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Genetic studies of yield and yield component of Linseed (*Linumu sitatissimum* L.)

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Abstract
The phenotypic and genotypic variances, correlation and path coefficient, heritability and genetic advances were estimated for grain yield and yield traits in fourteen genotypes of linseed at Zonal Research Station (*Birsa Agricultural University*), Chianki during *Rabi* 2012-13. Phenotypic variance was greater than genotypic variance that indicates influence of environment on the traits studied. Heritability estimate values ranged from 0.36% for plant height to 0.97% for days maturity. High heritability estimates indicated that improvement may be made through selection. Genetic advance as percent of mean was recorded highest for seed yield per plant (86.76) followed by biological yield (57.67) and number of capsules per plant. High heritability coupled with high genetic advance as per cent of mean (>20%) was observed with seven yield components. Grain yield (g/plant) had significant and positive association with number of branches per plant, number of capsule per plant, 1000-seed weight, days to maturity and days to flowering both at genotypic and phenotypic levels. Therefore, these traits may improve the breeding efficiency of linseed in the future breeding programs. Path analysis demonstrated that number of branches per plant, number of capsule per plant and 1000-seed weight had the positive direct effect in determining the seed yield in linseed. According to result, breeding for high grain yielding genotypes of linseed, number of capsule per plant should be given first and foremost importance followed by number of branches per plant, 1000-seed weight, and plant height.

Keywords: Variability, genotypic correlation, phenotypic correlation, path analysis, Linseed

Introduction
Linseed (*Linumu sitatissimum* L.) is one of the important *rabi* oil seed crop and grown in the country next to rapeseed and mustard in area as well as in production. It is grown for both oil and fiber purposes. It contains very high amount of saturated fatty acids namely palmitic acid and stearic acid along with unsaturated fatty acids viz., oleic, linoleic and linoleinic acids. Due to presence of these acids, its oil is largely of drying type and non-edible. Percentage of oil in linseed seed is 33-45% and having protein content of 24% (Gill, 1987) [9]. Linseed oil is rich in omega-3 fatty acid which is thought to be helpful in decreasing cholesterol level when included in the diet chain. (Singh and Marker, 2006) [23]. It is globally an important oilseeds crop and its production is 19.23 lacs tons from an area of 22.18 lacs ha with an average yield of 867 kg/ha.

India ranks first in area and fifth in the production in the world and it contribute 7 percent to the total world linseed pool. Total production of linseed in India is 1.47 lacs tons from an area of 3.59 lacs ha with an average productivity of 408 kg/ha. Grain yield is a complex character influenced by a number of component traits. Hence, selection of genotypes with desirable characters could be greatly enhanced, if significant correlation between yield and its component characters are established as well as path coefficient analysis suggested by Dewey & Lu (1959) [6], it is very useful in understanding the cause and effect relationship between the dependable variables like grain yield and in-dependable yield components. A clear picture of contribution of each component in final expression of complex character may emerge through the knowledge about extent of genetic variability of different traits, correlations and path coefficient analysis revealing different ways in which component attributes influence the complex trait. In order to achieve the goal of increased production by increasing the yield potential of the crop, knowledge of direction and magnitude of association between various traits is essential for plant breeders. Therefore, there is a need to generate information on interrelationships of yield and yield related traits among linseed genotypes. Accordingly, the present investigation was carried out to study the association of seed yield and its component of linseed.

Materials and Methods
The experiment was conducted at Zonal Research Station (*Birsa agricultural University*),

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Chianki in *Rabi*, 2012-13. Fourteen linseed genotypes/lines viz., BAU-2K-16, Shekhar, RLC-94, Subhra, PCL-42-1, NDL-2006-10, NL-259, PKDL-91, RL-27005, PCL-40, SLS-74, SLS-75, LMS 2007-4 and T-397 (NC) were laid out in the Randomized Block Design with three replications in dryland condition. All recommended agronomic package of practices were followed during the crop growth period for raising good crop. The data were recorded on ten randomly selected plants from each genotype for eight quantitative traits *viz.*, Days to 50% flowering, Days to maturity, Plant height (cm), Number of branches per plant, Number of capsule per plant, Number of seeds per capsule, 1000 seed weight (g), and Seed yield (q/ha) along with biological yield and harvest index. All the data were analyzed using Windostat version 9.1 from Indostat service Hyderabad, India. Heritability was estimated as per Allard (1960) [3], Genetic Advance was computedas per Johnson *et al.* (1955) [10], Correlation coefficients between yield and yield contributing characters were estimated as suggested by Burton (1952) [4] and path analysis was carried out following Dewey and Lu (1959) [6].

