yield per plant with seed yield per plant (0.662**). Seed yield per plant showed highly significant and positive association with days to 50% flowering (0.325**), capsules per plant

(0.564**), biological yield per plant (0.662**) and harvest index (0.362**). A significant and positive correlation was also recorded between seed yield per plant and plant height (0.238*) and seeds per capsule (0.194*). A numerically positive correlation were also recorded for the characters such as, seeds per capsule with biological yield per plant (0.151) and number of primary branches per plant with seed yield per plant (0.068). However, negative significant correlations were noticed between plant height and harvest index (-0.383**); biological yield per plant and harvest index (-0.437**); and between harvest index and number of primary branches per plant (-0.377**). Similar findings were also observed by Gauraha *et al.* (2011) [9], Gudmewad *et al.* (2015) [10] and Kumar & Paul (2016) [18].

Table 3: Estimates of genotypic (G) and phenotypic (P) correlation coefficients among ten characters in linseed.

Characters	Days to 50% flowering	Plant height (cm)	Primary branches per plant	Capsules per plant	Seeds per capsule	Days to maturity	Biological yield per plant (g)	Seed yield per plant (g)	Harvest index (%)	1000 seed weight (g)
Days to 50% flowering	G 1.000 P 1.000	0.268 0.251* *	-0.002 0.007	0.555 0.494**	0.351 0.279**	-0.074 -0.046	0.481 0.436**	0.393 0.325**	-0.204 -0.118	-0.243 -0.164
Plant height (cm)		G 1.000 P 1.000	0.519 0.336**	0.489 0.430**	-0.207 -0.102	0.100 0.062	0.621 0.531**	0.312 0.238*	-0.687 -0.383**	-0.001 -0.005
Primary branches per plant			G 1.000 P 1.000	0.545 0.386**	-0.410 -0.155	0.077 0.138	0.422 0.353**	0.001 0.068	-0.807 -0.377**	-0.178 -0.142
Capsules per plant				G 1.000 P 1.000	0.230 0.162	-0.099 -0.063	0.733 0.636**	0.697 0.564**	-0.248 -0.113	-0.124 -0.133
Seeds per capsule					G 1.000 P 1.000	0.048 -0.000	0.202 0.151	0.205 0.194*	0.056 0.081	0.208 -0.087
Days to maturity						G 1.000 P 1.000	0.156 0.118	0.008 0.069	-0.314 -0.096	0.124 0.106
Biological yield per plant (g)							G 1.000 P 1.000	0.798 0.662**	-0.523 -0.437**	-0.014 0.011
Seed yield per plant (g)								G 1.000 P 1.000	0.086 0.362**	0.260 0.051
Harvest index (%)									G 1.000 P 1.000	0.350 0.038
1000 seed weight (g)										G 1.000 P 1.000

*, ** significant at 5% and 1% level, respectively

The results pertaining to direct and indirect effects are presented in Table-4. Genotypic path coefficient analysis of seed yield and its contributing characters revealed that biological yield per plant had the highest positive direct effect on grain yield per plant (1.041) followed by harvest index (0.590), capsules per plant (0.243), days to maturity (0.069) and plant height (0.030). The direct effects of the remaining characters on grain yield were negative and of low magnitude. The direct effect of primary branches per plant and days to maturity were higher but its correlation with grain yield was non-significant which were due to negative indirect effect via other characters. On the other hand the characters 1000 seed weight, days to 50% flowering and seeds per capsules had negative direct effects but their correlation with grain yield was positive which might be due to high positive indirect effects via other characters. Days to 50% flowering contributed the indirect positive effect on grain yield via biological yield per plant (0.501) and capsules per plant (0.135); plant height contributed the indirect positive effect on grain yield via biological yield per plant (0.647), capsules per

plant (0.119) and seeds per capsule (0.028); primary branches per plant contributed the indirect positive effect on grain yield via biological yield per plant (0.440), capsules per plant (0.132) and seeds per capsule (0.056); capsules per plant contributed the indirect positive effect on grain yield via biological yield per plant (0.763); seeds per capsule showed the indirect positive effect on grain yield via biological yield per plant (0.210), primary branches per plant (0.072) and capsules per plant (0.056); days to maturity showed the indirect positive effect on grain yield via biological yield per plant (0.163); biological yield per plant contributed the indirect positive effect on grain yield via capsules per plant (0.178) and plant height (0.019); harvest index showed the indirect positive effect on grain yield via primary branches per plant (0.142) and days to 50% flowering (0.016); 1000 seed weight showed the indirect positive effect on grain yield via harvest index (0.206), primary branches per plant (0.031) and seeds per capsule (0.028). Similar findings were also observed by Rafiq *et al.* (2014) [14], Kumar *et al.* (2015) [13] and Naik *et al.* (2016) [5].

Table 4: Estimates of path coefficient showing direct and indirect effects of nine component characters on grain yield at genotypic level in linseed.