Results and Discussion

The analysis of variance revealed significant differences among genotypes for all the characters indicating the presence of adequate variability among the genotypes (Table 1). It is well known that the genotypic co-efficient of variation is more important to phenotypic co-efficient ofvariation, because of high amount of genetic variation. This helps in the formation of effective breeding programme for crop improvement. Therefore, emphasis should be given on genetic variation as compared to phenotypic variation as it is not suitable index for the amount of variation, which may get fixed in subsequent generations and carries the effect of environmental influence also. The estimates of genotypic variance, phenotypic variance, phenotypic and genotypic coefficients ofvariation (PCV and GCV), heritability in broadsense (h^2) and genetic advance presented in Table 2 revealed that PCV estimates of all characterswere slightly more than that of GCV indicating theless influence of environment. The GCV was higher for seed yield/plant followed by biological yield, number of capsules per plant, harvest index, number of seeds per capsule, number of branches per plant 1000-seed weight indicating that these traits can be effectively selected for improvement. Similar results were reported by Mahto and Mahto (1988) [12], Mishra and Yadav (1999) [14] and Kumar *et al.* 2013 [11]. The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. Heritability is a good index of transmission of characters from parents to its progeny. The estimates of heritability help the plant breederin selection of elite genotypes from diverse genetic population. Therefore, high heritability helps in effective selection fora particular character. Heritability is classified as low (below 30%), medium (30-60%) and high (above 60%). The estimates of heritability were higher for all the characters studied except harvest index, number of seeds per capsule and plant height. High heritability indicates the scope of genetic improvement of these characters through selection. Similar results have also been reported by Dayal*et al.* (1975) [5], Rai *et al.*, (2000) [18], Rama Kant *et al.*, (2005) [19]. The genetic advance is a useful indicator of the progress that can be expected as result of exercising selection on thepertinent population. Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson *et al*., 1955) [10]. High heritability coupled with high genetic advance asper cent of mean (>20%) was observed with seven yield components viz., biological yield (57.68), harvest index (49.19), number of branches per plant (35.60), number of capsules per plant (52.99), number of seeds per capsule (30.07) and 1000-seed weight (22.19). Almost similar results were also reported by Satapathi *et al*. (1987) [21], Patil and Chopde (1981) [17] and Dobbins and Wiley (2004) [7].

Genotypic correlations (Table 3) were higher in magnitude than the phenotypic correlation indicating strong inherent relationship among the characters except harvest index which could be due to modifying effects of the environment. Similar findings were reported by Savita *et al*. (2011) [22]. Genotypic correlation provides a measure of genotypic association among different traits and helps in identifying the traits in selection.

Correlation among yield and yield components indicated that seed yield per plant had positive significant association both at genotypic and phenotypic levels with biological yield, harvest index, branches per plant, number of capsules per plant, 1000-seed weight, days to flowering and days to maturity (Table 3). This indicated that simultaneous selection for these traits might bring an improvement in seed yield. Further number of capsules per plant had positive significant association with number of seeds per capsule, days to maturity and days to flowering. The number of branches per plant had also positive correlation with 1000-seed weight. These results are in conformity with Mirza *et al.* (1996) [13], Mishra and Yadav (1999) [14], Pal *et al.*, (2000) [16], Akbar *et al.* (2003) [2], Adugna and Labuschagne (2003) [1], Sohan *et al.* (2004) [24], Nagaraja *et al*. (2009) [15], Gauraha and Rao (2011) [8] and Tarique *et al.* (2014) [25].

The path coefficient analysis (Table 4) provides a more realistic evidence of the interrelationship, as it considers direct and indirect effects of the variables by partitioning the correlation coefficients. The genotypic as well as phenotypic correlation coefficients between grain yield and different traits were subjected to path coefficient analysis separately partitions intodirect as well as indirect effects via. various yield contributing characters are summarized in (Table 4). Coefficient analysis showed that number of branches per plant had maximum direct effect (3.761 and 4.364) fallowed by number of capsules per plant (3.252 and 3.9357), harvest index (2.932 and 3.948), biological yield (2.084 and 2.424), plant height (2.221 and 1.044) and number of seeds per capsule (1.858 and 1.075), days to flowering (1.817 and 1.574), days to maturity (1.570 and 1.440), yield per plant (0.858 and 0.769) and 1000-seed weight (0.369 and 0.318). The authors, Akbar *et al.* (2003) [2], Savita *et al*. (2011) [22], Reddy *et al.* (2013) [20], Tarique *et al.* (2014) [25] also reported similar trend of results.

From the inference of present investigation it can be concluded that number of branches per plant, number of capsule per plant and 1000-seed weight are the most imperative selection parameters for the enhancement of grain yield in linseed as all these above traits correlate with seed yield significantly and positively at both genotypic as well as phenotypic level. Whereas path analysis also suggests that these traits had the positive and direct effect on the grain yield.

Table 1: Analysis of variance (ANOVA) for yield and yield related traits in linseed cultivars

Source of variation	d.f.	Yield/ plant (g)	Biological yield	Harvest Index	No. of branches/ Plant	No. of capsules/ plant	No. of seeds/ capsule	1000-seed wt. (g)	Days to 50% flowering	Days to maturity	Plant Height (cm)
Replications	2	0.06	2.89	30.61	0.83	37.56	5.77	0.01	16.71	0.14	13.8
Treatments	13	31.18**	202.72**	1275.87**	154.54**	1360.07**	52.05**	13.02**	645.64**	1748.57**	310.83**
Errors	26	2.33	8.84	264.16	15.68	182.97	20.45	1.34	2.43	33.86	228.20

*,**: Significant at 5% and 1% levels respectively.

Table 2: Estimation of genetic parameters for agronomic traits in linseed cultivars

Particulars	Yield/ plant (g)	Biological yield	Harvest Index	No. of branches/ Plant	No. of capsules/ plant	No. of seeds/ capsule	1000- seed wt. (g)	Days to 50% flowering	Days to maturity	Plant Height (cm)
Genotypic variance	0.77	5.08	29.33	3.76	32.53	1.07	0.32	15.74	44.40	5.04
Phenotypic variance	0.86	5.42	39.49	4.36	39.57	1.86	0.37	18.18	45.70	13.82
GCV (%)	34.72	22.55	21.62	14.53	22.14	15.00	9.06	4.94	5.93	5.77
PCV (%)	36.68	23.29	25.09	15.65	24.41	19.75	9.77	5.31	6.02	9.55
Heritability (h^2)	0.90	0.94	0.74	0.86	0.82	0.58	0.86	0.87	0.97	0.36
Genetic Advance 1%	2.19	5.76	12.32	4.75	13.65	2.08	1.38	9.75	17.34	3.58
Genetic Advance (1%) as % of Mean	86.76	57.64	49.19	35.60	52.99	30.07	22.19	12.13	15.44	9.20

Table 3: Genotypic and Phenotypic correlations between yield and other related characters of Linseed

Character		Yield/ plant (g)	Biological yield	Harvest Index	No. of branches/ Plant	No. of capsules/ plant	No. of seeds/ capsule	1000 seed wt. (g)	Days to 50% flowering	Days to maturity	Plant Height (cm)
Yield/ plant (g)	G	**1.000**	0.8341**	0.7357**	0.1164**	0.2933**	-0.1699	0.1247**	0.4203*	0.4430**	0.0455
	P	**1.000**	0.7833**	0.7442**	0.0971**	0.2592**	-0.0628	0.1174**	0.3858*	0.4056**	0.0116
Biological yield	G		**1.000**	0.2444**	0.2771**	0.1953**	-0.2101	0.0452	0.2106	0.3843*	0.3774
	P		**1.000**	0.1762**	0.2432**	0.1647**	-0.1356	0.0223	0.1942	0.3604*	0.2569
Harvest Index	G			**1.000**	-0.0743	0.2343	-0.0481	0.1122	0.4683**	0.2984	-0.3761
	P			**1.000**	-0.0638	0.2034	0.0327	0.1203	0.3950**	0.2438	-0.2546
No. of branches/ Plant	G				**1.000**	-0.3832*	0.1469	0.3684*	-0.1697	-0.1970	0.2496
	P				**1.000**	-0.3435*	0.0566	0.3408*	-0.1266	-0.2091	0.0787
No. of capsules/ plant	G					**1.000**	0.7222**	-0.1738	0.6419**	0.4097*	0.1960
	P					**1.000**	0.4846**	-0.1385	0.5620**	0.3705*	0.1733
No. of seeds/ capsule	G						**1.000**	-0.1910	0.5208*	-0.1913	0.0310
	P						**1.000**	-0.2067	0.3589*	-0.1292	0.1188
1000 seed wt (g)	G							**1.000**	-0.3723	0.0361	0.1731
	P							**1.000**	-0.3014	0.0330	0.0400
Days to 50% flowering	G								**1.000**	0.4616**	-0.1276
	P								**1.000**	0.4174**	-0.1173
Days to maturity	G									**1.000**	0.3528
	P									**1.000**	0.2411
Plant Height (cm)	G										**1.000**
	P										**1.000**