Characters	Days to 50% flowering	Plant height (cm)	Primary branches per plant	Capsules per plant	Seeds per capsule	Days to maturity	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Correlation with seed yield (g)
Days to 50% flowering	-0.082	-0.022	0.000	-0.045	-0.029	0.006	-0.039	0.016	0.020	0.393
Plant height (cm)	0.008	0.030	0.015	0.015	-0.006	0.003	0.019	-0.021	0.000	0.312
Primary branches per plant	0.000	-0.091	-0.176	-0.096	0.072	-0.013	-0.074	0.142	0.031	0.001
Capsules per plant	0.135	0.119	0.132	0.243	0.056	-0.024	0.178	-0.060	-0.030	0.697
Seeds per capsule	-0.048	0.028	0.056	-0.032	-0.138	-0.006	-0.028	-0.007	0.028	0.205
Days to maturity	-0.005	0.006	0.005	-0.006	0.003	0.069	0.010	-0.021	0.008	0.008
Biological yield per plant (g)	0.501	0.647	0.440	0.763	0.210	0.163	1.041	-0.545	0.015	0.798
Harvest index (%)	-0.120	-0.406	-0.476	-0.146	0.033	-0.185	-0.309	0.590	0.206	0.086
1000 seed weight (g)	0.004	0.000	0.003	0.002	0.004	-0.002	-0.000	-0.006	-0.019	0.260

Residual Effect = 0.062

Phenotypic path coefficient analysis Table-5 of seed yield and its contributing characters revealed that biological yield per plant had the highest positive direct effect on seed yield per plant (1.001) followed by harvest index (0.804), capsules per

plant (0.038), days to maturity (0.029), 1000 seed weight (0.003) and plant height (0.001). The direct effects of the remaining characters on seed yield were negative and of low magnitude. The direct effect of primary branches per plant,

days to maturity and 1000 seeds weight were higher but its correlation with grain yield was non-significant which were due to negative indirect effect via other characters. On the other hand the characters days to 50% flowering and seeds per capsules had negative direct effects but their correlation with grain yield was significantly positive which was due to high positive indirect effects via other characters. Days to 50% flowering contributed the indirect positive effect on grain yield via biological yield per plant (0.436) and capsules per plant (0.019); plant height contributed the indirect positive effect on grain yield via capsules per plant (0.016) and biological yield per plant (0.532); primary branches per plant contributed the indirect positive effect on grain yield via biological yield per plant (0.354) and capsules per plant (0.015); capsules per plant contributed the indirect positive effect on grain yield via biological yield per plant (0.637);

seeds per capsule showed the indirect positive effect on grain yield via biological yield per plant (0.151) and harvest index (0.065); days to maturity showed the indirect positive effect on grain yield via biological yield per plant (0.119); biological yield per plant contributed the indirect positive effect on grain yield via capsules per plant (0.024); 1000 seed weight showed the indirect positive effect on grain yield via harvest index (0.031) and biological yield per plant (0.011). On the other hand the characters days to 50% flowering and seeds per capsule had negative direct effects but their correlation with grain yield was significantly positive which might be due to positive indirect effects via other characters. Similar findings were also observed by Reddy *et al.* (2013) ^[15], Sahu *et al.* (2016) ^[16], Shalini *et al.* (2016) ^[17] and Sharma *et al.* (2016) ^[18].

Table 5: Estimates of path coefficient showing direct and indirect effects of nine component characters on grain yield at phenotypic level in linseed.

Character	Days to 50% flowering	Plant height (cm)	Primary branches per plant	Capsules per plant	Seeds per capsule	Days to maturity	Biological yield per plant (g)	Harvest index (%)	1000 seed weight (g)	Correlation with seed yield (g)
Days to 50% flowering	-0.027	-0.006	-0.000	-0.013	-0.007	0.001	-0.012	0.003	0.004	0.325**
Plant height (cm)	0.000	0.001	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000	0.238*
Primary branches per plant	0.000	-0.001	-0.004	-0.001	0.000	-0.000	-0.001	0.001	0.000	0.068
Capsules per plant	0.019	0.016	0.015	0.038	0.006	-0.002	0.024	-0.004	-0.005	0.564**
Seeds per capsule	-0.006	0.002	0.003	-0.003	-0.021	0.000	-0.003	-0.001	0.001	0.194*
Days to maturity	-0.001	0.001	0.004	-0.001	0.000	0.029	0.003	-0.002	0.003	0.069
Biological yield per plant (g)	0.436	0.532	0.354	0.637	0.151	0.119	1.001	-0.437	0.011	0.662**
Harvest index (%)	-0.095	-0.308	-0.304	-0.091	0.065	-0.077	-0.351	0.804	0.031	0.362**
1000 seed weight (g)	-0.000	0.000	-0.000	-0.000	-0.000	0.000	0.000	0.000	0.003	0.051

Residual Effect = 0.185

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