*,**: Significant at 5% and 1% levels respectively.

Table 4: Phenotypic (P) and Genotypic (G) path coefficient analysis showing direct (bold) and indirect effects of different characters inLinseed

Character		Yield/ plant (g)	Biological yield	Harvest Index	No. of branches/ Plant	No. of capsules/ plant	No. of seeds/ capsule	1000 seed wt. (g)	Days to 50% flowering	Days to maturity	Plant Height (cm)	Correlation with seed yield/plant
Yield/ plant (g)	G	**0.769**	0.834	0.735	0.116	0.293	-0.169	0.124	0.420	0.443	0.045	1.000
	P	**0.859**	0.783	0.744	0.097	0.259	-0.062	0.117	0.385	0.405	0.011	1.000
Biological yield	G	1.650	**2.084**	0.244	0.277	0.195	-0.210	0.045	0.210	0.384	0.377	0.8341**
	P	1.690	**2.424**	0.176	0.243	0.164	-0.135	0.022	0.194	0.360	0.256	0.7833**
Harvest Index	G	3.495	2.985	**2.932**	-0.074	0.234	-0.048	0.112	0.468	0.298	-0.376	0.7357**
	P	4.334	2.579	**3.948**	-0.063	0.203	0.032	0.120	0.395	0.243	-0.254	0.7442**
No. of branches/ Plant	G	0.198	1.211	-0.780	**3.761**	-0.382	0.146	0.368	-0.167	-0.197	0.249	0.1164**
	P	0.188	1.183	-0.837	**4.364**	-0.343	0.056	0.340	-0.126	-0.209	0.078	0.0971**
No. of capsules/	G	1.467	2.512	7.235	-4.238	**3.252**	0.722	-0.178	0.641	0.409	0.196	0.2933**
	P	1.511	2.413	8.038	-4.513	**3.957**	0.484	-0.138	0.562	0.370	0.173	0.2592**

plant												
No. of seeds/ capsule	G	-0.154	-0.490	-0.269	0.295	4.265	**1.072**	-0.191	0.520	-0.191	0.031	-0.1699
	P	-0.074	-0.430	0.280	0.161	4.156	**1.858**	-0.206	0.358	-0.129	0.118	-0.0628
1000 seed wt (g)	G	0.061	0.057	0.342	0.403	-0.553	-0.111	**0.318**	-0.372	0.036	0.173	0.1247**
	P	0.066	0.031	0.459	0.432	-0.527	-0.171	**0.369**	-0.301	0.033	0.040	0.1174**
Days to 50% flowering	G	1.463	1.884	10.062	-1.302	14.527	2.139	-0.833	**1.574**	0.461	-0.127	0.4203*
	P	1.524	1.928	10.584	-1.125	15.071	2.086	-0.781	**1.817**	0.417	-0.117	0.3858*
Days to maturity	G	2.590	5.774	10.767	-2.542	15.570	-1.319	0.135	1.204	**1.440**	0.352	0.4430**
	P	2.541	5.674	10.357	-2.953	15.756	-1.190	0.135	1.031	**1.570**	0.241	0.4056**
Plant Height (cm)	G	0.089	1.911	-4.574	1.087	2.510	0.072	0.219	-1.137	5.279	**1.044**	0.0455
	P	0.039	2.224	-5.948	0.611	4.052	0.602	0.090	-1.859	6.059	**2.221**	0.0116

*,**: Significant at 5% and 1% levels respectively.

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